Wireless World

VOL 67 NO 7 JULY 1961

Components and Assemblies

THE emergence of the Radio and Electronic Component Manufacturers Federation's exhibition from the comparative privacy of Grosvenor House to the open halls of Olympia was regretted by many on sentimental grounds, but is nevertheless symbolic of the growth and prosperity of the root stock of the British radio and electronic industry. Formerly a sort of club where industrial and Government departmental buyers could negotiate the preliminaries of contracts with technical sales representatives of the component manufacturers, the exhibition has now opened its doors to the world, which is showing increasing interest not only in the quality of the goods, but also in the price. It is no secret that Continental equipment manufacturers often find it cheaper to buy British and to an extent which is reflected in the statistics. In 1960 exports were standing at a value of £13.5M (36.5% more than in 1959) and preliminary returns for the early part of 1960 show a further increase of the order of 20%.

By contrast the component assemblers—the manufacturers of complete equipment—have been finding things more difficult. In particular, the television receiver industry is becalmed in a sea of surplus sets. To some extent the component manufacturers must accept part of the blame, for the reliability of British television receivers has exceeded expectations, and estimates of the production necessary for replacement in a virtually saturated market have proved to be too high. German television manufacturers also have large surplus stocks, but the hold-up has been caused by vacillation over means of providing a second TV programme, and by misjudgment of the timing in the introduction of technical improvements, e.g., the "square-cornered" picture tubes. The future prospects for television sales on the Continent are bright, for it will be at least five years before the number of viewers reaches the level already achieved in the U.K.

Meanwhile the basic problem everywhere is the proper use of an excess productive capacity. This is not a new development. For many years the pattern of the industry has been formed by a number of medium- to large-sized firms each with production lines which, if working to full capacity, could have satisfied well nigh the whole of national demands. Fluctuations in demand have to be met by seasonal working and a reservoir of manufacturers' or dealers' stocks.

The possession of surplus stocks may have advantages in meeting quickly and at the right price export orders from unexpected quarters, and in this situation we find one of the strongest arguments for a change from our 405 lines to the 625-line standard. Since most of the underdeveloped countries are adopting this standard, Continental manufacturers have the advantage of being able to deliver from stock. British manufacturers are competitive in price, but not in delivering times.

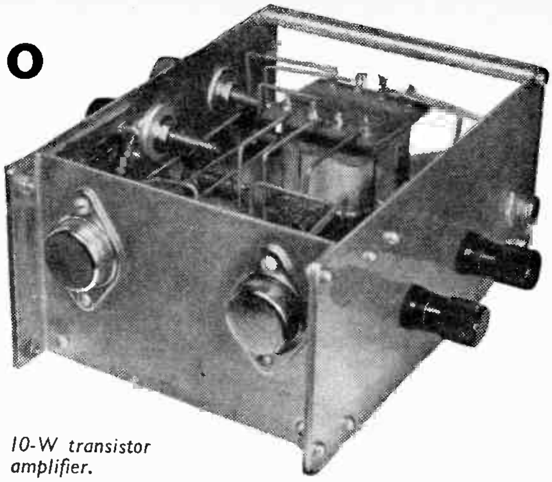
The rate of introduction of new technical developments can also have a considerable influence on the attitude of mind of the buying public. If the potential customer gains the impression that he is on the threshold of a period of fresh advancement he may well decide to stick to his old set until the situation is clear. It is unlikely to be so if manufacturers make a continuous succession of changes in design regardless of the state of the market. This aspect of the economy was underlined at a recent conference of international radio technical journalists by Herr Werner Meyer, director of the export commission of the radio and television branch of the German electrical industry (Z.V.E.I.). After pointing out the difficulties which had resulted in Germany from the successive introduction of 21-in then 19-in and 23-in tube sizes, all within a year, he reminded manufacturers that they had some responsibility for letting dealers sell existing stocks before placing new designs before the public. In his opinion the time had come when there should be intimate co-operation between the technical departments of all the important factories in Europe (and he personally hoped that these would include England and the Scandinavian countries) to secure agreement on the timing of changes and to safeguard the stability of the market.

We realize that these matters are controversial and will be stigmatized by some as restrictive practices. We prefer to describe them as planned economy which will in the long run benefit the consumer as much as the manufacturer. Recent signs and events all point to the fact that the British radio industry has decided that its future, either as a competitor with or a partner in the European Common Market, will be best assured by regrouping, consolidation and more unified control. Our own view is that it has little to lose and much to gain by collaboration with the rest of Europe in developing the markets which still remain to be served.

Transistor Audio Amplifier

By R. C. BOWES, B.Sc., A.M.I.E.E.

DESIGNS FOR 4W AND 10W OUTPUT WITH LESS THAN 0.1% DISTORTION



10-W transistor amplifier.
(Crown Copyright photograph)

POWER transistors which are suitable for audio power amplifiers have existed for some time, but most designs, up to date, cannot be classed as high quality from a distortion point of view. The currently accepted standard for total distortion is less than 0.1% at all levels up to full output (whether such a low distortion is really necessary is another matter) and the amplifier described has this performance up to maximum output which is 4 to 10 W. A transformerless class-B output stage is used to feed a 15-Ω load directly, and the distortion is kept low both by overall feedback and local feedback on the output transistors. The article describes the 4-W amplifier in detail and the modifications for a 10-W output are given at the end.

Circuit Description.—The complete 4-W amplifier circuit is shown in Fig. 1 and the logic of the design will now be considered, starting at the output stage. The current and voltage ratings of power transistors are very suitable for directly driving a 15-Ω speaker load, and the output stage is a transformerless class-B push-pull circuit with the transistors connected in series. The elimination of the output transformer has the advantage of saving a large and costly component, especially if full power is

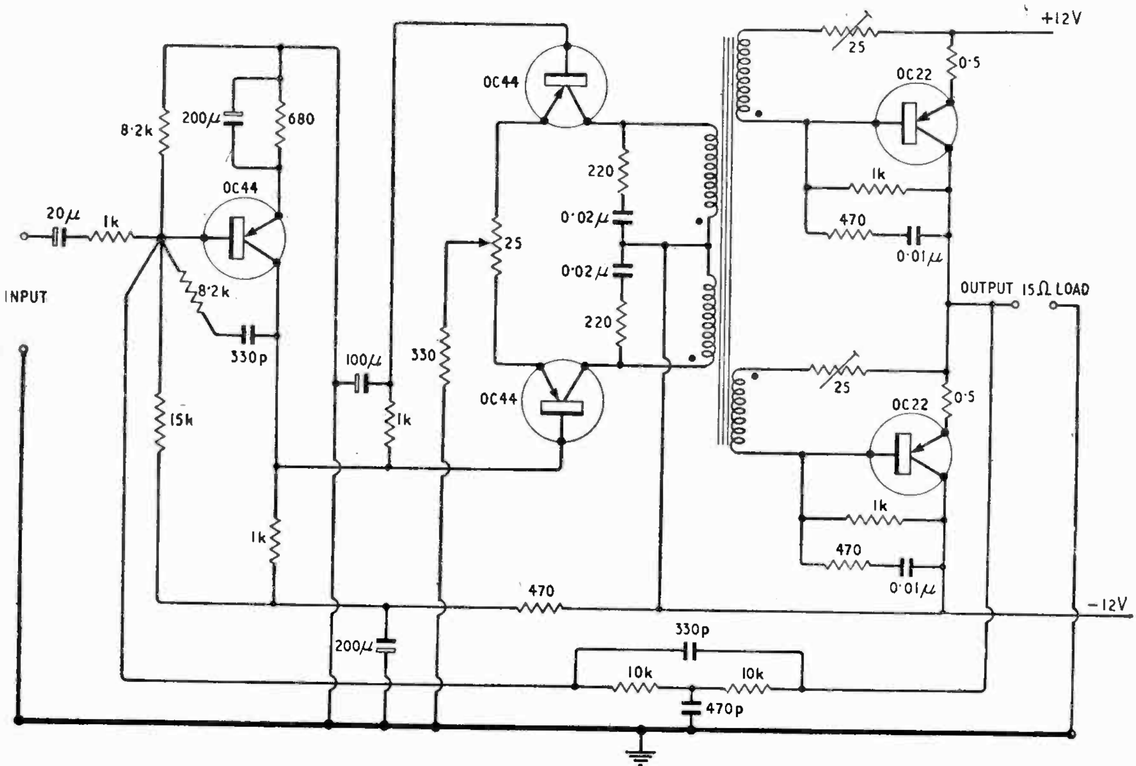


Fig. 1. 4-W amplifier circuit.

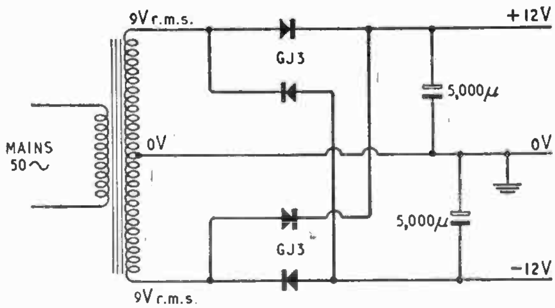


Fig. 2. Power supply for 4-W amplifier.

required at low frequencies. The use of a class-B output stage keeps the power dissipation low in the output transistors, which makes thermal run-away easier to avoid, and gives the amplifier a good overall power efficiency. The last point is usually trivial unless battery supplies are used. A symmetrical power supply of +12 and −12 V (Fig. 2) has been used because it enables the load to be connected directly between the output point and earth. (If a single supply of 24V is used two rectifiers and a large smoothing capacitor are saved, but a large capacitor is required in series with the load to earth, and if the feedback is still taken from across the load an additional low-frequency lead is introduced.)

The quiescent current (50mA) in the output transistors is determined by the 1-kΩ resistors from collector to base and the 25-Ω preset resistors in the base-emitter circuits. The output transistors are stabilized against thermal run-away both by low base-emitter resistors (about 15Ω) and the addition of 0.5-Ω resistors in the emitter circuits. This enables the amplifier (in its 4-W version only) to be safely operated in an ambient temperature of up to 40°C. This method of biasing the output transistors provides feedback at signal frequencies which reduces the current gain by about four and also decreases the distortion.

The output transistors are driven by a transformer as this is a convenient way of obtaining the floating input required by the lower output transistor. The use of a transformer has the advantage of providing a current gain of three and the resistance in the base circuit of the output transistor is kept low, which helps the d.c. stability. The transformer (details in appendix) is quite small and easy to design providing there is no d.c. polarization. The latter requirement has been met by feeding the primary, in push-pull, from the collectors of a long-tailed-pair circuit, the currents being balanced by the preset potentiometer between the emitters. At audio frequencies the primary is current driven and therefore so are the bases of the output transistors. These can be looked upon as "virtual earth" points because the input impedance of a transistor is low and the local feedback makes it even lower.

The input transistor is directly coupled to one base of the long-tailed-pair, the other base being fed through a 1-kΩ resistor with a large capacitor (100μF) to bypass signal frequencies to earth. With this circuit any d.c. drift of the collector voltage of the input transistor is fed to both bases of the long-tailed-pair circuit and so does not upset the balance of the currents in this circuit, but only slightly alters their magnitude.

The design of the output and driver stages having been fixed, the input stage is added to increase the forward gain so that about 34dB of overall feedback can be applied while still leaving an input-output voltage gain of 20 times. The input stage is a common-emitter circuit in which the d.c. conditions are stabilized by an emitter resistor, which is decoupled, in associated with a potential divider to supply the base voltage.

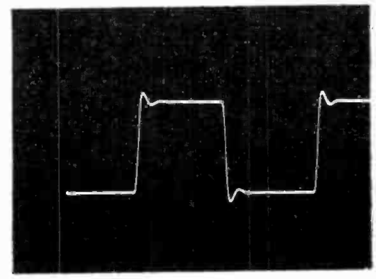
The amplifier has overall feedback applied in an anode-follower manner, the base of the input transistor being the virtual earth. The input arm consists of a 20-μF capacitor and 1-kΩ resistor, and the feedback arm is a 20-kΩ resistor which is fed directly from the output point.

Loop Gain and Stability.—The loop gain at 1kc/s is 34dB, and it is 3dB down at 100c/s and 10kc/s. Taking low frequencies first, the most important phase lead is due to the driver transformer and the only additional leads are transitional ones due to the decoupling capacitors on the emitter of the input transistor and on one base of the long-tailed-pair circuit. There is no difficulty in choosing the corner frequencies of these leads so that adequate stability at low frequencies is obtained.

The high-frequency loop response is more complex. It is determined both by the transformer and the transistors, and is shaped by local feedback on the input and output transistors. The effects of resonance in the transformer are reduced by the addition of a capacitor-resistor network across the primary which changes the drive from current to voltage at high frequencies. Also, a phase advance is obtained in the feedback network by the addition of a capacitor (330pF) in parallel with the feedback resistor. The combined effect of these shaping networks is that unity loop gain is obtained at 150kc/s with a phase shift of about 120°, which is a very adequately stable system. This has been verified by feeding the complete amplifier with square waves and observing the transient response. The photograph of the small-signal response with a square wave input at 5kc/s and a load of 15Ω shows that this is very satisfactory and indicates the amplifier is adequately stable. Although OC44 type transistors (which have an average f_α of 15Mc/s) have been used in the prototype and for the loop-gain calculations, the fitting of OC45 type transistors (average f_α=6Mc/s) still gives a satisfactory transient response.

The purpose of the 470-pF capacitor from the centre tap of the feedback resistor has been ignored up to the present. In the early design stages this capacitor was not fitted and the overall frequence response was down 1dB at 10kc/s and 3dB at

Output waveform with a 5kc/s square-wave input and 15-Ω load.



25kc/s (see Fig. 3). This was considered to be inadequate and the 470-pF capacitor was added to reduce the feedback around 25kc/s and improve the 1dB point to 45kc/s (see Fig. 3) without altering the feedback at higher frequencies.

Power Supply.—The power supply (Fig. 2) consists simply of two germanium rectifiers and a smoothing capacitor for each line. The total resistance (transformer winding and wiring) in series with the rectifiers should be about 0.4Ω in order to limit the peak current under the worst possible condition, which occurs when the mains switch is closed at peak voltage.

Distortion.—Fig. 4 shows both the harmonic distortion up to the 5th harmonic and the total distortion, for power output levels up to 4 W with a 1 kc/s signal. The total distortion with an output of 4 W is 0.031% and this low level of distortion is a result of the large amount of feedback in the amplifier. The local feedback on the output transistors reduces the gain by about 4 and the overall feedback reduces the gain by 50, so that the total feedback factor is 200 (so far as the output transistors are concerned). This means that at an output level of 4 W, if both feedback paths were made imperative, the total distortion would be about 6%, which is a typical figure for a transistor power amplifier in which no techniques are used to reduce distortion.

The push-pull output stage produces no even harmonic distortion if everything is perfectly symmetrical, and it is therefore desirable that the α's of the output transistors should be matched to better than 20%, at large currents (about ½A), so as to keep the second harmonic distortion below 0.05%. The transistors used in the prototype were matched to about 10%, and the amplifier gives just over 0.02% second harmonic distortion at an output power of 4W.

Operating Conditions.—The quiescent current of each output transistor is adjusted to about 50mA by measuring the voltage drop across the 0.5-Ω emitter resistors. This relies on the 0.5-Ω resistors being accurate, and a cross check on the equality of the quiescent currents is to measure the voltage across the load, which should be zero. If it is not zero it should be made so by readjusting the quiescent current of one of the output transistors.

The currents in the long-tailed-pair are balanced by connecting a voltmeter with a f.s.d. of the order of 1 to 5V between the two collectors, and adjusting the potentiometer in the emitter circuit for zero reading. The resistance of the transformer primary provides sufficient voltage drop for this measurement.

The input stage collector potential should be about −6V and the emitter potential about −2.6V. Variations from these voltages of up to 20% are not serious. (These voltages only apply to the 4-W amplifier.)

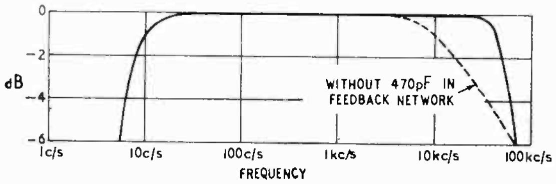


Fig. 3. Small-signal overall frequency response of 4-W amplifier.

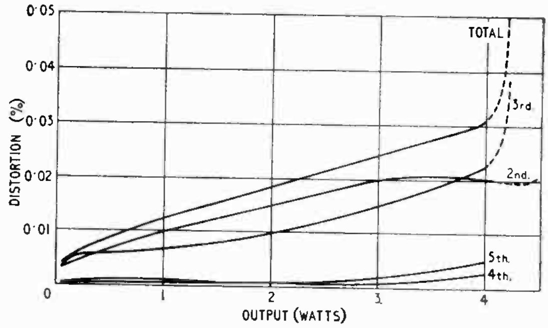


Fig. 4. Distortion at 1kc/s with a 15-Ω load (4-W amplifier)

Constructional Details.—The circuit diagram gives the output transistors as type OC22 but OC23's or OC24's are equally suitable. Each output transistor should have a heat sink of about 9 sq in and in the prototype the chassis forms the heat sink, mica washers being used to insulate the transistors. The layout is not critical but care should be taken to ensure that the feedback is taken from close to the output point, in order to avoid part of the wiring (which has finite resistance) to only *one* of the output transistors being included in series with the load. This is because each transistor only works on alternate half cycles and a second harmonic signal (which the overall feedback would not affect) would be added in series with the load.

Modifications.—The amplifier described will comfortably deliver 4 W into a 15-Ω load but this can be increased to 6 W by raising the power supply, for the output transistors, to +15 and −15 V. The only limitation on the amplifier, with this modification, is that the safe ambient temperature falls to about 35°C from 40°C. It is convenient to use the −15 V line also to supply the driver circuits. However, this requires an additional change because −15 V would cause the maximum power dissipation of the OC44 transistors in the long-tailed-pair circuit to be exceeded. The solution is either to fit a suitable dropping resistor to reduce the supply voltage to the driver circuits to −12 V, or to use XA102 transistors, which have a higher maximum power dissipation than OC44 types, in the long-tailed-pair circuit. The total distortion, with these modifications, when supplying 6 W into a 15-Ω load at 1kc/s, is under 0.05%.

More recently, the power output has been increased to 10 W by raising the power supply to +20 and −20 V. The circuit modifications required to the long-tailed-pair are the use of XA102 type transistors and the increase of the "tail" resistor from 330 to 560 Ω. Also, OC22 type output transistors cannot be used because of the increase in the supply voltages, but either OC23 or OC24 types are still suitable. The only limitation on the amplifier, with these modifications, is that the safe ambient temperature falls to about 30°C. The total distortion when supplying 10 W into a 15-Ω load, at 1kc/s, is under 0.1%.

The author would like to thank Mr. P. J. Baxandall for many helpful discussions during the design of this amplifier.

APPENDIX

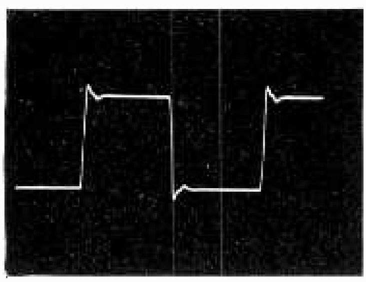
Performance of the Prototype 4-W Amplifier:—

Power Output:—The maximum power output is 4 W into a 15-Ω load and the total distortion at 1kc/s is 0.031% (see Fig. 4). Full power is available up to 10kc/s, but at low frequencies the maximum power output decreases, due to the magnetizing current in the driver transformer. Even so, over 3 W is available at 10c/s.

Overall Gain:—The overall voltage gain is approximately 20 which means that an input of about 0.4Vr.m.s. is required for full output. (For the 6- and 10-W versions 0.48 and 0.62V respectively are required.) The small-signal response is shown in Fig. 3 and is within 1dB from 10c/s to 45kc/s.

Loop Gain:—The loop gain at 1kc/s is 34dB and is 3dB down at 100c/s and 10kc/s.

Input Impedance:—The input impedance is 1kΩ and since full output is obtained with an input of 0.4V r.m.s. the maximum input current is 0.4A r.m.s.



Output waveform with a 5kc/s square wave input and a load of 15Ω and 0.05μF in parallel.

Capacitive Load:—A capacitor load of up to 0.05μF in parallel with the normal 15-Ω load does not seriously affect the stability of the amplifier. The transient response with a 5kc/s input (see photograph) differs trivially from that with a 15-Ω load only. If the amplifier is driving a speaker which is an inductive load at high frequencies, *and* there is capacitance in parallel greater than about 0.001μF (due to a very long speaker cable, perhaps) a 15-Ω resistor in series with a 1-μF capacitor should be connected across the amplifier output terminals so as to make the amplifier load still look like approximately 15Ω at high frequencies.

Hum and Noise:—Hum and noise power at the output is more than 70dB below the maximum output of 4 W.

Temperature:—The amplifier has been designed to operate safely in an ambient temperature of up to 40°C, provided that each output transistor has a heat sink of about 9 sq in.

Constructional Details of Driver Transformer:—

Core:—A square stack of 15-thou thick 39T (E's $1\frac{5}{8}$in by $1\frac{1}{8}$in) Radiometal laminations is used. The E's and I's are assembled with no gap and a moulded bobbin is used.

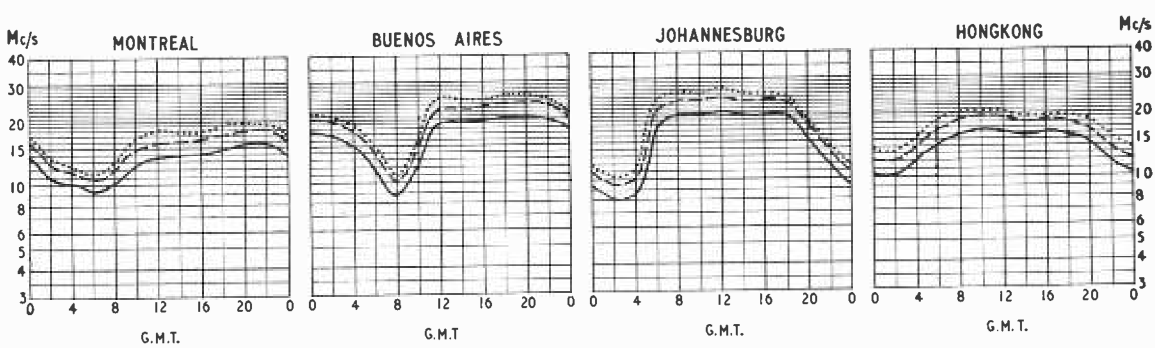
Primary:—The primary is the inner winding on the bobbin and consists of two conductors of 38 s.w.g. enamelled wire which are bifilar wound for about 630 bobbin revolutions. This took 12 layers in the prototype. (As the turns ratio of the transformer is not critical, the last layer may be completely filled.) 1-thou transformer paper is used between layers, with two turns of paper at the finish.

Secondary:—The secondary is the outer winding and consists of two conductors of 32 s.w.g. enamelled wire which are bifilar wound for about 200 bobbin revolutions. This took 8 layers in the prototype. (Again, as the turns ratio of the transformer is not critical, the last layer may be completely filled.) A 3 to 1 ratio should be aimed at. 1-thou paper is used between layers and the finish is with Empire cloth or as desired.

Measurements on Prototype Transformer:—The resistance of primary (1) was 38.6Ω, primary (2) 38.6Ω, secondary (1) 4.49Ω and secondary (2) 4.495Ω. The inductance of primary (1) was 0.57H, primary (2) 0.57H, secondary (1) 0.059H and secondary (2) 0.059H. These inductance measurements were all made under small-signal conditions at 1kc/s.

SHORT-WAVE CONDITIONS

Prediction for July



THE full-line curves 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 Great Britain during July.

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

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

— — — PREDICTED MEDIAN STANDARD MAXIMUM USABLE FREQUENCY

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

WORLD OF WIRELESS

Independent Television Growth

SINCE it was established in August, 1954, the Independent Television Authority has appointed 15 programme companies to operate its stations. The recent appointment of the Wales Television Association (Teledu Cymru), which will cover west and north-west Wales, may be said to "complete the institutional structure of independent television." The I.T.A. has stated that no more programme companies can be appointed on its present allocation of channels in Band III.

Eleven companies with 13 transmitters are now operating. By the end of this year there will be 17 stations and by the end of 1962 another four. The service areas of both the Lichfield and Black Hill transmitters will be improved within the next few months by the introduction of better aerial systems and a higher mast is to be erected at Croydon next year. The Wales Television Association will initially operate two stations; one in Pembrokeshire and one on the Lleyn Peninsula.

Grampian Television, the programme contractors for North East Scotland, plan to open their two transmitters on September 30th. The main station at Durris (not Mongour as previously announced), near Aberdeen, will have a maximum e.r.p. of 400 kW and will radiate in Channel 9. The satellite station covering Inverness-shire, which is at Mounteagle (not Roskill), will radiate in Channel 12 with a maximum e.r.p. of 50 kW.

Brit. I.R.E.

ADMIRAL of the Fleet the Earl Mountbatten of Burma, K.G., who has accepted a second term of office as President of the British Institution of Radio Engineers, speaking at their 1961 Dinner, stressed the importance and responsibility of engineers in developing rapidly the scientific discoveries which were now being made at an exponential rate.

Principal speakers at the dinner included Sir Howard Florey, President of the Royal Society, H.E. the Hon. George A. Drew, Q.C., High Commissioner for Canada, and W. E. Miller, M.A., a past president of the Institution.

The Institution's seventh convention, the theme of which is to be "Radio Techniques and Space Research," opens at the University of Oxford on July 5th.

Servicing Ideas

A COMPETITION for the best ideas for improving or simplifying the servicing of sound and television receivers is being sponsored jointly by Radio Industry Exhibitions Ltd., organizers of the National Radio Show, and *Wireless & Electrical Trader*. It is open to anybody without qualification of any kind.

Entry forms, which must be returned by July 15th, are obtainable from the *Trader*, Dorset House, Stamford Street, London, S.E.1. Three prizes of £50, £25 and £10 are being offered. Prize winners' entries and those of some runners-up will be exhibited at the Radio Show (Aug. 23-Sept. 2).

Birthday Honours

AMONG the recipients of awards in the Queen's Birthday Honours List are the following:—

Knighthood

Allen G. Clark, chairman and managing director, Plessey Company.

Charles J. A. Moses, general manager, Australian Broadcasting Commission.

C.B.

A. V-M. T. U. C. Shirley, Deputy Controller of Electronics, Ministry of Aviation.

Alan Wolstencroft, Director of Radio Services, G.P.O.

C.B.E.

W. H. Penley, deputy chief scientific officer, R.R.E.

Dr. N. H. Searby, manager, Ferranti's Guided Weapons Department.

G. A. Whipple, chairman and managing director, Hilger and Watts.

Dr. F. C. Williams, F.R.S., professor of electrical engineering at Manchester University.

O.B.E.

T. W. Bearup, representative of the Australian Broadcasting Commission in the U.K.

E. A. Hamilton-Hill, director and general manager, Rediffusion (Malta), Ltd.

M.B.E.

W. E. Bell, superintendent, G.E.C. Applied Electronics Laboratory, Portsmouth.

G. Crichton, Government Communications H.Q.

J. S. Darling, communications officer, Foreign Office.

F. W. Fowler, first radio officer, m.v. *Rangitata*, N.Z. Shipping Co.

H. S. Gibbs, chief telecommunications supt. G.P.O.

R. G. Hawkins, chairman and managing director, Redcliffe Radio & Engineering Co.

I. P. Massy, Government Communications H.Q.

L. H. Rowley, senior station radio officer, Admiralty.

B.E.M.

J. M. Gardiner, R.A.F. Ground Radio Servicing Squadron, Kinloss.

S. Stallybrass, radio technician, London Airport.

Australia's v.h.f. sound broadcasting service is closing down on June 30th. Stations have been operated by the Australian Broadcasting Commission in four of the State capital cities for the past four or five years. The Australian f.m. broadcasting band (92-108 Mc/s) is to be used to increase the number of television channels. Here are the lower frequencies for each of the 7-Mc/s channels in the new 13-channel plan: 1, 45; 2, 56; 3, 63; 4, 85; 5, 94; 6, 101; 7, 137; 8, 174; 9, 181; 10, 188; 11, 195; 12, 208; 13, 215.

A Soviet Trade Fair opens at Earls Court, London, on July 7th for three weeks. Radio, television and electronic equipment (both consumer and capital goods) will be included and television receivers adapted to receive 405-line transmissions will be demonstrated. The Fair will be open on weekdays from 10.0 a.m. to 10.0 p.m. and admission will cost 3s 6d.

Telecommunications Engineering Establishment of the Ministry of Aviation, at Gatwick Airport, was officially opened on June 6th. The establishment, which incorporates what used to be known as the G.C.A. Maintenance and Inspection Unit at Blackbushe Airport, is concerned with "the field engineering of safety devices" and the installation and maintenance of telecommunications equipment.

Television Society Premiums.—The following Premiums "for outstanding papers read before the London meetings in 1959/60" have been awarded by the Television Society:—E.M.I. premium to Dr. Rolf Moller (Fernseh GmbH) for his paper "Television in Germany"; *Electronic Engineering* premium to B. Eastwood (A.E.I.), for "Deflection Techniques for 110° Picture Tubes"; Mervyn premium to S. T. Palmer (G.E.C.) for "Television Receiver Production"; *Wireless World* premium to A. J. Garratt (International Scientific Research Exhibitions) for "Science on Television"; and Mullard premium to R. N. Jackson (Mullard Research Labs.) for "Single-gun v. Three-gun Tubes".

Audio Manufacturers.—At the second annual general meeting of the Audio Manufacturers' Group of the British Radio Equipment Manufacturers' Association on May 17th, the following firms were elected members of the management committee (their representatives names are in parentheses):—A.E.I. (L. R. Metcalfe); Clarke & Smith Mfg. Co. (Major J. F. E. Clarke, vice-chairman); Decca Records (P. B. Cooper); Easco Electrical (E. L. Eastell); Electric Audio Reproducers (L. Stone); Gramophone Co. (H. F. Ford); Grampian Reproducers (J. E. Morley); Jason Motor & Electronic Co. (G. Blundell); Lowther Manufacturing Co. (D. M. Chave, chairman); Philips Electrical (F. P. P. Tielens); Standard Telephones & Cables (J. L. Goodwin); and Trix Electronics (D. A. Lyons).

T.E.M.A.—At the annual general meeting of the Telecommunication Engineering and Manufacturing Association W. F. Oakley, director of Automatic Telephone and Electric Co., was elected chairman and W. G. Patterson, M.B.E., divisional director and general manager of Associated Electrical Industries, vice-chairman.

Radar & Electronics Association.—At the fifteenth annual dinner of the association on May 12th, the president, Sir Robert Renwick, presented prizes to the "best student members of the year". The recipients were D. W. Kent, D. J. Chapman and G. B. Davies. They are all students at the Northern Polytechnic where last year a Students' Branch of the Association was formed. W. D. Day, who is a senior lecturer in radar and advanced engineering at the Polytechnic, is president of the Students' Group of the Association and is also a member of the Council of the Association.

R.I. Club.—Ernest Brown, director of Brown Bros. Ltd., who has been a member of the Radio Industries Club since its formation and was chairman in 1934, has been elected president for 1961/62. The London Club now has a membership of 948. The eight affiliated clubs in the provinces and Scotland have a total membership of 1,378.

