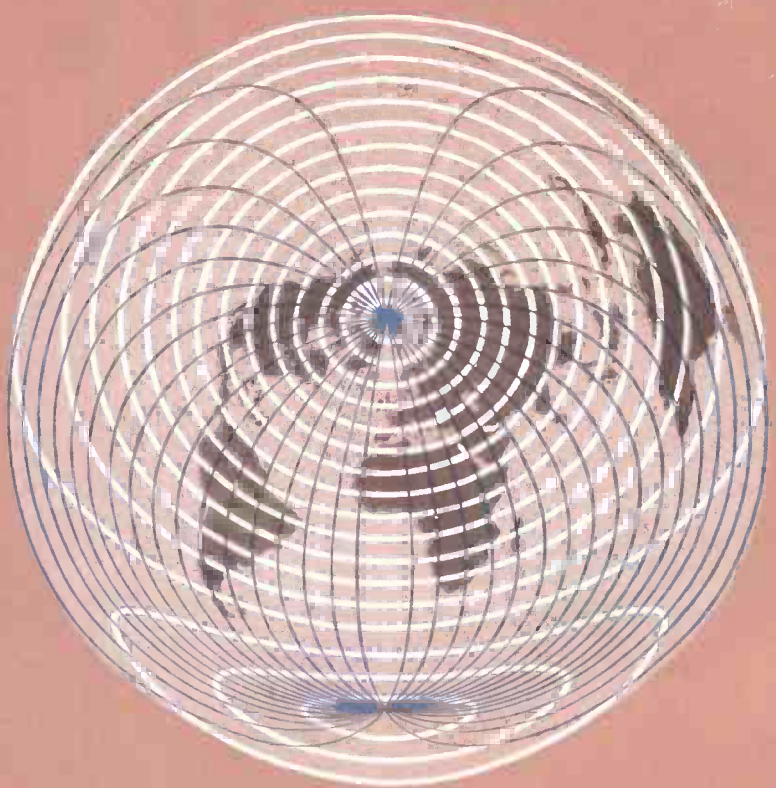
AUGUST 1957

TWO SHILLINGS

Wireless World

ELECTRONICS

Radio · Television



FORTY-SEVENTH YEAR OF PUBLICATION

Wireless World

ELECTRONICS, RADIO, TELEVISION

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AUGUST 1957

In This Issue

VOLUME 63 No. 8

PRICE: TWO SHILLINGS

FORTY-SEVENTH YEAR OF PUBLICATION

Offices: Dorset House, Stamford Street, London, S.E.1

Please address to Editor, Advertisement Manager or Publisher, as appropriate.

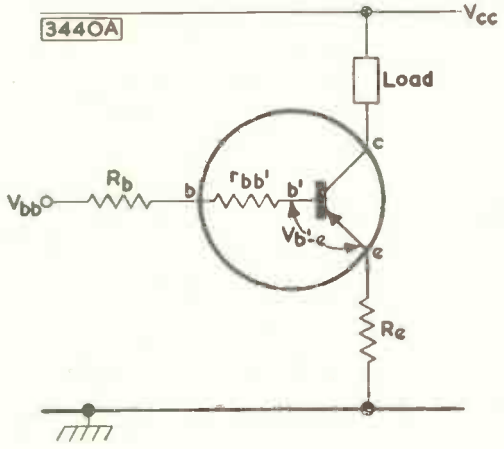
Telephone: WATerloo 3333 (60 lines)

Telegraphic Address: "Ethaworld, Sedist, London".

PUBLISHED MONTHLY (4th Tuesday of preceding month) by ILIFFE & SONS LTD., Dorset House, Stamford Street, London, S.E.1. *Telephone:* Waterloo 3333 (60 lines). *Telegrams:* "Iliffepres, Sedist, London." *Annual Subscription:* Home and Overseas, £1 12s. 6d. U.S.A. and Canada $5.00. BRANCH OFFICES: *BIRMINGHAM:* King Edward House, New Street, 2. *Telephone:* Midland 7191. *COVENTRY:* 8-10, Corporation Street. *Telephone:* Coventry 5210. *GLASGOW:* 26B Renfield Street, C.2. *Telephone:* Central 1265. *MANCHESTER:* 260, Deansgate, 3. *Telephone:* Blackfriars 4412. OVERSEAS OFFICES: *U.S.A.:* 111, Broadway, New York, 6, N.Y. *Telephone:* Digby 9-1197. *CANADA:* 67, Yonge Street, Toronto, 1, Ontario. *Telephone:* Empire 6-0873.

Transistor Base-to-Emitter Voltage Compensation

It is well known that satisfactory transistor performance can only be obtained by restricting the variation of collector current with temperature. Under the worst conditions of operation, stabilisation of the working point is also essential to prevent thermal runaway. The most widely used method of d.c. stabilisation consists in deriving the base bias from a potential divider connected across the base in conjunction with an emitter resistor. One possible refinement is to give the emitter resistor a positive temperature coefficient. This method is of particular importance in circuits using power transistors, such as the OC16, with low impedance bias supplies.



Temperature Dependence of Base-to-Emitter Voltage

The increase in collector current with temperature arises in part from the temperature dependence of the base to emitter voltage. Under certain conditions, and particularly with power transistors, this increase may become more important than that produced by the temperature dependence of the collector leakage current. Referring to the figure, the base to emitter voltage which can be measured on an actual transistor exists between b and e, and itself depends on the internal base resistance, $r_{bb'}$, and the voltage between b^1 and e. This latter voltage, V_{b^1-e}, changes with temperature at a rate which is theoretically the same for all transistors, and is equal to —2·5mV/°C. The minus sign indicates that V_{b^1-e} decreases with temperature.

Emitter Resistors of Pure Metal

The change of V_{b^1-e} with temperature can be compensated by using temperature sensitive elements in the circuit. Thermistors having a negative temperature coefficient can be used in the bias circuit, but as their temperature coefficient varies with temperature, it is not possible to obtain exact compensation.

On the other hand, if the emitter resistor is wound from wire made of some pure metal, such as copper or nickel, it will have a positive temperature coefficient and compensation for changes in V_{b^1-e} can be obtained over the entire temperature range.

For exact compensation, the voltage across R_e should have an equal and opposite coefficient to V_{b^1-e}, that is, the voltage across R_e should increase by 2·5mV/°C. Pure metals such as copper and nickel have temperature coefficients of about +0·004/°C. If the value of R_e is chosen to give a voltage drop of about 630mV, this voltage drop will increase by about $630 \times 0{\cdot}004 = 2{\cdot}5$mV/°C as required.

If the drop is higher, or if in fact V_{b^1-e} decreases by less than 2·5mV/°C, the circuit will be overcompensated. However, overcompensation is not a disadvantage as it helps to stabilise against the collector current changes produced by the temperature dependence of the collector leakage current.

Advantages

In general, an emitter resistor having a positive temperature coefficient reduces variations in collector current but does not directly improve the stability of the circuit with respect to thermal runaway, because the emitter resistor reacts to changes in ambient temperature, not junction temperature.

Signal handling capacity is reduced to a smaller extent by any rise in ambient temperature.

The collector dissipation does not rise so much with temperature. It is therefore possible to increase the dissipation by 10 or 15%, or to permit a higher ambient temperature, with any given heat sink: under these conditions the runaway stability remains unaltered.

Alternatively, a somewhat smaller heat sink suffices: the runaway stability then deteriorates somewhat and better circuit stabilisation is required.

Mounting the positive temperature coefficient resistor on the heat sink makes only a negligible improvement to the runaway stability and may actually be inadvisable because of the heat dissipated in the emitter resistor itself. It would, however, reduce the current changes which occur when first switching on.

Heat Sinks

Transistors with higher dissipation ratings, such as the OC72 and OC16, have to be fitted with some sort of metal cooling fin or mounting plate which serves to conduct away, and radiate away, heat generated in the transistor itself.

Although these heat sinks operate on such a simple principle, it becomes necessary at the power rating of the OC16 to specify the dimensions, material, and the gauge and finish of the metal plate rather exactly. Usually the chassis can be designed to be the heat sink, but, if the chassis gets hot because of the presence of valves or other heat generating components, a separate sub-chassis may be necessary.

It is regretted that the circuit shown in Fig. 2 on this page of the July issue was incorrect. The electrolytic capacitor C should be omitted. There should be a single load resistance Z as shown in Fig. 1 and the top of the resistor R1[1] should be connected to the collector of Tr1 (point X).

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Wireless World

Endurance Test

WHEN the International Geophysical Year began last month an SWI (Special World Interval) was already in force and observers in all parts of the world were hard at work measuring the effects of large solar flares on the ionosphere, the earth's magnetic field, the aurorae and many other phenomena. The sun had collaborated in confirming the choice of timing of the experiment, the world telecommunication network (tested by practice alerts since January) went " operational " for the first time, and all the months of elaborate preparation for this massive international scientific experiment gave place to the second phase, namely that of observation.

Much of the information we have about the constitution of the ionosphere is obtained by radio pulse reflection at vertical incidence. The number of stations making this type of continuous automatic measurement has been trebled and particular attention is being paid to the regions near the earth's geomagnetic equator. The basic information given by radio sounding methods is the time taken for the pulse to go and return through a heterogeneous stratified dielectric, and although much has been deduced from studies of the behaviour of pulses of different frequency, the direct physical measurement of electron density and dielectric constant has only recently been extended by rockets above the 20-mile limit of balloons. During the IGY there is to be a much-increased expenditure of rockets, including at least twelve rounds of the specially designed " Skylark " from the Woomera range.

Studies of the turbulence of the upper atmosphere and the measurement of drifts in the ionosphere, hitherto made from observations of the scintillation of noise from radio " stars," will, if all goes well, be given an element of greater precision when the fixed-frequency, point-source transmitters of the artificial satellites come into operation. Those stations which are fortunate enough to be able to plot the track of the satellites visually, as well as by radio methods, will have a double check on the refracting properties of the ionosphere. It is confidently expected that signals will be heard in this country from the American satellite, though its power will be only of the order of milliwatts, and plans have been made to follow its course with the Jodrell Bank telescope and by means of a special interferometer to be set up and operated by the Royal Aircraft Establishment at Lasham aerodrome in Hampshire. At this distance and with a low-elevation propagation path through the atmosphere the apparent track of the satellite will show measurable deviations from its true velocity. From these deviations it is hoped to learn something more of irregularities of the ionosphere and their variation with height.

Which turns our attention to the third and most important phase—the reduction and digestion of results. This will not begin in earnest until the end of IGY in 1958, when copies of all the figures will be sent to the World Data Centres in the U.S.A., U.S.S.R. and elsewhere.

The IGY already stands as a monument to Man's ability to organize on an international scale, and will require of him qualities of steadfastness and concentration in making what will often be dull routine observations. In this country, Sir David Brunt, Secretary of the Royal Society, has been intimately concerned with the detailed preparation of the British contribution, including responsibility for the establishment of the Halley Bay observatory in the Antarctic, and we can wholeheartedly endorse his hope, expressed at a recent conference, that we shall be given the wit and perseverance, when the time comes, to make good use of the results of all this collective effort. Some lines of enquiry are already laid down with reasonable precision and have as their object the filling in of blank areas of world maps of known geophysical phenomena by the addition of data from strategically placed new observing stations. Others, deriving from the use of new tools for measurement, such as the rocket and the artificial satellite, will extend the range of measurement and confirm or refute those of our ideas which at present rest only on hypothesis. But the hidden treasure of new knowledge can be revealed only by painstaking sifting and imaginative correlation of apparently unrelated data.

Colour Television Marks Time

RESEARCH TRENDS FROM THE PARIS INTERNATIONAL SYMPOSIUM

APART from a new French colour system which may prove a competitor to the N.T.S.C. system on 819 lines, *Wireless World* did not find anything at the Paris Symposium to indicate a turn in the tide away from the broad principles and techniques of American colour television. It is true that development is going ahead on a simple and cheap receiver display device to make colour television an economic possibility for the ordinary viewer. And if, as seems possible, this turns out to be something like the single-gun beam-switching or -indexing tubes, it may recommend a transmission system somewhat different from the American pattern. But no hint of this came out in Paris. Rather we found that most of the papers described researches which either lent direct support to the N.T.S.C. system or were neutral on this point.

It was perhaps significant that the French company Laboratoires d'Electronique et de Physique Appliquées, which described and demonstrated its own "double-message" system, also described and demonstrated 819-line and 625-line versions of the N.T.S.C. system. (Under the particular viewing conditions and with the display equipment available it was difficult to see much difference between any of them.) Moreover, it appears that the powerful Philips organization in Holland, which has devised its own "two-subcarrier" system, is now virtually won over to the N.T.S.C. system. In a paper describing their experiments with a 625-line version, they stated the definite opinion that such a system would be the best one for introduction in Europe.

Bandwidth Requirements

A question which seemed to concern a great many contributors to the Symposium was the bandwidth of colour television signals—particularly with regard to the subjective requirements of the viewer in picture sharpness and clarity. Here the general view seemed to be that the bandwidth of the luminance, or brightness, signal could be considerably smaller than that generally laid down for existing monochrome transmissions. For example, a paper from the Sylvania-Thorn company (Britain) described subjective viewing tests which found the optimum bandwidth for 405-line monochrome pictures, viewed at ten times the picture height, to be only 1.5 Mc/s (and for 625-line pictures only 3.0 Mc/s). In colour pictures a B.B.C. communication stated that if the chrominance component is given our full 3-Mc/s bandwidth, then the luminance component can be somewhat degraded before any loss of sharpness becomes visible. An R.C.A. paper mentioned that some statistical redundancy in American television pictures can be removed simply by passing the video signal through a 2-Mc/s low-pass filter and the result is still very acceptable. All this was confirmed, said a representative of one British receiver manufacturer, by the fact that the buying public do not seem to show any preference for commercial receivers with wider bandwidths.

The point here seems to be that in the N.T.S.C. system there is really no need for the colour subcarrier signal to share the same band as the brightness (monochrome) signal because the viewer's eye is unable to perceive the brightness information over the shared part of the video spectrum. In other words the brightness signal could be band-limited at the optimum point so that the two signals would not overlap and there would be no sub-carrier interference problem. It is well known, of course, that American monochrome receivers do in fact achieve this effect when displaying compatible N.T.S.C. pictures by virtue of their somewhat restricted video bandwidths.

High Definition Pictures

The idea was illustrated in another way by the demonstration of the French 819-line N.T.S.C. system, with its exceptionally wide 10-Mc/s monochrome bandwidth. Glancing at the compatible picture on a black-and-white receiver, one was almost impelled by the extreme fineness of detail to view it at close quarters—much closer than ten times the picture height—but then the disadvantage of the wide bandwidth became immediately apparent in the marked visibility of the colour sub-carrier dot pattern.

Incidentally, it was perhaps significant to hear two representatives of British television broadcasting privately, enthusing over the French 819-line monochrome pictures, which at their best are undoubtedly superior to the best we can do on 405 lines and 3-Mc/s bandwidth. On the other hand, it was observed that the higher definition does not seem to offer much advantage in colour television—particularly when the R.C.A. tri-colour tube with its restricted resolution of 400 lines is used as a display device.

Indeed it is true to say that most of the existing colour display devices leave much to be desired in general performance, quite apart from the question of cost. A comparative paper from Hazeltine in the U.S.A. put the single-gun beam-switching and beam-indexing tubes first in order of performance, followed by the three-gun focus-grid tube, the three-gun shadow-mask tube and finally the three-tube projection system. This was also roughly the order of increasing cost. A representative of Pye, however, disagreed with the low performance assessment of projection systems. Describing a large-screen projection equipment using three Schmidt-type optical systems, he mentioned that the problem of accurate registration had been largely overcome by making all adjustments mechanical in form so that any drifts resulting from electrical controls were eliminated. This equipment used large dichroic mirrors for optical superimposition, but another speaker said he had used side-by-side Schmidt systems successfully (with

optical correction) and thereby gained in light output, definition and contrast ratio.