Institution of Electronics sixteenth annual exhibition and convention is being held at the College of Science and Technology, Manchester 1, from July 6th to 12th (excluding Sunday 9th). Complimentary admission tickets, giving times of opening, are obtainable free from the general secretary, W. Birtwistle, 78 Shaw Road, Rochdale, Lancs.

A one-day symposium on "Internal Stresses in Electrolytically Produced Coatings and their Influence on the Properties of the Basis Metals" is being held at the Borough Polytechnic, London, S.E.1, on Thursday, July 6th; fee 2gn, including meals.

"**Electromagnetic Theory and Antennas**" is the title of a symposium being organized jointly by the International Scientific Radio Union (U.R.S.I.), and several Danish bodies for next year. It will be held in Copenhagen from June 25th to 30th, 1962. The U.K. correspondent is J. Brown, Department of Electrical Engineering, University College, London.

A radio telescope, which will have a steerable parabolic aerial about 80 ft in diameter, is to be built at a site near Crowthorne, Berkshire, for the Radio Research Station of the Department of Scientific and Industrial Research. It is expected to be completed and in operation towards the end of 1963 at an estimated overall cost of £250,000. The Ministry of Works, which is responsible for the construction, has invited tenders for the telescope.

Inst. P.—Phys. Soc.—In the course of the first presidential address of the amalgamated Institute of Physics and Physical Society, Sir John Cockcroft suggested that in view of the harmonious amalgamation, the separate origins of the partners could be forgotten and that they might "perhaps even change the rather clumsy title of the Institute of Physics and the Physical Society."

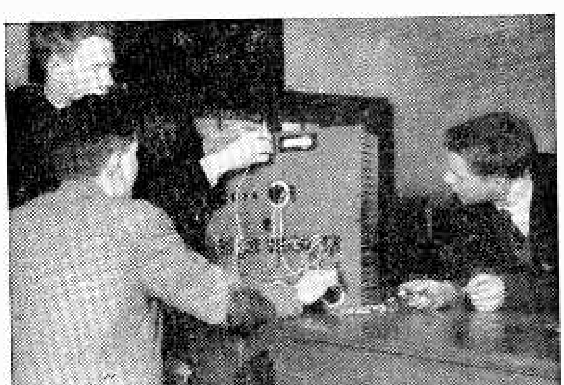
IBM Data Centre opened recently is equipped with IBM 1401 and 7090 data processing systems for operation by the customer. The 7090 is believed to be the most powerful computer in general service in the world —it can add more than a quarter of a million ten-digit numbers every second.

Educational Filmstrip.—"The History of Television" is the title of a new Mullard colour filmstrip which is complementary to "The History of Radio" released earlier. It deals with the history of picture transmission from the middle 19th century to the present day and its simple approach makes it suitable for use in Secondary Modern Schools or in senior classes where science is taught as a general knowledge subject rather than one for examination. The 28-frame filmstrip with teaching notes is available from the distributors, Unicorn Head Visual Aids Ltd., 42 Westminster Palace Gardens, London, S.W.1, price 25s.

"**Inside**"—a 16mm sound and colour film which runs for approximately 20 minutes—describes the research, manufacture, testing and uses of Formica industrial laminates. Copies of the film are available on free loan from Formica Public Relations Department, 84/86 Regent Street, London, W.1.

"**Computer Achievements**", a new E.M.I. 22-minute sound-colour film which shows five uses to which EMIDEC data processing computers are being put, is available for free loan on application to E.M.I. Electronics Ltd., Hayes, Middlesex.

1962 Audio Festival & Fair will be held at the Hotel Russell, London, from April 26th to 29th.



SCHOOL COMPUTER.—Some of the members of the VIth Form of the Ross-on-Wye Grammar School who, under the guidance of C. Grant Dixon, their physics master, have built the analogue computer described in our May, 1960, issue.

Personalities

Sir Bernard Lovell, O.B.E., F.R.S., Professor of Radio Astronomy at the University of Manchester and Director of the Nuffield Radio Astronomy Laboratories, Jodrell Bank, has been appointed scientific adviser to the recently formed "space" consortium, British Space Development Company. During the war, Professor Lovell was a member of the Telecommunications Research Establishment (now R.R.E.), and one of his notable contributions was to H2S, the blind bombing device, for which, with Professor P. L. Dee, he was responsible.

F. S. Mockford has relinquished his appointment as commercial manager of Marconi's W/T Company in order to undertake special duties for the managing director. Mr. Mockford joined the company as an engineer in 1930. He is succeeded as commercial manager by **F. Wheeler** who has been deputy manager of the company's Aeronautical Division since January. The new deputy commercial manager is **H. Baker** who has served the company abroad for many years, latterly as managing director of the Marconi Company in South Africa.

R. Telford, B.A., M.I.E.E., has relinquished his position as general works manager of Marconi's W/T Company and is appointed general manager responsible to the managing director for the overall co-ordination of the commercial, engineering, and manufacturing activities of the company, which he joined in 1946. **H. J. H. Wassell,** who joined the company in 1929, is appointed works manager, Chelmsford. He was appointed head of the radar development group in 1949 and was subsequently chief radar engineer and manager, Test Department. **E. Eastwood,** Ph.D., M.Sc., M.I.E.E., chief of research at Marconi's research establishment at Great Baddow since 1954, is appointed director of research. Dr. Eastwood joined the company in 1948 after two years with English Electric in charge of the radiation laboratory. He is to receive this year's Wakefield Gold Medal of the Royal Aeronautical Society for his contributions towards safety in the air. **E. N. Elford,** O.B.E., A.M.I.E.E., has relinquished his position as manager of the radar division in order to undertake special duties for the managing director, particularly in connection with the company's activities in the defence field. Lt. Col. Elford joined the company in 1946 after a career in the regular army. The new manager of the radar division is **T. W. Straker,** M.Sc., Ph.D., who was appointed deputy manager last September.

C. O. Stanley.—The City and Guilds of London Institute has conferred upon C. O. Stanley, C.B.E., chairman of the Pye Group, the Fellowship of the Institute (F.C.G.I.) in recognition of his "professional status and achievements." He qualified at the City and Guilds of London Institute in 1922.

Charles A. Marshall, B.Sc., A.M.I.E.E., editor of *British Communications & Electronics*, has been elected honorary secretary of the Television Society, in succession to Geoffrey Parr whose death we record with regret on page 349. Mr. Marshall, who graduated from Manchester University in 1944, was for three years with Philips and six years in electronic research and development at the Mullard Research Laboratories, before going into technical journalism in 1954.

R. A. Smith, C.B.E., M.A., Ph.D., A.M.I.E.E., who is at present head of the Physics Department of R.R.E., Malvern, has been appointed Professor of Physics at Sheffield University. Dr. Smith will take up his duties on October 1st and will succeed **Professor W. Sucksmith,** F.R.S., as head of the department when he retires in September next year.

Air Commodore H. G. Leonard-Williams, C.B.E., who is 50 and was until recently commanding the R.A.F. apprentices' radio school at Locking, Somerset, has been appointed Chief Signals Officer, Fighter Command Headquarters. He entered the R.A.F. from the R.A.F. College, Cranwell, in 1932. He was at one time chairman of the British Joint Communications Board and in 1953 was a deputy director of signals, Air Ministry.

Edwin Dunne, A.M.I.E.E., has become chief inspector of the Farnborough Plant of the Solartron Electronic Group. He joined Solartron in January, having previously held the posts of deputy chief inspector with de Havilland Propellers and chief inspector with A. C. Cossor and Cossor Radar & Electronics.


E. Dunne


L. A. Thomas

L. A. Thomas, B.Sc., F.Inst.P., A.M.I.E.E., has been appointed chief physicist of the Hirst Research Centre of the General Electric Company, Wembley. Mr. Thomas, who is 44, joined the Research Laboratories of the G.E.C. in 1935. He was appointed head of the Materials and Components Division in 1960 and will retain his responsibilities in this field.

W. W. Shaw-Zambra, C.V.O., C.B.E., T.D., retired at the end of March from the post of secretary-general of the Commonwealth Telecommunications Board, which he has held since the establishment of the Board in 1949. He was secretary of its predecessors, the Imperial Communications Advisory Committee (1938-1944), and the Commonwealth Communications Council (1944-1949). He was joint secretary of the Imperial Communications Committee of the War Cabinet (1940-1944) with the military rank of Colonel. He is succeeded at the C.T.B. by **W. Stubbs,** C.B.E., M.C., M.I.E.E., M.Brit.I.R.E., who is 49, and was formerly Director-General of Telecommunications for the Federation of Malaya and State of Singapore.

F. D. Bolt, B.Sc. (Eng.), M.I.E.E., has been appointed by the B.B.C. head of the transmitter equipment section of the Planning and Installation Department, in succession to **D. B. Weigall,** M.A., M.I.E.E., who has been transferred to the staff of the senior superintendent engineer, external broadcasting for special duties. Mr. Bolt joined the B.B.C. in 1934 and was appointed to the Daventry station. In 1951 he was made head of the aerial unit in the Planning and Installation Department.

S. W. Thompson, A.M.I.E.E., who joined the B.B.C. in 1941 as a maintenance engineer, has been appointed head of the technical services section in the Department of the Superintendent Engineer, Transmitters.

C. W. Sowton, O.B.E., assistant staff engineer at the Post Office, is to be the U.K. representative on the Panel of Experts which is to meet in Geneva in September "for the purpose of devising ways and means of relieving the pressure on the bands between 4 and 27.5 Mc/s." This investigation was called for at the Geneva I.T.U. conference in 1959. Mr. Sowton is chairman of the C.C.I.R. national study group VIII concerned with monitoring and is secretary of the technical sub-committee of the Television Advisory Committee.

J. F. Young, A.M.I.E.E., A.M.Brit.I.R.E., who is manager of the Electronics Division of Donovan Electrical Company, of Birmingham, has received the Insignia Award in Technology (C.G.I.A.) from the City and Guilds of London Institute. He served his apprenticeship with G.E.C. and then spent some time with W. & T. Avery and Lancashire Dynamo Electronic Products on industrial electronic development, later returning to the G.E.C. where, until recently, he was in charge of the Electronic Development Group at Witton. He has contributed several articles to *Wireless World.*

R. S. Gilling, B.Sc., A.M.I.E.E., has been appointed manager of the A.E.I. Military and Marine Radar Works at Leicester, which form part of the company's Electronic Apparatus Division. He served an engineering and graduate apprenticeship from 1927 to 1934 with the British Thomson-Houston Company, now A.E.I. (Rugby) and in 1940 went into the electrical measurements section of the Research Laboratory, where he played an important part in the development of military radar. In 1946 he was appointed a section leader of the Electronic Engineering Department and since 1955 has been superintendent of the Military and Marine Radar Works.

Major J. F. E. Clarke, chairman of Clarke & Smith Manufacturing Co., of Wallington, has also become chairman of Specto Ltd., manufacturers of cine, photographic and tape-recording equipment, of Vale Road, Windsor, and of Lentar Ltd., the associated company in the optical field. The following executive directors have also been appointed to Specto, **E. M. Eldred,** M.I.E.E., M.Brit.I.R.E. (managing); **L. C. Crook** (deputy managing) and **D. J. Frost** (sales).

Brian A. Curtis has recently joined **P. C. Robinson,** A.M.I.E.E., on the board of Startronic Ltd., manufacturers of laboratory equipment and regulated power supplies, of New Malden, Surrey. Mr. Curtis, like his co-director, was until recently on the staff of Solartron which he joined in 1953. In 1955 he was appointed chief test engineer of Solartron Laboratory Instruments where he was subsequently chief standards engineer.

OUR AUTHORS

R. J. Hitchcock, M.A., A.M.I.E.E., who with P. A. C. Morris writes in this issue on possible techniques for further reducing interference in h.f. communications, represented Cable & Wireless Ltd. on the Provisional Frequency Board in 1949/50. During the next 10 years he attended most of the important international radio-frequency conferences on behalf of the Company. He joined C. & W. in 1948 and until 1959 was in charge of the section of the engineer-in-chief's department responsible for the design of aerials, radio propagation, prediction of optimum usable frequencies and other radio-frequency matters such as interference. He is still associated with Cable & Wireless and is a member of the U.K. study group of the C.C.I.R. dealing with ionospheric propagation and satellite communications.

P. A. C. Morris, B.Sc., A.M.I.E.E., joint author of the article on p. 375, joined Cable & Wireless in 1957 and took over the radio propagation section of the engineer-in-chief's department in 1959. He represents the company on the U.K. study groups of the C.C.I.R. concerned with ionospheric and tropospheric propagation.

R. C. Bowes, B.Sc., A.M.I.E.E., author of the article describing a low-distortion transistor amplifier, has been at the R.R.E., Malvern, since graduating at King's College, Newcastle, in 1950. He is a principal scientific officer in the Circuit Research Division and for the last five years has been concerned primarily with transistor circuitry. He is 35.

OBITUARY

Geoffrey Parr, M.I.E.E., who on May 15th retired from the honorary secretaryship of the Television Society, died on May 30th. He had served the society for 25 years, first as its lecture secretary and since 1945 as honorary secretary. Born in 1899, he entered the radio industry in 1926 when he joined Edison Swan as a valve development engineer, having previously been a lecturer and demonstrator at the City and Guilds Technical College. From 1932 until 1940 he was head of technical service in the company's Radio Division. He was appointed editor of *Electronic Engineering* in 1941 and since 1949 has been technical director of Chapman & Hall. He had a deep-rooted interest in the subject of technical writing on which he frequently lectured and produced a book—"The Technical Writer."

John Walter Ryde, F.R.S., F.Inst.P., the chief scientist of the Hirst Research Centre of the G.E.C., at Wembley, died on May 15th, at the age of 63. He joined the company as a physicist in 1919. His work on the scattering of light, first applied in the '20s to optical diffusing media in glasses, was developed by him during World War II to classic studies of the attenuation and the radar echoes produced by meteorological phenomena at centimetre wavelengths. His researches in World War II included velocity modulation tubes and crystal valves for microwave mixer devices. He had been chairman of the Davy-Faraday Laboratory Committee of the Royal Institution since 1951.

H. Anthony Hankey, who died on May 12th, aged 74, can be numbered among the pioneers of wireless for he was in charge of the Cullercoats station in 1907. He joined the Royal Navy in 1914 and was later posted to Hong Kong as Port Wireless Officer. After the war he joined Marconi's. He was in charge of the 100-watt 2LO transmitter at Marconi House at the time of the first broadcast. In 1928 he went on a world tour to further "Empire Broadcasting" and the following year joined the Baird Company. During the last war, he was a radio officer in the Royal Navy.

Dr. Eugen Nesper, "the last of the grand old men of German wireless," died on May 3rd in his 82nd year. He assisted Professor Slaby in his early experiments at Potsdam in 1897. In 1904 he joined the Telefunken company, but two years later went to C. Lorenz A.G., where he worked on the Poulsen arc continuous wave system. He became director of the Lorenz factory in Vienna. Dr. Nesper, who campaigned for the introduction of broadcasting in Germany in the early 1920s, published 35 books on wireless and in 1943, a "society for the exploitation of Dr. Nesper's inventions" was founded in Berlin. His published memoirs are called "A Life with Ratio."

William G. J. Edwardes, who died recently in his 80th year, had been general secretary of the I.P.R.E. since its formation as the Institute of Practical Radio Engineers in 1936. He spent some years in North America, where he was associated with Lee de Forest in the development of the triode valve, and for ten years before returning to his native England in 1934 was working in Australasia.

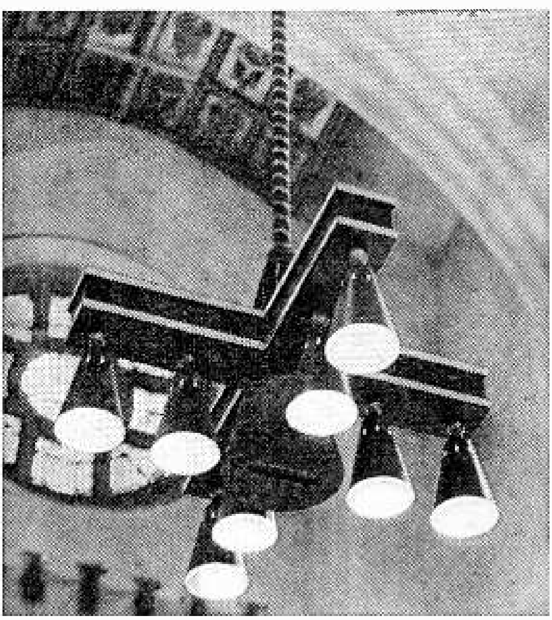
Derek M. Hall, B.A., manager of the Home Trade Sales Division of Mullard Ltd., which he joined in 1948, died on May 21st, aged 49. He was this year's president of the Incorporated Practitioners in Radio and Electronics (I.P.R.E.).

News from Industry

Ultra's domestic radio and television interests, which were concentrated in Ultra Radio and Television Ltd., Pilot Radio and Television Ltd., and their subsidiaries have been sold to Thorn Electrical Industries for £2.4M. The cash transaction includes Ultra's factory at Gosport, Hants, and other premises at Ruislip, Eastcote and Park Royal. Thorns, who already use the trade names Ferguson, Philco, Champion, Avantic and, under licence from E.M.I., Marconiphone and His Master's Voice, state that they intend to preserve the separate identities of Ultra and Pilot. Trevor C. Standeven, formerly general manager and director of Ultra Radio and Television, becomes managing director. The head office will remain at Eastcote. It was announced last month that Ultra Electric (Holdings), the parent company, had entered into two financial agreements with companies in and Western Hemisphere regarding its electronics subsidiary—Ultra Electronics Ltd.

Ultra Electronics Ltd. has acquired Trix Electronics Ltd., which since incorporation on 1st May has been a subsidiary of the Trix Electrical Company. Trix Electronics will continue to manufacture and install sound amplification equipment for public address and aircraft work.

Plessey-Regentone.—It has been confirmed that the Plessey Company has acquired the Eastern Avenue, Romford, factory of Regentone Products Ltd. for £507,000. Plessey has also entered into an agreement with the company whereby Regentone and R.G.D. television and sound receivers will be manufactured by Plessey to Regentone specifications. The sets will continue to be marketed by Regentone.



Sound Reinforcement:—*Some of the loudspeakers for the sound reinforcement system in the recently consecrated Guildford Cathedral are embodied in the lighting fittings. In the nave there are also line source loudspeakers. As the plaster finish to the upper faces of the columns and vaultings of the roof absorb the high frequencies, the system, planned by Standard Telephones and Cables, is operated with high-frequency lift to obtain good speech intelligibility.*

Relay Exchanges Ltd., which in addition to its numerous sound and television relay companies owns Goodmans Industries and operates a rental service under the name Rentaset, reports a surplus on trading in 1960 of £3,949,892 compared with £3,350,640 the year before. From this figure must be deducted £2,747,397 for depreciation of installations and £177,670 for taxation, which leaves a net group profit of £1,024,825. The group's fixed assets have recently been increased by over £4M to £21.6M.

Philips.—The annual report of N. V. Philips' Gloeilampenfabrieken, of Eindhoven, shows the following territorial distribution of the company's assets—Netherlands fl. 1,893M, other European countries fl. 2,575M, Western Hemisphere fl. 726M and other countries fl. 301M. Trading profit rose from fl. 740M in 1959 to fl. 862M last year and the net profit from fl. 351M to fl. 397M.

"House of Siemens."—The 1959-1960 report of Siemens & Halske AG, of West Germany, records that the group has its own distributing companies in every country in Europe excepting the U.K., Austria, and the Eastern bloc. The German company's turnover reached a total of DM 3,556M compared with DM 697M ten years ago. Just over 25% of last year's total turnover was exported.

Wayne Kerr—Gertsch Agreement.—A reciprocal sales and manufacturing agreement has been made between Wayne Kerr Laboratories Ltd. and Gertsch Products Inc., of Los Angeles. It provides for the manufacture and marketing of a wide range of Gertsch instruments in the U.K. solely by Wayne Kerr and also for the sale of Wayne Kerr instruments by Gertsch in California, Nevada and Arizona.

Belling & Lee are making a range of interference suppression filters, introduced by Filtron Co. Inc., of America, to be known as "Belling-Lee Filtron" filters. They are hermetically sealed and suitable for operation in the temperature range $-55°C$ to $+85°C$ (some types up to $+125°C$).

Solartron's portable double-beam oscilloscope and the rack-mounted version of the same instrument are to be manufactured in the United States by Packard Bell Electronics Corporation.

Ericsson.—A trading profit of £1,086,650 for 1960 compared with the 1959 figure of £653,160 (which included £100,000 transferred from the company's research and development reserve) is recorded in the annual report of Ericsson Telephones Ltd. The company, together with English Electric and A.T.E., jointly own Associated Transistors Ltd.

Vickers.—Reference is made in the 1960 review of Vickers Ltd. to the handling of tellurometers, the radio survey instrument, by its subsidiary Cooke, Troughton & Simms who are managing agents for Tellurometer (U.K.) Ltd. The Vickers Group's net profit of £6,252,000 last year compares with £4,934,000 in 1959. The tax payable on the 1960 gross profit was £5,381,000.

Murphy Radio.—A 30% increase in exports is recorded in Murphy's annual report but during 1960 the group incurred a loss of £76,039 compared with the previous year's profit of £668,085.

BASF recording tape and some BASF chemicals are now being marketed in this country by the recently formed BASF Chemicals Limited, of 5A Gillespie Road, London, N.5 (Tel.: Canonbury 2011). F. A. Hughes & Co. are no longer U.K. agents for BASF.

Banana-Tube Colour-Television Display

USE OF OPTICAL-MECHANICAL FIELD-SCAN SYSTEM

NONE of the colour television display devices so far developed is without disadvantages and only one—the shadow-mask tube, in which the picture is built up from triads of colour-luminescent material activated by three electron guns carefully aligned to "fire" through holes in a metal plate behind the screen, each gun lighting only one of the three phosphors—has achieved any significant commercial use. Research for a better device continues and one of the fruits of this search is the "banana" tube and system, so named not only because of the shape of the c.r.t. but also after the fashion of American Philco's code name "apple", for their beam-indexing tube.

Simple Construction of Tube

Two drawbacks of existing direct-viewing displays are the need for application to the tube screen of a complex pattern of phosphor dots and the use of complicated structures inside the tubes. The first was removed in the banana tube by the use of three contiguous lines of phospher in the primary colours red, green and blue parallel to and scanned in the line, or horizontal, direction (Fig. 1). The beam from the single gun is made to light up the appropriate phosphor bands by vertical "spot wobble." The display thus has all lines of the picture superimposed and to expand these vertically into a "viewable" picture, an optical frame-scan system is used.

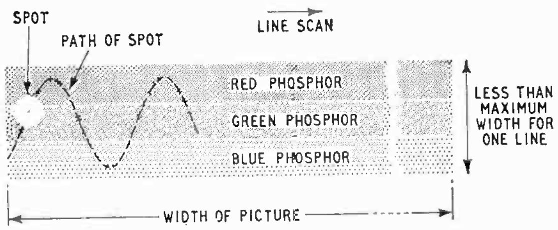


Fig. 1. Construction of tricolour "screen" of phosphor stripes for banana-tube display system. Three-stripe line is about ¼in wide and 16in (the width of the picture) long.

If projection onto the usual diffusing light-reflecting screen were to be employed then the banana tube display would suffer from a serious shortcoming similar to that of normal direct-viewing c.r.t.s in which the phosphors are light-coloured and reflect incident ambient light. This is a double disadvantage for colour TV because not only contrast but also saturation is reduced (the white reflected light "dilutes" the colours).

Instead a virtual-image viewing technique is used, resulting in a picture presented against a dark ground provided by the scanning system and having brightness of the c.r.t. screen reduced only by the inevitable losses in the optical components, and not by scattering at a screen.

Mechanical-optical Field-scan

A cylindrical lens—a rod of glass—has the property of rendering visible a line behind and parallel to it over a range of positions at right angles to its major axis. Now, if this rod were placed appropriately with reference to the banana-tube line display, movement of the rod round the phosphor stripes would enable the viewer to see the displayed superimposed lines separated and thus a picture would be built up in space.

To avoid the difficulty of making the one rod

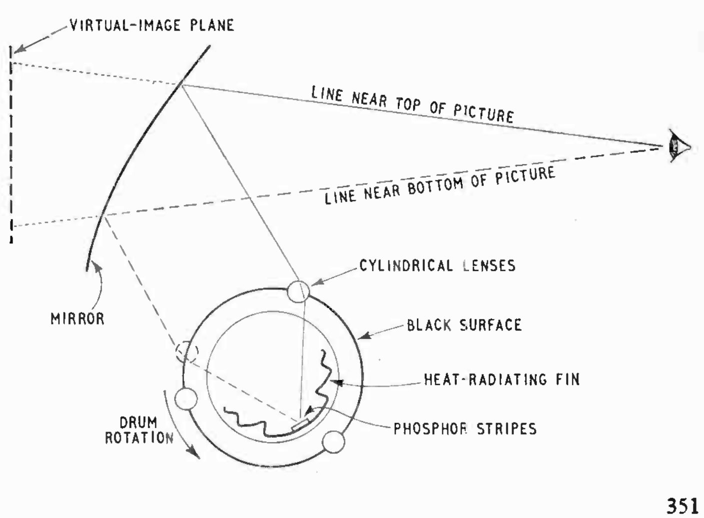


Fig. 2. Simplified "end-on" view of display system, showing light paths to viewer for lines near top and bottom of picture. To clarify details scale is distorted: diameter of banana tube itself is about 4in and height of virtual image is about 12in.

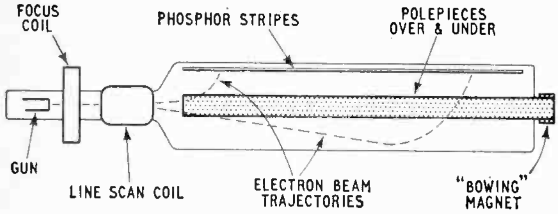


Fig. 3. Plan view of tube and some ancillaries. Line scan is provided by slightly-modified 90° coils and graded magnetic field produces "bowing" of beam to improve angle of "strike" of beam on phosphor. Spot-wobble is achieved magnetically (coils not shown).

fly back to the top of the picture during the field-blanking period, a rotating drum encircling the tube and carrying three equi-spaced rods is used: as one rod finishes its operation at the bottom of the picture (one field or frame scan) another starts work at the top. Fig. 2 shows an end-on representation of the system together with a curved viewing mirror that magnifies the picture to its correct height and corrects the curvature of the image.

To provide a dark background for display of the picture the spaces between the rod lenses are covered with a matt black material.

Field Synchronization

Frame-sync depends on the correct speed and phase of the lens drum, which is rotated at about 1,000 r.p.m. by an induction motor and which, in the absence of control, runs slightly fast. An eddy-current brake is used and the current through the magnet, and thus the speed of rotation, is controlled by a comparator basically not unlike the well-known flywheel line sync system. To detect the speed and position of the lens rods a small lamp is mounted outside the drum opposite a phototransistor on the inside.

Interlace should be better than that obtained from an electronic timebase as the inertia of the drum is far too great to allow line pulses (one of the major causes of loss of interlace) to have any effect. The major disadvantages are the extra control equipment required and the effect of mechanical shortcomings—which can give rise to bounce, jitter and line crawl.

C.R.T. Details

The banana tube has its gun at one end so that it may be inserted into the lens drum and a diametric magnetic field, graded along the length of the tube, is used to cause the beam to curve out so that it strikes the phosphors normally (Fig. 3). As has been mentioned previously, the c.r.t. uses a single gun and the spot is "wobbled" across the phosphor stripes to provide, in conjunction with variations of beam current, the required mixtures of primary colours. Each line is laid down on top of the preceding line, so the afterglow of the phosphors must have decayed, not in several fields, as can be allowed with a conventional c.r.t., but by the time that the next line is drawn, otherwise loss of vertical resolution and streaking will result. Sulphide-type phosphors with a suitable afterglow have been developed and it is fortunate that there are also some of the most efficient, so aiding the production of a bright picture. The green is not of the best colour for full coverage of the colour triangle, but with appropriate correction in the video circuits good colour rendering can be achieved over a large area of the triangle, encompassing natural objects.

E.h.t. required is about 25kV at beam currents up to 3mA. Naturally, this represents a fairly high loading on the "screen," which is thus deposited on a metal radiating fin inside the tube so that phosphor efficiency is not seriously reduced by a rise in temperature. The maximum instantaneous peak current density, though, is only about twice that for an ordinary direct-viewing black-and-white tube.

Demonstration

During a demonstration recently given at the Institution of Electrical Engineers, N.T.S.C.-type signals were provided by the B.B.C. and were displayed on two experimental "receivers" using the banana system, giving acceptable results when the video processing appropriate to the type of display was used. The vertical angle of view is slightly restricted compared with a direct-view tube, but it was a pleasant change to see the whole of the picture with truly square corners. The virtual image "hanging in space" behind the mirror seems a little odd at first; but this has the advantage that the viewer's eyes are focused on the picture and not on imperfections in the mirror surface. Important advantages are the very high brightness—about 40 foot-lambers—and the absence of adverse effects from quite high ambient light levels.

Which of the "fruit machines" (or the less exotically named devices) hits the three-lemon jackpot of commercial success remains to be seen. Mullard, developers of the "banana", freely admit that further work is necessary before this display system can be admitted to the set manufacturers' stakes. There is no doubt, though, that the work of Dr. Schagen, his team at Mullard Research Laboratories, and Dutch Philips (who carried out part of the investigation and made the phosphors) has added a most interesting and original device to the known colour display systems.

Further details will be given in I.E.E. papers (Nos. 3561 to 3566 inclusive: to be published in Vol. 108, Part B, *Proc.I.E.E.*) by Dr. P. Schagen, B. A. Eastwell, K. G. Freeman, H. Howden, R. N. Jackson and B. R. Overton.

RADIO VALVE DATA

Seventh Edition

COMPLETELY revised and enlarged, the seventh edition of "Radio Valve Data" (which is compiled by the staff of *Wireless World*) contains in its 156 pages, data on nearly 5,000 semiconductor devices, valves and cathode-ray tubes.

In particular the junction-transistor section occupies five times the space taken in the previous edition and includes many "American" listings. Other additions to the data on semiconductors include sections dealing with power rectifiers and zener diodes.

New valves and cathode-ray tubes have been added and features found useful in previous editions—the listing of valve base connections and equivalents in the index, for instance—have been continued.

The seventh edition of *Wireless World* "Radio Valve Data," published by Iliffe Books Ltd., costs 6s. or 6s. 10d. by post.

Gramophone Record Deformation

RELATIONS BETWEEN STYLUS RADIUS AND TRACKING WEIGHT FOR CONSTANT DEFORMATION

By J. WALTON*

DUE to the efforts of Dr. Peter Lord of Salford Technical College with the Taylor-Hobson "Talysurf" in making roughness graphs of indented record surfaces at 50,000 times magnification (see Fig. 1) and to the ingenuity of Dr. P. Chippindale of the same college in devising a means of examining and photographing the contours of the record groove under the electron microscope, it has been possible to re-examine the question of record deformation and the relations between stylus radius and tracking weight.

Now it is apparently generally assumed that, for constant record deformation, the tracking weight varies as the square of the stylus tip radius. This seems to be based upon the classical Hertzian equation for *elastic* deformation:—

$$w = \left[\tfrac{3}{4}Wgr\left(\frac{1-\sigma_1^2}{E_1} + \frac{1-\sigma_2^2}{E_2}\right)\right]^{\frac{1}{3}} \quad .. \quad (1)$$

where w is the radius of the indent, W the load, g the acceleration due to gravity, r the radius of the indenter tip, σ_1, σ_2 the Poisson ratios of the ball and material respectively, and E_1, E_2 the corresponding Young's moduli for the two materials.

From equation (1) it is deduced that the area of the indent for the case when the flat material is much softer than the spherical one is given by:—

$$A = \pi\left[\tfrac{3}{4}Wgr\left(\frac{1-\sigma_2^2}{E_2}\right)\right]^{\frac{2}{3}} \quad .. \quad (2)$$

and therefore the mean pressure

$$P_m = \frac{Wg}{\pi\left[\tfrac{3}{4}Wgr\left(\frac{1-\sigma_2^2}{E_2}\right)\right]^{\frac{2}{3}}} \quad .. \quad (3)$$

and for constant pressure P_m we can write

$$k_1 = W^{\frac{1}{3}}/r^{\frac{2}{3}}$$

where, as elsewhere, the ks are constants.

$$\text{i.e. } W : r^2 \quad .. \quad .. \quad (4)$$

which is for constant mean pressure under the indenter.

If we take either the area of indent or its width as the criterion for constant deformation, then from equations (1) or (2) we get

$$W : 1/r \quad .. \quad .. \quad .. \quad (5)$$

However, it is obvious that an inverse relationship between W and r is at variance with our purpose of reducing deformation.

Moreover, when considering record groove deformation, the type of deformation with which we are concerned is that which affects the output of the pickup. Thus, whether this is mono or stereo, we are primarily concerned with deformation which gives rise to or eliminates any undulations in a plane at right-angles to the normal plane of the record wall, i.e. we are concerned with the *depth* of any deformation.

If we start from Hertz's equation again under the same condition of an inelastic sphere on an elastic plane, we can reduce it to

$$w = k_2(Wr)^{\frac{1}{3}} \quad .. \quad .. \quad (6)$$

$$\text{Now } w = \sqrt{2rD - D^2}$$

where D is the depth of the indent (see Fig. 2).

$$\therefore \sqrt{2rD - D^2} = k_2(Wr)^{\frac{1}{3}}$$

If D/r is small (as in our practical case) we can write

$$\sqrt{2rD} = k_2(Wr)^{\frac{1}{3}}$$

$$\text{or } D = k_3W^{\frac{2}{3}}r^{-\frac{1}{3}} \quad .. \quad .. \quad (7)$$

And for constant depth of penetration D we get

$$W : r^{\frac{1}{2}} \quad .. \quad .. \quad .. \quad (8)$$

and not $W : r^2$ as results from considering constant pressure under the stylus.

This of course refers to the elastic region of

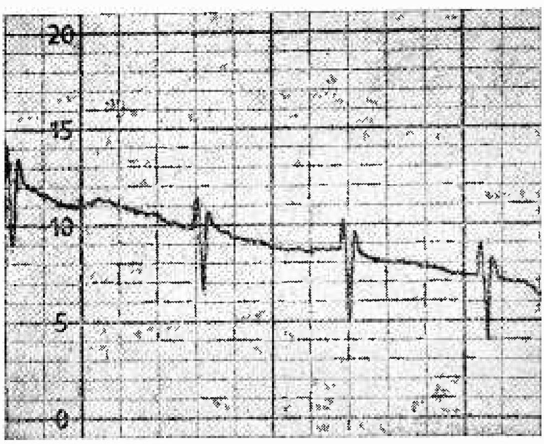


Fig. 1. Cross-section of indented record surface at 50,000 times vertical magnification and 100 times lateral. Four indents may be seen.

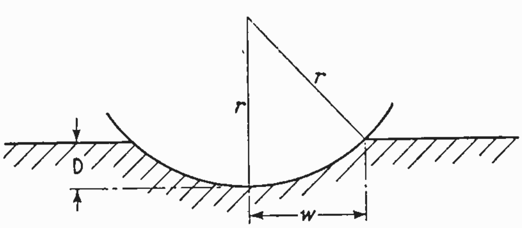


Fig. 2. Fixed indenter of radius r producing an indent of depth D and radius w.

*Decca Record Co.

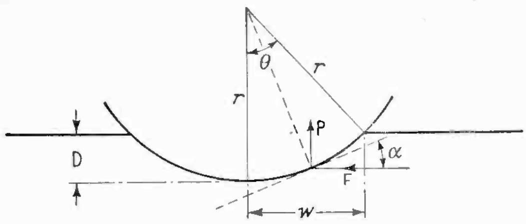


Fig. 3. Moving indenter acted on by a frictional force F.

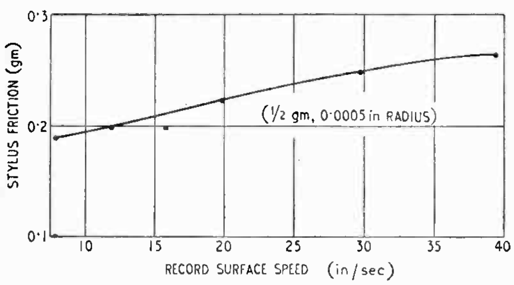


Fig. 4. Elastic region stylus frictional force plotted against record surface speed (for ½gm tracking weight and 0.0005-in radius stylus). Here, as elsewhere, the measurements were made with blank discs.

deformation and I have not so far been able to find a suitable direct means of measuring this. The results of an indirect approach to this measurement are presented farther on in this article.

However, we are not concerned with static indents on a gramophone record, but with gliding ones, and it was found that a considerable difference exists between the indent dimensions in the two cases.

The following is an attempt to explain this in terms of a " surf board " action which causes the stylus to ride more on the surface of the medium upon reaching a certain critical speed below which there is a tendency for the stylus to sink by a greater proportion than that of the speed reduction until equilibrium is once again obtained.

Consider a stylus under a tracking weight W moving along the surface of a blank disc so that F is the frictional (drag) force experienced. *To the extent that* this force acts against the stylus at a mean angle α and produces a reaction along the radius of the indenter, then, from Fig. 3

$$P = F\cot\alpha$$

where P is the vertical component upthrust produced by F.

$$\text{Now } \alpha = \theta/2$$

$$\therefore P = F(2r - D)/w$$

$$\text{But } w = \sqrt{2rD - D^2}$$

$$\therefore P = \frac{F(2r - D)}{\sqrt{2rD - D^2}}$$

Since D/r is small in our case

$$P = 2Fr/\sqrt{2rD}$$

$$= Fr\sqrt{2}/\sqrt{rD} \qquad \ldots \quad (9)$$

It is found by experiment that F *almost* is inde-

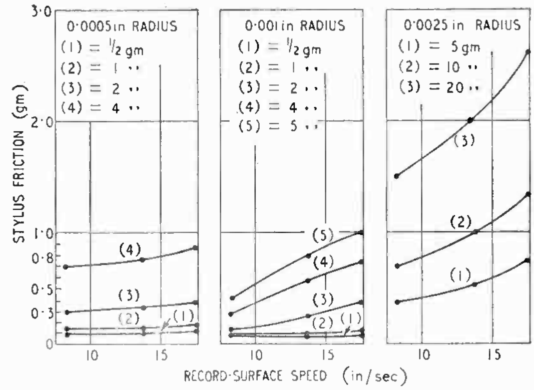


Fig. 5. Stylus friction plotted against record surface speed for various tracking weights and stylus radii.

pendent (see Figs. 4 and 5) of velocity in the elastic cases, and so we may therefore write

$$P = k_4\sqrt{r/D} \qquad \ldots \quad \ldots \quad (10)$$

Equation (7) must now be readjusted to allow for this upthrust P, i.e. W must be replaced by W–P and we get

$$D = k_3(W - P)^{\frac{2}{3}}r^{-\frac{1}{3}} \qquad \ldots \quad (11)$$

and from equation (10)

$$D = k_3(W - k_4\sqrt{r/D})^{\frac{2}{3}}r^{-\frac{1}{3}} \quad (12)$$

$$\therefore r^{\frac{1}{3}}D = k_3(W - k_4\sqrt{r/D})^{\frac{2}{3}}$$

and for constant D

$$r^{\frac{1}{2}}k_5 = W - k_6r^{\frac{1}{2}}$$

$$\therefore W = k_7r^{\frac{1}{2}}$$

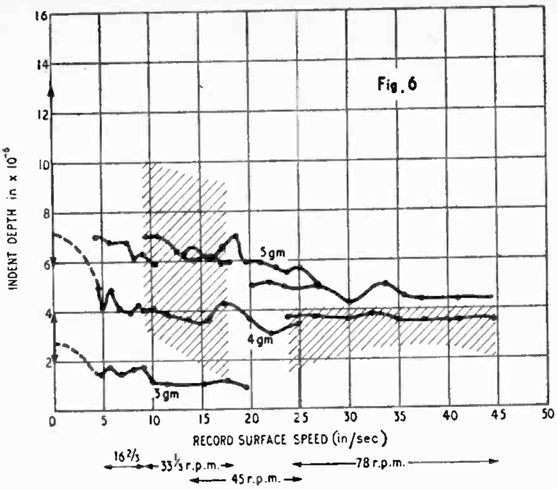
$$\text{i.e. } W \propto r^{\frac{1}{2}} \qquad \ldots \quad \ldots \quad (13)$$

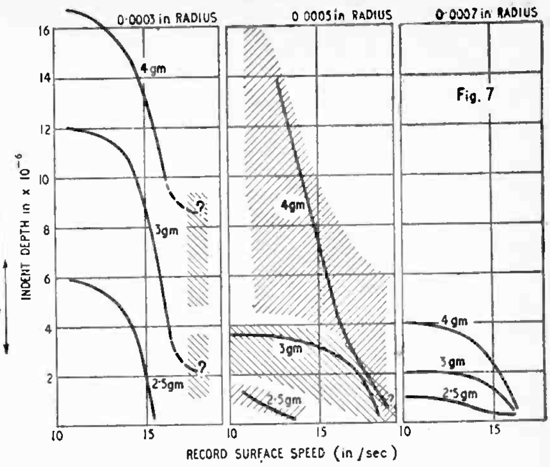
i.e. the movement of the indenter does not affect the basic relationship between W and r in the elastic region, although of course the *magnitudes* are affected, as will be shown. It will also be noted that as D (the depth of penetration) is decreased, the upthrust due to sliding is further increased, so that a region of rapid change may be expected.

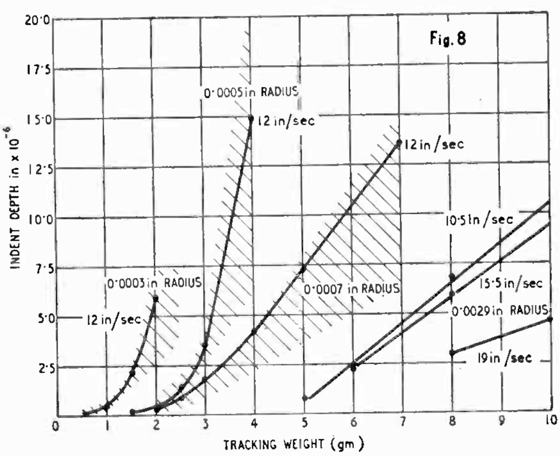
Now the foregoing theories relate to elastic deformation whereas, since I have not yet been able to devise a method of measuring such deformation, the measurements relate to *plastic* deformation. I excuse this anomaly on the grounds that the practical considerations of record wear are primarily those of plastic deformation, and also I felt it necessary first of all to attack the inappropriateness of the " W varies as r^2 " elastic-region theory, since this has been used as a basis for choosing the stylus radius.

The experimental measurements gave the results shown in Figs. 6, 7, 8 and 9. These show the most consistent single sets of readings as well as the extent of the scatter between different sets of readings (the reason for which is still obscure to me). Whilst these cannot be considered to be very useful quantitatively, one can detect qualitative trends in the shape of the curves, since the two other (not shown) sets of readings which were taken follow similar, if displaced, curves. (It should be remembered that these measurements are of a very

(*continued on page 355*)







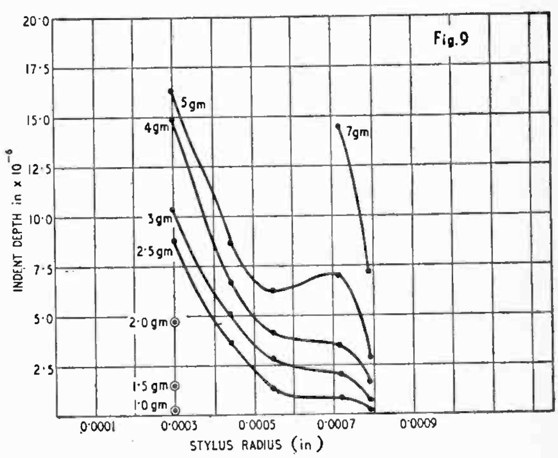


Fig. 6. Indent depth plotted against record surface speed for various tracking weights (0.0005-in radius stylus). As also in other graphs, the curves show the most consistent set of measurements and the shaded areas and arrowed lines the spread over the three sets of measurement which were taken.

Fig. 7. Indent depth plotted against record surface speed for various stylus radii and tracking weights. The arrowed lines show the spread of the measurements in the static case.

Fig. 8. Indent depth plotted against tracking weight for various stylus radii.

Fig. 9. Indent depth plotted against stylus radius for various tracking weights (record surface speed ≈ 13.5in/sec).

few microinches.) Here, as elsewhere, the measurements were made using blank discs.

It would appear from Fig. 7 that below a certain critical speed there is little appreciable increase in deformation as the indent approaches a static value and also that the elastic limit can be effectively raised by an increase in groove speed for certain ranges of stylus radii and tracking weights.

On the "surf board" theory the groove speed would tend to be either sufficient to keep the stylus "afloat" or low enough to let it "sink" and from Fig. 7 the working region of most pickups would seem to be on the critical "float/sink" part of the curves. This may have something to do with the difficulty of getting consistent results between one set of experiments and another. Further work is being attempted with closer control of temperature, stylus radius and disc hardness.

Fig. 9 shows that at higher groove speeds there may be little difference in indentation between a 0.0005in and a 0.0007in radius stylus. The reason for the "knee" in the curves is still obscure.

Fig. 10 shows that the relation between tracking weight and stylus radius for constant indent depth under practical gramophone reproducing conditions is certainly nearer to a linear than to a square law.

Before drawing any conclusions from the above direct measurements of indentation let us consider another approach to the assessment of record wear which should also have meaning in the purely elastic region of deformation.

To the extent that any deformation is purely

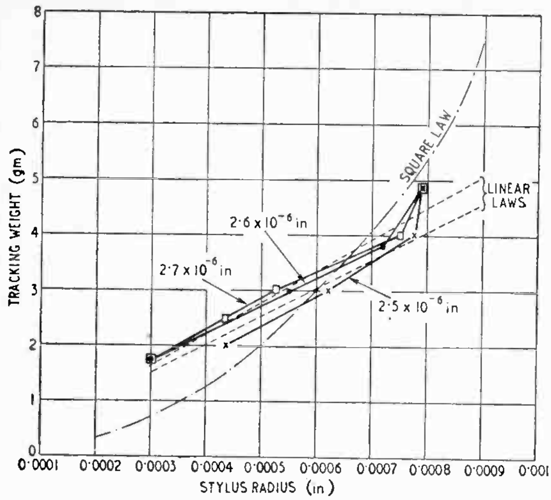


Fig. 10. Tracking weight plotted against stylus radius for various indent depths (record surface speed ≈ 13.5in/sec).

elastic, the energy used temporarily to displace the record material should mainly be returned to the stylus. I say mainly, because there would be some mechanical hysteresis loss. To the extent, however, that there is *plastic* deformation, the energy will be dissipated in moving some of the record material. This energy should be measurable as a reaction on the pickup, i.e. as the *plastic* deformation increases so should the frictional drag of the pickup. This drag was measured, with the results shown in Figs. 11 and 12.

The methods of measurements were as shown diagrammatically in Figs. 13(a) and (b). In Fig. 13(a) in which the pickup head H is at right angles, rather than tangential, to the record motion, for small horizontal deflections x of the hanging weight W

$$F = Wx/l$$

where l is the length of the vertical thread. This method was found cumbersome because the base of the pickup had to be continually moved to track different disc radii as well as to keep the angle between the pickup head and the horizontal thread to a right angle. In Fig. 13(b), again for small deflections x,

$$S = Wx/l$$

where S is the side thrust. Taking moments about the pivot P

$$nS = Fm$$
$$\therefore F = Wxn/lm$$

Here the motor board must be orientated to keep the angle between the side thrust S and horizontal thread to a right angle, but this is easier than the alterations required by the first method. It should be pointed out that if l is 75in, and W 1gm, a deflection of 1in corresponds to a force of 0.013gm.

From Fig. 11 one can see that approximately at the point coinciding with the elastic limit as determined previously, there is a change in slope showing a lower frictional loss per gm below the elastic limit to above it.

Fig. 12 shows considerable linearity in the relation between tracking weight and stylus radius for constant frictional (destructive) force in both the elastic and plastic regions.

There appears to be considerably more consistency in the results obtained by measuring the frictional force, and this may be due to the method of measuring in serial fashion, with one measurement following directly after the other as the indent proceeds to form. The direct measurements of indent depth involved a discontinuity between formation and measurement and also between one indentation and another: these are discontinuities that were not necessary in the friction method. It

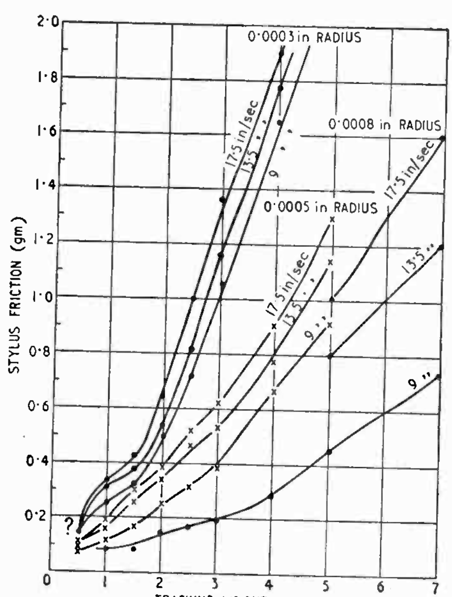


Fig. 11. Stylus friction plotted against tracking weight for various stylus radii and record surface speeds.

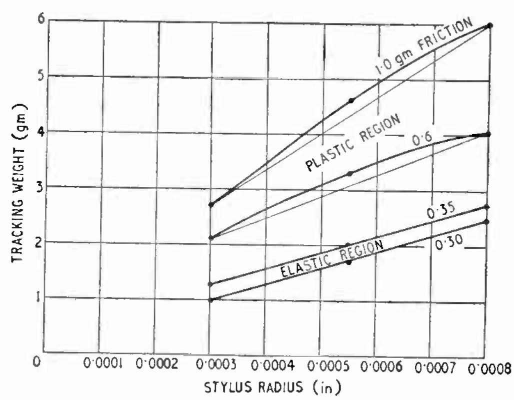


Fig. 12. Tracking weight plotted against stylus radius for constant stylus friction (record surface speed 13.5in/sec).

is nevertheless interesting to compare the results of the two methods (see Figs. 8 and 11).

General conclusions we draw are:—

(1) The experimentally determined linear relation between stylus radius and tracking weight for constant record wear does *not* confirm either the existing theoretical conceptions or the theoretical conceptions presented here, and further work is necessary for its understanding.

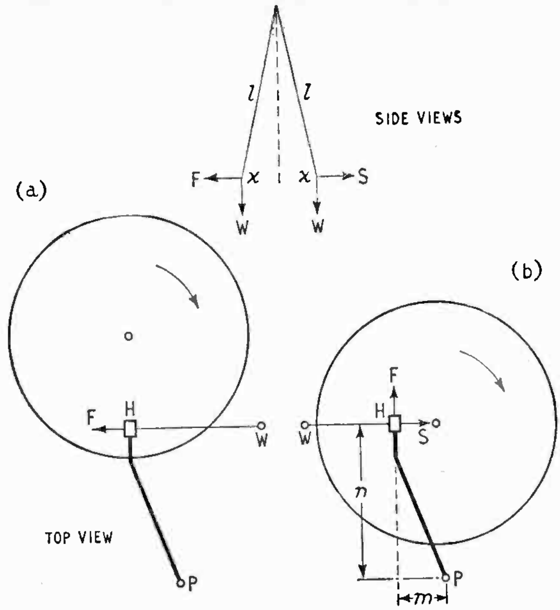


Fig. 13. Two methods of measuring stylus friction on a blank disc.

(2) The conception that, for constant deformation, the tracking weight varies as the square of the stylus radius seems inappropriate, and a better approximation is that it varies directly as the radius (unsquared).

(3) The elastic limit seems to be appreciably raised for a moving indenter as compared with the static case. Recourse to lower groove speeds (such as with 16⅔ r.p.m. records) would entail a lowering of the effective elastic limit of the record material and has serious implications for pickup design. This is made extremely undesirable when one considers that the recorded wave-lengths would be shortened to such a degree that, either excessive tracing distortion would occur, or the ensuing necessary small stylus radii would increase the record wear problem to degenerate proportions. Other ways of increasing the playing time of l.p. records should be considered.

While the relations between the mechanical impedance of the stylus tip and the tracking weight required are well known, the effect of stylus tip radius has usually been considered partly on the basis of record wear and the "W varies as r^2" relation. It should be realised that an increase in tip radius can also increase the acceleration required of the stylus in conditions of tracing short wavelengths and that large tip radii may not save the record, therefore, as much as might be hoped.

Although the above measurements have considerable spread, they were nevertheless used as the basis for the design of a stereo pickup that will track the whole frequency range of a modern l.p. disc within the elastic limit of the material. It was calculated that while this entails a tip mass in the region of 1mgm, the tracking weight could be raised to about 3gm for a ½-thou stylus rather than the somewhat lower weights required on the basis of Hunt's or Barlow's† static measurements. Tests were carried out on this and other pickups and photographic evidence gave ample vindication on the general programme of work.

While it is not considered that the above work is anything but a beginning of an attempt to understand record wear in reproduction, publication of these first results has been considered to be useful as both a corrective and a pointer for further work in the sphere of both recording and reproduction of gramophone records.

This information, work and graphs are published by courtesy of the Decca Record Co., Ltd.

†F. V. Hunt, *J.A.E.S.*, Jan. 1955, D. A. Barlow, *J.A.E.S.*, Oct. 1958.

BOOKS RECEIVED

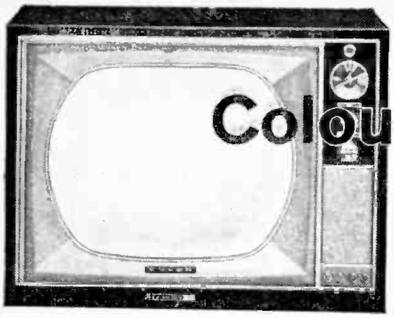
An Introduction To Machine Translation, by Emile Delavenay. A survey of the present state of the art. An opening chapter discusses the justifications and implications, and is followed by a discourse on the possible use of computers in translation. An analysis of the problems of machine translation related to differing grammatical forms and idioms takes up the major part of the book, and the final chapter propounds possible developments in the translation of literary and poetic works. Appended is an actual translation made by an I.B.M. 704 computer. Pp. 144; Figs. 5. Thames and Hudson, Ltd., 30, Bloomsbury Street, W.C.1. Price 25s.

Principles of Semiconductors, by M. G. Scroggie. A grounding in semiconductor theory, by way of atomic physics. The first few chapters describe the mechanism of semiconduction, as an introduction to the action of devices such as diodes and transistors. Further chapters are concerned with photoelectricity and a variety of semiconducting devices and their applications. The book is written in a down-to-earth style, and is intended to provide a basis for more advanced works on the subject. The book was first published in an Americanized edition by the Gernsback Library, and this new version has been re-written with new illustrations. Pp. 156; figs. 115. Iliffe Books, Ltd., Dorset House, Stamford Street, London, S.E.1. Price 21s.

Elsevier's Dictionary of Amplification, Modulation, Reception and Transmission, compiled by W. E. Clason. A list of nearly three thousand terms is given, with a precise definition, in English, of each. On facing pages are set out the equivalents in Dutch, French, German, Italian and Spanish. Following the list are indexes in these five languages, linked to the dictionary by reference numbers. Pp. 804. D. Van Nostrand Co., Ltd., 358, Kensington High Street, London, W.14. Price £6.

Introduction To Hi-Fi, by Clement Brown. Offers advice to the music-loving layman on the approach to domestic sound reproduction. The treatment is well suited to the potential readership, and the author does not assume either a living room the size of the Festival Hall, or an unlimited bank balance. An appendix contains a list of recommended tape and disc recordings. Pp. 198; Figs. 84. George Newnes, Ltd., Tower House, Southampton Street, London, W.C.2. Price 21s.

Radio Transmitters, by Laurence F. Gray and Richard Graham. Intended for the maintenance engineer and operator, the book deals in an essentially practical manner with design principles and operation of amplitude, frequency, phase and pulse modulated transmitters. Pp. 462; Figs. 398. McGraw-Hill Publishing Company, Ltd., McGraw-Hill House, 95, Farringdon Street, London, E.C.4. Price 97s.



Colour Television in the United States

By JACK DARR

PROGRESS REPORT: THE PRESENT STATUS

THE Editor has requested that I hold forth somewhat upon the subject of colour television as we know it in the United States. Knowing that I had been associated with it for several years, and had already expressed views on the subject,† he asked for a report straight from the horse's mouth, as it were. And, while I bridled a bit, I found myself saddled with the task! (Oh, *dear!* I *am* sorry. Shan't do it again.)

We have had colour TV broadcasting for quite a while now. To run over the system as quickly as possible, we use a 525-line, dot-sequential system, entirely compatible with present B/W standards. Colour information is in the form of phase modulation of a completely suppressed "sub-carrier" of roughly 33.597545 Mc/s. This carrier is removed at the transmitter, probably to save postage! It is restored by a crystal-controlled oscillator in the receivers. Three basic colours are transmitted, red, green and blue, and the "shadow-mask" RCA three-gun tube is still the standard. Other types of colour tubes have been tried, but so far none of them has made the jump, commercially.

In the very beginning, in 1950, the F.C.C. authorized colour broadcasting using the C.B.S. system, a field-sequential arrangement. At the receiver, a "colour-wheel" was set up in front of the screen; it had slides of the three colours, and was (theoretically) rotated in synchronism with the transmitted "fields," each of which contained all the picture information for that particular colour.

Theoretically, this was all right, and the results obtained in lab. tests were very good. I have heard that this device produced colour pictures of amazing quality! However, when one contemplates the spectacle of a 4-foot colour wheel spinning at something like 440 r.p.s., sitting atop one's TV receiver in the living room, it is rather frightening. So, after four years, this was abandoned in favour of the present all-electronic system.

Of course, when it all began, quite a few manufacturers leaped on the bandwagon, and there were several makes of colour sets on the market. Most were quite expensive: I can remember one model, using a 15-inch tube, which sold for over $1,500! According to the grapevine, this set cost the maker over $1,450 to produce! Unkindest cut of all, just as they finished the first production run of 1,000 sets, the 21-inch tube was introduced! When last heard of, this poor soul was tearfully trying to dispose of the sets at about $800 apiece!

At first, no significant numbers of colour sets were sold. Those which were went to bars, restaurants, and "status-seekers," to dip into the latest jargon: ownership of a colour TV was roughly equivalent to owning a Rolls or Bentley. Prices were far above the average pocketbook, and programming was quite scarce. So, for purely economic reasons, all of the colour-set makers except RCA faded out of the picture. RCA, having a vested interest in colour, and a fat investment to boot, gritted its corporate teeth and stayed with it. Through the past years, this firm has carried colour TV on its back like a polychromatic Old Man of the Sea, doing nothing at all for its financial structure in the process! Although at first both N.B.C. and C.B.S. networks carried colour programmes, C.B.S. gradually withdrew, and N.B.C. sailed on alone.

Sales of colour TV to the public remained at an extremely disappointing level (to RCA's comptroller, at least) for many years. RCA, by all reports, went deep in the red each year on its colour (that's only a very mild pun; may I be forgiven?). However, they kept on grimly, holding many service meetings for technicians, advertising, issuing a complete colour-TV training course through RCA Institutes, and even selling colour-TV sets to interested technicians on hire-purchase, at a liberal discount.

Turn of the Tide

Engineers in the meanwhile kept digging into the "innards" of the colour set, excising parts here and there and developing a new all-glass colour c.r.t., 21CYP22, to replace the original metal-coned 21AXP22. The number of valves was reduced drastically: from 44 in the first models to 26 in 1956, and a few less in current models! After years of waiting, 1960 was *das Jahr* for R.C.A. colour TV set sales went into the black for the first time! According to "informed sources" they sold something like 200,000 sets, and predicted that the total number in use by the end of 1961 would be over 750,000 sets! Other set makers began to prick up their ears. They dusted off some designs that had been lying fallow for quite a while, and Admiral, Westinghouse, G.E., and others

* Ouachita Radio-TV Service, Mena, Arkansas.
† See for example "Rainbow Round my Shoulders," *Wireless World*, Aug., 1957.

announced the production of colour chassis. Even the conservative Zenith corporation announced that they would bring out a colour TV chassis in 1961.

Prices fell: from the original $1,500, colour sets now selling for about $495. RCA, and, from what I can discover, all others, make only a single chassis: the price differential lies solely in the cabinetry. Even we in our small town in the Hills felt the impact: our colour-TV population increased by a whopping 300%! (Instead of *one* set, we now have four!)

Programme Hours

Colour TV programming has steadily increased, although still concentrated on the lone network, N.B.C. C.B.S. still has no colour shows at this time, although they may still have the camera equipment squirreled away somewhere: they did broadcast some excellent colour. Another network, A.B.C., has publicly announced that it has no plans for getting its feet wet with colour, although this may be changed by the time this is printed. For an example, the N.B.C. colour programme for May, 1961, lists 4 hours and 15 minutes of regular colour shows every weekday in half-hour "segments." This plus an average of one full hour each week-night, two hours on Saturday and 2½ hours on Sunday, gave me a total of 121 *hours* of colour programmes for the month. Besides these, there are "specials" which pop up from time to time, usually in colour; these are full hour shows. There are several daytime shows in colour, put on so that the TV dealers can demonstrate their wares, but a significant percentage is scheduled in what the advertising agency boys call "prime-time," between 7 and 10 p.m., especially on Sundays, when there is colour from 7 p.m. to 9 p.m. every week.

Once each year, NBC puts on a special "Colour-TV Day"; colour programming begins at 6.30 a.m. and continues until midnight, with only a five-minute news-break at 11.55 and a 4.00 to 6.00 p.m. B/W break for "kiddie shows." Even the evening news report is in full colour! A total of 18 different colour shows are given on this day, the first being a part of the daily programming, an educational show called "Continental Classroom": college lecturers give talks and demonstrations in their specialties, and I understand that there is a regular course of study which may be undertaken, with credits, etc. The colour enables them to demonstrate chemical reactions, etc., with ease, although the whole course is in colour. Calculus in colour must be seen to be believed!

The other side of the coin, after the sets have been built and the programmes broadcast, is service. There is no doubt about it: colour TV sets do require more service attention *on the initial installation* than B/W sets. Colour TV sets must be set up by a competent technician with proper test equipment. However, simplification of design has brought the set-up time down from the original four hours by two men with a lorry load of equipment, to about a half-hour by one man with a cross-hatch generator; and at least half of that is usually taken up in showing the customer how to run the thing!