Another problem in registration, but this time in direct-viewing colour c.r. tubes, is to get the electron beam to fall accurately on the required phosphor at all points without energizing adjacent colours. An improved tube described in a Philips paper gave a "post focusing" action between a mask (comparable with a shadow mask) and the screen. The focusing was obtained by slits in the mask of almost elliptical shape and a reducing voltage gradient between the mask and screen. Because the holes in the focusing mask were larger than in the R.C.A. shadow mask, a considerable improvement in transparency was obtained (actually a transparency of 60 per cent), but since the screen potential was reduced by a factor of 4 there was not an equivalent gain in brightness. However, further improvements were being made by the introduction of a second mask.

A difficulty comparable with registration is the accurate matching of the gamma characteristic in the three electron guns of a tri-colour c.r. tube or in three separate projection tubes. Discrepancies can cause errors, particularly in the reproduction of brightness information. A subjective viewing test described in a Mullard paper was designed to discover what differences were permissible between the transfer characteristics of the three primary-colour channels of a colour system, and this led to the conclusion that the tolerances on tube manufacture would be very tight indeed.

At the transmitting end, there are equivalent difficulties in the registration and matching of the three camera pick-up tubes, and any discrepancies are particularly noticeable in the quality of the composite black-and-white picture. A paper from Telefunken (Germany) emphasized the desirability of using just a single tube with a three-colour filter to avoid this situation but here of course the optical and instrumental difficulties are enormous. The photoconductive pick-up tube was said to have great possibilities for three-colour cameras, and a new type using a layer of lead monoxide for the light-sensitive element was described in another Philips paper. This tube was characterized by its high sensitivity, fast response at low light levels and negligible dark current. The usual problem of storage in photoconductive tubes was overcome because the decay of the signal after interruption of light was primarily determined by the discharging scanning beam and not by the inherent inertia of the photoconductor itself.

Receiver Performance

It was disappointing to hear no results of the B.B.C. experimental transmissions on the N.T.S.C. system, but one British receiver manufacturer (G.E.C.) described subjective viewing tests which took advantage of these transmissions to discover permissible tolerances in colour receiver performance. In particular the phase stability of the local colour reference oscillator is important because it controls the hue of the displayed colours. Deliberate phase changes were made gradually to simulate drift and it appeared that the more discriminating viewers would not tolerate more than a $\pm 5°$ variation in phase angle. At the same time, there was a range of adjustment as wide as 30° over which they were willing to actually *set* the reference phase control for optimum colour reproduction. Viewers' ideas of what constituted pure white on the screen were somewhat varied, and changed with the room lighting. The results, moreover, were not centred round the official Illuminant "C" on the C.I.E. chromaticity diagram.

The G.E.C. contributors had also investigated the subjective effects of noise in colour television receivers. Another kind of interference, resulting from multi-path reception, was discussed in a paper from the Swiss P.T.T., who had taken advantage of the Swiss mountains to study the effect of this phenomenon on the frequency spectra of monochrome television signals. A swept frequency oscillator was used at the Band-I transmitter and the disturbances resulting from the multi-path propagation were assessed statistically from measurements at various domestic receivers. It was concluded that for colour television the narrower the bandwidth of the colour signal the better. These effects, of course, are likely to create quite a problem in any future colour services in Bands IV or V.

For colour television recording, a method using a lenticular film was described in a paper from the Eastman Kodak Company. The film has a fine cylindrical lenticular pattern on one side and its emulsion on the other. Three primary colour component images are directed on to the lenticular surface from different angles and they appear on the emulsion as three separate sets of interlaced thin bands—the exposure in each case corresponding to the primary colour content. One big advantage is the speed and simplicity with which the film can be developed and copies can be made.

Electronics in Automation

Viewpoint on the Brit. I.R.E. Convention

THE introduction of digital computers into process control systems was probably the most significant thing discussed at this year's Brit. I.R.E. Convention. Significant, because it is a definite step in the direction of Norbert Wiener's imaginative forecast of ultimate automation to which we drew attention two years ago*—the overall control and co-ordination of complete factories by electronic systems comparable with large-scale digital computers.

Hitherto digital computers have been isolated in laboratories and business offices and used merely as aids to human calculation. Even when employed for production planning in factories they have needed human supervisors to feed in and take out information. But there are signs of a change in this situation. Already engineers are beginning to explore the possibility of incorporating digital computers directly into control loops so that more variables can be taken into account than by ordinary servo-mechanisms.

Many people think that digital computers are

* "The Automatic Factory," *W.W.* August 1955.

inherently too slow for operation in "real-time" control systems. This idea was refuted by one speaker at the Convention who described a "real-time" digital computer which received its input information from shaft rotations (coded into digital form) and gave an output which directly operated an electro-hydraulic servo-mechanism. The "real time" in this instance did not mean instantaneously but extremely fast—the process of addition, for example, taking only 40μsec.

This high speed was attained by using the "parallel" mode of operation (all digit pulses of a number advancing simultaneously on separate wires instead of in sequence on one wire). The programme of instructions was built into the connections and very little storage capacity was required because of the direct manner of receiving, processing and despatching the numerical data. High-frequency transistors were used for the logical circuits and the whole machine occupied only about one-third of a cubic foot.

The technique of feeding information directly into a digital computer from measuring instruments, instead of via the medium of punched cards on tape, was mentioned by another speaker, who described how an existing business machine (the Elliott "405") was adapted for this purpose. The output, incidentally, was used to operate an analogue type of plotting device.

Conveyer-belt Systems

In some applications, the "real time" could mean something really slow—for example, in the control of manufacturing processes based on conveyer belts. One of the Convention papers discussed the control of a conveyer-belt system in which the products on the belt could be varied in design (e.g., different paint colours on motor-car bodies) according to the day-to-day fluctuations in demand from customers. In the control apparatus the slow movement of the conveyer belt was simulated by a storage medium moving equally slowly past a complexity of "reading" and "writing" heads connected to the digital computer. Numerically coded information about the items on the belt was "written" by the computer at corresponding places on the storage medium. As a particular item reached a "decision point" on the belt, the stored information on what was to be done at that point came to a reading head, which gave out the appropriate signals for actuating the process.

Another paper considered the use of computers in control systems applied to continuous-process chemical manufacturing plants. Here the object was to keep the plant output as near as possible to a desired specification. The outputs from local control loops already existing in the plant would be continuously monitored in a scanning sequence and compared in the computer with the desired values for the product. According to the results, the computer output would be used to apply correcting signals to the control-loop equipment. It was felt that electronic circuits using such components as transistors and cryotrons would be desirable in this application so that voltages could be kept to low values for safety reasons.

A particular feature of computers used for this type of production control would be a multiplicity of input and output devices distributed about the factory. One speaker went further and suggested that the computing circuits themselves would probably have to be decentralized and distributed in a similar manner.

In order to feed information from measuring devices into digital computers it is usually necessary to convert an analogue type of indication into digital form. When, say, the angular movement of a shaft has to be measured, this can easily be done by using a commutator disc or "digitizer" on the shaft. When the output of a measuring transducer is in the form of a varying voltage, however, it is necessary to use an all-electronic converter. A high-speed electronic converter described in one paper was basically a servo-mechanism using a non-linear feedback element. The voltage to be measured was compared with a voltage analogue of a number held in a register. Any resultant error signal was used to gate digit pulses into the register in such a way that the error was reduced to zero. Thus the number in the register increased and decreased in accordance with the input voltage variations.

A somewhat sophisticated digital measuring technique described in another paper gave its output as a ratio, or as a percentage of some reference value. For this, independent sources of pulses were counted and then compared. The device was said to have applications in revolution counting and tachometry and where comparative measurements have to be made between driving and driven apparatus. Another rather complex type of digital measurement under discussion was the evaluation of correlation functions from statistical operating data taken from different points in a control system. This could be used, for example, for determining the transfer function of a control system while it was still in operation. Correlation computers are traditionally analogue devices, but greater accuracy can be obtained from digital methods, and a digital machine was described which accumulated the sum of products of pairs of numbers for this type of evaluation. It operated in the decimal scale, using Dekatrons for the arithmetic circuits. Working on pairs of two-digit decimal numbers, it could accumulate 100 products per minute.

Analogue Techniques?

The emphasis on digital computers in control loops is perhaps rather unexpected when analogue computers seem at first more obviously suited to the purpose. Analogue computers do have certain applications in continuous-process control loops, but, as one paper pointed out, when the manufactured product consists of a number of items, each with a particular identity, then these machines are quite inappropriate. It is the arithmetical accuracy, ability to perform logical operations and facility for storage of data and instructions which make the digital machine more suited to the complex organization of overall control.

Many other aspects of automatic control and inspection were discussed—machine-tool position control, ultrasonic inspection, pH control, fluid density measurements, to name just a few. It was, however, rather surprising to find a whole day's session devoted to simulators. If these come under the heading of automation then *Wireless World* gives up all hope of discovering what automation really means.

WORLD OF WIRELESS

Medical Electronics

AN international organization to foster the application of electronics to medicine is being formed by Dr. V. K. Zworykin, the well-known American pioneer in electronic television. Interviewed recently by *Wireless World* in Paris, Dr. Zworykin said he felt that electronics should be applied more directly than it has been to the benefit of humanity. Already he has been instrumental in establishing a Medical Electronics Centre in the Rockefeller Institute for Medical Research in New York. The aim here is to develop new electronic techniques for the medical world without any form of commercial exploitation and already several devices have been produced on this basis. Dr. Zworykin has also composed a bibliography of medical electronics literature. He hopes to organize an international conference on the subject, possibly at the time of the 1958 Brussels Exhibition.

Further Education

WITH the opening of the scholastic year in September, we have received prospectuses of radio and electronics courses from a number of polytechnics, colleges and other bodies.

The Northern Polytechnic, Holloway, London, N.7, has introduced a one-year evening course (one evening a week) covering the audio-frequency engineering syllabus, Part 5, for the Brit. I.R.E. Graduate Exam. The television engineering course (evenings) has been extended to two years and now includes the fundamentals of colour systems.

Among the short courses provided at the South-East London Technical College, Lewisham, S.E.4, is again one on transistors and their applications. The College also has a four-year C. & G. electrical technicians' course in which specialization in industrial electronics is provided.

Details of evening courses on v.h.f. techniques, radar maintenance, and radio and television servicing, plus full-time day courses in telecommunication engineering are given in the prospectus issued by the Norwood Technical College, London, S.E.27.

Courses in preparation for the Radio Amateur Examination are again being provided at the Brentford (Middlesex) Evening Institute, Ilford (Essex), Literary Institute and Northwood (Middlesex) Evening Institute.

NATIONAL RADIO EXHIBITION

(Earls Court, Aug. 28th—Sept. 7th, 11 a.m.—10 p.m.)

WIRELESS WORLD SHOW NUMBERS

September: Show Guide (publication date August 27th). Plan of the stands with stand-to-stand guide to the exhibits.

October: Show Review (publication date September 24th). An assessment of trends in the design of television and sound receivers.

I.E.E. Premiums

APPROXIMATELY a third of the awards made by the I.E.E. for papers read, or accepted for publication, during the 1956-57 session are for contributions in the radio and electronics field.

Two papers on signal-noise ratio in radiotelegraphy have won for H. B. Law, of the G.P.O. Research Station, Dollis Hill, the Kelvin Premium (£25). Mr. Law also shares the Fahie Premium (£10) with his Post Office colleagues, J. W. Allnatt and E. D. J. Jones, for their paper "Frequency diversity in the reception of selectively fading binary f.m. signals."

For their paper "Fading of long-distance radio signals and a comparison of space- and polarization-diversity reception in the 6-18 Mc/s range," Dr. G. L. Grisdale (Marconi's), J. G. Morris (Government Communications Headquarters), and D. S. Palmer (Marconi's), receive the Duddell Premium (£20). Professor H. E. M. Barlow (University College, London), is awarded the Ambrose Fleming Premium (£15) for "Hall effect and its counterpart, radiation pressure, in microwave power measurement." There were also ten extra premiums, valued at £5 each, awarded for papers presented to the radio and telecommunication section.

Tape Exchanges

DURING the past five years various organizations have been formed, both in this country and abroad, to encourage the exchange between individuals of tape recordings.

World Tape Pals, which issues a bi-monthly publication *Tape Topics*, was founded in Dallas, Texas, in 1952. The British representative is Roger D. Smallwood, of 28, Wrekin Road, Sutton Coldfield.

The only British organization is the recently formed British Amateur Tape Recording Society, of which E. Yates, of 210, Stamford Road, Blacon, Cheshire, is general secretary. The society is issuing a tape-recorded bulletin—playing time, one hour—and also a quarterly tape "magazine" for blind members.

B.A.T.R.S., the Voicespondence Club (Noel, Va., U.S.A.), and the Australian Tape Recordists Association (Adelaide), are the founder members of the International Association of Recording Clubs.

In addition to the American clubs already mentioned there are Tape Respondents International, United Recording Club, International Tape Worms, and National Tapespinners.

Amateur Recording Contest.—Copies of the rules and entry forms for the Concours International du Meilleur Enregistrement Sonor, which is organized by the world's amateur recording associations, are obtainable from H. J. Houlgate, 12, Strongbow Road, London, S.E.9, on receipt of a stamped addressed envelope. Last year two British entries won prizes in this international contest organized to find the best amateur examples of recording techniques for various subjects. The closing date for entries is September 15th.

I.G.Y. Broadcasts.—Warnings of expected increases in solar activity and declarations of Special World Intervals, issued by the Royal Society during the International Geophysical Year, are being broadcast by the B.B.C. at 11.03 p.m. in the Home Service after the news and before the weather forecast. These announcements supplement the communications system already established by the World Warning Agency.

Test transmissions from the site of the I.T.A. station being built at St. Hilary, Glamorgan., to serve South Wales and the West of England will start on September 2nd. The station will operate in Channel 10 (199.75 Mc/s vision, 196.25 Mc/s sound). The test transmissions will be radiated from an aerial mounted at a height of about 350 feet on the partially completed 750-foot mast, and will have an e.r.p. of about 1 kW. It is hoped to start programme transmissions from the station before Christmas.

Scottish Television.—With the opening on August 16th of the B.B.C.'s television station at Rosemarkie, near Inverness, the coverage of the Scottish television service will increase to 93% of the population. The station, which is the B.B.C.'s seventeenth, will operate in Channel 2 (vision 51.75 Mc/s, sound 48.25 Mc/s) with horizontal polarization and an e.r.p. of 1.5 kW. Test transmissions will be radiated from 10.0 a.m. to 1.0 p.m. each weekday from July 31st until the station is brought into service.

Welsh V.H.F.—A site at Cyrn-y-Brain, near Llangollen, Denbigh, has been chosen by the B.B.C. for the north-east Wales v.h.f. sound transmitter. It is expected that the station will be brought into service by the autumn of next year. It was originally intended to build the station at Corwen, Merioneth., and to transmit only the Welsh Home Service, but it is now planned as a three-programme station radiating on 88.9, 91.1 and 93.3 Mc/s with an e.r.p. of 6 kW.

Television licences increased by 68,390 during May bringing the total to 7,118,698. The overall number of broadcast receiving licences in the United Kingdom, including those for television and 312,528 for car radio, was 14,583,256 at the end of May.

1958 Audio Fair.—Next year's London Audio Fair will again be held at the Waldorf Hotel, but it will be for five days instead of four (April 18th to 22nd). A day will be reserved for trade buyers, overseas visitors and the press.

Northern Audio Fair.—Plans are being made to hold a three-day Audio Fair at the Grand Hotel, Harrogate, from October 25th. Particulars of this show and next year's London fair are obtainable from Audio Fairs, Ltd., 42, Manchester Street, London, W.1.

Band IV television from the Television Society's transmitter installed at the Norwood Technical College are being discontinued during the summer vacation, but will be resumed on September 9th. The transmissions, which are radiated on 427 Mc/s, vision, and 423.5 Mc/s, sound, and consist of Test Card C and a tone, will be on Mondays, Wednesdays and Fridays from 7.0 till 9.0.

Mobile Radio.—Reference was made at the British Electrical Power Convention at Eastbourne to the growing use of v.h.f. radio-telephony by the electricity supply industry. There are now 99 fixed stations and well over 1,000 mobile transmitters in use by electricity boards.

Amateur Television.—There are now 32 amateur television transmitting stations in the U.K. A list of call signs and locations is given in the summer edition of *CQ-TV*, issued by the British Amateur Television Club.