In early sets, convergence, colour-temperature, and signal strength had to be checked and, in many cases, completely readjusted upon installation. This was a long process. Nowadays, any number of sets operate correctly "right out of the box"! I hauled my own set more than 100 miles, lugged it into the living room, set it up, turned it on, and made only one or two minor adjustments! It didn't need convergence at all, aside from a touch-up at one or two places. Convergence was the big bugaboo; manuals told you that the set must never be moved, for fear of magnetizing the tube from the earth's magnetic fields! (This results in the gathering of much lint behind colour TV sets!) Also, in some technician's heads!

As to service required, I firmly believe that the average well-built colour TV set requires no more service attention per tube than any equivalent B/W set! I base this opinion on five years of colour-TV work, plus experience with my own set, which was secondhand when I got it. So far my only troubles have been such relatively straightforward things as a shorted audio output valve, which took a resistor with it: a weak line-scan output valve, which merely drew the picture in from the sides, and a shorted B-Y (blue) amplifier tube, a 12BH7, which caused the screen and the owner's face to turn a livid green. (Owner was thinking of the phrase in the service manual, "Bright green screen; no picture—defective picture tube"!)

There is another two-sided coin in the service end, too. Training, for one (this would be "heads," I'd think) and test equipment. Training began quite early. All major setmakers had (and still have) training courses on colour TV fundamentals; all leading magazines ran stories on colour, and there were a number of excellent books written. So, if the average U.S. TV technician hasn't a full knowledge of colour, it is definitely not because of a lack of opportunity! Quite a bit of this material was given away by setmakers, who also conducted service meetings in every major city at regular intervals, and many of the smaller towns to boot. They are still doing this, by the way.

Theory and Practice

Now, may I bring forth a long-cherished personal opinion? Like everyone else, I dived headlong into the fascinating study of colour TV at first. Reading all the material I could, I found myself enmeshed in a maze of college-level maths! Vectors, colorimetry diagrams, chromaticity diagrams, percentages of each colour at the camera, calculus, trig., etc., etc. After about a year of this, I discovered that I was almost completely befuddled! I had done, perforce, a lot of brushing-up on my long-forgotten maths, never one of my better subjects, but I *still* didn't know beans about how a colour-TV set worked!

Frankly speaking, and this is the result of much inquiry among my brethren over the past few years, this approach scared the pants off the average TV serviceman! He apparently thought, "Well! If it's going to take *this* kind of stuff to work on colour TV, the heck with it!" The actual language used, of course, has been greatly edited! As a result, he developed an unconscious *resentment* of colour TV! Aside from a hard core of devoted grinds who studied from the sheer love of it, most of the boys sheered off, and wound up with an active opposition to colour. This came out in their discussions with customers, who were also prospective colour TV buyers! When asked, "What do you think about colour?" they generally replied, "It's not ready yet!" So, quite naturally, buyer is not ready to take the financial plunge on something their pet expert has just disparaged! This is an actual quotation from any one of several technicians of my acquaintance, as of a few years back. Personally, I have been doing colour TV service work for quite a while, and have never found the occasion to use the knowledge as to "What angle is green?"! (It's rather like the chap who learned the Swahili word for "thunderstorm,": he said, "It's nice to know, but somehow it's hard to work into a conversation!)

So, of late, our periodicals and books have taken more to the "simplifying" approach; I can plead guilty to having done a few of these myself. We're trying manfully to get the U.S. technician over his fear of the complexity of colour TV sets.

Now, as to test equipment: in the early days, we were told that we'd have to have colour-bar generators, extremely wide-band oscilloscopes, and a host of other expensive test equipment. I can say from personal experience that the average well-equipped TV shop will have to have only *one* new piece of test equipment, and that is a cross-hatch bar or dot generator, for convergence work! These are available in U.S. from $15-$20 on upward, and will soon be in the U.K., if they are not already. You do not have to have a colour-bar generator to service colour, nor yet a wide-band 'scope; to *design* it, yes, but not to service it. A standard, good-grade 'scope will, in the hands of a capable technician, produce just as good results in *everyday* service work as the finest laboratory 'scope on the market! My own two 'scopes are far from broadband, being good-grade average equipment, and I've never found anything that I wanted to know that they didn't tell me, quite accurately!

The most helpful thing, of course, just as in B/W TV, has been the simply tremendous simplification of circuitry since the beginning. This is most apparent in the latest colour sets. In the original chassis, something like 30 adjustments were necessary; in the last model, this has been reduced to a *maximum* of 15, of which only 3 or 4 customarily need adjustment on installation. Time has been reduced from four to five hours to about 15 minutes!

Just as an experiment, I checked the time on the last installation I made; I was finished and talking to the customer in less than 20 minutes!

All of the convergence controls except the "statics" (the small magnets on the neck of the picture tube, for getting the beams centred at the beginning) have now been concentrated on one small PC board about 4 inches square. This is mounted on the back of the cabinet, and can be loosened and set up above the top of the cabinet facing the front. Now, the technician can make all convergence adjustments from the front of the set, without the need for mirrors. Combination adjustments are now used on the controls: "R-G," for instance, moves *both* red and green beams for vertical convergence at the *right side* only. One control is provided for each side of the tube! Using this system, almost 100% perfect convergence can be obtained on the new sets; a far cry from older sets like mine. I blush to admit that mine own is slightly off at the bottom of the screen, but you've all heard the old saw about the shoemaker's barefoot children.

The "colour temperature" adjustments have also been simplified. This was always one of the worst headaches, at least to me; getting the screen so that it was really *a black and white* picture, without colour-tinting in either highlights or "lowlights." Older sets, set up under incandescent light, look greenish in daylight. These new sets, using the new picture tube, can be set up so that one cannot distinguish between colour and B/W screens at a distance of ten feet! I've seen this done! Daylight washed out the pictures on old colour tubes; the latest tube can be viewed in light as bright as that possible with any B/W tube.

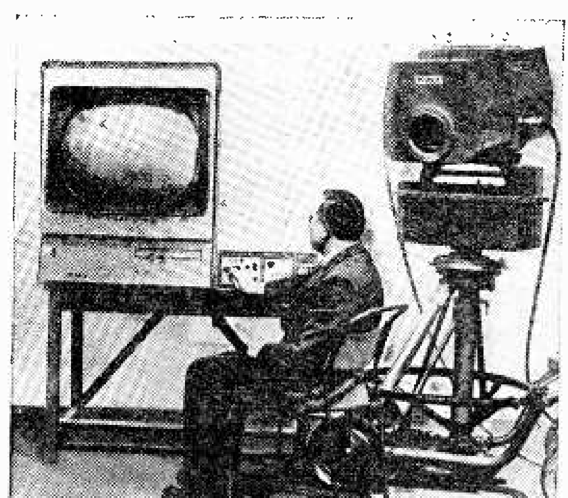
So, in conclusion, I can say that my truthful opinion, for whatever it's worth, is that colour is no harder to service than B/W TV; that it can be serviced with ordinary TV test equipment, and that a minimum of theory, aside from a thorough knowledge of B/W TV theory, is needed. Colour, from the viewing standpoint, is wonderful: many of our most colourful events are breathtaking when broadcast in colour: the Parade of Roses on New Year's Day, the World's Series (baseball, that is), and the many "specials" which are usually lavishly produced musical comedies, with gorgeous costumes, etc. And, I might add, for "Free Grid's" benefit, that he simply hasn't lived at all until he sees one of his favourite blondes in "Living Colour." (P.S. He can, by manipulating the hue control, change her to any shade of hair he wants! Green, purple, etc.—spectacular, if properly done!)

"Bibliography"

All opinions given herein are strictly those of the writer, as gained from talking to people, reading articles and books on the subject, and from practical experience. All definite figures quoted are taken from "reliable sources," which are at least as reliable as those quotations from political equivalents.

Industrial Colour Television

THE equipment shown in the photograph is part of an industrial colour-television system developed recently by E.M.I. Electronics Ltd. The camera is designed for use in hazardous situations and can be controlled from a point 1,000 feet away. As shown here, the operator is looking at a 21-in tube colour display; but a large-screen display using a projection system can produce picture up to 12 feet high and 18 feet wide. The ancillary equipment can be rack-mounted (not shown).



Radio Components Show

NEW EQUIPMENT AND DEVELOPMENTS

ALTHOUGH the change in venue from Grosvenor House to Olympia has given the advantage of extra space, the exhibition has taken on a more impersonal aspect, and exhibitors seem to be a little wary of showing equipment which is not immediately available in large quantities. As the purpose of the show is primarily to sell components, this is understandable. However, it is a pity that more prototypes could not be shown, if only because the new ideas which are our "bread and butter" seem to show up better in their original form.

Fixed Resistors.—In the main, major changes in fixed resistor design were noted only in the high-stability types, where unusual encapsulating materials were being used. For instance, Dubilier employ a p.v.c. sleeve, whilst Plessey use an epoxy-resin moulding as do Rivlin and Welwyn. Ashburton employ nylon moulded round the resistor.

Generally the use of fine wires seems to have reduced sizes and increased resistance values, for instance, Erg had on show their Type MPRB22, with a maximum value of 1MΩ on a $\frac{5}{8}$-in long by $\frac{3}{16}$-in diameter bobbin, rated at $\frac{1}{4}$W.

A novel form of wire-wound power resistor was seen on the Elcom stand. A flexible glass-fibre core supports the wire, rather after the nature of a short length of linecord, and the terminations are mild steel lugs.

Variable Resistors.—Once more miniaturization has resulted in further reduction of the size of potentiometers and a common style this year seems to be about $\frac{1}{2}$-in diameter with a $\frac{3}{16}$-in spindle.

The A.B. Metal Products version can be supplied for fixing without a spindle bush for a compact edge-control assembly and the Egen Types 365 and 363 both employ die-cast bodies and nylon spindles. Morganite's Type K has up to three tapping points for the fitting of a.f. response correction networks.

In the field of precision variable resistors the multi-turn helical potentiometer seems to be gaining ground on account of its high resolution. However, another method of achieving high resolution was shown by Colvern: their Type CLR 85/00 potentiometer has a single turn action and employs three parallel, concentric windings so that movement of one wiper from turn to turn is masked by the other parallel wipers.

Fox are using alloys of noble metals and noble-metal wipers in their potentiometers—this, they claim, improves life and reduces noise.

Continuous elements, of course, avoid resolution troubles: for instance the moulded-track type (Plessey) which, made in a square shape, is particularly convenient for a sine/cosine potentiometer. On the Ministry of Aviation stand another infinite-resolution element was seen; this was a 400-angstrom-thick layer of chromium deposited on a Pyrex rod.

Fixed Capacitors show generally development to meet transistor requirements—working voltages have been reduced by the use of thinner dielectric films so reducing the overall bulk also.

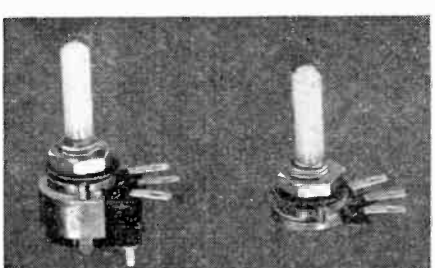
Ratings of 20 (Lemco), 30 (Mullard), and 50 (TMC) V were found in "plastics" types, typical dimensions being 12×11×5 mm for 0·1 μF (Mullard), 5mm long by 2mm diameter, 100 to 300 pF (Lemco); $\frac{15}{32}\times\frac{3}{16}$in for 0·5μF (TMC).

On the Ministry of Aviation stand the production of stacked barium-titanate capacitors by a slip casting process was shown. Barium titanate is spread in 0·001-in thick layers in the form of a slip or "mud." On top of this electrodes are printed with nickel oxide, being covered by another layer of dielectric, and so on, until the desired number of layers has been applied. Then the whole is cut up and fired in a reducing atmosphere to produce nickel electrodes and leadout wires are fitted. Capacitances of the order of 100μF/in^3 at 50V working are achievable.

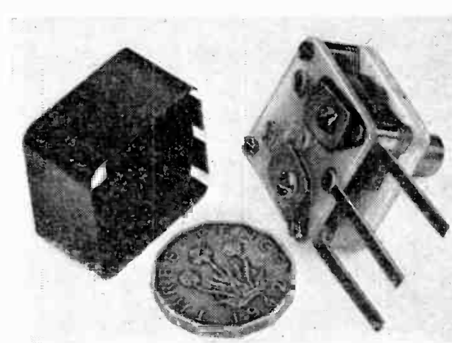
For valve circuitry a trend appears to be the offering of synthetic-dielectric capacitors for ordinary coupling purposes (Suflex "Polycaps").

Another alternative to the paper type is ceramic—Erie were showing ceramic disc capacitors in ratings up to 0·1μF at 500V d.c.

Electrolytic Capacitors, like the paper and plastics-dielectric types were presented in various new forms of covering: Hunts, Plessey and T.C.C. were all using various types of plastics moulding. The T.C.C. "Elkomold" series is designed for operation at 75° C without de-rating



Left: Egen potentiometers with die-cast bodies $\frac{1}{2}$-in diameter. Switch-on Type 365 is rated at 50V, 150mA.



Right: Jackson Brothers Type S.D.1 miniature tuning capacitor.

and Plessey were rating capacitors in polypropylene cases at 85° C.

C.C.L. were showing a new range of electrolytic capacitors designed for printed-wiring use in transistor circuits. A typical size was 35μF, 6V working and the transistor-like appearance was brought about by the aluminium can with the leads, sealed in epoxy resin, emerging from one end.

Variable Capacitors.—Most noticeable on the majority of stands of variable-capacitor manufacturers were small, solid-dielectric two-gang tuning capacitors of roughly similar dimensions (about 1-in square and ½-in deep). Mullard and Jackson use "tracked" vanes, so that an additional oscillator padder is not required (maximum capacitances about 180pF and 80pF) whilst the Plessey unit has a switch fitted which earths two contacts when the 180° rotation point is passed. These contacts are used to add parallel capacitors for reception of the l.w. Light Programme with m.w. coils, the extra rotation of the capacitor providing a fine tuning function.

Also using a solid dielectric was a capacitor from Suflex, covering the range 0·035 to 0·1μF. This consists of a specially-wound tubular polystyrene capacitor which is "squashed" to provide the capacitance variation. Other values are 0·45 to 0·5μF and 1μF ± 3% and the long term stability claimed is better than 0·1%.

L.F. Transformers.—A new range of sub-miniature ($\approx$ 1in^3) transformers shown by Ferranti used a new type of epoxy resin which sets at least ten times as fast as normal resins and so allows a much greater rate of transformer production.

Haddon showed a three-phase saturable reactor in which a single control winding is used to produce more nearly equal powers in each phase than is obtained with the normal three control windings (one in each phase).

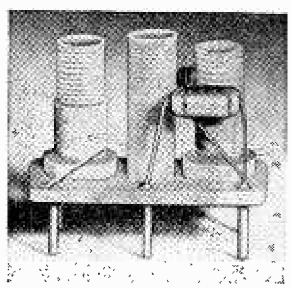
A range of small transformers shown by Andec are, for convenience in use, built around the mains plug. One of these also incorporates a rectifier to produce a 1-A, 12-V battery charger.

Aveley showed a range of toroidal variable-ratio transformers tapped in three decades to an accuracy of 1 part in 10^6. Similar accuracies are available for some units of the Gertsch range of multi-decade ratio transformers shown by Wayne Kerr.

R.F. and I.F. Transformers.—A range of transformers for f.m. receivers shown by the Wireless Telephone Company has the useful facility that the coupling can be varied without altering the tuning of the individual coils. The two coils (with their ferrite tuning cores) are placed side-by-side with their axes parallel. To vary the coupling a third parallel ferrite core is screwed in between the coils.

As coils are increasingly miniaturized it becomes more difficult to form threads on ferrite cores for them. This difficulty has been avoided by the Wireless Telephone Company and by Weymouth by using a non-threaded core attached to a larger threaded polystyrene plug. The Wireless Telephone Company used the normal movable internal core, but Weymouth used a fixed inner core and varied the inductance by means of an external parallel movable rod. Another approach adopted by Weymouth in their P80 series was to use a comparatively large hollowed-out threaded core which is screwed down over the coil and internal fixed core.

To avoid radiation at the i.f. or its harmonics several companies have in the past mounted the detector and its filter capacitor inside the screening can of the last i.f. transformer. This idea was carried still further this year by Brayhead, who also included the last i.f. transistor and its d.c. biasing components inside the screening can.

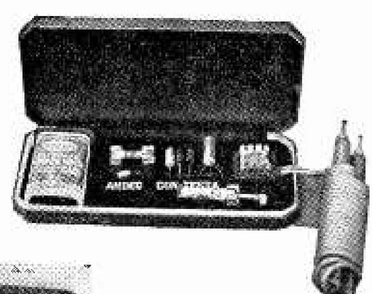


Plessey first i.f. 10.7 Mc/s f.m. transformer in which the coupling can be varied (by moving the core in the centre former) without altering the tuning of the two outer cores.

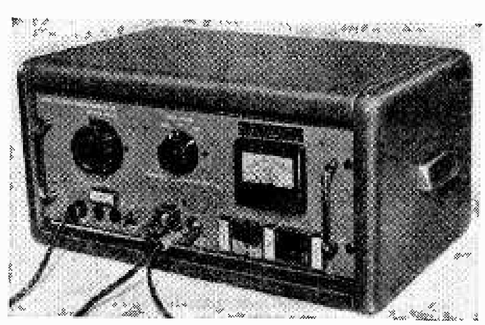
Component Testing.—Rapid voltage proof testing is provided by the Lemco equipment. The normal test —the required direct-voltage of one minute's duration—is replaced by a high-voltage pulse applied for a matter of milliseconds, front-panel lamps indicating pass or fail. Connections are provided for the operation of automatic equipment, when the rate of test can be up to 100 components per minute. Voltage is continuously variable up to an equivalent 2kV d.c.

Resistance Measurement. — Continuity-checking is simplified by the use of the Andec Con-Test. This consists of a transistor oscillator working in the audio range, with the output feeding a small speaker. Probes are applied to the measuring point, and the resistance encountered between them, being in series with the oscillator supply voltage, varies the frequency in linear proportion. The current applied to the external circuit is of the order of microamperes and the instrument may be used on live circuits up to 50V. Sensitivity is sufficient to discriminate between a short-circuit and a dry joint.

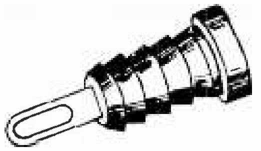
Extremely low loading of the resistor under test is afforded by the B.P.L. RM196 Wheatstone Bridge. The maximum dissipation demanded is 15mW, over the range 0.001Ω to 10MΩ. Null indication is by centre-zero meter, fed by the output of a chopped d.c. amplifier. Switch indications are by neon in-line indicators, with a decimal point. Accuracy is within 0.1%.



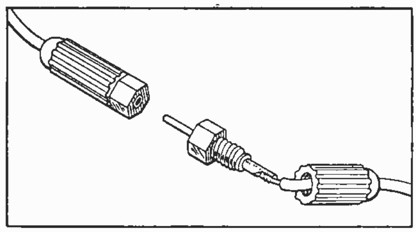
The Andec Con-Test continuity tester.



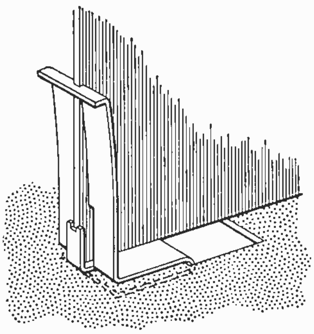
Left: Voltage proof testing equipment shown by Lemco, which simulates 2 kV d.c. for 1 min. by means of high-voltage pulses.



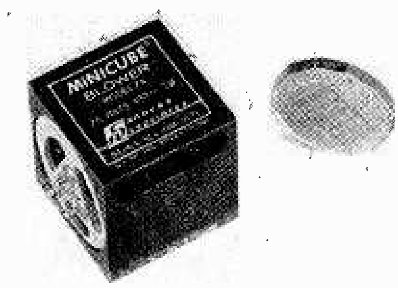
Quick-fixing chassis socket—the Fasfit—by Spear Engineering. The socket is simply pushed into place and is held by the moulded serrations.



Miniature plug and socket shown by Harwin. Either half can be male or female, and a very positive connection is achieved.



Salter retaining springs for printed boards. A slot in the board edge prevents accidental withdrawal.



Contained in a 1-in cube, this blower by A. K. Fans will move 2.2 ft^3/min.

Switches.—A.B. Metal Products showed a new range of push-button switches built on a single-piece frame which is bent into the shape of a trough. This is claimed to be more robust than the normal four-plate frame.

Ardente showed a miniature ($\approx\frac{1}{2}$-in diameter) 2-pole 3-way rotary switch with the unusual facility of spring return. This is designed to replace the normal lever key switch.

Printed circuit switches were shown by Plessey and Harrison.

Relays.—S.R.D.E. showed a number of relays made up from single-changeover cylindrical capsules only $\frac{1}{8}$-in in diameter and 1-in long. Each capsule contains a spring-loaded armature plunger which in operation is attracted (by the field of the exciting current in an external coil) away from the non-magnetic contact at one end of the cylinder towards the magnetic contact at the other.

Plessey showed a relay in the unusual shape of a cylinder in which a disc armature moves an axial rod at right angles to the disc plane. This relay is also unusual in that it is the outer rather than the inner contacts which move.

Chassis Fittings.—Miniature lamps were shown by Thorn Electrical. The Mite-T-Lite is only 0.055-in in diameter and 0.175-in long. It requires 1-1.5V at a maximum current of 35mA. Output is 35 millilumens. The Micro-Lite can be operated from an 0.8V supply at 6mA.

Transistor retainers were shown by Rendar and Lewis Springs. The Rendar fitting is single-screw fitting and moulded from polypropylene. A beryllium-copper spring retains the transistor. The Lewis retainer is a beryllium-copper spring and assists in heat dissipation; fixing is by clipping into a hole in the chassis or p.c. board.

Valve retainers shown by Electrothermal are made from heat-resisting rubber and are designed to fit any size of valve. The VRE retainer ends are serrated and are simply pulled through holes in the chassis until the correct tension is obtained.

For the mounting and locking of potentiometers and trimmers, General Controls have introduced the Flush Lock. The potentiometer is set back from the panel, and all that protrudes is a $\frac{1}{32}$in surround. The spindle is locked by a grub-screw pressing on a ball arrangement.

Plugs, Sockets and Connectors.—For use in circumstances where longitudinal strain is applied to the centre contact, Transradio have introduced a modified contact pin with a shoulder. The coaxial plugs fitted with the new pin are the Types "BNC," "C" and "N."

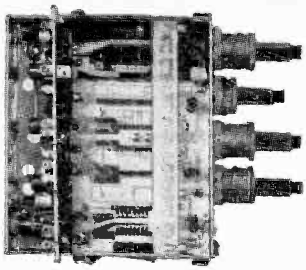
"Collecon" and "Camlecon" are the names of multiway plugs and sockets made by Belling and Lee. After insertion, which requires very little force, contact is made by compressing the socket round the plug-pin, by means of a cam action.

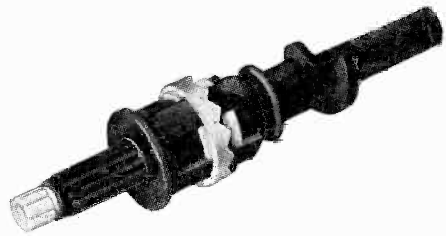
Designed for use on remotely controlled television receivers, the Pressac 8-way shuttered plug and socket contains an independent pin-holding plate which may be removed for easy connection of wires. The units are moulded from high-impact polystyrene.

Sub-Assemblies.—Transistor power supplies may conveniently be assembled using the Mullard sub-assemblies. Two basic unstabilized supplies giving 1A or 5A at voltages from 1-39 may be combined with a stabilizer reference circuit to give 1-30V at 250mA, while for heavier currents a series regulator is added, giving up to 0.5A. More current is obtained by the addition of further series regulators. Stability with mains variations is 200:1 for +10% −15%.

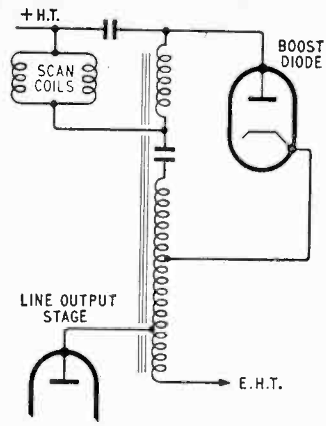
What must surely be the ultimate in compactness was shown on the stand of A.K. Fans—the makers of Airmax blowers. This is a blower contained in a 1in cube and moving up to 2.2 cubic feet per min, depending on the pressure. The hysteresis motor consumes only 3W at a variety of a.c. voltages and is guaranteed for a continuous running life of 1,000 hours at normal ambient temperatures. The blower is made by the American firm of Sanders.

Television Components.—In the Cyldon Type PC80 tuner, the mechanism allows selection of any of the thirteen channels on any push-button. The tuner is of the incremental type, using a flat, printed "coil-board" across which a shorting slider moves, positioned by a 13-step cam on each button (the button is turned to pre-select channels) and the manufacturers claim a reset accuracy of 50 kc/s. Several versions of this tuner are available, one of which uses three Type AF102 transistors in the grounded-base mode. This company were also showing a u.h.f. tuner using two triodes. Resonant lines form the tuned circuits and are coupled together by slots in the screening partition. Primarily (at the moment) for the export market, this tuner com-

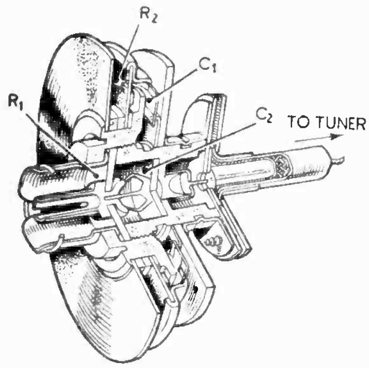




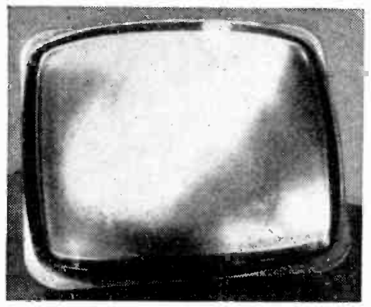
A. B. Metal Products new transistor TV tuner (left) and (below) 13-step cam channel-selector button.



Circuit used by Plessey and Elac for cancelling flow of d.c. through line-output transformer windings.



Aerial isolator for a.c./d.c. television receivers (Egen).



Integral-safety-shield television c.r.t. by Cathode Ray Tubes Ltd. "Ears" at corners ease mounting problems.

plies with the German radiation specifications.

A.B. Metal Products were also showing a transistor tuner, but this was of more conventional turret design. What is unusual is that the three transistors (Semiconductors types) are operated in the earthed-emitter connection. The noise performance compares well with valve tuners, but the minimum-gain specifications (Band III, 19dB) look disappointing until it is realized that these figures are *power* gains, and not voltage gains between unrelated impedances, as are usually quoted for valve tuners.

Brayhead's BT 19 series of tuners uses printed-coil aerial and r.f. biscuits as well as including a range of variations, two of which are the use of a tetrode r.f. amplifier and a back-biased junction diode for the fine tuner.

For transistor television, Elac, working on the basis of a 90° c.r.t. at 12kV e.h.t., have adopted wave-winding for the e.h.t. coil to reduce the self-capacitance of the overwind which employs a greater step-up ratio than is usual today for valve working. The scan coils look conventional except for round correction magnets with long pole pieces extending round the coil: these provide a slight amount of scan magnification. Some of Plessey's components had been developed along the same lines; but in addition they had an experimental design for a 110° c.r.t. at 16kV.

With valves, "desaturation" of the line-output transformer for 110° c.r.ts. usually employed an isolating choke; but both Elac and Plessey were showing an arrangement which uses instead the scan coils (see circuit). The cancellation of d.c. flow has, too, allowed a smaller core to be used—tighter coupling of the e.h.t. winding is thus possible and an e.h.t. series impedance of about 7.5MΩ (compared with 12MΩ) has been achieved. A new component from Egen, the aerial isolator Type 364, is completely coaxial in its construction. The drawing shows the main features; R_1, the "static discharge path between inner and outer of the aerial cable, is completed by a resistive sprayed carbon-composition coating on the insulating washer. The r.f. circuit is made by C_1, formed by a metallized mica annulus between the aerial and tuner-lead sections, and C_2, a ceramic disc capacitor. The leak resistor from chassis to aerial is again constituted by a composition coating, R_2. Features are a very small insertion loss and an s.w.r. at u.h.f. of only 1.56.

Cathode-Ray Tubes.—The quest for the slim television set has forced matters even further than the 110° tube; the safety-glass and mask have now been eliminated! Brimar were showing tubes with both Diakon and toughened-glass shields cemented to the tube-faceplate, the corners of these shields carrying ears for clamping the c.r.t. to the cabinet, and Cathode-Ray Tubes Ltd. had on show tubes with shields in Perspex and Diakon. When imploded, the glass of the tube face-plate, although broken, remains "glued" to the protective panel.

For transistorized television sets Mullard were exhibiting a 14-in 90° c.r.t. with a heater rated at 11.5V, 165mA, to suit a nominal 12-V battery on discharge.

Oscilloscopes.—The pattern of plug-in amplifiers to the basic instrument is adopted in the Serviscope D33. This is a dual-channel instrument, using a double-gun G.E.C. tube with P.D.A.. Three types of amplifier are available—a wide-band unit 0-6Mc/s at 100mV/cm., a differential amplifier 0-200kc/s at 1mV/cm., and a high gain a.c. unit 5c/s-150kc/s at a sensitivity of 100μV/cm. The wide-band amplifier may be switched to increase gain 10 times at reduced bandwidth.

Frequency Measurement. — Examples of the integrating discriminator frequency meter were shown by Greencoat Industries, and have been developed for the measurement of shaft rotational speed. Two types were shown, a hand-held and a bench instrument. The hand-held device will measure speeds in the

(*Continued on page* 365)

range of 10 r.p.m. to 20,000 r.p.m. in four ranges at an accuracy of 2 in 10^4, and will indicate changes of 2 r.p.m. at 10,000 r.p.m.

A frequency-divider unit developed by Greencoat will deliver outputs from 100kc/s to 10c/s, from either an internal Xtal oscillator or an externally applied signal. The unit may be employed as a digitally preset square-wave generator, delay pulse generator, frequency divider with divisor 2-200,000 or as a crystal calibrator.

Voltage Measurement.—A small high-sensitivity test meter—the Minitest—was exhibited by Salford. On d.c. volts the resistance is 20,000 Ω/V, and 2,000 Ω/V when measuring a.c. volts. D.c. and a.c. voltage measurement from 2.5V to 1,000V full-scale is offered while d.c. current from 50μA f.s.d. and resistance up to 20MΩ may be determined.

Meters.—A very neat little panel-mounting meter is the edge-wise reading Pullin Series 10. The front measurements are $1\frac{1}{2}$in and $1\frac{1}{4}$in, and the 1-in scale may be either horizontal or vertical. Full scale deflections from 20μA to 500mA are available, and a self-contained a.c. unit is produced.

Metal Rectifiers. — Developments made by Salford Electrical Instruments include a range of "economy-class" contact-cooled rectifiers of simple construction, "semi-contact-cooled" types and increases in the p.i.v. ratings of selenium elements.

The "semi-contact-cooled" types are primarily for low-voltage-rectification: in appearance they resemble ordinary air-cooled types except that the plates are very much closer together and a large insulated metal bush is fitted at one end. When bolted to a reasonable area of chassis the bush transfers heat from the plates to the chassis. S.E.I. make their plates by a vacuum deposition process and improvements in this are raising constantly the peak-inverse maximum rating of the elements from about 27 to, at the present stage of development, 32 to 40.

Semiconductor Diodes.—The remarks made about transistors could be applied, with appropriate modifications, to diodes. Ranges on show have been very widely extended both in voltage and current rating and switching speeds have been increased, in some cases to a startling extent. Recovery times of the order of 1 nanosec are achieved by several manufacturers: stored charges are 20 to 50 picocoulombs.

Television h.t. rectifiers are now available from many manufacturers and single 800-V units are available. The major difficulty in this type of application is caused by the presence of high-voltage spikes on the mains supplies: most rectifiers are rated at, say, 800 p.i.v. but 1.25kV for occasional periods of less than 10msec.

Voltage-variable capacitors (back-biased diodes) are becoming available in a variety of shapes and sizes for most applications. G. & E. Bradley (Lucas) were demonstrating two reverse-biased 750-mA rectifiers in use for the tuning of an ordinary a.m. superhet. A capacitance swing of about 75 to 550 pF was achieved with a voltage variation of about 150.

Tunnel and parametric diodes continue to be presented in experimental forms but do not seem yet to have achieved any major use. The latest type of tunnel diode from S.T.C. (JK30A) is contained within a very short ceramic tube fitted with tag contacts.

Zener Diodes, too were found in great profusion. Perhaps the most interesting ideas in this field come from Brush and Ferranti. Brush has a metal block (called Statavolt) containing holes into which Zener diodes are inserted: by the correct choice of characteristics and the use of reversed devices a reference independent of temperature variations is produced. Ferranti combine Zener diodes and an ordinary junction in one tube with the same aim.

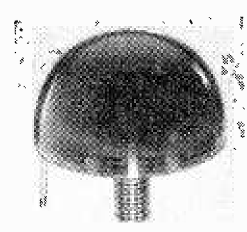
Brush "space-saver" design for medium-power transistor packages.

Photo-electric Devices.—As is well known, the efficiency of the silicon photo-electric device can be as high as 10%. International Rectifier were showing what they describe as "ruggedized" cells in which an alloying technique is used to attach the contact strips to the silicon wafer. Ferranti have fitted experimental hemispherical wide-angle lenses of epoxy resin to their cells, to avoid the necessity for "tracking" the cell on to the source of energy.

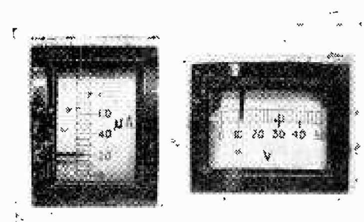
Transistors.—A high rate of development continues in this field and many new types were on show at the exhibition; for instance Newmarket introduced completely new ranges (type numbers NKT) covering both industrial and entertainment devices. There seems to be a general movement towards the use of the American JEDEC standard cases for transistors—in fact the only noticeable "rebel" was Brush with their "space-saver" design which is about $\frac{3}{8}\times1\frac{1}{2}$in and can be used for devices up to about 10-W dissipation, with, of course, a suitable cooling fin.

Notable in the new Mullard range for radio and television are the AF102 and AF118; both of which are intended for transistor receivers. The AF102 provides a minimum current gain of 20 times at 25°C and has a noise factor (typical) of 6dB at 200Mc/s. The AF118 has an α of 200 and maximum collector ratings of 50V and 30mA; these ratings, together with a f_1 of 174Mc/s render it most suitable for use as a video amplifier. Semiconductors (Plessey group) too have a range of transistors suitable for the receiving circuits of transistor TV and the agreement made recently with the American Bendix organization should result in suitable timebase types being available. The alloy-diffused and micro-alloy-diffused types are now well established and make up the great majority of the h.f. ranges and devices made by the epitaxial technique show promise of fulfilling the higher power r.f. applications.

An illustrative example of thermo-



Solar cell by Ferranti with wide-angle lens for light-gathering.



Pullin Series 10 miniature meter.

electric cooling applied to a transistor was given by M.C.P. Electronics. Bismuth telluride cooling "cells" consuming 2½ to 3W were used to double the rating of a transistor rated at 2½W on a 10×10cm fin.

Microminiature Semiconductor components made by Hughes have been given the name "Microseal." We noted the "dot" diode a short time ago* and this and its companion transistor was on show. The transistor is pear-shaped in plan (0·7×0·062in) and 0.030 in thick. The collector "cap," which forms one end of the ceramic housing, is magnetic and coloured for identification. The other cap is split across and forms emitter and base connections. These devices can be wired-up by a "swiss-cheese" printed-circuit board which is of the same thickness as the units and bears conductors contacting the inserted microseals as if they were feed-through components.

Receiving Valves.—New valves for television "front-ends," are a "beam triode" (PC97) and a v.h.f. tetrode (Mazda 30F27), which use simpler circuitry than the cascode stage.

In a frame-grid triode the major part of the anode-to-grid capacitance is associated with the grid supports. Mullard have, therefore, enclosed the "ends" of the grid assembly of the PC97 in a shield like the beam-plates of a tetrode, and have shaped the anode so that C_{ag} is reduced to about a third of the normal value. Neutralization is still required and the gain is slightly less than that of the cascode stage, but the noise performance is unimpaired.

The tetrode, on the other hand, has a slightly worse noise factor than the cascode, due to partition noise, but Mazda have kept this and, at the same time, C_{ag} to a minimum by lining up the grid and screen-grid so that the latter is shadowed to some extent by the former.

Another Mazda development is a frequency changer triode-pentode (Type 30C17) to which a.g.c. can be applied so that cross-modulation is reduced. Normally a.g.c. would lead to excessive changes of input capacitance, but, by using a high-slope variable-μ pentode and good internal screening, the effect has been reduced to acceptable proportions.

Industrial and Transmitting Valves.—The largest valve on show was the English Electric Type 4KM5000LA four-cavity power klystron primarily designed for u.h.f. television transmission. Rated to give 10kW output this device has a gain of 57 dB and is tunable over Band IV.

For transmission on a smaller scale—from mobile sets—Mullard have produced a series of valves which have a warm-up time of less than one second. This is achieved by the use of either coated-ribbon or multiple parallel fine-wire filaments.

G.E.C. have in their Type A2900 a reliable version of the 12AT7, with a stated average life expectancy of 10,000 hours. Produced for computer and instrumentation applications, this long life is achieved by observance of close manufacturing tolerances and a redesigned heater and cathode assembly.

Brimar were showing a new double valve (ECF804) combining triode and pentode sections of high slope (7·2 and 11μA/V respectively, both at 150V h.t.). This should prove useful where the triode section of the television frequency-changer type limits the performance available from its companion pentode.

Frame-grid construction continues to show its advantages. Two valves from Mullard using this form of construction have very high figures of merit: E810F, 238Mc/s (slope 50mA/V); E55L, 194Mc/s (45mA/V, anode-dissipation 10w).

Microwave Valves.—An X-band t.w.t. amplifier shown by Ferranti is unusual in that it can be modulated by means of a grid incorporated in the electron gun. This enables the modulation power to be reduced at about a thousandfold below that required for cathode modulation.

Microwave Components. — Elliott showed how strip lines between two ground planes spaced only about 0·1-in apart could be used to produce a range of relatively-compact coaxial components.

A coaxial three-port circulator shown by Marconi for frequencies as low as 400Mc/s consists simply of a flat circular cavity containing a sandwich made up of a conducting plate (attached to the three equally-spaced coaxial inners) between two magnetically-biased ferrite discs.

In a three-port X-band switch shown by Sanders an isolation as high as 110 dB is achieved simply by loading the edges of the rotor with a suitable lossy material.

A range of waveguide components for wavelengths as short as 2mm was shown by Elliott.

Materials.—A new method of cabinet construction, based on the Imlok principle but much smaller, was shown on the stand of Alfred Imhof. Units as small as 4¼in cube may be constructed, although the material is also well-suited to much larger structures. A complete range of extrusions, screws, corners, panels, etc., is available.

Among the range of new alloys developed by Telcon are Telconstan and C.P. Alloy. The former is a resistance material used in wire, tape or foil form, and features a sensibly constant specific resistance over the range 20-100°C. Temperature coefficient of resistance is 0.000014/°C. over this range. C.P. (Constant Permeability) Alloy is also designed to be temperature stable, the parameter in question being its permeability, which is between 31,000 and 34,000 over the range −20 to +100°C. Otherwise it resembles Mumetal.

Calculated to reduce the incidence of high blood pressure among electronic engineers is Denamel, a substance produced by Hellermann for the easy removal of enamel from wire. Immersion in the liquid for one minute swells and softens the enamel and a wipe with a rag brings it off. Also from the Hellermann stable is CRC2.26 — a moisture-dispellant. This may be used to remove all moisture from equipment which has failed due to ingress of moisture or even immersion in water. It is available in either aerosol or bulk form and is completely inert.

Suflex exhibited a PVC-coated glass sleeving which will work continuously at 130°C. Dielectric strength is 5kV and bore sizes are from 1mm to 5mm. Material made by Symons is broadly similar and is stated not to exhibit pull back when in proximity to soldering operations. It is resistant to chemicals and oil.

Spirex is a new product of Langley London, offering a low-cost, precision insulating tube of many shapes and sizes. The tube may be rectangular or round, and is spirally wound from a variety of papers and plastics with coverings designed for many different applications.

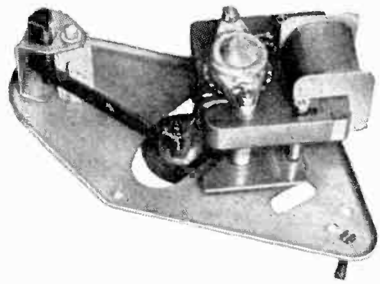
Loudspeakers.—In a new Plessey range the leads are taken directly to the voice coil, rather than *via* two terminals in the speaker cone. This avoids asymmetries in the high-frequency nodal pattern produced by the extra mass of the cone terminals, and also avoids distortions of the cone shape which can occur round these terminals as the cone expands and shrinks with atmospheric moisture changes.

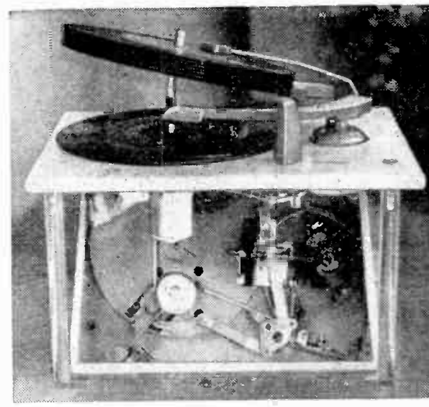
For miniature speakers it may be-

*Wireless World, p. 280, May, 1961.

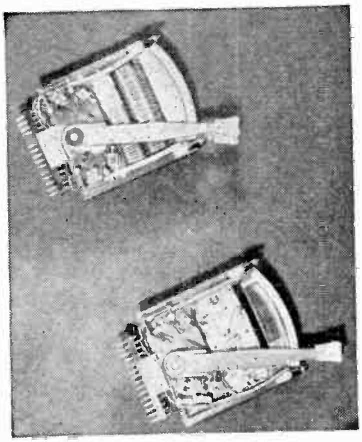
Right: Gramophone Company simple speed-change mechanism for record players.

Below: Electronic Components transistorized continuously-variable constant-impedance audio fader (below) designed as a plug-in replacement for their resistive network step fader (top).





Right: Sanders 7-in $33\frac{1}{3}$/45 r.p.m. autochanger with view of underside in mirror.



come economical to machine-cut a suitably shaped pot and to use a single-piece cylindrical centre-pole i.e. to do without a separate pot front plate and pole piece. This decrease in the number of separate parts results in an increase in the magnetic and acoustic efficiency. This principle was adopted by Fane, Goodmans and Plessey.

A new waterproof 1-watt pressure unit for underwater entertainment purposes was shown by Goodmans.

Microphones. — The plane-wave noise concellation produced when a microphone diaphragm is exposed to the air on both sides is used by Lustraphone to avoid handling noise in their new "Contadyne" miniature contact microphone for vibration measurements in medical and other fields.

Audio Amplifying Equipment.—Electronic Components showed a continuously-variable constant-impedance (within 1%) transistorized electronic fader designed as a plug-in replacement for their normal resistive-network stepped attenuator. Advantages of the new attenuator are, of course, the facility of continuous variation, as well as the avoidance both of the possibilities of noise due to multiple contact paths or sudden switching-voltage changes, and of high-frequency response correction difficulties.

Record Turntables.—Several new record turntables were introduced. In an unusual battery autochanger shown by W. H. Sanders for 45 or $33\frac{1}{3}$ r.p.m., 7-in records, the pickup arm is raised and lowered by mounting it on a ball which is partly rotated by contact with a vertical wheel driven from the turntable.

A new Greencoat battery record player has a number of unusual features. For example, the pickup arm rest is movable so that when not in use the pickup may be stowed for compactness half way across the turntable. The centrifugal governor contactor is in series with only one rather than all of the armature windings and the speed-change control moves the motor and spindle rather than the idler-wheel.

In a very simple speed-change mechanism introduced by the Gramophone Company the idler is moved by attachment to a spring-loaded pillar which bears in a groove of variable depth in the underside of the speed-change knob. Protuberances in the knob spindle move the connecting rod between the spring-loaded pillar and idler spindle so as to automatically disengage the idler as the speed is changed.

Tape Recording Equipment.—Battery motors suitable for tape recorders were shown by the Gramophone Company and also on the B.S.R. stand by Marriott.

An unusual feature of a range of magnetic tape heads shown by Thermionic Products is that only a single lamination (twisted to form the pole pieces) is used for each head. This, it is claimed, avoids harmful effects caused by the magnetic field not directly crossing the gap near the laminations, effects which will be accentuated if the laminations on the two sides of the gap are not aligned.

In the "X" range of heads introduced by Marriott a gap width of only 8×10^{-5}in has been achieved. This company also showed an erase head requiring only 34mW for a 4-track operation (52mW for 2 track).

A set of transistorized replay, record and bias plug-in units was introduced by Thermionic Products.

Data Processing Equipment.—Gresham Lion Electronics have combined digital read and write magnetic tape head gaps into a single double-gap head, thus reducing the separation between the read and write elements and also obviating the need for alignment between separate read and write heads.

Thermionic Products showed a time injection unit which provides an output in International shortened morse code 1,000c/s bursts for recording on magnetic tape.

Computer Bricks.—A range of plug-in modules designed by Bailey Meters and Controls is marketed by T.M.C. The units comprise a chopper, demodulator, oscillator and amplifier and are intended to comprise a d.c. amplifying system for use in instrumentation. The modules use solid-state circuitry throughout and are resin-encapsulated; the bases will fit a B.9A socket. The chopper is capable of handling an input of 1μV to 250mV d.c.

In the hope of converting the designers of industrial control equipment such as lift controls, weighing equipment, etc., from electromagnetic relays to electronic circuitry Panellit have introduced a system of logic—Minilog—using small encapsulated elements. A whole equipment may be designed using only one basic logic element and one or two driver units. The basic unit is "AND/OR" gate, providing a 6-way "inverted and" function. The output will drive up to 25 other units. Two more units serve as power amplifiers to drive relays, etc.

LETTERS TO THE EDITOR

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

Sound Reinforcement at the I.E.E.

I FEEL bound to comment on the last paragraph of the report entitled "Television and Film Techniques" appearing on pages 321 and 322 of your June 1961 issue.

Why, you ask, should the cobbler always be the worst shod of men? But it is not the cobbler's fault if those to whom he lends his shoes get the laces inextricably tangled up! The cobbler much regrets the unusual limping that resulted on the evening in question but it has led him to formulate new conditions for the lending of shoes.

The foregoing parable refers in particular to the behaviour of the sound reinforcement system. So far as the slide-projection arrangements were concerned, the meeting in question was lucky to get any slides shown at all; owing to the badly constructed frames of the slides with which the projectionist was provided, they jammed as often as the old-fashioned Gatling—necessitating, incidentally, a repair job on the slide carrier.

London, W.C.2. W. K. BRASHER,
Secretary,
The Institution of Electrical Engineers.

The Jigger

"FREE GRID'S" theory of the origin of "jigger" as far as wireless is concerned is hardly right if what I heard very early in the game was true.

Marconi, I think, devised these r.f. transformers probably at the Haven, and their action was described to Kemp.

Kemp was his well-known ex-naval assistant who, it will be remembered, was one of the two assistants Marconi had with him on the first Newfoundland tests.

Kemp immediately remembering his life on board ship said "Oh, that's a jigger", which seems to be a general expression for a lever, and the name stuck.

Two early wireless nicknames which, however, haven't been perpetuated were "sea serpent" for h.f. power cable (used on the giant transmitting jigger at Clifden) and "Crippens" for the large l.f. chokes which were hung by ropes from the roofs. Clifden stock lists containing these names were seriously questioned by the London Office.

London, E.C.1. H. J. ROUND.

Stereophonic Broadcasting

I HAVE followed with interest the correspondence in your columns on the subject of stereophonic broadcasting.

I think, sir, we must face the brutal facts. There are no real *technical* problems against the introduction of compatible stereo broadcasts that cannot be solved by skill and acceptance of compromise. The pure and simple truth of the matter is that of the vast millions of radio listeners in this country, those that would actively agitate for the introduction of such a service would be very minute indeed. If it were otherwise the future outlook would be very different.

I have arrived at this conclusion with some regret since for me, at least, stereophonic reproduction has no attraction at all unless it is of a live broadcast concert (or at second best, a tape). Commercial recordings in their present form only serve to emphasize the synthetic origins of their programme content. That there are technical problems to be solved has to be admitted, but I would remind you, sir, of the controversy that raged in your columns in pre-f.m. days—the gloomy prophecies on the cost of suitable receivers, difficulties of alignment, etc., etc. I suspect the main difficulty is the relatively low standard of the land lines linking studio centres and transmitters. Even in my part of the country, fairly close to London where the experimental broadcasts originate, one has only to listen to the poor quality of the "sum" signal to appreciate the degradation that can result from land lines with unmatched phase shift. But this *could* be solved, and extension of the audio bandwidth to realize the full potentialities of the f.m. service is long overdue. As witness recent events, it would seem no effort can be spared to provide a communication link a few *megacycles* wide over thousands of miles—yet all the reasons in the world are advanced for not providing an extra half an octave on the audio bandwidth of my local f.m. transmitter.

So, sir, I fear the conclusion is inescapable and we, who still enjoy steam radio more than the almighty "goggle-box," might reflect on it. We are unlikely to have a regular stereo broadcast service in ten years—or ever for that matter. I, for one, will have to content myself with an occasional tape from more fortunate enthusiasts in the U.S.A.

Furthermore, I suggest the B.B.C. cease the experimental broadcasts altogether. It's like having a carrot dangled in front of one's nose without the likelihood of ever eating it.

Norwich. R. WILLIAMSON.

Television Standards

MANY readers will commend Mr. Heightman's wish to improve our definition standard (May, 1961), if only because they would like to enjoy the superior picture which the larger screens should offer. As he says, attempts to fill the gaps between the lines by elongating or "wobbling" the spot are no substitute for balanced definition.

Our present scanning analysis is optically unbalanced, being continuous along the lines and discontinuous in the "frame" direction. It is, in fact, *unidirectional*, for there is no scanning vertically, merely chopping into 377 parallel strips. The definition *along* the lines is excellent—but they do not touch! If our scanning were balanced Test Card C could be turned through any angle without loss of definition. For that perfection the lines would have to touch, whatever their total number, leaving no cracks for omission and distortion of details and for spurious patterning.

Mr. Heightman may not be aware that many of us "realise that vertical picture resolution is not equal to the number of picture lines." After considerable experiment a Kell factor of about 0.6 was accepted, from which it is safe to say that vertical definition is down about a third. I have my own way of proving this, and have demonstrated the simple test on several receivers. With focus adjusted for sharpest definition, reduce the picture height until the traced lines touch. The resulting Cinemascope-shaped picture will be much clearer and brighter, and will leave about one-third of the screen dark, part above and part below. This tells us that one-third of our picture is missing, surely of some importance in technical circles also?

Some years ago several workers found that the focused scanning point diameter never exceeds 0.7 elemental line-pitch, even in bright areas of the screen. It surprises me that these investigators did not realize that the spot area is therefore only 0.49 elemental. To discover that our scanning point is only a half-element in size should have shaken those who adhere to the unreal formula for f_{max} which fixes our line total and scanning pitch. Conventional equations assume the spot to be elemental, based on Nipkow's idea that an element-size scanning aperture can sweep along a row of pictorial elements, analysing and reproducing them individually. This fallacy was quietly discarded when the c.r. tube took over from the mechanical systems, and the scanning point was reduced well below element size to obtain horizontal resolution. The lines contracted and separated, but Nipkow's second fallacy of elemental pitch was not recognized, so never remedied. The scanning point was too small for the line total, but the dark grid did not matter much on 12-inch screens. Now our largest screens are nearly four times as large!

Since aspect ratio is universally 4:3, the revised line-standard formula for balanced definition, in which the practical half-element point scans at $\frac{2}{3}$ elemental pitch, closing up its lines, simplifies to $f_{max}=(\frac{2}{3}l)^2 f_p$. For 625-line definition each vision channel requires less than $4\frac{1}{3}$ Mc/s.

We should be unwise to copy "Continental" 625-line channel planning, where guesswork allows $4\frac{1}{2}$, 5 and 6 Mc/s per channel. Our Television Advisory Committee finally reduced their interim recommendation of 6 Mc/s to $5\frac{1}{2}$ Mc/s, which would still waste over 1 Mc/s per channel by encouraging engineers to reduce the scanning point still further—again separating the lines and spoiling vertical definition.

Worthing. A. O. HOPKINS.

Colour Tube Costs

IN the past months colour television has been discussed in Parliament and has been the subject for conflicting statements by various bodies. The colour tube in particular has been singled out for criticism on account of its cost. The facts on the price are as follows.

Until recently RCA Great Britain, Limited, offered the 21CYP22A colour picture tube in small quantities in this country at a price of approximately £48 net ex New York, adding shipping charges of approximately £5 per tube, making £53 in all. This became the price to the United Kingdom user. Following a recent reduction in the U.S. the price for this tube is now £44, making a landed cost of approximately £49.

A few weeks ago RCA announced a new colour picture tube—type 21FBP22—which offers an increase of 50 per cent in brightness due to the new sulphide phosphors used. The price of this tube is approximately £46 ex. U.S. (landed cost £51). In all cases these prices are for small quantities only, so that freight and insurance is a rather expensive factor.

The price for the new 21FBP22 tube in large quantities, say in excess of 500 tubes, is expected to be certainly less than £40 landed United Kingdom. Customs duty has not been called for as there is no equivalent product in manufacture in the United Kingdom. If this position is changed duty would be payable at an appropriate rate.

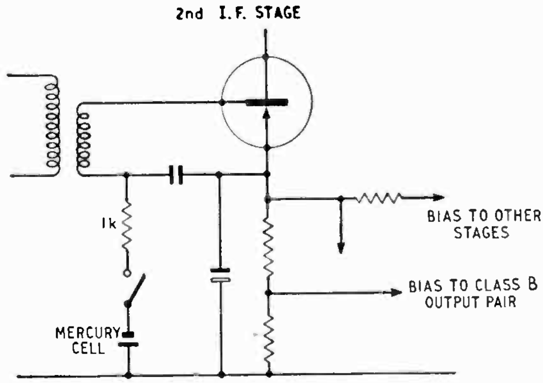
It is hoped that future statements will bear these figures in mind.

Sunbury-on-Thames DONALD MACPHAIL
RCA Great Britain, Ltd.

Transistor Bias Supplies

I AM not aware of any commercial transistor receivers which use a base bias supply for all stages separate from the main battery, although there seem to be worth-while advantages in doing so.

In the circuit suggested, the current drawn from the



single bias cell is so low (say 50 microamps) that a mercury cell might well be installed as a semi-permanent component. Actually the cell biases the 2nd i.f. transistor only, but in doing so controls the bias for all the other stages. With this steady bias it is possible for the output transistors to have the minimum required quiescent current even with a new main battery while still giving reasonable quality right down to half voltage, with the added saving of no wasted battery power in potentiometer networks.

Also, design is made very simple, emitter resistors being chosen for the required working currents at the constant base bias available. Incidentally, several resistors are saved, and none needs to be very accurate apart from ensuring the correct ratio between the two emitter resistors.

It has been found to be stable and reliable in practice.

Dunstable E. JACKSON

"Suppressed Carrier Double-Sideband Systems"

MR. G. W. SHORT has done a most useful service in drawing attention (May, 1961) to the ingenuity of the synchronous detector developed by Dr. J. P. Costas, W2CRR, for suppressed carrier double-sideband reception. But on a few points his article calls for comment.

The statement that the d.s.b. system is "almost unknown" in Britain does less than justice to the amateur radio enthusiasts who have shown a lively awareness of this system for several years, as innumerable references in the amateur radio journals show. This interest was, incidentally, commented upon in my article "Amateur Radio Progress" in your November, 1960, issue.

Then Mr. Short, quoting classic radio theory on the subject, may give readers the impression that d.s.b. signals cannot be successfully received unless the locally generated carrier is exactly equal in frequency and phase to the original (suppressed) carrier frequency. This will bring a wry smile to the many amateur operators who regularly listen to d.s.b. transmissions on conventional (though selective) receivers. The answer—as I tried to indicate in the article already referred to—is simply to listen to only one set of sidebands and to filter out the other set of sidebands *in the receiver.* Admittedly, the synchronous detector is a much more elegant system and permits an improvement in signal-to-noise ratio, but surely it is time we buried the classic theory of the difficulty of d.s.b. reception along with that other famous theory exploded by the radio amateurs of the 'twenties—"the uselessness of short waves."

It may also be of more than academic interest to draw attention to Costas's later article in *Proc. I.R.E.* (December, 1959) in which he set out to show that, in a congested band, broader bandwidths and many channels (as possible with d.s.b.) can be expected to provide better communication reliability than s.s.b. He suggested that for certain applications (including military), narrow band techniques (for example, s.s.b.) lead progressively to more expensive communications systems and less expensive jammers.

Finally, can I suggest that we avoid introducing yet another abbreviation "d.s.b.s.c." since the shorter "d.s.b."—although illogical in some respects—has already firmly established itself, and is in line with s.s.b. for single-sideband suppressed carrier systems and i.s.b. for independent sideband suppressed carrier systems.

London, S.E.22. J. P. HAWKER.

The author replies:

I have been expecting some reader to send in the cryptic message, "1961 − 1956>4." Mr. Hawker's letter gives me the opportunity to correct an error in my article, caused by the ravages of time, and, I hope, to save a little face into the bargain. When I wrote that details of the d.s.b. system were published "nearly four years ago" (in 1956) this was correct. My article was actually sent in *before* Mr. Hawker's interesting review of amateur progress appeared. For the rest, I can only plead ignorance, apologize to the "hams" and alter my statement to "almost unknown *outside amateur circles.*" This, I think, is true.

The method of receiving d.s.b. described by Mr. Hawker requires a very selective and stable receiver, and considerable operating skill. It is definitely not the thing for Aunt Jemima. Costas' synchronous receiver, on the other hand, should be easy to tune and, once tuned, the a.f.c. (or, rather, a.p.c.) should keep it tuned. The synchronous d.s.b. receiver, therefore, has possibilities as a broadcast receiver for a.m. signals in general, whether s.s.b., d.s.b.., with carrier, or without it. G. W. SHORT.

Museum Pieces

"FREE GRID" wonders why a wireless museum has not been established and advances a few possible reasons for its non-existence. He omits to mention one important fact, that it would not be in the interests of present-day receiver manufacturers to have such a museum. Why?—read on.

Up until about twenty-two years ago, when the Corporal started getting involved with this country, wireless receivers were steadily improving in every way, and models were available ranging from a simple three-valve "straight" up to superhets containing nine or more valves. Automatic tuning; "magic eyes"; push-button tuning; several wavebands; large speakers and beautiful polished wooden cabinets were the order of the day. Also large detailed glass dials, which were calibrated with a useful degree of accuracy were fitted. Dual-speed tuning was another asset. All the big names in receivers produced such sets and older hands will recall the beautiful range of models produced by leading firms.

Since the war, a generation has grown up which, on the whole, to judge by what it eats, wears, is entertained by and generally appreciates, has no conception of quality. Manufacturers have been quick to seize upon this fact, and on the principle of "any old muck will fill a bin" have in most cases reaped a rich reward.

Wireless has probably been hit harder than most things, with the result that it is almost impossible to find in the average shop anything better than a midget, five-inch speaker, ferrite aerial four-valve plus nothing superhet (does the public think "super" means good or best?). This thing gets about two local stations reasonably clearly and sometimes a succession of regionals accompanied by a loud hiss. No one puts up an aerial today: the sets would be a bag of whistles if they did since screening is almost unknown and all design is cut to the bone. These atrocities cost between about ten to thirty guineas, probably not far removed from the pre-war prices.

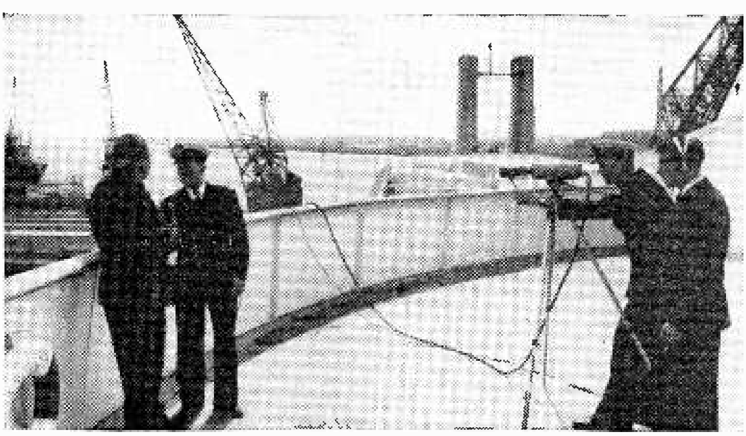
We know that greed and national pride have ruined the medium wavebands, but we had "whistles" in the early 'thirties I believe, and if one takes the trouble to put up a useful aerial and earth and knocks up a simple reacting 1-v-1 with decent inductors, one will be amazed how much can be obtained than can be heard on the *standard* superhet.

Had wireless progressed since 1939, we should by now have had a *standard* receiver which, taking into account modern production technique, should retail for about thirty pounds (plus tax) and contain the following features: r.f.; mixer; oscillator; two i.f.s; det.; a.f.; push-pull output; rectifier. A dozen wavebands (nine band-spread); 10-inch speaker; push buttons; a.f.c.; continuously variable selectivity; a *real* dial that means something; bass and treble controls; r.f. gain control as well as the usual controls; full range of sockets for pickup; extended speaker; aerial *and* earth and some form of aerial tuning.

The box would be no bigger than most television sets. Also remember how the manufacturers cried down the r.f. stage on the grounds of putting an extra pound on the price? I don't remember hearing much screaming when the f.m./a.m. set hit the market. We might just as well put the clock back to P. P. Eckersley and his wired wireless; we shall soon reach it if present-day retrogressive progress is a pointer. He must have been able to see into the future!