Circuit details, or instruction manual, of the Eddystone 358X receiver is being sought by a reader. Information should be addressed to M. Osborne, c/o The Editor.

Electronic Telephone Exchanges.—The Post Office has entered into an agreement with five telephone equipment manufacturers for the pooling of ideas with the object of "designing the best possible electronic switching system," and to this end a research committee has been set up under the chairmanship of the Post Office engineer-in-chief. This is recorded in the annual report of the Telecommunication Engineering and Manufacturing Association.

Computer Society.—Last year the London Computer Group was formed and from this has now grown the British Computer Society with headquarters at 29, Bury Street, St. James's, London, S.W.1. The primary object of the Society is to "further the development and use of computational machinery." Among the members of the provisional council is Dr. A. D. Booth, of the Birkbeck College Computational Laboratory.

Computer Exhibition.—Plans for this country's first Electronic Computer Exhibition, to be held at Olympia, London, from November 28th to December 4th next year, include an international technical symposium organized by the National Physical Laboratory. It is also proposed to hold a business computer symposium arranged by the sponsors of the exhibition, the Radio Communication and Electronic Engineering Association and the Office Appliance and Business Equipment Trades Association. Incidentally, the Exhibition is non-profit making and any excess of receipts over expenditure is to be returned to exhibitors.

Thorn-Champion.—Rumoured change of ownership of the Champion Electric Corporation was confirmed when Thorn Electrical Industries (makers of Ferguson receivers) announced on July 8th their acquisition of a group of three companies—Champion Corporation, Newhaven Cabinet Works, Ltd., and Austin Clark (London), Ltd.

Thorn-Bendix.—An agreement with Bendix Aviation Corporation, of the U.S.A., permits Thorn Electrical Industries to manufacture the Bendix range of A.N.. Pigmy and Unitor connectors.

Soviet Television.—According to a note in *Soviet News*, which is issued by the Soviet Embassy in London, the U.S.S.R. now has 24 television stations and a further ten will be opened this year. In April there were about 1.5M television receivers in the Union.

"Operation Smoke-Puff" is the title given to a series of tests being undertaken in the United States to establish two-way radio communication by reflecting signals from man-made ionized clouds produced by releasing nitric oxide gas from rockets. Members of the American Radio Relay League are participating in the tests which are sponsored by the U.S. Air Force.

Audio Engineering.—This year's convention of the Audio Engineering Society of America, at which some fifty papers will be presented, is to be held in conjunction with the New York High Fidelity Show. Both will be held in the New York Trade Show Building from October 9th to 12th.

U.S. Electronics Conference.—The 13th annual National Electronics Conference will be held from October 7th to 9th at the Hotel Sherman, Chicago. Information on the Conference and the associated exhibition is obtainable from the N.E.C., 84 E. Randolph Street, Chicago 1, Illinois, U.S.A.

Interkama—an International Congress and Exhibition of Measuring Instrumentation and Automation—is being held in Düsseldorf, West Germany, from November 2nd to 10th. Particulars are obtainable from Nordwestdeutsche Ausstellungsgesellschaft m.b.H., Ehrenhof 4, Düsseldorf.

I.E.E. Students.—The 1957-58 chairman of the London Graduate and Student Section of the I.E.E. is F. L. Fielding, of Standard Telephones & Cables, and the honorary secretary, L. A. Harris, of Marconi's.

I.E.E. Council.—The new president of the I.E.E. is T. E. Goldup, a director of Mullard, and Dr. Willis Jackson, director of research and education, Metropolitan-Vickers, is elected a vice-president for the second term of three years. Those elected to fill the vacancies among the ordinary members of the council include F. C. McLean, deputy chief engineer, B.B.C., and C. E. Strong, chief radio engineer, Standard Telephones & Cables, who was a member of the council from 1949 to 1953.

Radio Section Committee.—The new chairman of the committee of the I.E.E. radio and telecommunication section is Dr. J. S. McPetrie, and the new vice-chairman M. G. L. Pulling. The three vacancies among the ordinary members of the committee will be filled by R. J. Halsey, an assistant engineer-in-chief at the G.P.O., Dr. B. G. Pressey (Radio Research Station, Slough), and W. E. Willshaw (G.E.C.).

B.S.R.A. Committee.—New members of the executive committee of the British Sound Recording Association are F. Langford-Smith, appointed a vice-president, and G. W. Higgs, E. F. R. Lilley and C. W. Morle elected members. J. F. Doust continues as president.

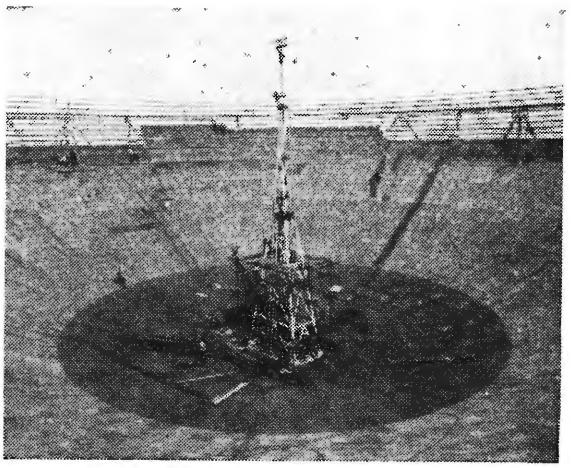
C. and G. New Headquarters.—A site has been secured at 76-78, Portland Place, London, W.1, together with the premises at the rear, for the new headquarters of the City and Guilds of London Institute. It is planned to be ready for occupation early in 1959.

"Foreign Attachments."—In the past telephone users in the U.S.A., as in this country, have not been permitted to fit "foreign attachments" to telephone instruments except in certain circumstances. The Federal Communications Commission has, however, now ruled that the telephone companies must permit the use of devices which do not impair the operation of the telephone service.

Recommended materials and finishes for telecommunication and allied electronic equipment and components are listed under "new work started" in *B.S.I. News* issued by the British Standards Institution.

FORTHCOMING EVENTS

National Radio Show (R.I.C.) Earls Court, London, S.W.5.	**Aug. 28–Sept. 7**
Engineering, Marine, Welding & Nuclear Energy Exhibition Olympia, London, W.14.	**29–Sept. 12**
Farnborough Air Show (S.B.A.C.) Farnborough, Hants.	**Sept. 3–9**
British Sound Recording Association Exhibition and Convention. Waldorf Hotel, London, W.C.2.	**Sept. 20–22**
Conference on Automatic Measurement of Quality in Process Plants (Society of Instrument Technology), University College, Swansea, Glamorgan.	**Sept. 23–26**
Radio Hobbies Exhibition (R.S.G.B.), Royal Horticultural Society's Old Hall, London, S.W.1.	**Oct. 23–26**



RADIO TELESCOPE—The interior of the 250ft diameter bowl of the fully steerable radio telescope at Jodrell Bank, Manchester (now nearly complete), showing the 60ft aerial mast with two dipoles at right angles for simultaneous observation on 90 and 170 Mc/s.

PERSONALITIES

T. E. Goldup, C.B.E., elected president of the Institution of Electrical Engineers for 1957/58, is a director of Mullard, which he joined in 1923. He had been a vice-president of the Institution since 1952. Mr. Goldup is particularly interested in technical education and training, and has been a member of the board of governors of the Ministry of Supply's College of Electronics, Malvern, since 1949, and chairman of the board since 1952. Mr. Goldup, who was appointed C.B.E. in 1954, was from 1950 to 1954 a member of the Radio Research Board of the Department of Scientific and Industrial Research.

J. S. McPetrie, Ph.D., D.Sc., the new chairman of the committee of the radio and telecommunication section of the I.E.E., has been head of the radio department of R.A.E., Farnborough, since 1950. For the previous six years he was superintendent, signals research and development in the Ministry of Supply, prior to which he was for a short time radio-physicist on the staff of the British Joint Services Mission in Washington. From 1925 to 1943 Dr. McPetrie was at the National Physical Laboratory.

M. J. L. Pulling, O.B.E., M.A., who becomes vice-chairman of the I.E.E. radio and telecommunication section, has been senior superintendent engineer (television) with the B.B.C. since 1949. After leaving Cambridge University in 1929 he went into industry and was for a few years with Murphy Radio, where he was in charge of production testing. He joined the engineering division of the B.B.C. in 1934 and was for eight years superintendent engineer (recording) prior to being appointed to his present position.

J. N. Aldington, B.Sc., Ph.D., F.Inst.P., M.I.E.E., managing director of the new company Siemens Edison Swan, Ltd., joined Siemens at Preston in 1923 as an analytical chemist in the lamp works laboratory. Dr. Aldington was appointed head of the company's lamp research laboratories in 1935 and in 1949 was elected to the board of Siemens Electric Lamps and Supplies, Ltd. Three years later he became managing director of the company, and when, in 1955, it ceased to act autonomously, he became managing director of Siemens Brothers, the parent company. He is also chairman of Submarine Cables, Ltd., which is jointly owned by Siemens Edison Swan and the Telegraph Construction and Maintenance Company.

In addition to those mentioned last month, **Air Commodore A. V. Harvey,** C.B.E., M.P., a director of Mullard, Ltd., since 1950, was created a Knight Bachelor in the Birthday Honours, and **J. A. Dunkley,** senior development and experimental engineer at R. B. Pullin & Company, was appointed M.B.E.

News from the Industry

Siemens Brothers & Company and the **Edison Swan Electric Company** have now finally been merged into a single company to be known as Siemens Edison Swan, Ltd. It will be recalled that in 1955 Siemens Brothers joined the Associated Electrical Industries group of companies, of which Edison Swan has been a member since 1928, and that last year a temporary company, Siemens-Ediswan, Ltd., was set up to co-ordinate the activities of the two companies. The new company, of which Dr. J. N. Aldington is managing director, has been divided into 18 "product divisions," each specializing in a particular type of equipment. Each division will have a chief engineer, manufacturing manager and sales manager, but there will be a single research organization for which three blocks of buildings are being built at Harlow New Town, Essex. The director of research is Dr. T. E. Allibone.

British Tungsram Radio Works, Ltd., West Road, Tottenham, London, N.17, announce that in consequence of the merger, of Siemens and Edison Swan, Tungsram valves will no longer be distributed by Siemens but by its own distribution organization.

British Communications Corporation have been awarded a contract for the supply of a large quantity of multi-channel recording equipment for the Ministry of Transport and Civil Aviation. The equipment, which will be used for air traffic control, provides for the simultaneous recording of up to twenty channels on a single tape.

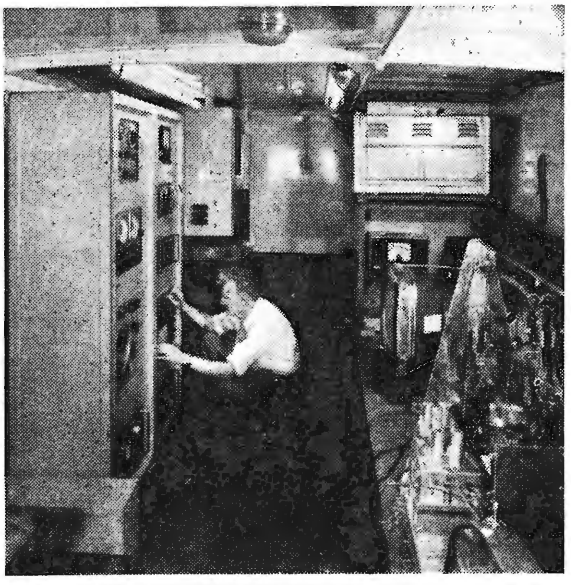
Avo, Ltd., is the new name adopted by the Automatic Coil Winder & Electrical Equipment Company, manufacturers of the well-known series of Avo test and measuring instruments and Douglas coil-winding equipment.

Amphenol (Great Britain), Ltd., has been formed jointly by Gas Purification and Chemical Company and Amphenol Electronics Corporation (of Chicago) for the handling of Amphenol components in the British Commonwealth (except Canada) and on the Continent. Initially components will be imported, but it is planned eventually to manufacture in this country. Among the subsidiaries of Gas Purification and Chemical Company are Grundig (Great Britain), Wolsey Television and A.B. Metal Products.

Livingston Laboratories, of Retcar Street, London, N.19, have been appointed exclusive sales representatives for the United Kingdom by Hewlett-Packard Company, of Palo Alto, California.

Battery-operated industrial television equipment was recently installed experimentally in a Swiss train by Pye. Tests were conducted to assess the possibilities of its use for examination of inaccessible parts of the train especially whilst in motion.

Metro-Sound Manufacturing Company has been formed by M. S. Myers (until recently with Goldring Manufacturing Company) for the manufacture of gramophone accessories. The address is 64, Stoke Newington High Street, London, N.16 (Tel.: Clissold 1549).



ON THE SPOT investigations, to check the results of laboratory work on a.g.c. systems for 625-line television receivers, are being undertaken on the Continent by Mullards with a mobile experimental unit. The comprehensive equipment in the vehicle, which carries an extendible aerial system for Bands I and III, includes a line selector unit for the analysis of individual line waveforms and a line pulse generator used for measuring flywheel sync characteristics.

Radio Heaters, Ltd., manufacturers of Radyne radio-frequency heating equipment, have opened a new research laboratory at Wokingham, Berks, where they have their works. The services of the laboratory will be available to any potential industrial user of r.f. induction and dielectric heating equipment.

Plessey Company have transferred the production of their standard communication equipment from Ilford, Essex, to West End Mills, St. Ives, Hunts. (Tel.: St. Ives 2095.) P. A. Tremaine remains as unit manager.

Morganite Resistors, Ltd., announce the appointment of M. G. B. Mason as general sales manager and of Dr. W. W. Marshall, as manager of their technical department.

Marconi Instruments are building an extension to their factory at Longacres, St. Albans, Herts., which will provide an additional 22,000 square feet of manufacturing space.

EXPORT NEWS

G.C.A.—Three British manufacturers working together have secured a contract for the supply and installation of a complete ground-controlled approach system for one of the airfields of the Royal Rhodesian Air Force. Standard Telephones and Cables are responsible for the overall planning of the G.C.A. installation and are supplying the precision approach radar, Cossor are manufacturing the surveillance radar and International Aeradio are supplying the control and communication equipment.

Public address equipment, incorporating facilities for simultaneous interpretation, for the new Paris headquarters of U.N.E.S.C.O. is to be supplied by Pamphonic Reproducers.

Electronic control equipment for machine tools is being shown by E.M.I. Electronics at the Machine Tool Exhibition to be held in Hanover, West Germany, in September.

Electro-acoustic apparatus, including domestic broadcast receivers and sound reproducing equipment, is amongst the consumer goods to the value of nearly £6M which Yugoslavia is permitting to be imported this year. The names and addresses of Yugoslav organizations participating in the scheme are obtainable from the Board of Trade, Commercial Relations and Exports Dept., Horse Guards Avenue, London, S.W.1. (Ref. C.R.E. 5919/56.)

An Alternative Colour TV System

BETTER QUALITY REPRODUCTION FROM NON-REDUNDANT COLOUR INFORMATION

By E. J. GARGINI*

THERE is a great temptation in Britain to adopt the American N.T.S.C. colour television system —suitably modified for 405-line standards—exactly as it stands. This would be very unwise, however, until the details of the system have been critically examined, particularly in the light of recent developments.

The author has been investigating colour systems with the ultimate aim of finding the best method of transmission to result in a simple and cheap domestic receiver—on which the success of colour television so much depends. In the course of this work several deficiencies of the N.T.S.C. system have come to light, and these have led to a proposal for an improved alternative system using a fundamentally different method of transmitting the colour information. However, the broad principle by which the N.T.S.C. system obtains its compatibility is retained—that of transmitting a luminance, or brightness, signal in the correct form for monochrome receivers, together with a colour signal providing the additional hue and saturation information required for colour receivers.