I recently handled a "communication" receiver which was made by a well-known firm. This set, *in my opinion*, is not as good as some of those pre-war "domestic" receivers mentioned above. From a circuit point of view there was less in it.

Pershore, Worcs. JOHN A. MUNNING.



***TV Afloat.**—In addition to being able to receive broadcast television programmes regardless of the standards employed (405, 525, or 625 lines), the Marconi installation in the liner* Canberra *provides for closed-circuit TV for interviews and the relaying of ship's concerts, etc. Initially the vessel, which is on her maiden voyage, is equipped with forty receivers but provision is made for up to 350.*

Transistor Measurements

1.—PRACTICE AND THEORY

By C. BAYLEY

MAKING transistor measurements is quite different from measuring the characteristics of any other sort of electronic component. The method of measurement is, in principle, very simple and as we will see, almost elementary measuring arrangements are involved; but the real difficulty arises in defining parameters themselves and in "translating" their implications in circuitry.

In recent years a tremendous amount of theoretical literature on transistors has appeared. Unfortunately there is much less information available on the practical side of this business—speaking more precisely—how to link transistor-characteristic data with the requirements of electronic circuits. This could be result of the fact that there are many interpretations of transistor parameters. There are "four pole" parameters, r parameters, hybrid parameters—and most of these can be expressed differently, depending on the transistor circuit configuration.

In view of this state of affairs it is no wonder that there is confusion among engineers, let alone the unfortunate beginner.

The writer considers that one of the best ways to understand the fundamentals of transistor parameters is to gain practical knowledge of transistor behaviour in circuits in the first instance. Then the meaning of transistor parameters emerges and, in later stages, theoretical deduction is easier to follow as the user should then be able to attach a real, physical meaning to parameters.

In this article the writer hopes that, apart from outlining the basis of transistor measurements, he has made a link between the physical behaviour of the transistor in a circuit and the transistor's theoretical parameters. Although junction transistors are considered, many of the measuring methods are also applicable to point-contact devices.

Transistor as Two Diodes

The transistor, as it replaces in function a thermionic valve, is often compared in its behaviour with the latter. However this can be misleading and a much more logical comparison would be with two diodes (see Fig. 1). From semiconductor construction, the transistor can in fact be considered as two diodes connected in series, back-to-back.

Biasing arrangements become quite clear from such a representation as the input "diode"—which is in fact the emitter circuit—has to conduct and therefore is forward-biased. The collector circuit is biased in the reverse direction and the presence of collector current results from emitter-current multiplication in the junction.

To complete our short analogy, it must be emphasized that the paramount feature of the transistor is that collector current caused by the presence of emitter current is only slightly smaller than the emitter current itself (in point-contact devices it is larger), in spite of the much higher resistance of collector as a "diode": hence the amplifying property of the transistor junction.

Basic "T" Parameters

It is quite important to realise that, whatever transistor configuration is being used in an electronic circuit, there are only five basic parameters which can characterize the device. Fig. 2(a) shows the well-known T representation of transistor, where resistances r_e r_b and r_c represent emitter, base and collector resistances respectively. The fourth parameter is the current gain, α which, generally speaking, is the ratio of the alternating currents in the collector and emitter arms, assuming that the external load of the collector circuit is several times lower than r_c (r_c is usually high—hundreds of kΩ). It is significant that first three parameters could be expressed without mentioning any particular loading conditions. α, however, as defined as a

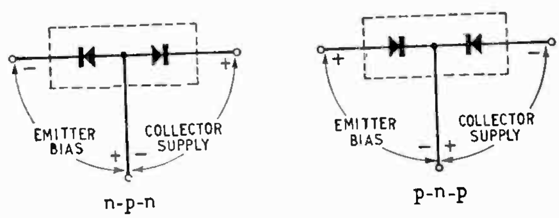


Fig. 1. Twin-diode analogy for (a) n-p-n and (b) p-n-p transistors.

function of currents, cannot be considered without closing both collector and emitter circuits.

As the values of r_e and r_c are very simply related to the input and output resistances of transistor working as an amplifying device, initial biasing conditions for emitter and collector circuits cannot be disregarded. r_b could be defined as the common part of both input and output circuits and thus have smaller significance when the transistor is employed as a l.f. amplifier. So we can see that four parameters, as outlined above, are sufficient to define the characteristics of a transistor, assuming that the frequency is sufficiently low to avoid any departure from d.c. conditions. With a rise of frequency, internal capacitances have shunting effect across r_c and r_e: consequently the value of α is affected.

Therefore the so-called α-cut-off frequency $f_{c\alpha}$ is usually quoted in transistor data and this would be fifth important parameter. The exact definition of $f_{c\alpha}$ is the frequency at which α is lower by 3dB than its value measured at a low frequency, say, 1kc/s.

To remind our reader of the order of typical

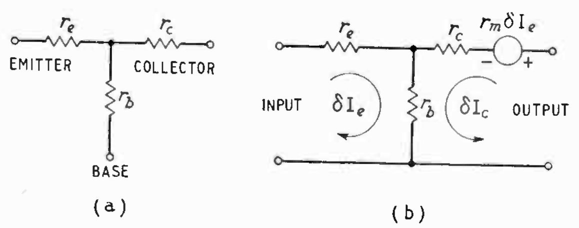


Fig. 2. (a) General "T" network representation of transistor and (b) its form in earthed-base mode where amplified power in the collector circuit is represented by constant - voltage generator $r_m \delta I_e$ or (c) where collector signal is $\alpha \delta I_e$ flowing in r_c.

values of internal resistances, an average r_e would be a few hundred ohms, r_b a few tens of ohms and r_c a few hundred kilohms. α usually ranges between 0.9 and 0.98. In talking about essential transistor parameters, we must mention another useful parameter, α' or β which is the current amplification when the transistor is connected in the common emitter (c.e.) configuration shown in Fig. 3.

In such a configuration, small changes of base current cause much larger variations of collector current and average values for β are from 10 up to 60.

"Four-Pole" Parameters

Fig. 2(c) represents a transistor as an amplifying network. In this case input and output terminals are chosen and the presence of amplified alternating power (caused by emitter a.c.) in the collector circuit is expressed by $\alpha \delta I_e$ flowing through r_c.

Fig. 2(b) gives another interpretation of the amplified power in the collector circuit expressed this time by a constant-voltage generator $r_m \delta I_e$ connected in series with r_c. As we will see in a later section, the value of r_m is helpful in measurements; for the time being it is sufficient to imagine r_m as an internal resistance.

The so-called "four-pole" parameters are values of resistances which can be measured related to the transistor T-network. It must be realized, that direct measurement of r_e r_b r_c is physically impossible because the position of the junction between them is not clear and in any case is not accessible from the outside.

Four-pole representation of the transistor (Fig. 4) is useful as a basis for all transistor measurements. With fixed loads on the input and output of such a network, values of I_1 I_2 v_1 v_2 can be measured by external means. To analyse the relation between these quantities (expressed by d.c. values), it is necessary to fix the value of at least one of them, then the other three would be related by two functions. For instance, having decided that the transistor will be used in the common-base configuration and changing the notations appropriately (e for 1 and c for 2) we may fix the value for v_c as constant and make v_e a function of I_c and I_e as follows:

$$v_e = f_1(I_c\, I_e) \quad \ldots \quad (1)$$

By making the value for v_e constant, v_c could be expressed as another function of I_c and I_e :—

$$v_c = f_2(I_c\, I_e) \quad \ldots \quad (2)$$

Each of these functions has two independent variables I_c and I_e. By fixing in turn I_c and I_e it is possible to derive four functions each with one independent variable, namely:

$$v_e = f_1(I_e) \ldots \text{ with } v_c \text{ and } I_c \text{ constant} \quad \ldots \quad (3)$$
$$v_e = f_2(I_c) \ldots \text{ with } v_c \text{ and } I_e \text{ constant} \quad \ldots \quad (4)$$
$$v_c = f_3(I_e) \ldots \text{ with } v_e \text{ and } I_c \text{ constant} \quad \ldots \quad (5)$$
$$v_c = f_4(I_c) \ldots \text{ with } v_e \text{ and } I_e \text{ constant} \quad \ldots \quad (6)$$

These four equations (3 to 6 inclusive) express four sets of static transistor characteristics.

As we are chiefly interested in establishing relations between r_b r_c r_e and measureable values v_e v_c I_e I_c or their increments δv_e δv_c δI_e δI_c it is not worth analyzing any more similar characteristics.

The two previous expressions (Eqns. 1 and 2) for v_e and v_c could be rewritten as :

$$v_e = r_1(I_e\, I_c) \quad \ldots \quad (7)$$
$$v_c = r_2(I_e\, I_c) \quad \ldots \quad (8)$$

where voltages v_e and v_c could be expressed as function of various products of resistances and currents. Assuming that we are operating in small increments of v_e v_c I_b I_c δv_e and δv_c can be expressed by a Taylor series:

$$\delta v_e = \frac{\partial v_e}{\partial I_e}\delta I_e + \frac{\partial v_e}{\partial I_c}\delta I_c + \quad \ldots \quad \ldots$$
$$\delta v_c = \frac{\partial v_c}{\partial I_e}\delta I_e + \frac{\partial v_c}{\partial I_c}\delta I_c + \quad \ldots \quad \ldots$$

where terms of higher order can be neglected.

As we have just said, $\partial v / \partial I$ will be expressed as particular resistances which are:

$$r_{11} = \frac{\partial v_e}{\partial I_e} \ldots \text{ with } I_c \text{ constant} \quad \ldots \quad (9)$$
$$r_{12} = \frac{\partial v_e}{\partial I_c} \ldots \text{ with } I_e \text{ constant} \quad \ldots \quad (10)$$
$$r_{21} = \frac{\partial v_c}{\partial I_e} \ldots \text{ with } I_c \text{ constant} \quad \ldots \quad (11)$$
$$r_{22} = \frac{\partial v_c}{\partial I_c} \ldots \text{ with } I_e \text{ constant} \quad \ldots \quad (12)$$

r_{11} and r_{22} correspond with input and output resistances of the transistor; the coefficient r_{12} (from the definition above) represents the change of collector current that would change the emitter voltage whilst keeping current of the latter constant. As amplification is basically forward, that is, from the emitter to the collector, such an effect is in the opposite

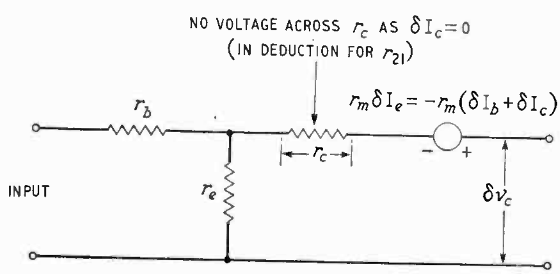


Fig. 3. Common (earthed) emitter connection of transistor represented by T-network parameters. Generator $r_m \delta I_e$ becomes $-r_m(\delta I_b + \delta I_c)$, the change in sign representing the waveform inversion.

Fig. 4. Four-pole-parameter representation of transistor. Here measurable quantities are labelled generally 1 (input) and 2 (output) and replaced by notation appropriate to mode of connection. For instance, mode: common base, then 1 becomes e and 2 becomes c.

direction to amplification and therefore indicates feedback action. r_{12} is usually called the feedback resistance and has no analogue in thermionic valve techniques.

Parameter r_{21} represents the way in which collector voltage changes with a change in emitter current (collector current constant) and is of great importance. Some analogy with the valve could be made here, as the function r_{21} is similar to the slope of I_a/v_g characteristic, assuming that voltages are replaced by currents and *vice versa*. r_{21} can be regarded as the slope of the transistor forward characteristic.

As far as amplification in the transistor circuit is concerned, r_{12} is in opposition to r_{21} and we will see in the next section that the coefficient r_m representing current multiplication in the collector circuit, is equal to $r_{21}-r_{12}$.

Before deducing relations between r_{11} r_{12} r_{21} r_{22} and r_b r_e r_c r_m we should underline again that :—

(a) All "four-pole" parameters should be defined under strict loading conditions, that is, with emitter or collector currents held constant (open-circuit conditions).

(b) "Four-pole" parameters can be expressed in the common-emitter configuration and will be different from those of the common-base configuration.

Transistor and "Four-Pole" Parameter Relationship

Common-base and common-emitter configurations are often used : therefore the relationships for both cases will be deduced.

Common Base.—Looking again at Fig. 2(c), values for r_{11} can be defined immediately as :

$$r_{11} = r_e + r_b \quad \ldots \quad (13)$$

The collector leg of the circuit does not affect r_{11} as I_c is assumed to be constant: that is, the collector circuit is open ($I_c = 0$).

In practice open-circuit conditions for the collector circuit are realized by the insertion of large resistor and the use of a fairly high voltage battery as a supply (to obtain initial collector current).

A similar relation can be deduced for r_{22}

$$r_{22} = r_c + r_b \quad \ldots \quad (14)$$

The situation here is reversed with the emitter circuit open: r_e is not included in the r_{22} value.

The expression for r_{12} can be deduced as :

$$r_{12} = r_b \quad \ldots \quad (15)$$

from the following analysis:

r_{12} is defined as the ratio of small increments of emitter voltage δv_e to the collector current δI_c assuming that the current of the former is constant (see Fig. 5(a)). This last condition implies that there is no voltage increment across r_e and the full voltage v_e appears across r_b. As only current δI_c is flowing through r_b :—

$$r_b = \frac{\delta v_e}{\delta I_c} = r_{12}$$

The relation between r_{21} and transistor parameters can be established in the following manner : (see Fig. 5(b)).

From the original definition r_{21} is equal to the ratio of increments of collector voltage and emitter current, assuming that collector current does not change (Eqn. 11). Therefore the voltage increment across r_c should be equal to zero and the following voltages would appear in the collector circuit :

across C-D — $\delta I_e r_b$
across A-B — voltage generator r_m δI_e
across B-C — increment δv_c

The generator r_m δI_e which is the source of e.m.f. in the collector circuit, is easier to express physically by a current generator $\alpha\delta I_e$ connected across r_c (Fig. 2(c)): that is, a generator of current $\alpha\delta I_e$ having internal resistance r_c. But for the writing of Kirchhoff equations for the collector circuit voltages have to be used and therefore it is necessary to introduce symbol r_m. From these equations the p.d. between A-B ($r_m\delta I_e$) should be equal to the sum of the voltage drops B-E and B-D :—

$$r_m\delta I_e = \delta v_c + (-\delta I_e r_b) = \delta v_c - \delta I_e r_b$$

It should be noted that δI_e has a minus sign as $r_m\delta I_e$ has the opposite sign to the voltage drop $\delta I_e r_b$.

From the last equation the value of $\delta v_c/\delta I_e$ can be easily defined as:—

$$\frac{\delta v_c}{\delta I_e} = r_m + r_b = r_{21} \quad \ldots \quad (16)$$

From the four relations deduced above (Eqns. 13-16 inclusive) transistor parameters can be easily calculated as :

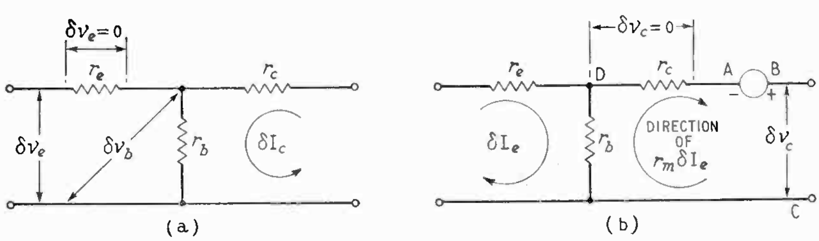
$$r_e = r_{11} - r_{12} \quad \ldots \quad (17)$$
$$r_b = r_{12} \quad \ldots \quad (18)$$
$$r_c = r_{22} - r_{12} \quad \ldots \quad (19)$$
$$r_m = r_{21} - r_{12} \quad \ldots \quad (20)$$

Common-emitter Mode.—Returning to Fig. 3 it should be noticed that the input impedance r_{11} will be expressed by the same formula as in common-base configuration :—

$$r_{11} = r_b + r_e \quad \ldots \quad (13) \text{ (repeated)}$$

as the open collector circuit does not contribute to any voltage increment across r_e. However the relation for r_{22} will be different from that of the common-base configuration.

Fig. 5. Deduction of relationship of transistor to four-pole parameters. (a) With emitter current constant there is no increment of emitter voltage across r_e. (b) With collector current constant no increment of collector voltage can appear across r_c.



Irrespective of configuration, the e.m.f. in collector circuit is equal to $r_m \delta I_e$.

Comparison of the expressions for r_{22} in the common-base set up with that for common-emitter mode (that is, Eqn. 12).

$$r_{22} = \frac{\delta v_c}{\delta I_e} \text{ where } \delta I_b = 0 \quad \quad (21)$$

shows that the former has the condition of I_e constant (increment $\delta I_e = 0$) instead of the condition for common-emitter, which is $\delta I_b = 0$.

Therefore the term $r_m \delta I_e$ cannot be disregarded when measuring the impedance r_{22}. Consider

$$r_m \delta I_e = - r_m (\delta I_c + \delta I_b)$$
$$= - r_m \delta I_c - r_m \delta I_b$$

(compare with the deduction for r_{21} in the common base configuration, Eqn. 11), $- r_m \delta I_b$ would disappear leaving only $r_c - r_m$ in the collector circuit.

Therefore the total output resistance in the common-emitter configuration will be:

$$r_{22} = r_e + r_c - r_m \quad \quad (22)$$

Making a similar deduction to that for r_{12} in the common-base case:

$$r_{12} = r_e \quad \quad (23)$$

Finally, the forward resistance r_{21} can be deduced the same way as in the common-base state by replacing the e.m.f. $r_m \delta I_e$ by $r_m(\delta I_b + \delta I_c)$. Then the Kirchhoff equation will be:

$$\text{e.m.f.} = - r_m (\delta I_b + \delta I_c) = \delta v_c + (- \delta I_b r_e) + r_c \delta I_c$$

As $\delta I_c = 0$

$$-r_m \delta I_b = \delta v_c - \delta I_b r_e$$

$$\frac{\delta v_c}{\delta I_b} = r_{21} = r_c - r_m \quad \quad (24)$$

(See Fig. 3).

From the above four relationships for the common-emitter case, the transistor parameters can be calculated as:

$$r_b = r_{11} - r_{12} \quad \quad (25)$$
$$r_e = r_{12} \quad \quad (26)$$
$$r_c = r_{22} - r_{21} \quad \quad (27)$$
$$r_m = r_{21} - r_{12} \quad \quad (28)$$

Next month we shall start by considering conductance and hybrid-parameter terms with their relation to basic parameters and deal with some of the ways in which measurements can be made.

(To be concluded).

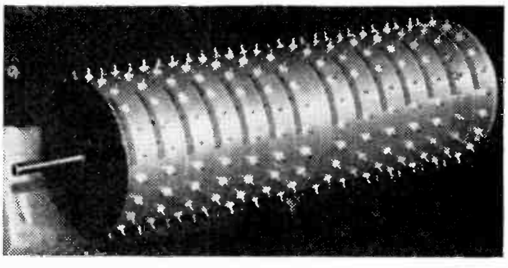
Communications Satellites

AN INTERNATIONAL symposium on communications satellites was held in London on May 12th by the British Interplanetary Society. It is to the credit of the Society that it, rather than other organizations more usually associated with telecommunications, should be the first to present here, in London, such a variety of authors from both sides of the Atlantic, on this most important of subjects. It has of course the example of its past chairman A. C. Clarke, whose article on "Extra Terrestial Relays" appeared in *Wireless World* 16 years ago and whose suggestion of 24-hour or synchronous communications satellites was so much a point of discussion at this symposium. Inevitably one thought back to the time when scatter propagation was novel and when at meetings and symposia, speakers from this country had, in presenting their papers, little or no practical experience to draw on. The same handicap applied at this meeting. Whereas speakers from the United States could refer to the results of experiments with projects Echo and Courier, those from the U.K. could only talk in hope, for whether this country or the Commonwealth ever produces the rocket capability to initiate a system of its own has yet to be decided. Enthusiasm, however, was the keynote and it was interesting that the only hint of caution came from J. R. Pierce, of Bell Telephone Laboratories, the speaker with perhaps the most practical experience.

The papers were catholic in content. The first from G. K. C. Pardoe, of the de Havilland Aircraft Company, considered what might be called the logistics of putting a communications satellite in orbit whereas the second, by E. K. Sandeman, of English Electric Aviation, dealt more with the radio aspect, channel arrangements, modulation systems and power requirements. With all speakers in favour of active rather than passive satellites interest tended to centre on whether a communications system should be the low-level type calling for 30 or more satellites for global communication or of the 24-hour "stationary" type where only three would be required. The latter has obvious problems in altitude and attitude stabilization but there is also the question of the tolerability of the unavoidable time delay. A demonstration telephone circuit, incorporating the delay (0.28 secs) enabled participants to judge the effect for themselves, many appeared agreeably surprised. Speakers favouring the synchronous system included R. P. Havilland of the General Electric Company of America, E. K. Sandeman and H. R. L. Lamont who read a paper by E. A. Laport of the R.C.A. J. R. Pierce on the other hand preferred to make the first step the low-level system. W. F. Hilton, of Hawker Siddeley Aviation, emphasized the aspect of Commonwealth communications and concluded that a minimum of eight active satellites in six-hour elliptical orbits would suffice and that if the go ahead were given now such a system could be in service before the completion of the Commonwealth telephone cable in 1967. He thought the latter might then be uneconomic but J. R. Pierce was of the opinion that the two forms of communication would be complementary.

Further papers were presented by G. E. Mueller, of Space Technology Laboratories Inc., and by Lt. Col. J. T. Newman, of the U.S. Army, who read a paper on the Courier satellite by G. F. Senn and P. W. Siglin, of the U.S. Army Signal Research and Development Lab. A lively discussion followed both the morning and afternoon sessions.

Multi-gang Potentiometer



This 14-gang potentiometer with no fewer than 294 tapping points, was made for computer use; each of the fourteen sections has 21 tapping points, each welded to a selected turn on the winding. The operating torque necessary is only 2oz-in. (General Controls Ltd., Bowlers Croft, Honywood Road, Basildon, Essex).

The H.F. Band: Is a New Look Required?

POSSIBLE TECHNIQUES FOR FURTHER REDUCING INTERFERENCE

By R. J. HITCHCOCK,* M.A., A.M.I.E.E. and P. A. C. MORRIS,* B.Sc., A.M.I.E.E.

IN 1948, as a result of the radio conference held in Atlantic City the previous year, there was set up in Geneva two bodies—the International Frequency Registration Board (I.F.R.B.) as a permanent technical executive and the Provisional Frequency Board (P.F.B.) whose particular task it was to plan, on a logical basis, actual frequency assignments for all the fixed and mobile services in the h.f. band between 4 and 27.5 Mc/s. Although the P.F.B. worked conscientiously for two years, so far as the fixed services were concerned the attempt failed because, even when the most severe theoretical sharing conditions were applied, the requirements greatly exceeded the available spectrum space.

Since those days, however, the situation has worsened, for the decisions of the Atlantic City Conference to reduce the bandwidth allocated to the fixed services in this part of the spectrum by 678 kc/s (5% of the whole) have been implemented, and the frequency requirements, as indicated by the International Frequency List, have roughly doubled. The difficulties in obtaining frequency allocations for new or extended services and the possibility of such allocations adding to the general level of interference are well illustrated by the typical spectrum scan in Fig. 1. This shows the "frequency occupancy" at a particular receiving station for that portion of the fixed service band between 7.3 and 8 Mc/s.

As an example of the interference problems in the fixed service bands an analysis of four important transmitting stations, all well separated geographically, showed that out of a total of 142 allocations, 18, or 13%, were unusable or seriously affected by persistent interference and a further 69, or 49%, were of reduced value because of occasional interference. This analysis was made before the onset of the approaching sunspot minimum when a reduction in the reflecting properties of the ionosphere at higher frequencies will still further increase the congestion in the lower part of the h.f. band. Thus, while a decade ago it was agreed that the h.f. band was congested and in need of treatment, it is now generally agreed that today it is saturated and the necessity for such treatment has become a matter of urgency.

At the Administrative Radio Conference of the I.T.U. held in Geneva in 1959 a resolution was adopted which all users of the h.f. portion of the

* Cable & Wireless Ltd.

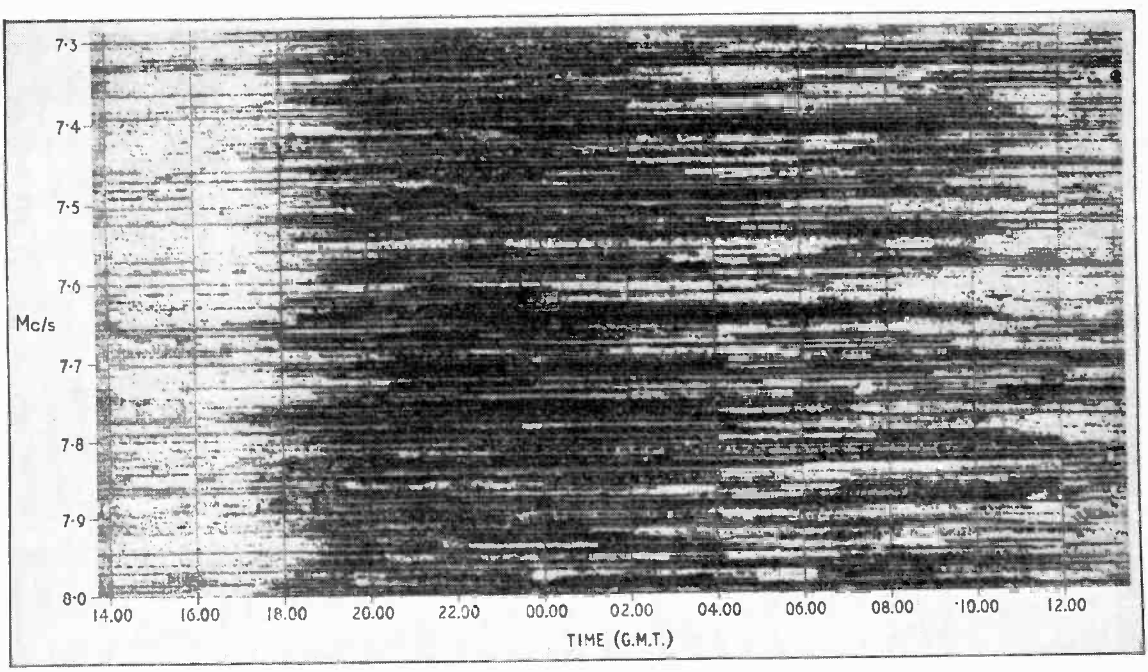


Fig. 1. Occupancy of a section of the h.f. band as recorded at a receiving station over a period of 24 hours.

radio spectrum must have welcomed. It read in part: "The Conference, considering the trend towards congestion and saturation in the bands between 4 and 27.5 Mc/s; realising that if this trend continues this portion of the radio frequency spectrum will become progressively less useful to administrations for purposes for which it is indispensable; . . . resolves that a Panel of Experts should be convened for the purpose of devising ways and means of relieving the pressure on the bands between 4 and 27.5 Mc/s." Thus the Conference voiced the deep concern of many radio engineers at the rapid increase in usage of this section of the spectrum, particularly at a time when decreasing sunspot activity is reducing the overall available bandwidth.

Although the panel of experts* is not due to meet until the autumn of this year preliminary investigations into frequency usage and habits are being made by the I.F.R.B. These preliminary investigations suggest that the panel may well be inclined to follow traditional and somewhat obvious lines in their approach to the problems confronting them. It would be a great pity if the opportunities that this study affords were to be wasted by adhering too closely to the conventional and to the expected. For example there are strong indications that administrations and operating organizations will be exhorted to follow certain lines, most if not all of which are no more than good engineering practice and good common sense and which in nearly every case *are already being followed*.

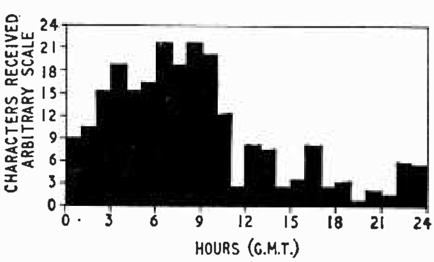


Fig. 2. Traffic utilization of a Singapore-Aden-London circuit.

It does not take an expert to realize that the most obvious way of reducing congestion is to thin out the requirements and, if the capital resources are available, to replace h.f. systems by other services using either a less crowded part of the radio spectrum or a different communications technique. An approach such as this must be in the mind of almost every user of the h.f. band and there can be few forward looking administrations or organizations who are not constantly increasing their v.h.f. systems at the expense of their h.f. systems, converting their radio-telephony circuits from d.s.b. to s.s.b. and in the broadcasting field changing their national short-range h.f. services to v.h.f. Thus any policy based on these and similar lines of thought is doing little more than running alongside the normal movement of events.

All communications engineers appreciate that one day, repeatered cables, satellite systems and waveguides will carry vast quantities of the world's communications traffic but experience suggests that h.f. services will be required for many years to come and it is difficult at this moment to see any immediate relief occurring in these bands unless more fundamental ideas are introduced.

* The U.K. representative will be C. W. Sowton of the G.P.O.—Ed.

Understanding the H.F. Medium

Since the ionosphere is dependent upon solar radiation its properties follow a strong diurnal cycle and so it is not by any means an ideal medium for 24-hour communications.

When a radio path is entirely in daylight or entirely in darkness it is possible with a suitable choice of radiated frequency to operate a long-distance circuit with modest transmitted power. However at the transition between day and night, and particularly when one terminal is in daylight and the other not, the available range of frequencies that can be propagated over the route becomes very narrow. Ideally at this time the radiated frequency should be continuously changing because the ionospheric parameters are rapidly varying. In practice circuits are operated during transition times with far too few frequency changes: this is for two main reasons:—

(i) The difficulty in co-ordinating the change at both ends of the circuit and

(ii) Insufficient knowledge of the optimum frequency to use at any instant.

The second of these reasons will be discussed later.

Now the diurnal peak of demand for telephone and telegraph facilities is centred upon local business hours: this is very fortunate because it fits in with daylight hours during which ionization is strongest. So, for communication between places with the same local time, i.e. north-south routes, the ionosphere as a medium is well suited to carry high-capacity traffic during business hours and, perhaps, a low capacity service during the remainder of the 24 hours.

However, as far as the United Kingdom is concerned this only facilitates communication with West Africa and the Arctic Ocean: the vast majority of trunk circuits connect places with a local time difference exceeding two hours. The result, for these circuits is, first that the transition between steady day- and night-time conditions is lengthened and, secondly, that the heavy traffic demands extends into these transition periods. Fig. 2 shows the utilization of the Aden relay of a Singapore-London channel on a typical day: the peak corresponds to midday in Singapore but to the pre-dawn ionization dip at London.

This is an unfortunate fact which must be taken into account by traffic planners. There is no easy solution but it is worth mentioning that one approach is to send the traffic the other way around the world at this time; another which can apply to certain types of traffic is to store messages until each terminal is in daylight—and, incidentally, until the customers at *both* ends are awake.

The former solution is one that only a unified world-wide communications system can organize: from this point of view and also with regard to the usage of frequencies the fragmentation of international systems as new nations emerge is unfortunate.