Three major features of the N.T.S.C. system are open to criticism, and these have already been discussed in *Wireless World*†. The first is the nature of the colour signal. This signal conveys colour-difference information—that is, differences from white—and is formed from colour-difference components E_R–E_Y, E_G–E_Y and E_B–E_Y (where E_R, E_G and E_B are the red, green and blue camera-tube outputs and E_Y is the luminance or "whiteness" signal). As colours become more saturated for a given brightness level, the E_R, E_G and E_B camera outputs become larger and more significant in the E_R–E_Y, E_G–E_Y and E_B–E_Y colour-difference signals, while the E_Y signal remains constant. Thus, any brightness detail in a saturated colour (e.g., dark shadows on a bright red curtain) will produce larger amplitude changes in the appropriate colour-difference signals than with a less saturated colour (e.g., the same shadows on a pale red curtain of equal brightness). In other words, the brightness information, which properly belongs in the luminance channel, is carried increasingly by the colour signal. Since in the N.T.S.C. system the colour signal is band-limited by filters to give a narrow-band colour signal—and hence slower rates of change—the result is that with saturated colours a good deal of the brightness detail (to which the eye is particularly sensitive) is completely lost.

In the proposed alternative system this particular disadvantage is avoided by transmitting a colour signal which carries no redundant brightness informa-

* E.M.I. Research Department.

† "N.T.S.C. Colour Information," by E. L. C. White, February, 1957, issue.

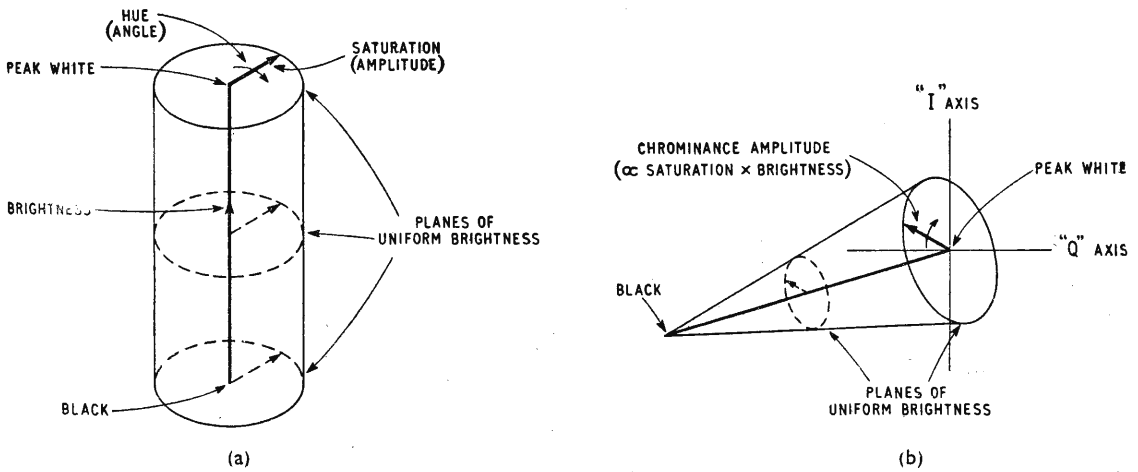


Fig. 1. Three-dimensional vector diagrams illustrating the difference between a chromaticity signal (a) and a chrominance signal as used in the N.T.S.C. system (b).

tion. Consequently only true colour information—that is, hue and saturation—is conveyed. For this reason the colour signal is called a *chromaticity* signal, as distinct from the *chrominance* signal of the N.T.S.C. system. The difference between the two is illustrated by the three-dimensional vector diagrams in Fig. 1. Here the colour signal vector represents hue by its phase angle and saturation by its amplitude. In the chromaticity signal (a) the colour signal amplitude is not influenced by different brightness levels, but in the chrominance signal (b) the amplitude is determined partly by the colour content and partly by the brightness.

Gamma Correction

The second feature of the N.T.S.C. system under criticism is the composition of the luminance signal. This is formed from a mixture of the red, green and blue camera-tube outputs (actually $E_Y=0.59E_G+0.3E_R+0.11E_B$) which are first individually gamma-corrected. The fact that an inverse square-law correction is applied to the individual components of the luminance signal at the transmitter leads to inaccuracies in the displayed luminance information at the receiver. Moreover, if the individual gamma corrections are not balanced properly the displayed colours will alter in hue and saturation at different intensity levels. This problem does not arise in the improved alternative system, since the luminance signal is gamma-corrected after formation.

The third questionable feature of the N.T.S.C. system is the use of a sub-carrier inside the normal monochrome vision band. In American receivers it is well known that the video response is substantially reduced at the sub-carrier frequency so the effect of interference from the colour signal is not very severe. In addition, although the so-called " I " modified colour-difference signal has extended sidebands to convey the more detailed information which the eye can appreciate at the red end of the optical spectrum‡, this extra information is not, in fact, utilized in current receivers.

Consequently the N.T.S.C. system as used in America is not really a band-sharing system, but one in which colour information is virtually transmitted outside the monochrome band in the unused area close to the sound carrier. If the system were adopted in Britain, however, the wider bandwidth of the average domestic model would insufficiently attenuate the colour sub-carrier and thus permit a display of dot patterning.

Although this may not be a severe price to pay for colour broadcasting, the fact that the colour receiver must treat the colour transmission as an outside-the-luminance-band transmission, means that the luminance detail at the colour receiver is restricted. This band restriction comes about because the sub-carrier itself must not appear at the colour receiver c.r.t. control electrodes otherwise it will increase the brightness of the colour components upon rectification in any particular electron-gun assembly. Moreover, if the guns are in any way fed with unequal amounts of colour sub-carrier the colour balance will no longer be maintained at different brightness levels.

A further difficulty arises because in practice it is necessary to use a " notch " filter at the transmitter to prevent those brightness transients which produce components at frequencies close to the colour sub-carrier from beating with the receiver's synchronous-detection local oscillator and so causing low-frequency colour beat patterning. This filter inevitably reduces the bandwidth of the brightness signal.

If it were possible to use a 3-Mc/s colour sub-carrier in Britain, however, instead of one at 2.66Mc/s, most domestic receivers would display very little dot patterning. This, in fact, is what is proposed in the alternative system. Moreover the " notch " filter mentioned above is not necessary because the low-frequency colour beat patterning is reduced by other means. In the N.T.S.C. system the interaction between the brightness transients and the colour sub-carrier actually occurs because the sub-carrier is positioned in the single-sideband part of the monochrome band. This is avoided in the alternative system by removing from the colour signal the component most susceptible to interference —the hue information—and transmitting it over the double-sideband part of the monochrome band around the main carrier. It is clearly not possible to have a sub-carrier at the same frequency as the main carrier, so the method adopted is to transmit the change of hue angle by phase modulation of the main carrier. The 3-Mc/s sub-carrier is then merely concerned with conveying the saturation information —transmitted by amplitude modulation.

The complete signal of the alternative system has a frequency spectrum as illustrated in Fig. 2. Summarizing the situation, it can be said that the chromaticity information to be transmitted is separated into its two components, hue and saturation, and the hue is conveyed by phase modulation of the main carrier and the saturation by amplitude modulation of a 3-Mc/s sub-carrier just outside the normal monochrome video band.

It will be noted, first of all, that the chromaticity signals are restricted in bandwidth, compared with the luminance signal, in the same way as the chrominance signals in the N.T.S.C. system. This restriction takes advantage of the general principle that the eye is less sensitive to small colour detail than it is to small brightness detail, and that a sharp colour picture can be synthesized by combining blurred, or narrow-band, colour information with sharp or wide-band, brightness information.

Actually the rate-of-change of hue information has been restricted to a bandwidth corresponding to that

‡ The other modified colour-difference signal, called the "Q" signal has a narrower bandwidth and conveys the less detailed information required at the blue end of the optical spectrum.

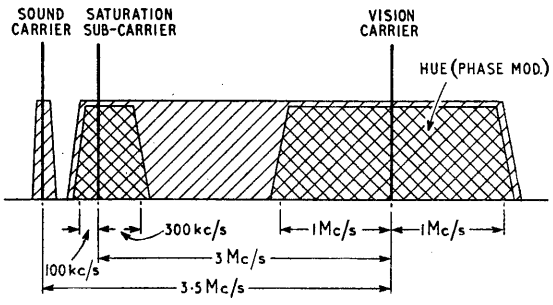


Fig. 2. Frequency spectrum of the proposed alternative system. The sub-carrier is at 3Mc/s instead of 2.66Mc/s as in the British N.T.S.C. system.

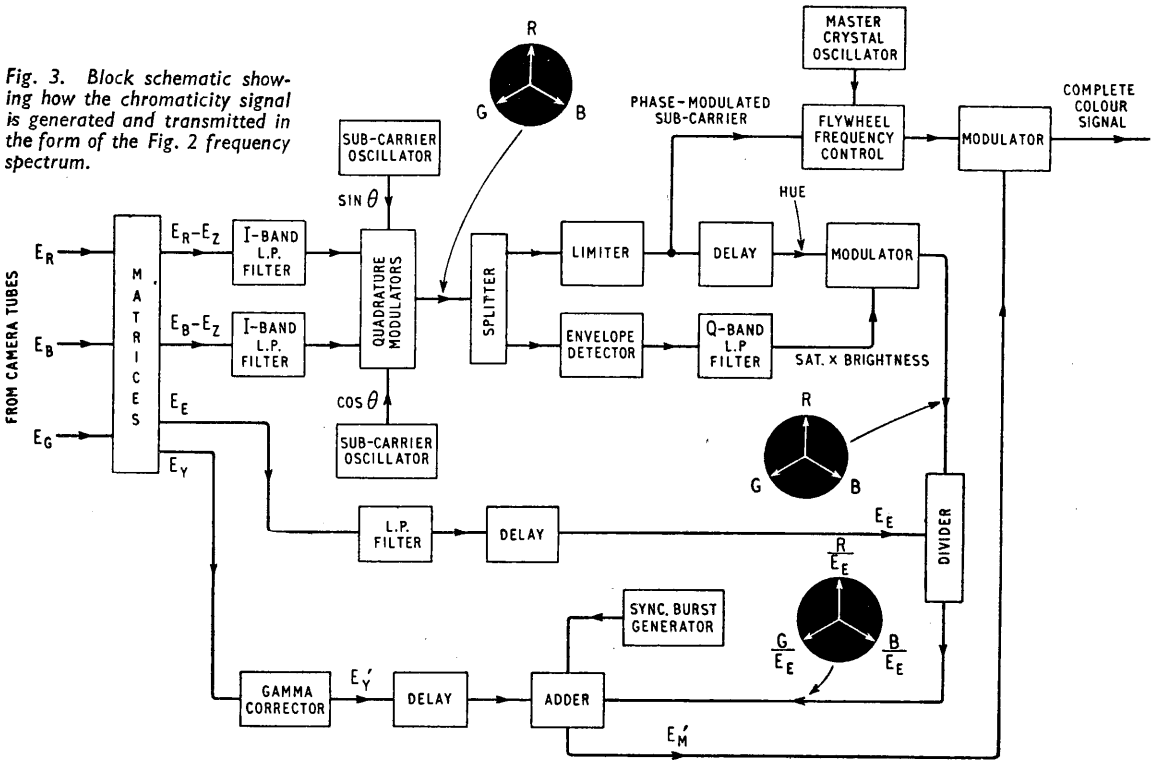


Fig. 3. Block schematic showing how the chromaticity signal is generated and transmitted in the form of the Fig. 2 frequency spectrum.

of the "I" modified colour-difference signal in the N.T.S.C. system, and the rate-of-change of saturation to a bandwidth corresponding to that of the "Q" modified colour-difference signal. This has been arranged purely for the purpose of comparative tests with the N.T.S.C. system. The fact that the saturation component is assigned the narrower band is mainly a matter of expediency—and it provides another reason why the transient hue information should be phase modulated on to the main carrier. With this arrangement it will be noted that the transmission of the colour information corresponds to the colour vector diagram in Fig. 1(a)—the hue being represented by angle or phase and the saturation by amplitude.

Signal Synthesis

It now remains to be shown how the chromaticity signal is manufactured in the form of hue and saturation components and how these are combined with the luminance information to form the complete colour signal in Fig. 2. A block schematic of the system is shown in Fig. 3. To begin with, the red, green and blue camera-tube outputs, E_R, E_G and E_B, are passed into proportional adding circuits known as matrices. Various proportions of these voltages are then combined to form three brightness type signals. The first is a luminance signal E_Y, as in the N.T.S.C. system ($E_Y = 0.59E_G + 0.3E_R + 0.11E_B$), the second is an "equal-energy" brightness signal, E_E, formed from equal amounts of the three camera outputs ($E_E = (E_R + E_G + E_B) \div 3$), while the third, E_Z, has a special composition which will appear shortly.

This E_Z signal is subtracted from E_R and E_B to form two colour-difference signals E_R-E_Z and E_B-E_Z, as shown. These are passed through low-pass filters which limit them both to a bandwidth corresponding to that of the I signal in the N.T.S.C. system. The two colour-difference signals are then used to amplitude modulate two components of a 3-Mc/s sub-carrier having a phase difference of 90° between them. The two modulated components are combined to produce a single chrominance-type signal at 3Mc/s which conveys hue information by its phase angle and saturation and brightness information by its amplitude. It differs from the N.T.S.C. chrominance signal, however, in that the composition of the E_Z signal is arranged so that the phase angles which represent the three primaries, red, green and blue, are equally spaced at 120° intervals. This arrangement is called a *symmetrical* colour-difference signal.

The symmetrical signal is passed to a splitter unit, one output of which is taken through a delay device, and the other to an amplitude detector. The output of this detector is the saturation × brightness component of the colour signal (see Fig. 1(b)) and has the character of a video type of signal. As the E_R-E_Z and E_B-E_Z components have been passed through "I-bandwidth" filters before modulation, it follows that the chrominance signal will possess phase and amplitude changes which are related to the rise times of the two component voltages. The detected saturation signal will therefore have a rise time which depends on the rise time of the original I-bandwidth modulation signals. Consequently this signal should be passed through a narrow-bandwidth filter to restrict the saturation × brightness amplitude rates of change to that of the Q band if a narrow-band saturation signal is desired as in Fig. 2.

The hue signal is formed by passing the chrominance signal from the splitter into a limiter circuit which limits on the first perceptible colour change from white (i.e., from zero amplitude). The output of this limiter, therefore, for any picture element other than white is a continuous 3-Mc/s signal, the phase of which is determined by the hue of the transmitted colour. This signal is next passed through a delay network to ensure that hue changes occur in step with the corresponding saturation changes and finally the restricted saturation signal is used to remodulate in amplitude the steady-amplitude hue carrier. A chrominance-type signal is thus re-formed which has the special feature that hue angle changes occur at a rate determined by the I bandwidth and saturation amplitude changes at the slower rate fixed by the Q bandwidth.

Segregating Colour Information

This signal now has to be converted from a chrominance-type signal, containing redundant luminance information, into a chromaticity signal. What is required is to remove the inherent modulation due to the brightness changes, and this is done by arithmetically dividing the instantaneous value of the chrominance signal by the instantaneous value of the E_E brightness or intensity signal occurring at the same time§. In other words, any changes due to brightness in the chrominance-signal "numerator" are automatically cancelled out by the same brightness changes in the "denominator," leaving just the changes due to pure chromaticity information.

Since the brightness rates-of-change in the "numerator" have already been restricted by a Q-bandwidth filter (used on the saturation × brightness information to give a narrow-band signal), it is obviously necessary to restrict the brightness rates-of-change in the "denominator" in the same way. This is achieved by passing the E_E signal through a low-pass Q-bandwidth filter, as shown, before it goes to the dividing circuit. (It is also passed through a "trimming" delay line to keep it in step with the "numerator" brightness changes.)

As a result of the division process a true chromaticity signal is produced, consisting of a 3-Mc/s oscillation modulated in phase by hue changes and in amplitude by saturation changes. It now remains to be shown how the hue and saturation components are separated as in Fig. 2. In the first place the 3-Mc/s chromaticity signal is added to the E_Y brightness signal (after the last-mentioned has been gamma-corrected), together with short bursts of sub-carrier frequency for colour synchronizing purposes. This gives the combined signal $E_{M'}$, which can be expressed mathematically as

$$E_{M'} = E_Y^{1/\gamma} + \frac{\sqrt{(E_R-E_Z)^2 + (E_B-E_Z)^2}}{E_E} \sin(\omega t + \theta)$$

where $\theta = \tan^{-1}(E_R-E_Z)/(E_B-E_Z)$, representing the changes of the hue phase angle.