In order to operate circuits under these transition conditions it has become necessary to provide ever higher transmitter powers. This, of course, is waste-

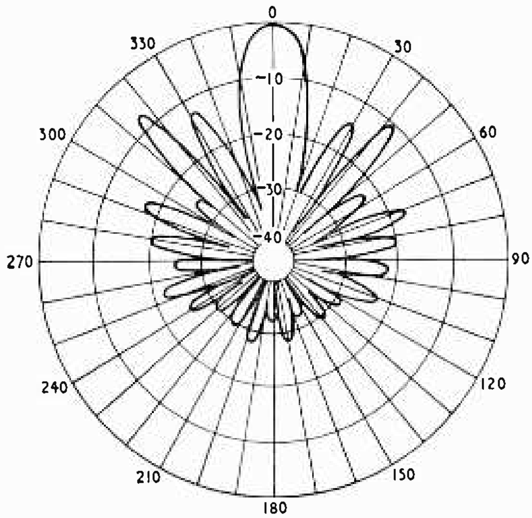


Fig. 3. Measured directivity characteristics of rhombic aerial. (From P.O.E.E.J., July 1958)

ful in itself since the required field strength at the receiver alters little and the extra energy may escape through the ionosphere or merely illuminate unwanted areas. But, much more important, the range at which other stations suffer harmful interference is thereby greater than it need be.

With the rhombic aerials commonly in use there are many side lobes which are no more than 15 to 25 dB below the main lobe (see Fig. 3). Consequently if the field strength at the receiver towards which the transmission is aimed is, say, 20-30 dB higher than necessary then the side lobes must be strong enough to cause interference at a similar range in almost any direction.

To some extent this emphasizes a basic handicap of operating at frequencies in the h.f. band. Since the wavelength is relatively so large it is impossible to produce really narrow beamwidths; although if it were it might well add to the difficulty of frequency selection.

The Power Requirement

It is a common practice for receiving station watch-keepers to insert substantial attenuation into their receiver aerial circuits during certain hours of the day. Every 6 dB of attenuation implies a 6 dB surplus of transmitter power at that time and this in turn implies that the radius exposed to interference is up to twice as great as it need be.

The planning engineer can get a very good idea of the effective radiated power required for a given circuit provided he confines his attention to the steady day or night conditions.

For an example the power required under these steady conditions for a simple telegraph channel between Nairobi and London is shown by the full line in Fig. 4. The very low power will be noted. Now if it were possible to calculate the transmission loss at the transition times the diurnal distribution of required power would appear something like the dotted line and the maximum power then has some relation to the actual powers used. In general one might suggest, therefore, that the full e.r.p. of a transmission is needed only for about one-third of the 24 hours.

So the excess power problem is very serious and it is proposed that consideration should be given to several lines of approach.

Suggested Approaches

The first is concerned with more thorough engineering control of circuit operation hours, so that whenever possible commitments are not undertaken for unfavourable times of day.

It is now common practice on teleprinter circuits to use automatic error correction (ARQ). This operates in the following way: when a received error is detected a request for repetition is automatically transmitted over the circuit to the sending end so that if one path has faded out the other path continuously repeats a group of characters until contact is restored. This is known as "cycling." Thus, on a system of this type it is necessary for the whole circuit—both the "go" and "return" directions—to be operating in order to pass traffic either way. So when conditions are only good enough for a marginal link in one direction it would not be able to clear any traffic when error-correction is in use. In practice there are times when circuits are nominally open but when the chances of both directions being open simultaneously are rather remote. Under these conditions it is often true that no increase in e.r.p., however great, can possibly maintain contact. *Everyone would gain and no one would lose if this was appreciated and the circuit was closed.*

The second approach to the problem would be to develop a system of automatic transmitter power control. The ARQ system, already mentioned, automatically controls the rate at which error-free characters are received: extending this principle one can visualize a "surplus signal/noise ratio detector" at the receiver sending impulses back over the circuit to control the transmitter power.

There might be, say, six power levels, spaced at 3-dB steps. Such a system has been worked out for application to tropospheric scatter circuits.[1]

Automatic control must surely have a beneficial

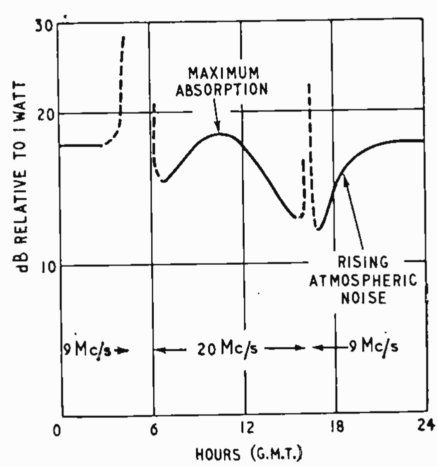


Fig. 4 Power required for 50-band telegraph channel between Nairobi and London during sunspot minimum period.

effect on the general level of interference if adopted widely; although it must cause some slight increase in "cycling" of ARQ systems under such circumstances as sudden bursts of atmospheric noise or "crashes." The development of world-wide telex would have been impossible without the benefit of ARQ, and we are approaching the time when, for further expansion, the inherent advantage of *feeding back control information* will have to be exploited to the full by operating on more rational margins.

The next approach to the conservation of spectrum space is to hasten the application of various ionospheric sounding techniques in order to reduce the proportion of total transmitting time during which incorrect frequency usage prevents the lowest-loss propagation mode being used. Such techniques will also discourage some operators from using several simultaneous transmissions to ensure reception.

At present, receiving station watch-keepers have only "long-range" monthly median predictions and their own experience to guide their hour-to-hour selection of frequencies. But by transmitting pulses at oblique incidence—i.e., directed in the same manner as the normal transmission—it is possible to examine the path and to measure the optimum frequency. The pulses may either be received by ground back-scatter at the transmitting end of the path or in the normal way at the receiving end.

The former method has the disadvantages of needing skilled interpretation of the echoes and also the difficulty of telling what strength of echo corresponds to a useful signal at the receiver but the sounding can be initiated and used by the watch-keeper without the need for the co-operation of any distant operator.

The Sweep-Frequency Technique

The alternative method in which the receiving watch-keeper observes a pulse transmission from the distant terminal may be superior, particularly if the sweep-frequency technique is used. In this system a transmitter and receiver, though separated by thousands of miles may be tuned rapidly from one frequency to another, and with accurate synchronization the time interval on each "spot" frequency may be a fraction of a second. The transmitters and receivers are rapidly step tuned with increments of the order of 100 kc/s to several hundred frequencies throughout the h.f. band and synchronization is achieved by reference to crystal clocks.

A sweep might be provided at, say, half-hour intervals during transition periods: those frequencies which are suitable for the instantaneous path conditions would be clearly indicated.

The sweep-frequency technique has been in use by research establishments for some years, e.g., by Kift of Radio Research Station, D.S.I.R.[2], on the path between Ascension Island and Slough. Suitable equipment is now available for the sweep-frequency technique: the pulse length used by one manufacturer is 10μsec and the p.r.f. 10 per second.

The harmful effect of sweep-frequency pulse transmissions upon other services appears to be a subject worthy of careful study. Even if it were in general use one would not expect to find objectionable interference to speech or music reception and the effect of such a short pulse length upon high-speed telegraphy, particularly with automatic error correction, may be tolerable. It is suggested that any harmful effects would be more than offset by the possible saving in redundant transmissions.

What is a Radio Frequency?

Finally, following the philosophy of Costas[3], the question arises, have we gone awry by our concept of *a* radio frequency? Emphasis has always been directed towards reducing the tolerances of transmitters so as to reduce the effects of mutual interference. However, instead of relying on accurate frequency division to discriminate against unwanted signals it is equally possible and it may well be more economical to use the dimension of time. No radio circuit is carrying information at every moment and all could tolerate a "controlled" amount of interference particularly when error correcting techniques are in use. By rigidly fixing tens of thousands of transmissions on individual and discrete frequencies we achieve neither an equitable distribution of interference nor any assurance as to how much any particular transmission will be interfered with, either in terms of time or severity. It would seem preferable, therefore, to accept a "controlled," randomly distributed amount of interference rather than an intolerable continuous interference to certain unfortunate operators.

A communications system can thus be visualized based on the sweep-frequency technique mentioned earlier. The step-tuning might be continuous such as that operated in France on a u.h.f. tropospheric scatter system[4] in which the transmitter and receiver are rapidly tuned across a band 500Mc/s wide ten times per second in synchronism with a long-wave-broadcast transmission. Whether an h.f. system should have step transmissions or continual sweeps need not be discussed here, but whichever were used it is envisaged that the frequency coverage would range across the usable band as dictated by propagation considerations. The frequency range could be obtained from either circuit predictions or more likely from trial sweeps at certain specified intervals of time. The final concept is one in which all-important transmissions in the h.f. bands will be ceaselessly sweeping across their individual optimum propagation spectra thereby ensuring that interference is equitably distributed amongst all users and that the maximum continuity of service is achieved.

Whilst in recent years vast improvements have been made in the performance of h.f. radio equipment, too little effort has been devoted to ways and means of conserving spectrum space. The need for international co-operation, however difficult to achieve, is inherently imperative and it is to be hoped that the I.T.U. Panel of Experts will be able to lead the way towards stabilizing the dissipation of one of the world's resources.

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[1] Axelby and Osborn, *I.R.E. Trans. on Communication Systems*, March 1960.

[2] *Wireless World*, May 1959, p. 234.

[3] Costas, *Proc. I.R.E.*, December 1959.

[4] Landauer, *I.R.E. Trans. on Antennas & Propagation*, July 1960.

CAR RADIO

By H. HOLT

—Yesterday, Today and Tomorrow

CAR radio designers are agreed in regarding 1961 as a year of great changes; it is, perhaps, not surprising that though they are reasonably in accord as to the main trend, they are at variance on detail developments. It is, of course, commercially important to be first in the field with new developments and techniques if that can be managed, but it is even more important to submit the right answer to the problem at first go, rather than be compelled to make major changes during a production run, which can be costly both in expenditure and in reputation.

Valves and Transistors

The background against which this intriguing scene is set is simple enough. After years of all-valve radio, for which the nominal 6 or 12 volts of the car's electrical system had to be turned by vibrator into a.c., stepped up in voltage and then rectified to d.c. again, came what is universally referred to as the hybrid set. This combines the advantages of valves which are capable of giving adequate radio-frequency performance on the nominal 12 volts of a car's battery, with the power transistor which handles only the audio-frequencies of the output stage, and is amply satisfied with that comparatively low voltage. This combination ensured the success of the Pye TCR 1000, first hybrid receiver on the market, introduced at the Earls Court Motor Show of autumn 1957, quickly to be followed by similar products of other manufacturers.

These, dispensing with the noisy and rather vulnerable h.t. vibrator, also brought the drain on the battery down to around 1.3 amps—less than half of what had been required by comparable all-valve sets. That is an important consideration in cars in which steadily and substantially increasing demands on the battery and generator have coincided with progressive decreases in the capacity of the battery installed. It is true that greater sophistication of the generator control system helps to improve input to the battery, but only so long as the engine is turning the generator fast enough to give the necessary output. Traffic density nowadays, however, can be such that, in town, the periods during which the battery is receiving a charge may be inadequate to balance the deficit which accumulates during the remainder of a journey. In cold, foggy weather the trouble is accentuated.

In addition to receivers with the single 2- or 3-watt transistor power stage, there are on the market output units offered as alternative equipment with a transistor driving two power transistors in push-pull, to give as much as 8 watts output to two or even more loudspeakers, yet requiring a surprisingly low current compared with the 5 or 6 amps of a comparable all-valve set.

Next stage, then, is the logical one—to use transistors, now available at an economic price, in the radio-frequency stages as a complete replacement for valves. In recent months all the major manufacturers have been testing prototype all-transistor receivers which are intended to give fully satisfactory performance both when operating in a moving car and when used as a personal portable at home or in an hotel, energized in the portable role by internal batteries. It is in this direction that in addition to meeting the rapidly developing demand for car radio, they hope to tap a potentially great new market.

Here is to be found one of the major divergences of opinion. One avenue of approach is to start with a good portable, and then modify it until it will give adequate service as a car radio; another is to design the car radio, and then arrange convenient detachment of as much of this receiver as will give satisfaction as a portable. Since the car radio application involves much more difficult conditions than are experienced in normal domestic use, it would seem logical to meet this requirement first, ensuring adequate quality, range, selectivity and freedom from fade and interference, at the same time satisfying amply the less demanding specification. However, both avenues of development are being thoroughly explored, and it may be that major success will go to the one which is first in the field with a satisfactory receiver, regardless of the technicalities. After all, few of the listening public are concerned about how the results are achieved, so long as the end product gives them what they are asking for.

Limitations of Portables

In the past two years there has been great increase in the use of domestic portables in cars. Some users have declared themselves to be quite satisfied; others, their appetite whetted but not satisfied, have then gone out and bought a conventional car radio receiver.

It is not surprising that the very good quality and performance of the transistor superhet portable at home has led many to expect equally good reception in a moving car, but usually with disappointing results unless the listener is prepared to accept lower standards.

One major snag is that the portable relies on a ferrite rod for aerial input, and because this has directional characteristics, signal strength varies considerably as the car's attitude in relation to the transmitter changes. There is serious fading, and automatic gain control to minimize this variation is not nearly so effective as in the conventional car-radio receiver.

A related difficulty is that within the steel shell of a car body the aerial is screened to some extent from the incoming signals unless the set is placed near a large area of glass—on a rear parcels shelf, for example, where it has the additional advantage of being as far as possible from the "power station" under the bonnet.

One way of overcoming these troubles is to inject signals from the normal type of exterior car aerial, and many portables now have a socket to accept the plug connector of such an aerial. This does not usually increase signal strength but it helps to keep it at a reasonably steady level.

The limited amount of sound available from a portable gives rise to another snag. In order to provide reasonable life from internal dry batteries, maximum output is kept down to around 0.3 watt, which is adequate for most domestic use, but not within a moving car, especially in traffic. One turns up the volume control to full in an effort to overcome the ambient noise—and the receiver, operating at a level where its distortion is also at maximum, loses much of its quality, while a small loudspeaker may itself be overloaded to the point of distortion. One can arrange, when such a receiver is used in a car, to drive it from the car battery, and also to feed an additional, larger loudspeaker. But so soon as the set uses power from the car's battery, says the G.P.O., it becomes necessary for it to have its own £1 radio licence just like the conventional car radio—and a surprisingly high level of sales resistance is then encountered.

Finally, portables are much more susceptible to ignition interference than is the conventional car radio which, after all, is designed specifically for its very exacting job, and the car electrical system must be fully suppressed if background noise is to be kept low.

Domestic portables as such, then, are not a fully satisfactory answer, except for occasional use by those who are not too finicky about quality of reproduction.

Car radio as we know it today is quite a remarkable achievement, for the car manufacturer normally provides a mere 7in by 2in facia space for the escutcheon and controls; most radio designers cope with this satisfactorily, and if fore-and-aft space is limited, they arrange the output stage as a separate unit which can be placed remotely from the tuner.

Loudspeaker Problems

But the loudspeaker is a more difficult proposition; in the present stage of sound reproduction, loudspeakers are like boxers—a good, big 'un will always beat a good, little 'un. Some manufacturers provide a grille in the facia, behind which a small elliptical speaker can be mounted, but no one plans accommodation for, say, a good 8in circular speaker. It is a happy stroke of fortune that current styling can provide reasonable space and environment for a large loudspeaker, notably in the large rear parcels shelf—yet singularly few manufacturers incorporate a suitable hole in the metal, which has to be trepanned. However, this provision is now taken so much for granted that when a radical styling change—as in the new Ford cars—sweeps away the rear shelf, accommodation of a loudspeaker again becomes as tricky a problem as it is in the cramped cockpit of a sports car.

In these circumstances the fitter is often driven to make use of space between inner lining and outer shell, perhaps beside the passenger's legs, but this usually directs the sound straight at a heavily carpeted gear box hump, which can affect the reproduction markedly.

In the experimental laboratories all kinds of expedients are being tried to find a more convenient replacement for the permanent magnet loudspeaker, but the ubiquitous elliptical speaker is very firmly entrenched—usually, for convenience, with its longer axis horizontal, though the purist would prefer it vertical. One ingenious idea is to modulate the incoming air stream of the ventilation system which most cars have nowadays, at some point in its ducting, so dispensing with the loudspeaker altogether—an ideal solution if it can be made efficient and not too expensive.

The Aerial

Much research is going on also into the possibility of dispensing with the conventional whip aerial, which is applied to a car as an afterthought—and from the styling point of view often looks like it! It is vulnerable to the curiosity of people who wonder how far it can be bent over, and it is apt to deteriorate in appearance and performance after a time in its very exposed position. Ferrite rod or block is a strong contender for the succession, but its directional effects are a disadvantage not yet overcome in production, though one hears of successful laboratory experiments. Fancy shapes are probably not the solution, for when they depart from the straight and narrow they impose new difficulties in winding the necessary coils upon them. The target is to devise an arrangement of ferrite material which is at least as efficient as the conventional whip aerial, costs no more, and can be built invisibly into the trim of the car, probably at the manufacturing stage. We have not yet arrived at the point where radio is as usual a fitting in a family car as a heater is at present, but the rapid increase in its use, as evidenced by official returns of car radio licences in force, shows the trend. Probably more than one in ten of cars on British roads today has radio, and the proportion is rising faster than the increase in motor vehicles. Car manufacturers are taking a greater interest in radio—two of our largest themselves market sets for accessory fitting—and the time is not far ahead when the aerial at least will be built in much as demisting ducts are now.

Unless there is a technical breakthrough which permits the current type of loudspeaker to be superseded—and this does not seem likely in the near future—the next stage will be when car designers include adequate provision at the manufacturing stage for a good, big loudspeaker.

British car radio receivers at present are of two basic types. The cheaper, manual tuning models, costing around £20 or so, cover medium and long waves, have a single output transistor mounted in a heat sink on the back of the receiver, giving up to three watts to an elliptical loudspeaker, and fed from a 3- or 4-valve superhet radio-frequency circuit. They vary in detail—some have smoother tuning than others, some pull in more long-range transmissions (and more interference), but there are very few poor ones in such a keenly competitive field, and most reach a very high standard.

Next refinement, coming into the £25 and upwards range, is the provision of press-button tuning, giving immediate selection of one long-wave and four medium-wave channels in addition to manual tuning; experience is that press buttons usually supply up to 99 per cent of one's listening. With this amenity may go tone control, variable intensity of panel lighting, and so on, and most manufacturers go on to offer choice of normal or high-power amplifying stages (up to 8 watts), and multiple loudspeaker installations with balancing controls.

No English manufacturer at present offers the American and Continental type of "self-seeker" tuning in which, after selecting a sensitivity level for, say, town or country, the receiver itself at the touch of a button tunes in turn all broadcasts reaching the preset level, automatically and accurately. Such a device puts up the price by £40 or more, and since the gamut of British broadcasting for most of us is covered by just three programmes—Light, Home and Third—we do not need such elaboration. Three medium-wave press buttons give us these, the fourth gives us one Continental (usually Luxembourg), and the Light Programme is available on 1500 metres in areas where the medium-wave transmissions are unsatisfactory.

Much greater interest is taken these days in quality, under the stimulus of good sound reproduction heard at home on the B.B.C.'s v.h.f./f.m. broadcasts. Indeed, one manufacturer is now producing a special "hi-fi" amplifier of 6 watts output, with matched high-quality 8in loudspeaker, which gives fidelity of reproduction comparable with that enjoyed in many good domestic installations.

There is no v.h.f.-tuning car receiver at present available from British manufacturers; one was offered some time ago, but was withdrawn. The difficulty is primarily one of suppression. One can spend a great deal to achieve near aircraft standards of screening to ensure satisfactory listening in one's own car, only to have the whole thing ruined by neighbouring cars in the first traffic jam. It may enjoy a resurgence, but that seems unlikely in the face of the quality now available from our conventional a.m. receivers. After all, those who wish to enjoy the highest achievable standards of reproduction are likely to want it in quiet domestic surroundings where they can devote full attention to it, rather than among the distractions and din of our crowded roads.

Road-speed Volume Control?

With good press-button tuning, then, one can drive all day with merely an instant's finger pressure to bring about a change of programme when required—except for the volume control. For anyone who must fiddle about with something or other, the volume control gives complete release, but since so many prefer to concentrate their energy on their driving, it seems odd that we have yet to see automatic control of volume as well as r.f. gain. In a small degree there is automatic audio volume control already, due to increased volts on the output stage, up to the point where the dynamo reaches its maximum voltage, but that usually occurs at less than 30 m.p.h. road speed, and the rise in audio output ceases at the point at which it would begin to have real value.

It need not be an elaborate affair, compensating for such onslaughts as a sudden change of gear of a neighbouring, noisy lorry—indeed, the combination might well be worse than the one nuisance alone. One can think of several ways, however, in which to contrive that volume could be set at a particular level by the hand control on the receiver, and thereafter augmented automatically as the speed of the car, and hence the level of ambient noise, increased. Ready to hand behind the facia, for instance, is the speedometer drive cable, the speed rotation of which is directly proportional to the speed of the car. It should not be difficult to derive from that a potential to govern gain, and so sound level, subject to the overriding control of the volume knob on the receiver itself. Nor would it be difficult to grade the ratio of sound increase—perhaps from a mere 100 per cent for the lordly Rolls to 1,000 per cent for the Whizbang Sports Special.

At least one manufacturer has on test a prototype embodying this refinement; one hears that its influence goes unnoticed—until it is switched out of action—that it is not expensive, that it has proved effective in a variety of cars, and that it is a simple, plug-in affair with no complications.

A final elaboration—there is on the market already a record player of high quality and great ease of operation, which plays through the car radio and is wellnigh immune to road bumps, hard cornering and similar disturbances. One just pops the record into a slot like posting a letter, and application of the pickup, starting and stopping the motor and final rejection of the record are all done automatically.

Soon we shall see an even simpler device, playing tape recordings through the car radio amplifier and loudspeaker. The tapes, in convenient cassette containers, will be threaded into the reproducing head automatically; less vulnerable than records, they will have a longer life in car use, and will be ideal for the time when suitable broadcast programmes are not available, or do not suit the listener's taste.

Commercial Literature

Thermal Relays made by G-V Controls (U.S.A.) are available from Coventry Controls Ltd. and use the longitudinal expansion of a heated stainless steel rod as the primary actuator. The movement of this rod is magnified by levers to open and close contacts. In one type—series GD—the magnification is 20 times, and neither 50g, 11msec shocks nor 20g vibration from 5 to 3,000c/s affect operation even when the contacts are within 0.001 in of closing. Leaflets from Coventry Controls Ltd., Godiva House, Allesley Old Road, Coventry.

Polystyrene Capacitors are well known for their stability under adverse climatic conditions and their good high-frequency performance. Polystyrene-dielectric capacitors made by S.T.C. range between 10pF and 0.5μF at 125V d.c. and up to 0.2μF at 350 and 500V d.c. working. Full details on Technical Data Sheet MC/106 from Standard Telephones and Cables Ltd., Connaught House, 63 Aldwych, London, W.C.2.

Minilog is the name given to a panel containing a solid-state logic unit manufactured by Panellit Ltd. These units can be used for the replacement of relays, stepping switches, contactors, etc., in control systems with a gain in reliability and performance. Leaflet from Panellit Ltd., Elstree Way, Borehamwood, Herts.

Radar Tape Recorder by Decca performs the same function for radar that is carried out by a video tape recorder for television. Description of apparatus and techniques used from Decca Radar Ltd., Albert Embankment, London, S.E.11.

"**Export**, Exportation, Exportacion" is the title of a four-language (English, German, French, Spanish) publication which aims to give an idea of the scope and products of the E.M.I. organization to the intending buyer from overseas. E.M.I. Electronics Ltd., Hayes, Middlesex.

Negative Feedback and Hum

By "CATHODE RAY"

THE title is one I have already used. But as that was 15 years ago and therefore in ancient history so far as many readers are concerned, and scepticism is openly expressed* about some of the conclusions I repeated recently†, I'd better go into the matter once more.

The chief point at issue is the common belief that negative feedback reduces distortion, noise, hum, etc., by the same factor as it reduces voltage amplification or gain; viz., $1/(1-AB)$, where A is the gain without feedback and B is the fraction of the output voltage fed back. If the feedback is negative, then B must be negative, cancelling the minus sign already there.

Last April we examined the distortion aspect, or at least that principal variety of it caused by non-linearity. Since non-linearity means that A varies over each cycle of signal, the familiar $1-AB$ formula as commonly used tells us how much the distortion is reduced only when there is no distortion to reduce.

By means of a more complicated analysis we found that negative feedback works according to plan so long as the amount of distortion is reasonably small without it, but if the amplifier is driven too hard the result is worse than the same output without feedback. The actual quantity of distortion may be less but its unpleasantness is greater. In short, like a certain little girl, when a negative feedback amplifier is good it is very very good but when it is bad (i.e., overloaded) it is horrid.

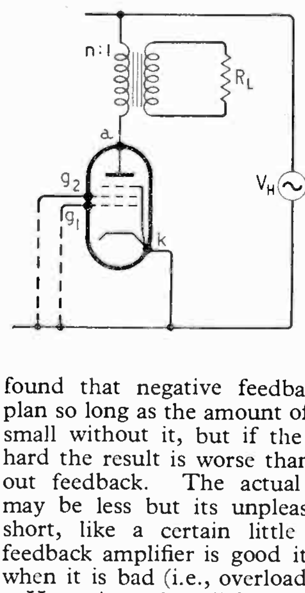

Fig. 1 By omitting everything not directly involved, we can see more clearly how much of the hum voltage V_H due to imperfect h.t. smoothing reaches the loudspeaker coil (a.c. resistance, R_L). The dotted lines indicate that in this case, so far as V_H is concerned, the grids are held at cathode potential.

Hum is quite differently involved, because it would never—we hope!—come anywhere near overloading the amplifier, and is most noticeable when the signal voltage is least. So we can regard A and B as constants, which means that the reducing factor is a constant and the complications just mentioned do not arise. There is therefore some excuse for supposing that hum is invariably reduced to the extent indicated by that factor.

It is hardly necessary to mention, perhaps, that although in ordinary speech "hum" means a particular sort of sound, in an electronic context it includes the alternating voltages and currents in an amplifier, etc., which cause that sort of sound to issue from the associated loudspeaker, if there is one, or corresponding undesirable effects to appear on the screen of a television receiver.

There are several ways in which hum can insinuate itself into circuits. The original source is the a.c. used for power supply, its frequency being (in Britain and many other places) 50 c/s. This can be picked up inductively from the mains transformer or capacitively from the wiring, but such action can be largely counteracted by screening and suitable placing of components. And, because of the insensitivity of the ear at such a low frequency, a reasonably small residue is unobjectionable.

A more important cause is the unavoidably imperfect smoothing of the rectified output, because that output necessarily flows through the valves, etc., and moreover the rectifying process creates higher and therefore more audible frequencies.

It will help to keep our inquiry within reasonable bounds if we concentrate it on the output stage, because that is always involved whenever negative feedback is used. It is also the one using by far the biggest share of rectified current, which is therefore the most difficult to smooth. Chokes to carry this large current with the loss of few volts, and at the same time to suppress the hum effectively, tend to be large, heavy and expensive, with a strong hum field surrounding them. Resistors tend to drop too many volts or not enough hum. So much is left to the capacitors to do, and they must be large. If feedback can substantially reduce hum it should enable smaller and cheaper smoothing components to be used, apart from any other benefits.

Hum arriving from the previous stage(s) comes along with the signal, so the ratio of one to the other is not improved by last-stage feedback. And because it is amplified by the last stage it must obviously be kept down to a very small amount, by extra smoothing for the other stages or by including them in the feedback loop, or both. It is usually both.

A Review of Circuits

My former article under the same title included triode valves and feedback from across parallel-fed loads. Looking at more than 50 circuits of recent sound and television receivers I notice a complete absence of either of these features in sound or vision output stages. Sound stages are invariably pentode (including, for brevity, tetrode) valves, transformer-coupled to their loudspeakers. Negative feedback is taken from either the anode or the secondary (or a tertiary) winding. Feedback is not used in video amplifiers except partially by means of a cathode

*Last month's issue, p. 311.
†April issue, p. 225, para. 2.

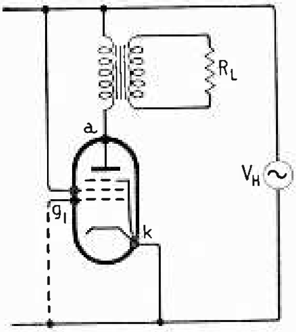

Fig. 2 This differs from Fig. 1 in that the g_2 current is not smoothed, so receives the full V_H.

resistor, and this can be considered at the end as a special case.

Fig. 1 shows as much of our output stage as concerns us for a start. D.c. and signals are ignored, and the hum current through the valve is regarded as due to a hum voltage V_H from a generator. One ought, strictly, to show a generator impedance, but as we—or some of us—saw in the November 1949 issue, the only variable that affects V_H materially is the amount of d.c. flowing, and we have no intention of altering that, even by the introduction of feedback. This is just as well, for the impedance would have to be different for each hum frequency.

The effective load resistance, R_L, is shown connected through the usual step-down transformer. We are going to be more interested in its equivalent across the primary winding, which is calculated by multiplying R_L by the square of the transformer ratio.

Let us suppose, first of all, that the potentials of the grids are kept constant relative to the cathode, which itself is kept at constant potential by means of a large capacitance across any bias resistor there may be between it and earth. Then V_H is divided between the load (primary side) and the valve, in the ratio of their impedances. The load is usually about one-eighth of the valve's r_a, so receives something like one ninth of V_H. It could receive quite a lot less, because the load resistance, n^2R_L, is shunted by the susceptance‡ of the transformer primary, which may be very appreciable, especially at frequencies as low as 50 c/s.

So far our pentode or tetrode is doing not too badly, compared with a triode, which would leave the load to take about two thirds of V_H. But the stipulation about the constancy of g_2 potential means that its current supply must be *perfectly* smoothed. In quite a number of actual sets, however, it is no more smoothed than the anode supply. The connection is then as in Fig. 2, so that the whole of V_H is applied to g_2. The result, so far as hum current through the anode circuit is concerned, is μ_2 times as much as in Fig. 1 μ_2 being my symbol for what is awkwardly if more officially denoted by μ_{g2-a}—the amplification factor of g_2. Its value, for a valve commonly used in the sound output stage of television receivers, is about 20. So use of the simple Fig. 2 connection multiplies the anode-current hum by that factor—as compared with perfect smoothing. In practice, of course, it is compared with the imperfect smoothing provided by components of economic value, but even that is enough to reduce the hum to a small fraction of what it would be without. And some valves have a much larger μ_2 than 20.

‡The reciprocal of the reactance. It is equal to $1/2\pi fL_p$.

It is now about time to see what negative feedback does to the hum. One method of applying it is to connect a path from the anode of the output valve to that of the previous one—or, what comes to the same thing, its own grid; Fig. 3. The previous stage has to provide a greater signal voltage to make up for the loss of amplification, and we don't know whether this will result in a correspondingly greater hum voltage or not. The signal/hum ratio is very unlikely to be made worse, and it might well become better. However, we are not taking hum from this source into account just now, important though it might be in practice. What about V_H?

As regards its direct assault on the anode, we saw that V_H is shared between the load and the valve in the ratio of their impedances, and, because the impedance of a pentode without negative feedback is relatively large, only about 10% of V_H reaches the load. One effect of negative feedback—at least, when applied as in Fig. 3—is a drastic reduction of the valve's r_a. In that respect the pentode virtually becomes a triode. So the proportion of V_H across the load is likely to rise to perhaps 70%, even with very moderate use of feedback.