The hue information, provided by the phase angle of the limited 3-Mc/s sub-carrier, is phase modulated on to the main vision carrier by means of a flywheel frequency control circuit‖, as shown, and the output of this is in turn amplitude modulated by the $E_{M'}$ signal. As a result of modulating an already phase-modulated carrier wave with the phase-modulated 3-Mc/s sub-carrier contained in the $E_{M'}$ signal, the transient phase modulation of the 3-Mc/s sub-carrier disappears. There remains only the saturation amplitude modulation of the sub-carrier, which appears as in Fig. 2.

Having transmitted a signal of the form shown in Fig. 2, we may now consider briefly the situation at the receiving end of the system. After the complete colour signal has passed through the usual r.f. and i.f. stages it is fed to a detector, which recovers the $E_{M'}$ signal as already defined—that is, an E_Y brightness signal plus a symmetrical chromaticity signal in which hue changes are I-bandwidth and saturation changes are of Q-bandwidth. Although originally the sub-carrier, considered as a transmitted signal, was modulated with the saturation signal only, the effect of heterodyning the steady-phase saturation signal against the hue phase-modulated main carrier at the $E_{M'}$ detector is to transfer automatically all the hue phase modulation, transmitted double sideband, to the sub-carrier signal.

This symmetrical chromaticity signal is synchronously detected, using a local 3-Mc/s reference oscillator, and the outputs are multiplied by an "equal-energy" brightness signal of the form E_E (necessary because of the division process at the transmitter). These operations subsequently yield the original E_R, E_G and E_B voltages which may be applied to the colour display device. The E_E signal at the receiver is actually derived by a converter circuit¶ from the received E_Y signal.

Lower Receiver Costs

It will be noted, incidentally, that the rate of change of colour information is determined by the transmitter filters, and no expensive filters or delay lines are required at the receiver. Nor is there any need, in certain receivers with single-gun colour tubes, for matrices as used in the N.T.S.C. system receivers. As far as the average monochrome receiver is concerned, there is substantially no sub-carrier to cause visual interference at the reproducing tube because of the considerable drop in the receiver's video response at 3Mc/s.

It would be an advantage in an alternative system to dispense with the colour sub-carrier altogether. This could be achieved by using the existing sound carrier as the colour sub-carrier as well as for conveying its own sound information. This is not possible with the existing 405-line system, in which the sound signal is broadcast as an amplitude modulation of the sound carrier. It is possible, however, to consider the inauguration of a new high-definition service in Band IV or V in which a number of changes could be made. For example, a 625-line system with brightness signals transmitted in the conventional vestigial side-band fashion, the hue component of the colour signal transmitted as phase modulation of the main vision carrier, the saturation signal transmitted as an amplitude modulation of the sound carrier, and the sound signal transmitted by the conventional 75-kc/s deviation of the f.m. sound carrier.

§ British Patent Application No. 10976/56.
‖ British Patent Application No. 19201/56.
¶ British Patent Application No. 6576/57.

Ionospheric Problems

By T. W. BENNINGTON*

APPLICATION OF IGY DATA TO RADIO COMMUNICATION

MANY geophysical phenomena are to be specially investigated during the course of the International Geophysical Year and among them are to be found several appertaining directly or indirectly to the ionosphere. From 1st July, 1957 to 31st December, 1958, ionospheric measurements of different kinds, and observations upon extra-terrestrial phenomena which affect the region, are to be made upon a world-wide scale, and from the mass of data thus accumulated it is hoped that much will be learned.

Our present knowledge of the ionosphere has been built up largely on the basis of the information obtained by the use of exploring radio waves; but much may be missed by such a process, for the echoes bring little information about the regions lying between the points where ionization maxima exist. Knowledge of the conditions within such regions is arrived at largely by deduction, which may not always be correct. Rocket flights into the ionosphere give different ideas as to the distribution of ionization with height, but the information so far obtained in this way is sparse. It is well, therefore, that the " radio " measurements to be made during the IGY will be supplemented by those obtained by flights into, and perhaps beyond, the ionospheric regions.

The IGY is, of course, mainly a scientific project, aiming to obtain more knowledge of the physical nature of the earth and its atmosphere and of the extra-terrestrial phenomena which affect them. But it is hardly conceivable that the ionospheric and other data obtained by this effort will not have direct application to the engineering problems of long-distance communication. And it must be admitted that communications engineers are sorely in need of more ionospheric information, for it cannot be claimed that their present techniques for making use of the ionosphere are by any means completely satisfactory. In this article, therefore, we will discuss one or two outstanding ionospheric problems which are of direct consequence in radio communication.

" Sporadic E ". One feature of the E layer about which little is known is that of the localized " clouds " of high ionization which frequently occur within the layer, and which are known collectively as "Sporadic E". This remains as perhaps the outstanding mystery of the ionosphere, for no real notion as to its cause yet exists.

The high ionization density of the sporadic E clouds are capable of reflecting radio waves of much higher frequency than is the normal layer. In fact, their ionization density is often high enough to " blanket " the wave from the F_2 layer, which lies higher up, and which would normally be the refracting medium for the wave in long-distance communication. Fig. 1 shows the highest frequencies which would have been reflected from the E, F_2 and sporadic E at oblique incidence during a day in June, as obtained from the vertical incidence ionospheric measurements made at a mid-latitude northern hemisphere station. It is true that during June sporadic E is especially prevalent in such latitudes, but it is seen that, for the greater part of the day, its MUF (maximum usable frequency) was far higher than that for the other layers. Thus, the sporadic E can modify the transmission mechanism for long distances in an important manner.

Over most of the earth's surface the sporadic nature of this phenomenon is most marked: it appears to form for no apparent reason, remain in being for up to several hours, then decrease in intensity and disappear. Nevertheless, in spite of this, it has some well defined general characteristics, which Fig. 2 will help to make clear. In point of fact, there appear to be several different types of sporadic

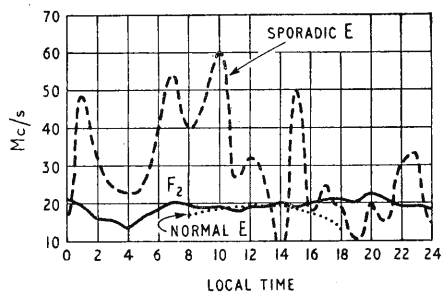


Fig. 1. Highest frequencies on which transmission could have been sustained during a June day at a mid-latitude northern hemisphere station.

E, even at a given location. There is certainly considerable difference between the types which predominate over different zones of the earth's surface, as is evidenced by, amongst other things, differences in the distribution with time of day and month of year. In the temperate zone, of which the location of Slough is typical, it is seen that the more intense sporadic E is largely a summer-time phenomenon, and, at that time, is chiefly prevalent during the day. In the auroral zones surrounding the geomagnetic poles, of which the Greenland station is representative, it is prevalent throughout the year, but is chiefly present at night, with a peak occurrence before midnight. At a station like Ibadan, near the geomagnetic equator, it is again prevalent throughout the year, but is largely confined to the daytime, with a peak occurrence around noon. In all zones it is often present for more than 30% of the time, and in the equatorial zone, during the daytime, has such a high degree of prevalence as to be practically a permanent feature of the daytime ionosphere. An ionospheric phenomenon such as this, capable of reflecting, at oblique incidence, frequencies higher than 25 Mc/s, and present over certain transmission paths for from 30% to over 90% of the time, is evidently of considerable importance, yet the

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means necessary for taking account of its effects are at present inadequate.

The pronounced diurnal and seasonal features in its occurrence rate point to some sort of solar control, but, on the other hand, its generally sporadic nature would seem to indicate that it is not directly caused by the sun. In the auroral zones the sporadic E occurrence has a high degree of correlation with auroral and with geomagnetic activity, and both of these phenomena are almost certainly due to the action of solar corpuscles which, on arriving in the vicinity of the earth, are carried by its magnetic field towards the geomagnetic poles. So the auroral sporadic E may also be due to the effects of these corpuscles upon the atmospheric gas. But over the rest of the earth's surface there is no such correlation, and the origin of the "clouds" remains unknown. Various possibilities have been investigated by different workers: for example, that they are due to electric energy discharged into the E layer from thunder-clouds in the troposphere, that they are a by-product of the large electric currents which circulate in the ionosphere, that they are caused by meteors or by ionospheric winds. Some evidence has been presented in support of each of these possibilities, but none has been by any means proven.

Night-time E Layer. In general, the behaviour of the E layer closely resembles that of a Chapman layer, in which the maximum ionization is proportional to the square root of the cosine of the sun's zenithal angle. This follows from a consideration of the rate of ion production by the absorption of solar radiation by the gas molecules, and of the rate of recombination and attachment, which depends on the density conditions in the atmospheric gas.

At the height of the E layer the gas is relatively dense, and during the day the ionization increases from a low value at sunrise to reach a maximum around noon, and to fall again to a low value around sunset. After sunset it would be expected to continue falling rapidly, and shortly to disappear entirely; but in point of fact, after falling rapidly for a time the rate of decay gradually diminishes until, sometime before sunrise the ionization appears to assume a constant value. The result is that the E layer has a low but definite ionization level throughout the night. It would appear, therefore, that there is a component in the E layer ionization which has a different recombination rate from that of the main body of the daytime ionization, and is due to a different cause, and that, after dark when the ionization due to the sun has disappeared, it is this which is maintained. Its origin is not, however, known, though it has, for many years, been thought to be due to the influx into the atmosphere of countless numbers of small meteors which, by reason of their high velocity, could ionize the gas atoms. It would seem that the ions produced in this way have a lower ionization potential and, therefore, a slower recombination rate, than those produced by the sun, and that, in this way, the ionization could be maintained. This night-time E-layer ionization is, at any rate, of considerable importance in communication, and particularly so in the new system which uses ionospheric scattering as the transmission mechanism, for this scattering occurs, both by day and night, in the ionization "turbulences" permanently existing in the E layer.

Ionospheric Disturbances. Long-distance communication via the ionosphere is subject to relatively frequent dislocation and interruption due to the effects of ionospheric disturbances. Yet little definite is known about the major kind of disturbance experienced; or, at least, insufficient is known about its cause and the mechanism of its production to be put to much practical use. If, for example, it were possible to tell within a day or two, or even within several hours, that such a disturbance were coming, extenuating measures could often be taken to prevent its worst effects.

Ionospheric disturbances are of two distinct kinds, though one kind is often associated with the other, and both have their origin in the sun. The sequence of events in their occurrence may be somewhat as follows.

An eruption occurs on the sun, usually near a visible sunspot, and the eruption itself may be observed as a solar flare. The electromagnetic radiation from it covers a wide range of frequencies, in addition to those of the visible light, including

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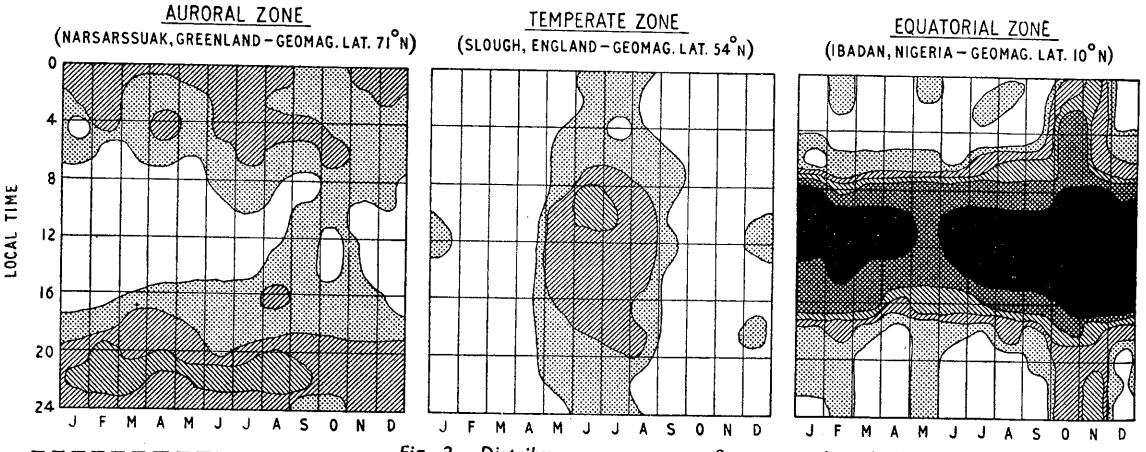


Fig. 2. Distribution, during 1955, of sporadic E (critical frequency 5 Mc/s) with time of day and month of year for auroral, temperate and equatorial zones.

some far into the ultra-violet part of the spectrum. This latter penetrates into the earth's atmosphere to the level of the D layer, where it temporarily raises the ionization to a very high level. Radio waves travelling through this much enhanced ionized region, where, at the same time, there is a high density of neutral gas molecules, are subject to a greatly increased amount of absorption, due to the frequency of the electron/molecule collisions which they engender, and the resultant dissipation of their energy as heat. They therefore fail to reach the ground again, and communication is interrupted by what is called a " sudden ionospheric disturbance." The condition giving rise to this does not last long, however, for the burst of solar radiation usually dies down within a few minutes and, the recombination rate at the height of the D layer being high, the abnormal ionization within it usually disappears within an hour.

The sequence of events so far is pretty clear and well established, and, since the incidence of solar flares varies with the degree of sunspot activity we should expect that of the sudden ionospheric disturbances to correlate with sunspot activity also. Fig. 3 shows that, in general, there was, over the years 1947 to 1956, a good correlation between the Annual Sunspot Number and the annual number of sudden ionospheric disturbances.

But the latter is not the cause of the major interruptions to which h.f. communication is subject (since it is of such short duration). At the same time that the electromagnetic radiation from the flare occurs there is also emitted from the solar atmosphere, according to present ideas, a stream of corpuscles, which, in the form of a cone-shaped jet, has the disturbed solar region at its apex. Though the corpuscles constituting it possess individual charges the stream as a whole is neutral, and the corpuscles travel with a velocity of approximately 1,600 km/sec. The earth in its orbit encounters this stream (if it is emitted in such a direction that this is possible) about 26 hours later. As the corpuscles approach the earth they are affected by its magnetic field, and are swept towards the magnetic poles, so that the effects which they produce are more intense in zones surrounding the magnetic poles (the auroral regions) than elsewhere. These effects are of several kinds, viz.:

1. Disturbances in the earth's magnetic field (magnetic storms).
2. Disturbances in the ionosphere (ionospheric storms) consisting of abnormal decreases in the ionization level and in the height of the F_2 layer, giving rise to deteriorations in h.f. radio propagation via that layer.
3. Displays of the polar aurorae and the setting up of abnormal earth currents.

All these phenomena, it should be noted, are different effects due to a common cause, the origin of which is a flare (or a sunspot region with which it is associated) on the sun. This type of ionospheric disturbance constitutes the major form of interruption to h.f. radio services, since it generally lasts for one or two days, and sometimes for as long as a fortnight.

The problem of forecasting these disturbances, which, given an up-to-date knowledge of the positions of sunspots and the occurrence of flares, might appear to be a simple one, is, in fact, very difficult. This is because, whilst the sequence of events leading to them appears often to be as just described, in many other cases it appears not to be so. Many ionospheric storms occur without there being a flare or even a sunspot on which to pin their occurrence, and, on the other hand, many

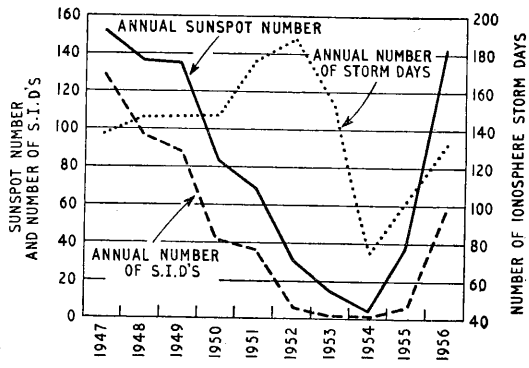


Fig. 3. Variation with sunspot activity in number of sudden ionospheric disturbances and in number of ionospheric storm days.

sunspots cross the solar disc without giving rise to any ionospheric disturbance. In short, the solar/terrestrial relations appertaining during the build-up and course of ionospheric storms are not yet properly understood, and it is well appreciated that the solar phenomena mentioned (and other solar data obtained by visual and radio means) do not correlate well with ionospheric disturbances.

In Fig. 3 the dotted curve is a plot of the annual number of days affected by ionospheric storms. In 1947, when sunspot activity was at a maximum, the number was high, having increased considerably from the previous sunspot minimum, and this was, no doubt, due to the connection of many storms with sunspots. But in 1951 when the sunspot activity was decreasing sharply, the number of storm days was increasing, and continued to increase in 1952. Only towards sunspot minimum in 1954 did the number of storm days decrease to a very low value. The 1952 peak in storm days corresponds with the well-known fact that, during the declining phase of sunspot activity, many storms of a type quite unconnected with sunspots occur. These storms show a very marked tendency to repeat themselves at 27-day intervals, and the mean period of the sun's synodic rotation, that is after allowing for the earth's motion in its orbit, is 27.3 days. Thus it is apparent that the cause of the storms is a certain region on the sun, which will always be " pointing " at the earth at approximately 27-day intervals. But these solar regions—called M regions—show no significant observable features to distinguish them from the rest of the visible disc, unless it be, as has occasionally been observed, a localized magnetic field, which may be a clue as to the special activity of the region.

Fig. 4 may be of interest in this connection. During 1953 the ionospheric storms associated with solar M regions were much in evidence, and 6th May marked the beginning of such a storm, as was evidenced by a deterioration in h.f. reception over transatlantic circuits. By calling this day and the next five days occurring at 27-day intervals from

i

t " zero days ", and by taking the average reception quality for these circuits for the six periods about these zero days as shown, the full-line curve was obtained. This shows that there was a marked deterioration in reception during the periods following the days at 27-day intervals from 6th May. In 1955 the M-region storms had subsided and the storms which occurred may have been due to sunspots. A disturbance started on 25th May and, in the same manner as described, the dashed curve was plotted for the average of reception during six periods at 27-day intervals from it. The dotted curve is that giving the average reception during the periods around six zero days which were the days following the central meridian passage of six large sunspots during 1955, which occurred at May 21.3, June 16.4, Aug. 10.9, Oct. 7.0, Oct. 28.8 and Nov. 13.6. Neither the dashed nor the dotted curves show any significant reception variation connected with the zero days, the inference being that during 1955 there was neither a marked 27-day recurrence tendency in the ionospheric storms, nor any marked connection between the storms and the passage of the six sunspots across the sun's central meridian.

It is of interest to note that geophysicists are able to distinguish the *magnetic* storms associated with M regions from those due to other solar causes, such as sunspots. The latter are usually of the type with a sudden commencement (S-C type) as though they were produced by the sudden beginning of a corpuscular stream, whereas the recurring storms are more often of the non-S-C type, as though

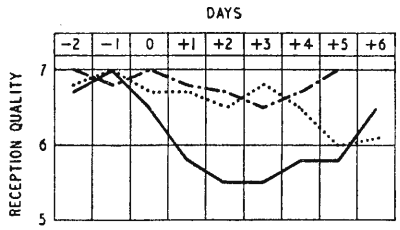


Fig. 4. Superposed epoch curves for quality of h.f. reception from eastern America based on the first day of the following events:

Full-line curve: Six 27-day intervals from 6th May, 1953.
Chain dot curve: Six 27-day intervals from 25th May, 1955.
Dotted curve: Day following CMP of six large sunspots 1955.

Reception quality: 7 = good; 6 = fair to good; 5 = fair.

produced by a persistent and long-lived stream. It has not, however, been possible to distinguish different types of *ionospheric* storms in this way, except by reference to their magnetic counterparts.

It will be gathered from the above—and that is the point of this discussion—that much remains to be learnt about this interesting subject, and the solar-terrestrial relations require to be better understood, before much practical use can be made of the data.

These, then, are three ionospheric problems affecting radio communications. And there remain, of course, many others. The IGY world-wide data should, when analysed and co-ordinated, throw some helpful light upon some of them.

French Air Show

New Electronic Developments at the 22nd Salon International de l'Aeronautique

VISITORS to aeronautical exhibitions are now accustomed to a large proportion of the apparatus shown being of an electronic nature and for new systems and devices to appear each year. However, although electronics are now more important than ever for the successful and safe operation of aircraft, a period of stabilization is being reached when the accent is more on the improvement of apparatus and its reliability than on new devices.

This position was confirmed at the 22nd Salon International de l'Aeronautique held at Le Bourget aerodrome near Paris recently, where aeronautical electronic equipment from a number of countries was shown. Specifications of apparatus were more comprehensive than hitherto, and guarantees of satisfactory performance at altitudes in excess of the existing world's record were given for some of the apparatus exhibited. As an example, for such a simple device as a 75-Mc/s marker receiver aerial for use with radio ranges and instrument landing systems (ILS), Collins supply curves of the v.s.w.r. over a temperature range between −60°C and +60°C together with a polar diagram of reception. S.T.C. quote the aerodynamic drag of their Bent Sleeve v.h.f. aerial as 6.25 lb at 400 m.p.h. The operating life of the American DF301 airborne DF equipment is quoted both in terms of stability before readjustment of pre-set controls is required and in terms of minimum operational hours before removal for a bench test is needed, these characteristics being equated to the *g* forces, vibration and acoustic noise of very high-speed aircraft.

An examination of the latest airborne radio equipment shows that much thought is being given to rapid servicing facilities, not only for military apparatus but also for that used in civilian aircraft. If it is borne in mind that the Boeing Type 707 jet air transport is designed to carry 55,000 passengers per year across the Atlantic (equivalent to the number carried by a large ocean-going liner) the small amount of time which this aircraft can be on the ground for servicing will be appreciated. The introduction of this aircraft into regular service in the very near future will probably bring about drastic

changes in aeronautical radio and radar technique, as well as in equipment design, as it will fly at twice the altitude and twice the speed of existing airliners. As these aircraft will be entering control zones where aircraft of much slower speed are flying and, due to their high speed, will only be visible for a relatively short period on surveillance radars, their early identification will be essential. At present the procedure for identification is for aircraft to carry out a turn while under observation from the radar; such a manœuvre would of course be unsuitable for the fast jet aircraft and to meet the new requirement Collins have introduced their Type 621A Air Traffic Control Interrogator-Transponder. With this system a directional aerial and associated transmitter and receiver are installed at the ground radar site and the aerial rotation is synchronized with that of the surveillance radar. The ground station sends out a pair of spaced pulses on a frequency of 1,030 Mc/s which is received in the aircraft. The reply is sent back from the aircraft on a frequency of 1,090 Mc/s and consists of a group of 2 to 8 pulses, each spaced by 2.9 μsec.

Exhibits at the Paris Salon showed that transistors are gradually finding their way into aircraft equipment where they are making an important contribution to the reduction in the size of units. A typical fully transistorized item of airborne equipment was shown by Collins in the form of their "Interphone" which measures $12\frac{9}{16}$ in deep, $2\frac{1}{4}$ in wide and $7\frac{5}{8}$ in high and weighs about 5 lb.

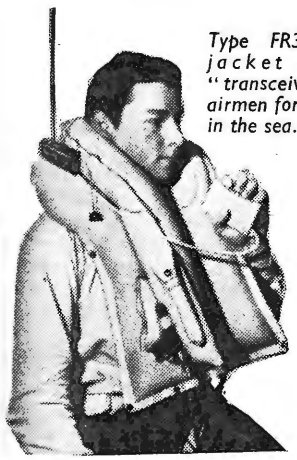
For medium frequency operation transistors in their present state of development work satisfactorily and it is therefore logical that a fully transistorized radio compass should be produced for airborne use. Lear Incorporated appear to be the first manufacturers to introduce such an instrument; it is their model ADF100. A total of 23 transistors is used with the Type 2N247 in the radio frequency stages, the Type 2N139 in the i.f. amplifier and a 2N158 supplying the AF output of 150 mW. In this receiver 80% of the circuits are of etched type and of standardized (modular) construction with plug-in units to facilitate servicing. The performance of the ADF100 is equal to that of a conventional instrument, the full band from 1,705 to 190 kc/s being covered, with a sensitivity varying between 10 and 20 microvolts for a 50-milliwatt output. The compass bearing accuracy and sensitivity are $\pm 2°$ with a signal of 50 microvolts per metre. The total weight of the equipment is under 20 lb and its current drain does not exceed 0.75 A.

Doubtless transistors will find increasing uses in aircraft, not only for radio and radar units but also for instrumentation and servo mechanisms. S.T.C. exhibited a device in this latter category, the type A1205 Transistorized Aircraft Catastrophic Warning Unit, designed to alert a pilot of an aircraft acoustically to an emergency. Normally this is done visually by warning lights on the dashboard, which illuminate in similar emergency circumstances. The A1205 Unit is connected into the circuit which normally operates these lights and it generates a sound closely resembling that of an alarm bell.

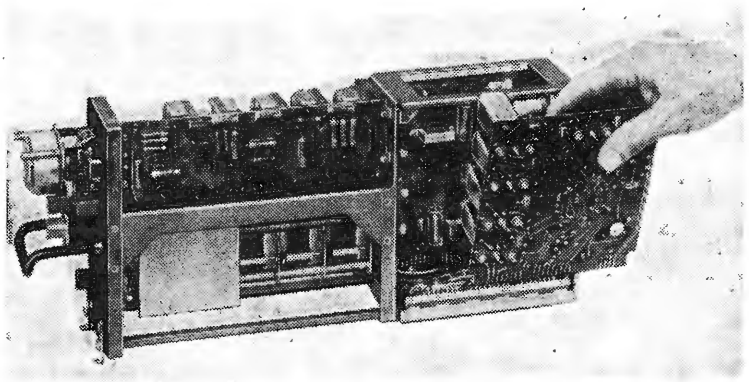
At the last Paris Salon in 1955, one prototype u.h.f. airborne equipment was shown for the first time publicly in Europe. This year one American and three French made airborne u.h.f. equipments were on view, in addition to a comprehensive range of u.h.f. ground station transmitters and receivers. The u.h.f. band lying between 225 and 399.9 Mc/s will be used exclusively by military aircraft eventually, but at present a large number of American aircraft operating in Europe are using this band for communications.

More Channels

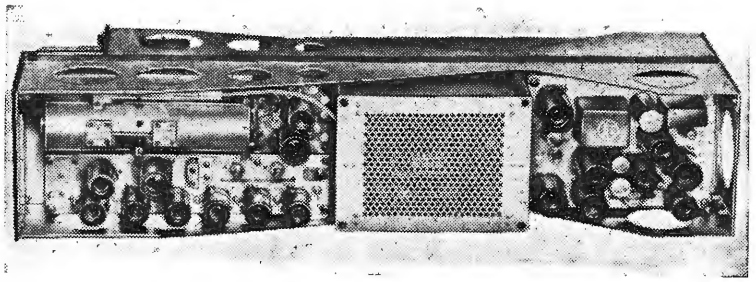
Operational needs with modern aircraft engaged on military duties are evidently very exacting, since, whereas in the 1939-45 war a total of 12 v.h.f. frequencies sufficed for most operational needs, today a total of 1,750 channels is required, any of which can be selected by the pilot, and 20 are needed for instant use. In addition, a guard-frequency receiver, entirely separate from the main receiver, is essential for command purposes. Such a specification has made it necessary to develop most advanced techniques in circuits and construction of sub-miniature units. In the American u.h.f. transmitter-receiver ARC52, pressurization is used to prevent flash-over at maximum altitudes of working, which are in the neighbourhood of 70,000ft. In all of the airborne equipments exhibited, printed wiring, modular construction and sub-miniature components are used. Pencil and sealed-disc valves are fitted in the r.f. circuits and cavity tuning is included in receiver input and transmitter output circuits. The table shows the main characteristics of these exhibits.



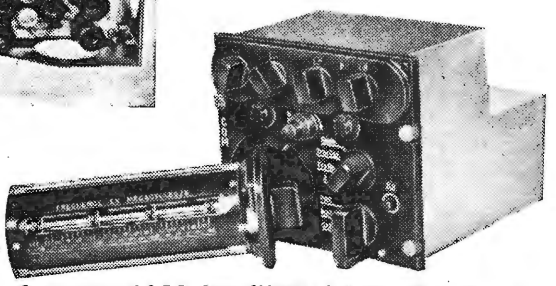
Type FR308 life-jacket beacon "transceiver" for airmen forced down in the sea.



Lear transistorized radio compass, Type ADF100.



Collins Type 621A Air Traffic Control Transponder for aircraft identification on ground surveillance radars.



Control box of S.F.R. Type SU205 u.h.f. aircraft equipment.

In the u.h.f. equipments at the Salon, all the control boxes are provided with a 20-frequency selector switch and also with a tuning arrangement consisting of four dials with which the hundreds, tens, units and tenths of megacycles are selected. The pre-setting of the 20 frequencies is very much simpler than with previous multi-channel apparatus, such as Service v.h.f. types, and is all done at the control box. A switch turret is removed and the contacts corresponding to each channel are adjusted to the frequency required by setting them up against a calibrated scale engraved on the turret.

To provide the 1,750 channels required, a master oscillator unit is used in current designs. Its output is multiplied and amplified directly up to the frequencies required for the first local oscillator in the double superheterodyne receiver. At the v.h.f. stage of multiplication some output is drawn for the transmitter and it is applied to a transposition stage where it is heterodyned with a crystal-controlled oscillator. This arrangement enables the same fundamental frequency to be used both for transmission and for the receiver local oscillator. The frequency of the master oscillator is held stable by a frequency-controlled stage consisting of a number of crystal oscillators operating into a phase discriminator. The output from this stage is used to control a reactor valve working directly on the master oscillator and also on the motor driving the variable tuning controls of the multiplier, amplifier and output stages associated with the transmitter; and the multiplier, amplifier and input stages of the receiver.

Make	Channels	Stability	Power output (watts)	Max. working altitude (× 1,000ft.)	No. of valves	Recvr. Sens. (μV)	No. of crystals	Weight
S.A.R.A.M. Type 7-50	20	±10 kc/s	15	65	—	5	—	25 kg
S.F.R. Type SU205	20	,,	10	—	65	5	18	25 kg
Derveaux Type 157B (pressurized)	20	,,	9	—	—	—	21	25 kg
Collins Type ARC52 (pressurized)	19	,,	20	70	43	5	36	23 kg

An interesting accessory to the u.h.f. airborne equipment, the Collins DF301, was shown for the first time in Europe. It presents bearing information on a normal radio compass dial display and has a bearing accuracy under service conditions of ±5°, and an "indicator hunt" of one degree on level flight. It is designed to operate to altitudes of 70,000 ft and between temperature limits of −55°C and +100°C.

The DF aerial, which in the form of a loop flush-mounted in the aircraft fuselage, receives the signal and a mechanically-operated switch reverses the polar diagram at a frequency of 100 c/s. This switching has the effect of modulating the signal with a square wave, the amplitude and phase of which varies with the angle of the aerial. The modulated signal is fed to the receiver where it is amplified and the r.f. component is removed. The 100 c/s square wave is then passed to a phase detector which in turn feeds a saturable transformer controlling the aerial drive motor, which can turn it in either direction, and which will find the null position when the input level to the receiver is constant and there is zero error signal. A synchronous transmitter associated with the aerial motor feeds the necessary voltage to the pilot's bearing indicator.

A useful outcome of the introduction of the u.h.f. radio compass is an improvement in the Air Sea Rescue service. It is now possible to home on to a u.h.f. signal and as a consequence of this development very small transmitters, such as the British Ultra "Sarah" and the Burndept "Talbe," have been designed which can be carried in the "Mae West" life jackets worn by Service pilots and which can be used to enable search aircraft to locate "ditched" airmen. A further example of these life jacket equipments is the Type FR308 made by Telecommunications Radioelectriques et Telephoniques. This model gives a tone-modulated transmission on the u.h.f. channel of 243 Mc/s, the international distress frequency, and also has facilities for the transmission of speech and for reception of u.h.f. signals. The speech sending and receiving facilities have been included for the practical reason that it is often easier for a "ditched" airman to see the search aircraft against a background of sky than for the search aircrew to see the man in the water against a background of sea, and it has been found that if the "ditched" airman can communicate with the aircraft he can often guide the aircraft to his position.