In More Detail

Readers who — very wisely — object to blindly accepting statements such as the foregoing about feedback reducing the valve's resistance will want to trace the action in detail. Let them consider the moment at which V_H is maximum positive on the anode side. The direct result will be to make more anode current flow, but very little more, as inspection of any pentode's I_a/V_a graph will make clear. The indirect result via feedback is that the control grid (g_1) gets a share of this positive voltage, which causes an amplified increase in anode current, and therefore more hum. It is just as if a lower-r_a valve (without feedback) had been substituted. Hence the doctrine that negative feedback reduces r_a.

That is assuming perfectly smoothed current for g_2. Next, let us see what happens if the same kind of negative feedback is applied to Fig. 2, as in Fig. 4. We noted that in Fig. 2 the direct effect of V_H via the anode was many times exceeded by that via g_2. We might therefore quickly assume that hum in Fig. 4 would be the worst of the lot, since it would receive V_H on all three electrodes in the same

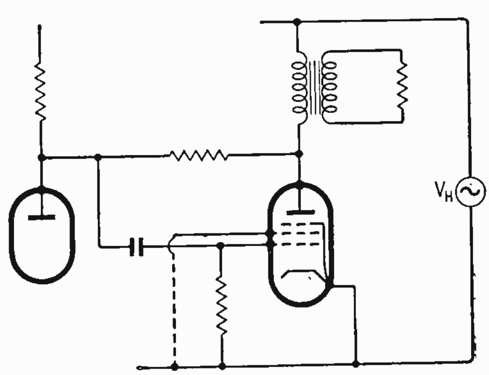

Fig. 3 Here, negative voltage feedback is applied from the anode, the conditions otherwise being as in Fig. 1.

phase, two of them amplifying it. It stands to reason that " unsmoothing " g_2 must make the hum worse! (We have already found that to be so in Fig. 2 as compared with Fig. 1).

Well, it only shows how wrong one can get by doing things in a hurry. Practical test (which was what I did for the 1946 version) shows that hum is *less* with Fig. 4 than with Fig. 2. Why?

The explanation is quite interesting. In Fig. 2, V_H, which is applied in full to g_2, is so much amplified that the hum voltage thereby developed across the load is almost certain to be greater than V_H. With typical valves it is likely to be about double. Consequently, at the moment when V_H is at its maximum positive the anode is being driven neagtive. It is this negative hum voltage that is fed back to g_1, where it opposes the positive hum voltage on g_2. If this gives us the idea that by a suitable choice of B—the feedback ratio—we can nicely balance out the hum, we are wrong again. The voltage applied to g_1 only does any balancing out so long as the hum voltage across the load *exceeds* V_H. So the best that can be done is to prevent it exceeding it much. It is hardly surprising that only three of the many models I examined make use of the Fig. 4 type of circuit, and their amount of feedback seems to be very limited. A somewhat larger number resemble Fig. 3 in having extra smoothing for g_2, or, what is perhaps rather better as regards hum, have extra smoothing for both g_2 and a.

A Popular Method

By far the commonest method of arranging negative feedback is from across the transformer secondary winding. Among these can be included some that have a special tertiary winding for feedback only. Either leaves the designer free to use a fedback voltage of either polarity, and almost invariably he takes advantage of this to apply it to the previous stage, roughly as in Fig. 5. The main idea behind this, no doubt, is to apply the distortion-reducing virtue of negative feedback to as much of the audio system as possible. But for the moment we are solely concerned with how it affects hum.

Here again we have to be rather careful how we reckon our potentials. Relative to cathode, the top end of the transformer primary is at full hum potential, V_H. Relative to that point, the anode is less positive. In Fig. 2—and Fig. 4—it is usually so much less that it is reversed in sign. Let us

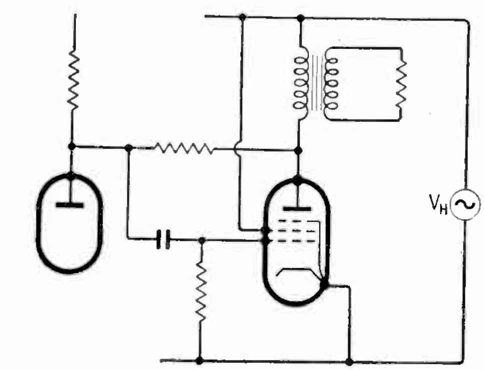

Fig. 4 This is the same as Fig. 3 except for absence of g_2 current smoothing.

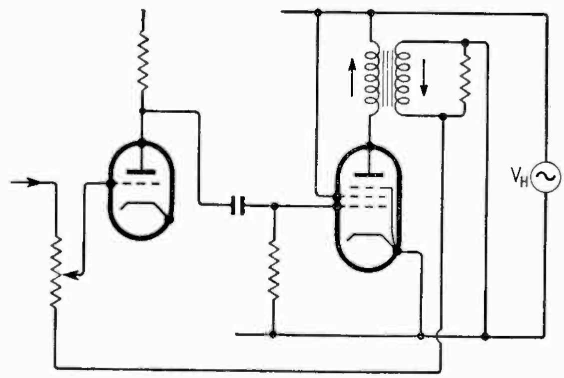

Fig. 5 This differs from Fig. 4 in the method of negative feedback, which is via the transformer secondary and the previous stage.

check that as shown in Fig. 5 the signal voltage feedback is in fact negative. The coils are shown in opposite rotation, so an increase in signal current through the valve, which would make the anode go negative-wards, would feed positive voltage to the grid of the triode and negative to g_1 of the pentode, opposing the cause and therefore correct.

The same applies to hum currents through the pentode, however caused. So far as this type of feedback circuit is concerned, then, it is true that hum is reduced in the same ratio as gain, distortion, etc. So even the potentially very bad hum situation of Fig. 2, which no amount of feedback from the anode can reduce to less than the full V_H across the transformer, can be substantially improved. Applying 20dB of feedback in a typical case would bring it down to about one fifth of V_H, or nearly as good as Fig. 1 without feedback. Applying it to Fig. 1, so that the circuit is like Fig. 5 plus effective smoothing of the g_2 current, the already relatively small Fig. 1 hum is reduced by however much feedback is used. More than half the feedback circuits examined were in fact of this type, the number without extra smoothing (Fig. 5) being relatively small. In two of the former and one of the latter the feedback was to the cathode of the pentode instead of the grid of the triode, but I don't think we need make a special study of that particular variation. There are also devices in some to increase the amount of feedback at high signal frequencies.

Another feature, appearing in nearly half the sets looked at, does perhaps deserve mention, seeing that it concerns hum—though not in relation to feedback. Instead of the h.t. current being fed in at the end of the output transformer it is tapped a little way down, as in Fig. 6. Hum current flows towards each end of the transformer winding in inverse proportion to the impedances of the paths available. As the impedance via R and C— of the order of only 1–2kΩ—is much lower than through the valve, the hum current is relatively high and only a few turns are needed to provide sufficient ampere-turns to neutralize those in the rest of the primary.

Here is yet another trap. The attentive but hasty reader may say Oh! But we are using negative feedback, so the valve impedance will be quite low! So we are, and in one way it is low, but in another it is

(*Continued on page 385*)

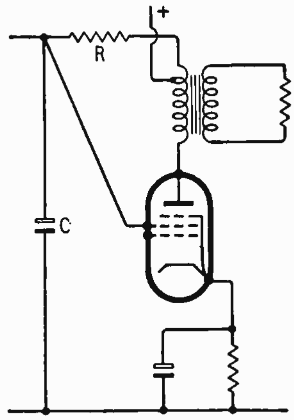

Fig. 6 A device for balancing out hum in the anode circuit is to tap the h.t. connection a little way down the transformer primary. The precise point depends on the ratio of the impedance of R (C being negligible) to that of the valve, which is usually enhanced by negative feedback.

very high. This ambiguous state of affairs can only be made clear by once again taking care how we reckon our potentials. From the point of view of the transformer (the h.t. voltage being constant) any voltage generated therein that increases current through the valve must be positive at the anode end. That feeds back negative voltage to the triode grid and positive to g_1, making the increase of current greater than it would have been without feedback. So in effect the pentode's resistance is less.

But now look from the h.t. supply's point of view. Any hum voltage that would increase the anode current would have to be positive at the supply end, which (owing to the increase in current) would be negative at the anode end—relative to + h.t., not to cathode. So voltage fed back would be opposite to that in the first case, tending to reduce the increase in anode current, just as if the valve impedance were higher than without feedback. Seeing that that is quite high, one can see why the h.t. tap need not be far down the primary.

The combined use of g_2 smoothing, negative feedback and transformer tapping should therefore add up to a satisfactorily low hum level even if the smoothing immediately following the rectifier has been planned with strict regard to economy.

Cathode Feedback

About a dozen of the audio stages surveyed, and the great majority of the v.f. output stages, departed from our assumption about constancy of cathode potential by having no effective hum-frequency bypass across the bias resistor (Fig. 7). All except two of these audio stages included other forms of negative feedback. The current passing through R_k, whether it be d.c. feed, signal or hum, biases all the other electrodes (anode, g_1 and g_2) negatively with respecto cathode, which is the reference or starting point in any valve. The effect on anode current via the anode voltage is small (say 5%) compared with that on g_2, and that in turn is usually even smaller compared with that on g_1, which by definition influences the anode current μ times as much as does the anode. So we concentrate on the g_1 bias.

By the way, just to get our terms clear, the word " bias " is usually applied only to the d.c. component of the voltage across R_k, and this component of course is there whether R_k is bypassed by a capacitor or not. But for convenience I am applying it to the hum voltage. And when I say it biases the grid (g_1) negatively I am counting as positive the half-cycles of hum voltage that add to the d.c. The negative half cycles bias the grid positively, since two negatives make a positive.

Now because this grid-biasing voltage is proportional to the current through R_k it is called current feedback. It increases the apparent resistance (r_a) of the valve, because its effect via the grid is to oppose any change in current produced by an externally applied voltage. In Fig. 1 we saw that the higher the resistance of the valve the smaller the proportion of V_H getting to the load. So cathode feedback reduces hum in that type of circuit. So far as hum voltage set up across R_k is concerned, it obviously reduces itself in the same proportion as signals—assuming there is nothing to discriminate between hum frequency and signal frequency. That is not an effect additional to the one mentioned earlier in this paragraph; it is just another way of looking at the same thing.

The argument applies also to the other circuits. For instance, in Fig. 2 the effect of V_H is magnified via g_2, but it equally magnifies the hum current through R_k and therefore the anti-hum voltage to g_1.

Like any other form of negative feedback, the cathode resistor reduces the gain and necessitates a corresponding increase in signal input. If most of the hum is coming in with the signal, the net improvement in signal/hum ratio may not be noticeable. In that case the designer's attention must be transferred to the previous stage. There, owing to the far smaller current drain, the smoothing problem is comparatively light. The main difficulty is likely to be inductive or—still more—capacitive pick-up. But screening is another story. And then there is modulation hum, due perhaps to poor smoothing in the r.f. stages.

Summing up the findings, we can say that negative feedback from the anode is not recommended, because with unsmoothed g_2 (Fig. 4) it is powerless to reduce the hum voltage across the output transformer to less than V_H, while if g_2 current is smoothed it brings back the hum so disposed of. Feedback from the secondary has the advantage—among others—of reducing hum in the same ratio as signal. To ensure very low hum, g_2 should have extra smoothing; and if even that is not good enough the dodge shown in Fig. 6 can be brought in. Cathode feedback (Fig. 7) is another that reduces hum in proportion to signal, and is cheap (its cost is minus that of a bypass capacitor) but its r_a-boosting property may not commend it to the hi-fi enthusiast. Finally, it profits little to eliminate hum in the output stage if the cure leads inevitably to more being brought in from the preceding stage, so don't overlook that source.

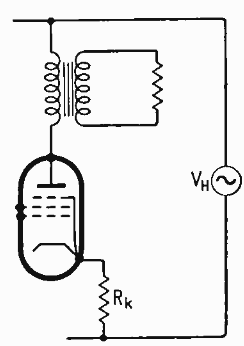

Fig. 7 The effect of a cathode resistor, R_k, when not bypassed to hum by a large capacitance, is to reduce the hum.

Elements of Electronic Circuits

27.—Pulse Modulation (2)

By J. M. PETERS, B.Sc. (Eng.), A.M.I.E.E., A.M.Brit.I.R.E.

WHERE the transmitting valve either has no grid (magnetron), or where it is inconvenient to use the grid for modulation, the anode supply is switched on and off. Anode modulators can employ either "soft" valves (e.g., the thyratron) or "hard" valves, for the switching function. Soft valves can be triggered easily and can pass larger currents with less power dissipation than hard valves, but their disadvantage is that the discharge has to be extinguished, rather than the flow of electrons interrupted, at the end of the pulse. This takes time and can militate against the use of the more economical device.

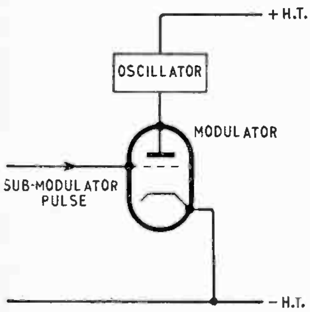

Fig. 1

The pulse-forming network is the source of supply for the oscillator and it stores and carries all energy that is to form the r.f. pulse and cover losses in the transmitter. This pulse energy is discharged into the oscillator, which is in series with the modulator valve, and we are therefore concerned with the control of the charging of the network, together with its subsequent discharge into the oscillator. If the modulator is of the hard-valve type, the control of the shape and duration of the modulator pulse is done at an earlier low-power or sub-modulator stage. The problem here is one of amplification, in other words, the provision of sufficient power to modulate the oscillator.

Anode Modulation

A hard-valve modulator requires the application of a positive pulse of large amplitude (which is produced by the sub-modulator) to make the modulator valve conduct as heavily as possible. As the action of the modulator depends on a large grid current flow with consequent low input impedance during the conducting period, the output impedance of the sub-modulator stage must also be

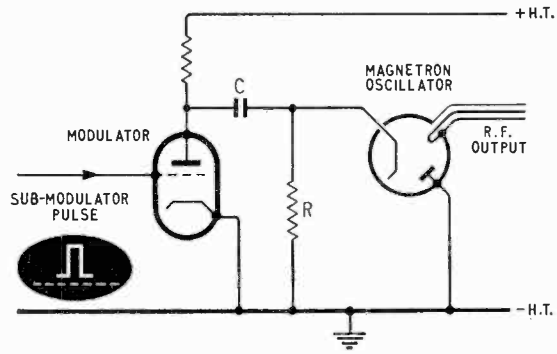

Fig. 2

low if the pulse shape is to be preserved and grid limiting prevented.

Fig. 1 shows the basic simplified circuit of a hard-valve modulator and Fig. 2 its connection to a magnetron type of oscillator. It will be noted that in the latter case, owing to the construction of the magnetron, it is necessary for the magnetron anode to be at earth potential: hence a method of shunt feeding is employed.

In order that the voltage across the magnetron may remain steady during the pulse, the C-R coupling circuit is arranged to have a long time constant.

The sub-modulator pulse for a hard-valve modulator may be derived from a single-valve circuit based on the one illustrated in Fig. 3. This circuit

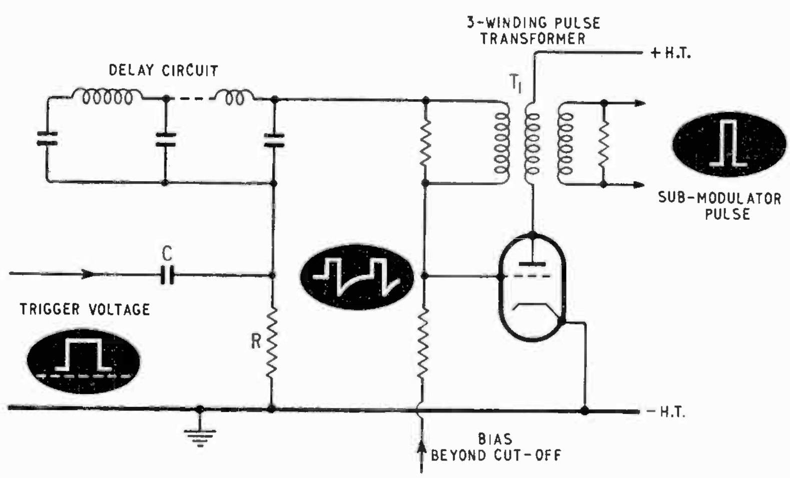

Fig. 3

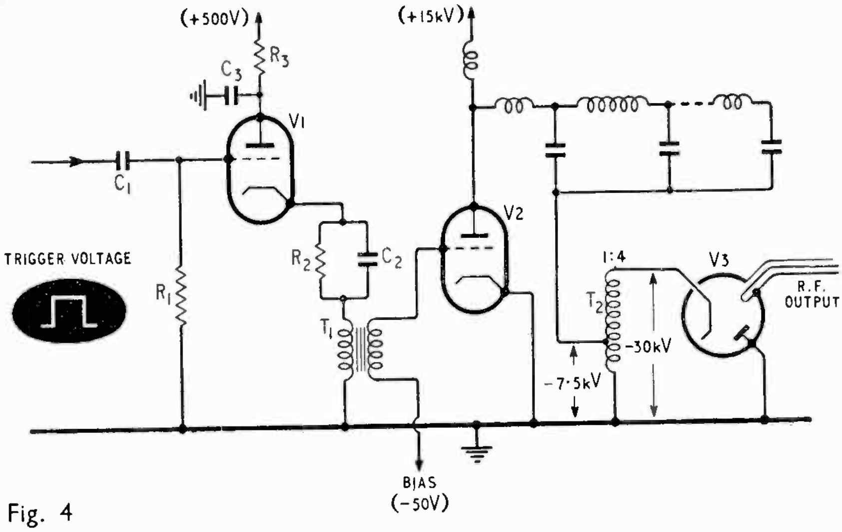

Fig. 4

employment of pulse transformers in both trigger and modulator circuits is shown in Fig. 4.

To assist in the explanation of the function of this circuit some typical voltage values have been chosen.

The positive trigger voltage is differentiated by C_1 R_1 to produce a narrow pulse on V1 grid (say 100μsec). V1 is initially cut off by the cathode bias produced by C_2 R_2 during the pulse and C_3 is charged to 500 volts. The short positive pulse on $V1_g$ causes V1 to conduct and C_3 discharges through V1, the primary of T_1 and C_2 (C_3 recharges through R_3 when V1 stops conducting). The bias voltage (say -50V) on the modulator valve V2 is overcome by the pulse from T_1 secondary and V2 consequently conducts heavily.

Prior to this the delay line had been charged to 15kV (by a separate rectified high-voltage supply).

When V2 conducts, a -7.5kV discharge pulse of, say, 1μsec length appears across the primary of T_2. The turns ratio of this transformer is chosen to fulfil two main functions:—

(i) it matches the magnetron to the delay-line impedance when the magnetron conducts (e.g., magnetron 640Ω, line 40Ω),

(ii) it steps up the modulator voltage to that required by the magnetron (e.g., 30kV).

The magnetron, passing a pulse current of approximately 30A, produces a 1 megawatt pulse of r.f. of 1μsec duration at the repetition frequency imposed by the trigger circuit (say, 500 pulses/sec).

For the sake of clarity much circuitry has been eliminated. Often methods are employed for shaping the pulses at the intermediate stages. It is also necessary to introduce clamping to prevent ringing or spurious oscillations. Overswinging of voltages and large grid currents caused by high voltage swings have to be restricted. Again, in a practical circuit the single delay line may be replaced by two identical lines in parallel, as in the Blumlein modulator.

This improvement can result in the delivery of a greater voltage to the load (i.e., the magnetron) and is brought about by the addition of wavefronts, caused by multiple reflections from the ends of the lines. One line is open-circuited, the other short-circuited, by the thyratron or triggered spark-gap.

Reflections at the short-circuited end produce a reversal in polarity of the voltage, whereas at the open-cicuit end there is no change in polarity on reflection. As the initial charging voltage divides between the lines, some reflections of the voltage wave combine and some cancel out with the result that the load voltage (i.e., that delivered to the magnetron) becomes the vector sum of the reflections.

It is important that both lines should be of identical construction, low-loss, of the same Z_0 and have the same transit time.

consists of a triggered blocking oscillator which includes an open-ended delay network to determine the length of the pulse to be produced. A positive trigger voltage applied to the short time-constant C-R circuit results in the grid of the valve being raised above cut-off. The valve conducts heavily and produces a high voltage across the grid winding of the triple-wound pulse transformer T_1: this charges the delay circuit.

When the negative-going reflected wave reaches the input (voltage reflection at the open end without change of phase), the valve is again cut off. The duration of the output pulse depends on the double transit time of the delay circuit (see No. 25 of this series; May, 1961).

Pulse Transformers

An important component in modulator circuits is the pulse transformer which is used for:—

(i) matching of the modulator to the magnetron (via any interconnecting cables),

(ii) phase inversion of a pulse where necessary, e.g., between sub-modulator and modulator valves,

(iii) coupling between two circuits when the direct potentials are different.

In each case the pulse transformer is required to pass the pulses without appreciable distortion of their shape. The working conditions are stringent: high voltage peaks, with peak pulse current that may reach hundreds of amperes and often (in airborne equipment at any rate) the running temperature may well be high.

One interesting and almost universal "dodge" adopted for magnetron transformers is the use of bifilar secondary windings. Through the two parallel coils flows the magnetron heater current (the turns are few, so there is no great loss) and this enables the magnetron heater to be energized from a supply at earth potential although its cathode may be some tens of kilovolts below earth during the pulse.

Practical Modulator

An example of anode modulation using a pulse forming network in the modulator circuit and the

RANDOM RADIATIONS

By "DIALLIST"

Radar Echoes from Venus

THE recent successful attempt by Russian scientists to obtain radar echoes from the planet Venus has produced some interesting results. Nothing is known of the surface of the planet, for it is always covered by dense layers of cloud which make telescopic observation of it impossible. The Russians have found that radio signals are reflected in different ways by various parts of the planet and from measurements made have calculated that Venus revolves on its axis about once in eleven days. Another interesting result of the experiment is a fresh determination of the mean distance between the Earth and the Sun, which they have found to be 92,868,000 miles. This agrees reasonably closely with the figure of 92,874,000 miles obtained by the Massachusetts Institute of Technology in 1948 and with Jodrell Bank's 92,876,000 miles in 1959. But it is a good deal less than the latest figure obtained at Jodrell Bank, which is 92,956,000 miles. All the same, I'd put my money on Jodrell Bank's being right—or, rather, more nearly right than they. . . Soon after I'd written that came news of a fresh determination of the mean solar distance by M.I.T. Their new figure is 92,954,000 miles—only 2,000 miles different from Jodrell Bank's.

'Phone via Satellite

IT'S good to know that we are to take part in experiments involving the bouncing of radio signals from artificial satellites. Our contribution is to be a transmitting and receiving station on the Goonhilly Downs, near the Lizard, in Cornwall. A similar station is to be built in the U.S.A. and the Americans will put the satellites into orbit. They're expected to be quite small, weighing only about a hundred pounds apiece, and will be shot up by Thor rockets from the Vandenberg base in California. Sir Ronald German, director general of the G.P.O., has said that if satellites can be guaranteed to remain in orbit for ten years the space method will be competitive with the cable. The station is to be equipped with an 85ft steerable paraboloid.

A British Satellite

SO we're to have a satellite of our own next year. We shan't fire it ourselves, for it will be put into orbit from Wallops Island by a four stage American Scout rocket. It's going to contain quite a lot of apparatus which will carry out tests designed by different teams of British scientists. The power for these is to come from solar batteries and it's reckoned that they will keep it at work for a year. Besides detecting cosmic radiation, it is to measure electron density in the ionosphere and analyse the gases which make up the outer parts of our atmosphere. Let's hope it will be a success and that the information which it is to send back to earth by wireless will make a useful contribution to our knowledge of conditions towards the fringe of the atmosphere.

"Backroom Boy"

THE story of the brief but very brilliant career of Eric Megaw who, when he died at the early age of 48, was Director of Physical Research, Royal Naval Scientific Service, is told in Arthur Stanley's biography, "A Backroom Boy". His hobby from the time when he was quite a small boy was wireless, in which he was later to do remarkable work. At 20 he won a Beit Research Fellowship at the Imperial College of Science and it was there that he became interested in very short radio waves, which became almost a passion for the rest of his life. In 1930 Dr. Megaw joined the staff at the G.E.C. Research Labs at Wembley, where he stayed for 16 years. I didn't know that he had anything to do with the development of the cavity magnetron, but Sir Edward Appleton is quoted in the book as saying, "Those who were in the business know how much the practical development of the cavity magnetron—the development that made it something that could go into operational use—was due to Dr. Megaw. Yet, smilingly, he let the credit go wholly elsewhere, although a large part of it was his." It was in 1946 that he left Wembley for the R.N. Scientific Service, where he was doing remarkable work up to the time of his death early in 1956. "A Backroom Boy", published by W. Erskine Mayne, of Belfast, is a little book which is really well worth reading.

Colour Television in America

A GOOD many firms of American wireless and television manufacturers believe that colour TV is about to stage a long-awaited leap into popularity in their country. It has certainly hung fire for a long while. What, I believe, hampered its progress was not the cost of receivers, for there must be plenty of Americans ready and willing to fork out the equivalent of £200-£250 (or to pay the corresponding "never-never" instalments) for something which could guarantee entertainment more pleasing than that provided by the black-and-white receiver. The main trouble in the past was the frequent knob twiddling required and the serviceman had to be called in too often. Well, manufacturers have now had plenty of time to improve things and, I understand, can now produce sets which are stable and reliable. If that's so, there's no reason why colour TV shouldn't quickly become almost as popular as the monochrome variety on the other side of the Atlantic. There are are now quite a number of colour broadcasts and if sets show signs of selling well my guess is they'll quickly increase in number and in duration.

Still π Chasing

A KIND reader who lives at Purley reminds me of some rhymed mnemonics I quoted in these notes in November, 1944, for the value of π and tells me that just for the sake of amusement he worked it out to some forty places. The chasing of π used to be a favourite hobby of mathematicians in the seventeenth and eighteenth centuries and it still goes on to-day. But two things have happened lately which are likely to bring it to an end. The first is the evolution of a proof that the value can never be worked out exactly. The second is the result produced by an Emidec electronic computer, which without turning a hair worked it out to 10,880 decimal places! I believe I am right in saying that the best human effort was that of W. Shanks. In the 1850s he reached 530 decimal places and he had another go some 20 years later and went on to 707 places. But I understand it was recently found that he had introduced an error in the neighbourhood of the 530th decimal place.

UNBIASED

By "FREE GRID"

Cure for Cacophoria

AS the years go by, my collection of *Wireless World* steadily grows and Mrs. Free Grid is—to put it mildly—getting very restless about the space they occupy, and is inclined to make sufficiently tart remarks about the matter to induce in me a feeling of cacophoria. There must be many of you suffering from similar symptoms of uxorogenic cacophoria due to the same basic cause, and I think we ought to get together and find a way out of the difficulty.

I have been wondering whether the correct procedure would be to make a tape recording of each volume or to microfilm it. Taking all things into consideration, a microfilm version of each volume would

"*Books cannot always please, however good.*"

seem to be the easiest way out of the difficulty as I should find it very tedious and voice-straining to read 50-years' volumes into a microphone.

With regard to future volumes, I wonder if we could get the Editor to approach his directors with the suggestion that at the end of each volume a microfilm version would be available to those who wished to buy it rather than pay to have their issues bound.* Since *W.W.* has a very large flock of sister journals, the cost of installing the microfilming apparatus would be small if spread over them all so that microfilmed volumes of each journal could be made available to their respective readers.

*Microfilms of *W.W.* since 1950 are available from University Microfilms Ltd.—Ed.

Le Mot Juste?

I WAS interested to see that our amicable French contemporary *Toute la Radio* devoted a whole page in its May issue to congratulating *W.W.* on its *noces d'or*. But in mentioning myself among the Editor's *vaillante équipe de collaborateurs*, I am not sure whether I ought to feel complimented or otherwise at being referred to as "*l'inénarrable* Free Grid," and I wonder if any of you Francophilologists can help me out; I cannot very well lose face by appealing to the Director of *Toute la Radio* for a translation.

I have been told on good authority that the expression means "the unspeakable Free Grid," but even if that be true I am still left wondering what the writer in our French contemporary really means. After all we speak of an exceptionally beautiful girl as being of "unspeakable beauty" but we also speak of a certain type of man as being an "unspeakable cad."

An alternative translation is "screamingly funny" and if Monsieur Aisberg really means this he must possess a first-class knowledge of colloquial English to have penetrated to the point of some of my more oblique allusions.

Who Invented Wireless?

IF the proverbial man in the street were asked the question in my title, it is more than likely that he would glibly answer "Marconi;" and if he were asked who invented the steam locomotive, he would probably say "George Stephenson." In the latter case he would, of course, be hopelessly wrong, for steam trains were running at Euston in 1808, over 20 years before Stephenson's "Rocket" appeared in 1829 and six years before his first locomotive, "My Lord," was built in 1814.

If he said that Marconi invented wireless, he would, in my opinion, be far more accurate than is generally realized. Now before you all dip your pens in H_2SO_4 to write to the Editor saying, "Free Grid must go," I would beg you to pause a moment and ask yourselves who, in your view, invented wireless. Probably you will think of a list of names like Hertz, Branly, Lodge and many others, and say they all contributed something but no one person could claim to be the inventor of wireless.

To get a clearer picture of what I am driving at, I think it would be better if I said that in my opinion it was Marconi who invented wireless communication, the emphasis being on the latter word. Transmitting messages from one room in a laboratory to another, or even across a large Italian garden as Marconi did at first, was valuable groundwork but if left at that "wireless" would not have been of much use as a practical means of communication.

It was Marconi—and nobody else—who changed all that when he added the missing link by attaching to his apparatus an elevated wire which we usually call an aerial. At that moment wireless communication was truly born and it was Marconi who acted as midwife. I am perfectly well aware that the Russians have staked a claim for Popov as the inventor of the aerial. But there is no evidence that in using such a device his idea was to do anything but collect atmospherics, and even in that he was forestalled over a century earlier by Franklin.

Tapped or Taped?

A FEW years ago some of us in the U.K. were worried about our telephone conversations being tapped by the authorities and questions were asked about it in the House. Since then, however, a far greater menace to the privacy of our conversation has arisen.

In the days of the telephone tapping scare, my blonde and I were forced to seek the sanctuary of speaking in Swahili in order to preserve the privacy of what we said to each other. But, as I foresaw at the time and mentioned in these columns (Aug., 1957), we had to abandon it as there was always the risk of the authorities sending tape recordings for interpretation.

The tapping menace seems to have faded away with the passing years, but the taping menace has increased to formidable proportions with the coming of tiny transistor tape recorders. People are buying them mainly, it seems, for the purpose of playing practical jokes on their friends by recording some of their foolish remarks (such as we all make at times) for reproduction later.

I can appreciate a joke as well as any man, but I am beginning to feel the strain of constantly keeping a guard on my tongue, and I realize that I must do something drastic to combat the menace by technical means, and it is here where some of you who are more up on the technique of tapology than I am, can probably help me. How can I generate a magnetic field of sufficient strength to wipe out the tape of a recorder which may be in the pocket of the person I am talking to?