LETTERS TO THE EDITOR

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

Gramophone Reproduction

IN your June issue Mr. D. A. Barlow refers to my article in *Electronic Engineering* for May 1950 and he suggests that the three components of load on the walls of a gramophone record groove, the lateral stiffnes, the lateral inertia and the vertical stiffness, do not add but that they are largely complementary.

Consider Fig. 1 where a plan of a groove is shown cut with a pulse of long wavelength and large amplitude, and superimposed on this is a short wavelength modulation. This type of cut often happens with loud music passages. The force acting on the needle due to the long wavelength pulse is equal to the product of the horizontal stiffness of the movement and the amplitude of the pulse. The force acting on the needle due to the short wavelength modulation is equal to the product of the horizontal inertia of the movement and the acceleration of the needle; the latter should not be greater than that which will be obtained when the minimum radius of curvature of the modulation is approximately equal to that of the radius of the needle tip.

Now in position A, Fig. 1, it is true to say that the inertial force acts on one groove wall and the stiffness force on the other. But in position B this is not true and the two forces add. Thus the tracking weight must be sufficient to counteract these added forces.

Fig. 2 shows a plan of a groove and the consequent vertical motion of the needle due to the pinch effect. Without modulation of the groove the needle remains in its lowest position such as at C. If the needle is pulsed vertically then no extra tracking weight is required to hold the needle down, in fact the force between the needle and the groove is increased due to the action of the vertical stiffness of the cantilever. But suppose we have a modulation giving a large-pinch effect amplitude continuing for

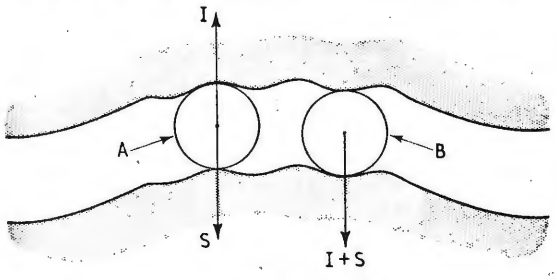


Fig. 1

a time longer than half the inverse of the low-frequency vertical resonance (and this happens often on records), then the pickup head will be raised and the needle will take up a mean position such as that shown by the line D and when the needle drops to a point such as E the vertical force on the needle will have been reduced by the product of the vertical stiffness of the cantilever and the maximum vertical amplitude (DE). This amplitude is not likely to be more than one-fifth of that I originally suggested, this later figure assumes a maximum velocity of cut of 20 cm/sec at 70 r.p.m. Unfortunately this reduction of vertical force occurs at a point when the force due to lateral stiffness and inertia is a maximum so that it is essential that the tracking weight counteract the sum of the three forces considered. Incidentally the vertical inertia may be ignored, not because it is unimportant but because its contribution to the tracking weight is small in the design of pickup considered. As the tracking weight is greater than the author suggests,

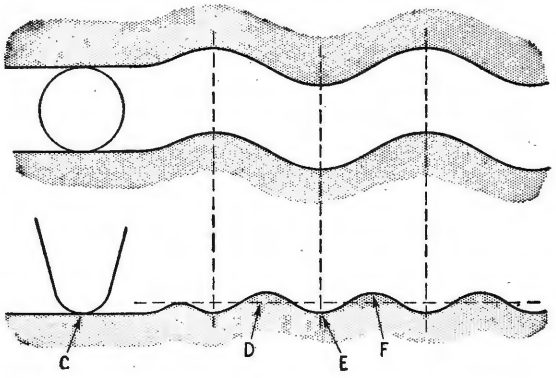


Fig. 2

the static load on the groove wall will be increased. Moreover the load will be greater still at points such as F, especially when there are only a few pulses of vertical motion. This makes the design of the pickup suggested even more difficult, perhaps impossible.

Be that as it may it is heartening to see yet one more article written by someone striving for better quality from gramophone records. The worst fault of present records is their radius or acceleration overmodulation. The recording companies are like a railway company who slowly improve their service from the "Rocket" days to the present time—the trains travel faster, are more comfortable, their meals become eatable—but they do not cure the unfortunate habit of laying their tracks with sharp corners so that the trains keep coming of the rails!

I maintain that some of the records cut before the war, e.g.—the Weingartner Beethoven Symphonies, are superior to most of those of the present day. On these old records there was a recording high-frequency cut-off at about 6,000 c/s and the modulation depth was lower than that of to-day, consequently there was no radius overmodulation. I would like better quality even at the expense of the high-frequency boost on recording which would give a noisier playback, or at the expense of the frequency response on recording which would give a consequent narrow playback frequency response, and then nobody could ask me to enthuse over the sound of pennies dropping or the spurious noises of orchestral instruments. However, as I grow older I tend towards the philosophy suggested in your June editorial and treat distortions as I do coughs and splutters in a live performance of music—something I do not like but which I must ignore.

Aldershot. E. S. MALLETT.

I FEEL that I should comment on Mr. D. A. Barlow's remark in the May issue that "it used to be the practice of record companies to monitor the original wax or lacquer disc before plating to make the master."

It was toward the end of 1922 that I joined J. E. Hough, Ltd., to organise the Radio Research Dept. That company (which later became Edison Bell, Ltd.) was then making Edison Bell records, gramophones, and also mouldings for the radio trade, and wished to make components and sets.

At that time, horn recording was used in the studio. That is, one or more horns were coupled to a special soundbox driving the sapphire cutting stylus directly. I had not been with the firm long before it occurred

to me that with a microphone, amplifiers and some cutting device actuated electrically (as the B.B.C. did its carrier), it should be possible to record a better representation of the original sounds.

The suggestion was well received and I was allowed to make experiments on the subject when my radio work permitted. So by 1924 I was in and out of the studio quite often and had first-hand knowledge of their methods.

By 1926, the new system which used a slack diaphragm condenser microphone and a moving coil cutter was being operated, and in 1927 I spent six months with duplicate equipment on a recording expedition to Zagreb, Jugoslavia, where I recorded over 600 titles. Other foreign expeditions followed and my last trip for Edison Bell was in 1933 to Scotland where we were recording for the Beltona label. Edison Bell ceased operations in the slump that year. I can therefore claim to have an intimate knowledge of recording as practised at Edison Bell in the decade ending 1933.

During the whole of that period master waxes were *never* played (monitored) prior to processing. Such an idea would have been condemned instantly by everyone connected with the work, for the wax used for making masters was very soft and would most certainly have been damaged most seriously.

The idea that waxes were monitored may have arisen from the fact that certain waxes were regularly played back. The waxes used for that purpose however were of a harder texture, were called test waxes and made a hissing noise while being cut. When the music had been selected, cut to fit into the time, the musicians rehearsed etc., the usual thing was to make a trial recording on to a test wax. This was then immediately played back to the artists on a special machine.

When I was recording, I allowed any master waxes spoiled by technical or musical faults to cool off and played them privately after the session before releasing them for re-shaving. This gave me a better check on the equipment, for the better wax with its silent background was more revealing than the noisy test wax.

Needless to say, in due time pickups and loudspeakers were used for the playback system, but no matter how delicate the pickup might be, satisfactory masters were *never* played prior to processing.

Lacquer discs are a subsequent development and I do not know what other companies did when using these. However, I would expect that the tradition that the master wax *must* be left intact would be carried forward indefinitely in professional circles.

Toronto. P. G. A. H. VOIGT.

Mobile Radio 25-kc/s Channelling Trials

THE report in your June issue (p. 256) regarding the Post Office trials of 25-kc/s mobile equipment, is not quite accurate. Trials, as recommended by the Mobile Radio Committee in fact commenced in May of this year, and are now under way using three adjacent channels in the low band and operating in the London area. They are being carried out with standard "Ranger" equipment manufactured by our Company.

The target 25-kc/s channelling specification referred to in the Committee's report, has been established with manufacturers' agreement, and is based on the same principles and requires the same degree of channel isolation laid down in the 50-kc/s specification. The Pye equipment has recently been approved to this 25-kc/s specification and some 500 "Ranger" mobiles meeting it are now in constant use in this country alone.

Our Company policy is to recommend 25-kc/s channelling equipment for all standard mobile schemes in this country even though the channels are at present spaced at 50 kc/s. At the same time all "Ranger series" equipment is readily convertible from one standard to another. In these circumstances users will have little difficulty in deciding which specification will give them maximum technical life and the minimum of channel sharing in the longer term.

Cambridge. J. R. HUMPHREYS,
Pye Telecommunications, Ltd.

Services Charges

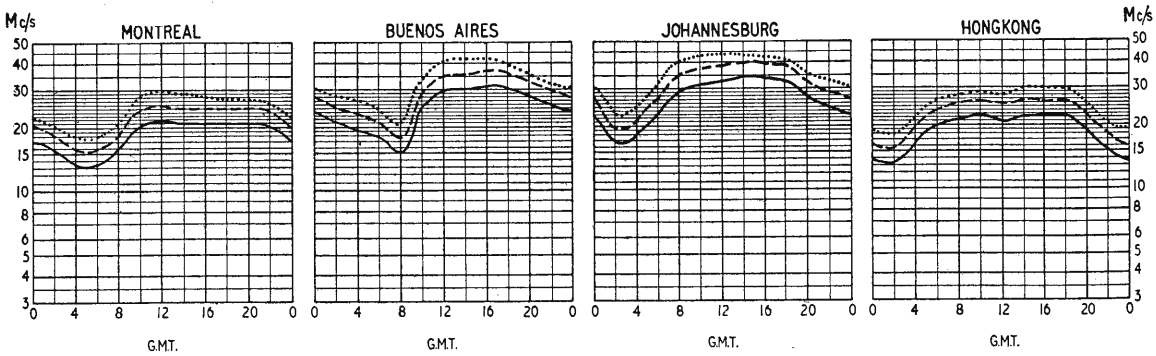
MR. MAYER, in his review of colour TV in the U.S.A., refers to the "lively imagination" of those who report that an engineer is required per set installed. Your contributor has made use of a good deal of the same thing in quoting £17 as the comprehensive service charge in this country for a black-and-white 17-in receiver.

My own company offers these facilities for £7 per annum; the dearest quotation I can trace is only £9.

It is to be hoped that his conclusions are not coloured by any other imaginative figures of conditions in the U.K.

Edgware. MAURICE SOKEL,
JMS Radio and Television, Ltd.

SHORT-WAVE CONDITIONS *Prediction for August*



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

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

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

— — — PREDICTED AVERAGE MAXIMUM USABLE FREQUENCY

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

Multi-Valve Cathode Follower Circuits

2—PRACTICAL DESIGN CONSIDERATIONS

By J. G. THOMASON, B.Sc.

(Concluded from p. 313 of the previous issue)

THE various cathode followers described so far may be classed as single-stage circuits since only one valve is directly providing loop gain, other valves (or neon tubes) merely improving the gain and signal-handling capacity of this valve.

Two-stage Cathode Follower.—Where a greater increase in performance is required, it is logical to try to add an extra stage to the cathode follower in order to secure a larger loop gain and feedback factor. It is not a straightforward matter of adding a stage to the forward circuit as in the conventional negative feedback system, since the negative feedback in the cathode follower is inherent with the configuration and not an external connection imposed by the designer. The only way in which negative feedback may be applied to two cascaded plain amplifying stages is by making a connection from the anode of the second valve to the cathode of the first valve. The output is taken from the anode of the second valve. Both valves now give gain in the forward circuit, which is superior to the use of local feedback in individual stages.

For operation at frequencies down to zero frequency, however, an anode output terminal is often inconvenient because of the inherent large positive quiescent voltage (say, +150 V). A simple resistive d.c. coupling network connected to a negative line can be used to obtain zero quiescent output voltage, but the price paid is a higher output impedance.

For this reason it is attractive to add an extra stage in cascade with the basic cathode follower and to make a shunt feedback connection from the cathode follower output to the grid of the first valve. A simple example of such a circuit is shown in Fig. 8, using the 12AT7 double triode. The gain of the outer negative feedback loop, via the two 1 MΩ resistors is about 12 and this reduces the output impedance of the overall circuit to about 16 ohms compared with the 200 ohms of the second triode as a simple cathode follower. The circuit will function as a feedback amplifier if the ratio of the feedback resistor (R_2) to feed-in resistor (R_1) values is increased above the figure of unity used in the circuit in Fig. 8. It may be shown that in any shunt feedback system the overall gain G is given by:

$$G = -\frac{R_2}{R_1} \cdot \frac{L}{1+L} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (9)$$

where R_1 and R_2 are the values of the feed-in and feed-back resistors respectively and L is the loop gain of the system. The minus sign indicates a phase reversal. By careful adjustment of R_1 and R_2 it is possible to make the circuit give an overall gain of exactly unity if required. This condition would only hold for a certain value of L, however, i.e.

$$R_2 = R_1 (1 + 1/L) \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (10)$$

The quiescent output voltage of the circuit (earthed input terminal) will be positive and equal to $(R_1 + R_2)/R_1$ times the grid bias on the left-hand triode e.g. approximately + 3.5 V for the circuit values shown, corresponding to a grid-cathode voltage of −1.75 V in the left-hand valve.

The circuit is a multiple-loop negative feedback system, but as the inner loop (i.e. the output stage cathode follower on its own) is stable and the outer loop remains stable whether the inner loop is operative or not, it is quite permissible to analyse the system disregarding the fact that the cathode follower stage derives its characteristics from an inherent feedback connection.

In this circuit, however, the input impedance is no longer determined by the inherent series feedback of the cathode follower but is controlled by the overall shunt feedback, giving a low input impedance (equal to R_1, approx.) which may limit the applications of the circuit as a buffer stage. Where it is desired to retain the high input impedance the added triode amplifier stage in Fig. 8 may conveniently be replaced by a long-tailed pair as shown in Fig. 9. The long-tailed pair (or " difference amplifier ") now performs the dual function of mixing, i.e. subtracting the input and feed-back voltages, and also providing extra gain for the external negative feedback loop. The long-tailed pair gives only half the gain of the single stage, but this loss is conveniently offset by changing to a low current high-μ valve such as the 12AX7, since one half is no longer

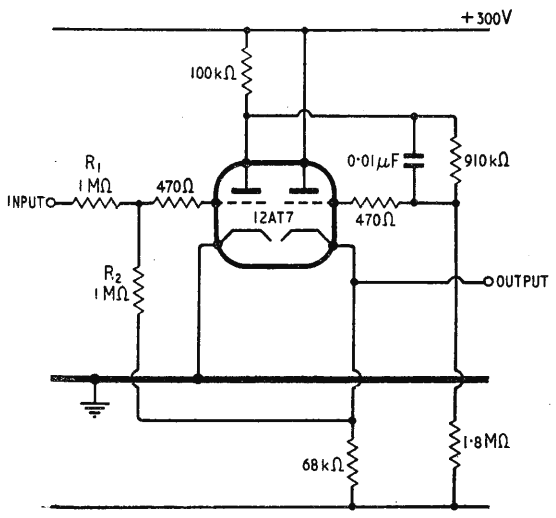


Fig. 8. Two-stage shunt feedback cathode follower.

required to function as an output stage. The loss of loop gain in the feed-back and feed-in resistors of Fig. 8 is eliminated and the circuit shown has a gain of 19 round the external loop. The feedback factor is thus 20, giving an output impedance of 10 ohms compared with the 200 ohms of the cathode-follower stage alone. Note that a control is provided for arranging to feed back only a fraction of the output voltage so that the finite feedback factor may be allowed for an exactly unity gain obtained.

A further useful feature of the circuit shown in Fig. 9 is its ability to provide a quiescent output voltage of zero. This condition is set up when the long-tailed pair is adjusted so that the two grid voltages must be equal for the current partition to be such that the anode voltage of the right-hand valve sits at the design value. The "balance" control shown enables this condition to be found since, for a given current partition, it varies the anode voltage of the left-hand valve and therefore its grid base with respect to the right-hand valve. This circuit is particularly useful where a simple buffer circuit is required which introduces neither attenuation nor d.c. shift. The long-tailed pair also assists in reducing drift due to heater fluctuations and cathode ageing, giving an improvement factor of about 10 compared with the single-ended circuits.

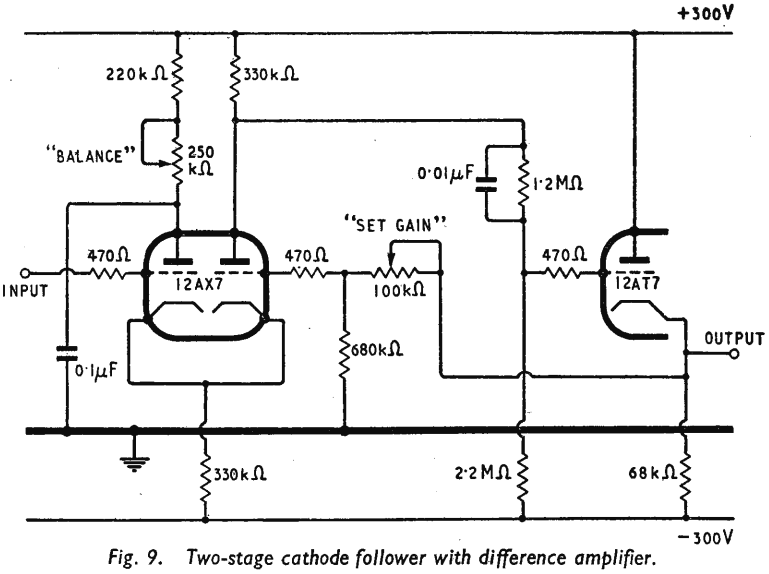


Fig. 9. Two-stage cathode follower with difference amplifier.

There are no stability problems with the multi-stage feedback circuits shown in Figs. 8 and 9. In the circuit of Fig. 8, there are two lags of almost equal time constant, at the amplifier triode anode and at its grid, a situation which can give a dangerously large phase lag when considering also the third small time constant lag at the cathode-follower cathode. The low value of loop gain in the circuit given, however, precludes the danger of oscillation and where a valve of higher gain is used, the lag at the amplifier stage grid could be removed by shunting R_2 with a 22 pF capacitor. The frequency response of the overall system is restored by similarly bypassing R_1 with the same value of capacitance. This stabilization method, of course, places an extra 22 pF capacitive load on the signal source.

The circuit of Fig. 9 is inherently more stable since there are only two lags, the lag of large time constant at the right-hand anode of the long-tailed pair (about 2μsec) and the lag of small time constant at the cathode-follower stage cathode (about 0.005 μsec).

In both circuits the capacitor in the d.c. intervalve coupling network prevents the formation of an extra lag at the cathode-follower grid, at the expense of increasing the time constant of the lag at the preceding anode. It is, of course, standard practice in negative feedback work to reduce the number of lags to the absolute minimum in the interests of stability.

Two Examples of Complex Multi-stage Cathode Follower Circuits.—When two amplifying stages are added in cascade with the basic cathode follower the individual phase reversals of the extra stages add to give no total phase reversal, and it is therefore possible to revert to cathode feedback in the first stage, as in the simple cathode follower or the two-stage a.c. circuit mentioned earlier. A simple version of this three-stage cathode follower is shown in Fig. 10, using a double triode to provide the two extra stages. Series feedback is provided by injecting almost the entire voltage from the output cathode follower into the input valve cathode. With the component values shown, the measured loop gain at 500 c/s is about 4000. At zero frequency the gain falls to about 700 due to losses in the inter-stage couplings and the local feedback caused by the cathode resistor of the input valve.

The input stage and second stage are both connected as low-consumption voltage amplifier stages, using the high-μ triode, 12AX7. The output stage is conveniently made a simple cathode-follower using a single triode, a pentode or a double triode. The output cathode-follower load is divided so that a fraction of the output may be fed back, to secure an overall gain of exactly unity for operation at very low frequencies. The quiescent output voltage may be adjusted to be zero by arranging cathode bias on the first stage as shown. With the input earthed, the 1.5 kΩ resistor and 1 kΩ potentiometer combination may be set so that their voltage drop is equal to the 1.6 volts grid bias required by the input stage plus the 3.1 volt drop across the 270-ohm resistor. The 100 μF cathode decoupling capacitor is effective for frequencies down to about 1 c/s, and at z.f. the stage gain is reduced to one-third approximately by the presence of this cathode biassing resistance.

The feedback loop is not inherently stable since there are three lags, at each of the amplifying stage anodes and at the output cathode follower cathode. Allowing 130 pF at the first valve anode, including anode-earth capacitance (0.4 pF), Miller effect at the grid of the second valve (110 pF), and wiring capacitance (20 pF), would give a lag of time constant:

(65 kΩ) (130 pF) = 8.5 μsec. (approx.)

The lag at the second valve anode is formed by,

(*Continued on page 375*)

say 20 pF capacitance to earth, giving a time constant:—

(65 kΩ) (20 pF) = 1.3 μsec. (approx.)

In both cases the anode-earth resistance is calculated as the value of the load resistance in parallel with the valve differential anode resistance (80 kΩ).

The time constant of the lag at the output is calculated from the differential resistance at the output stage cathode (100 ohms) and say 30 pF load capacitance, giving:—

(100 ohms) (30 pF) = 0.003 μsec. (approx.)

The phase advance provided by the cathode decoupling of the input stage and the two inter-stage couplings is arranged to be distributed over the band 1 c/s to 200 c/s (approx.) and does not affect the h.f. stability of the loop. The phase advance contributed by the 100 pF capacitor shunting the 270-ohm resistor is negligible at any frequency. The simple theory of the stability of the three-lag feedback loop indicates that with these three values of time constant, a h.f. loop gain of 2,940 (approx.) or higher will make the loop unstable. This critical value of loop gain L is calculated from the formula:—

$$L = (m + n)\left(1 + \frac{1}{m}\right)\left(1 + \frac{1}{n}\right)$$

where m and n are the respective ratios of the two larger time constants to the smallest one. In this design, stability has been achieved by the common method of increasing the largest time constant, in this case increasing the time constant of the lag at the input stage anode from 8.5 μsec. to 333 μsec (approx.) using the 0.005-μF capacitor shunting the anode load resistor.

The critical value of loop gain is increased to about 110,000, giving a generous gain margin and adequate bandwidth for most applications where circuitry with triode amplifying stages is considered appropriate. The phase margin is 90° over most of the cut-off interval. Low frequence stability is assured by the absence of a.c. couplings and the staggering of the phase-advance time constants. The output stage shown in Fig. 10 operates at 11.6 mA quiescent current and the overall output impedance is about 0.13 ohm at z.f., falling to about 0.025 ohm at 500 c/s.

The circuit shown in Fig. 10 has a very large loop gain at mid-band frequencies and if a smaller fraction of the output voltage is fed back, some of the loop gain may be conceded in exchange for overall gain. The reduced feedback is achieved simply by altering the ratio of the resistors forming the output stage cathode load, at the same time adjusting the d.c. conditions, or else changing to a.c. couplings. In this form it is usual to replace the triode amplifying stages by pentodes, when the circuit becomes the familiar " ring-of-three " fast pulse-counting amplifier commonly used in nuclear physics.

It is important to note that in the circuit of Fig. 10, the fraction of the output voltage which must be fed back in order to secure unity overall gain has not the value (loop gain)/(1+loop gain) which was used in the shunt feedback circuits (Fig. 8). The cathode injection method of subtracting the input and feed-back voltages does not give a perfect subtraction of the grid and cathode voltages since for a fixed anode current in the first stage, the difference between the grid and cathode voltages varies with the working anode-cathode voltage (screen-cathode voltage for a pentode). The ratio is simply the amplification factor μ of the first valve and it is seen that even if the stages following the input valve gave infinite gain, it would still be necessary to feed back a fraction $\mu/(1+\mu)$ of the output voltage in order to secure an overall gain of unity. In the circuit shown in Fig. 10, the μ of the first valve is 100 and with a loop gain of 700 at z.f., it is necessary to feed back about 1/90 of the output voltage to obtain unity overall gain at low frequencies and z.f. The overall gain stability must therefore be controlled largely by the characteristics of the first valve, however high the loop gain. Several ingenious refinements are available to remove this weakness of the circuit, the simplest being to use a pentode input stage with a.c. bootstrap screen decoupling, similar to the circuit in Fig. 6 in the first part of this article.

Imperfect signal subtraction caused by the changing valve operating conditions also occurs in the long-tailed pair. In the circuit of Fig. 9, for example, variations in the " tail " current of the double triode necessitates feeding back an appreciably larger voltage to the right-hand grid than the fraction (loop gain)/(1+loop gain), to give unity overall gain. For example, suppose the " balance " control in Fig. 9 has been adjusted so that with zero input

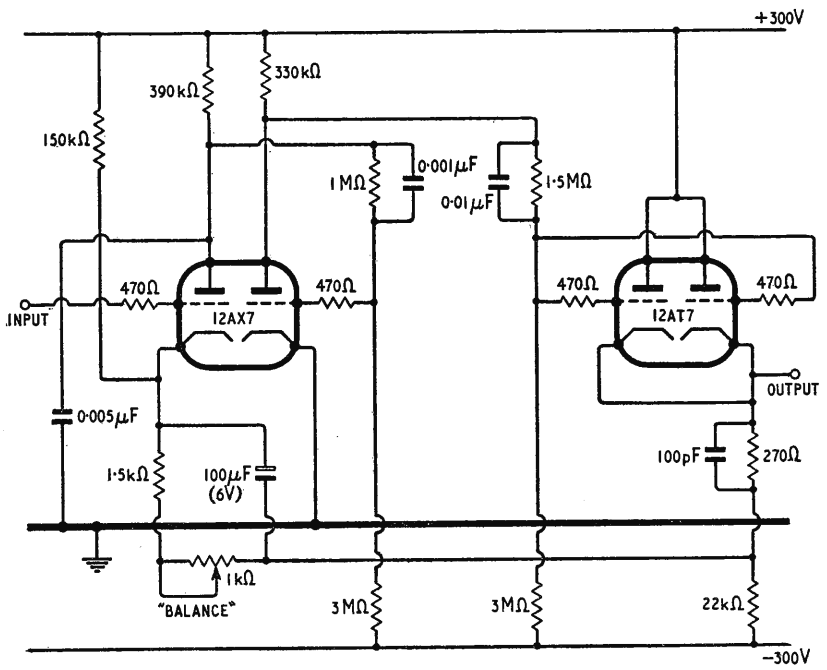


Fig. 10. Three-stage cathode follower.

voltage the two grid voltages need to be equal to produce a given voltage at the right-hand anode (say +150 V, which would give zero output voltage from the output cathode follower). If the left-hand grid voltage is now made, say +50 V, the +150 V at the right-hand anode will only be restored if the right-hand grid voltage is made slightly lower than +50 V. The common cathode voltage has increased, also by about 50 V, turning on an extra 0.15 mA in the 330 kΩ common cathode "tail" resistor. All this extra current, however, must flow into the left-hand triode since the current in the right-hand triode is constant, by virtue of its assumed fixed anode voltage. It is seen, therefore, that the grid of the left-hand valve will need to become more

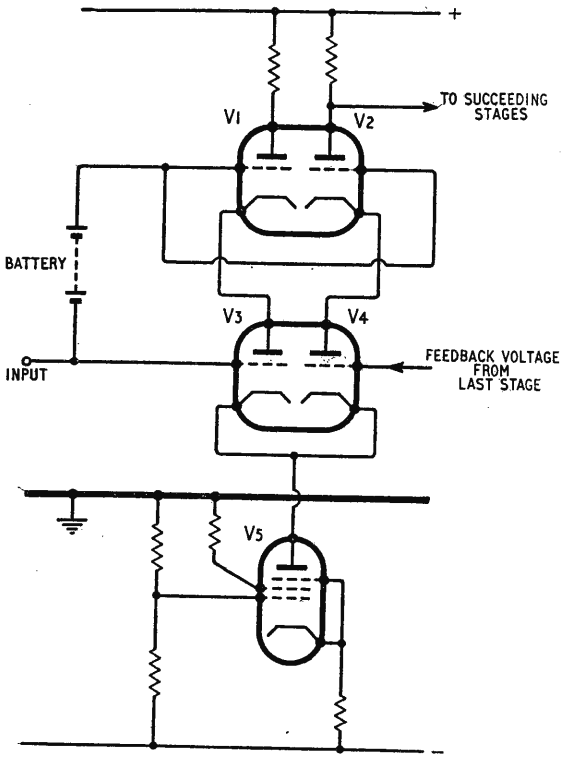


Fig. 11. Basic precision difference amplifier (Benjamin and Tomlin).

positive than that of the right-hand grid by a voltage equal to the increase in current divided by the working mutual conductance, in this example:—

$$\frac{0.15\text{mA}}{1\text{mA/V}} = 0.15 \text{ volt}$$

Both grid-cathode voltages must now be less since both valves have suffered a reduction of 50 V in anode-cathode voltage whilst one passes the same current as previously and the other even more current. In general, however, the simple long-tailed pair is a better difference amplifier than the cathode-injection stage, since the unbalance for a given input voltage is seen to depend on (mutual conductance) × (tail resistor), which can be made appreciably higher than the μ of a single stage without bootstrap refinements.

The major source of imperfection in the long-tailed pair difference amplifier can be removed by replacing the "tail" resistor by a good approximation to a constant current generator. The simple pentode "tail" as used in Fig. 7 of the first part of this article is usually convenient, giving a differential anode resistance of tens of megohms for values of R_c of about 2 or 3 kΩ, with the grid returned to a voltage of between + 10 V and + 20 V referred to the lower end of R_c. The long-tailed pair using this refinement is capable of good accuracy, since the extra "tail" current turned on or off with varying cathode voltage can be made negligible.

Even when the valves in the long-tailed pair are operated at constant current, the changing anode-cathode (or screen-cathode) voltage will cause slight unbalance unless the valve characteristics are identical An ingenious circuit* for overcoming this problem has been reported by Benjamin and Tomlin. Auxiliary cathode followers are used to maintain a constant anode-cathode voltage in each valve of the long-tailed pair, even though the input voltage is varying. The basic circuit is illustrated in Fig. 11, where V3 and V4 form the input long-tailed pair of a feedback circuit and V1 and V2 are cathode followers which maintain the anodes of V3 and V4 at a voltage e_b higher than that of the input grid, whatever the input voltage. The valve V5 provides an almost constant current to the common cathodes of V3 and V4. The load resistors for V3 and V4 are transposed to the anodes of V1 and V2 as shown.

In practice, the battery might be replaced by a neon tube connected to the long-tailed pair cathode (similar to the circuit of Fig. 5 in the first part). Alternatively where further stages are used to give a high loop gain, a method described by Benjamin and Tomlin is more convenient. In Fig. 12, V3 and V4 form the precision long-tailed pair triodes, using V1 and V2 to maintain substantially constant anode-cathode voltages and V5 to maintain substantially constant anode currents. The output from the precision long-tailed pair is taken from the anode of V1 and direct-coupled to the amplifying stage V6 as shown. The coupling between V6 and the output cathode follower V7 uses a further constant-current valve V8, as the lower element in the coupling network. The high differential anode resistance of V8 ensures that almost the full voltage excursion at the anode of V6 appears at the grid of V7. When the overall gain is made unity, the output voltage will exactly equal that at the input and also the voltage on the grid of V7 will be almost equal to that at the output, being slightly larger in fact, due to the slight loss in V7. Due to the absence of attenuation in the coupling network between V6 and V7, it may therefore be assumed that at the tapping point in the resistors in this coupling network, the voltage is also equal to that at the input, except for a positive bias, and a tapping point may therefore be chosen to provide the correct drive voltage for the cathode followers V1 and V2.

The z.f. loop gain of the circuit in Fig. 12† is about 10,000 and it is seen that a fraction (loop gain)/(1 + loop gain) of the output voltage is fed back to the input precision long-tailed pair, no allowance being made for imperfect subtraction of the two grid voltages.

The 500-ohm "balance" potentiometer in the cathode circuits of V3 and V4 enables the output

* Included in a publication of the Royal Naval Scientific Service (May, 1954)

† This is a variant suggested by the author.

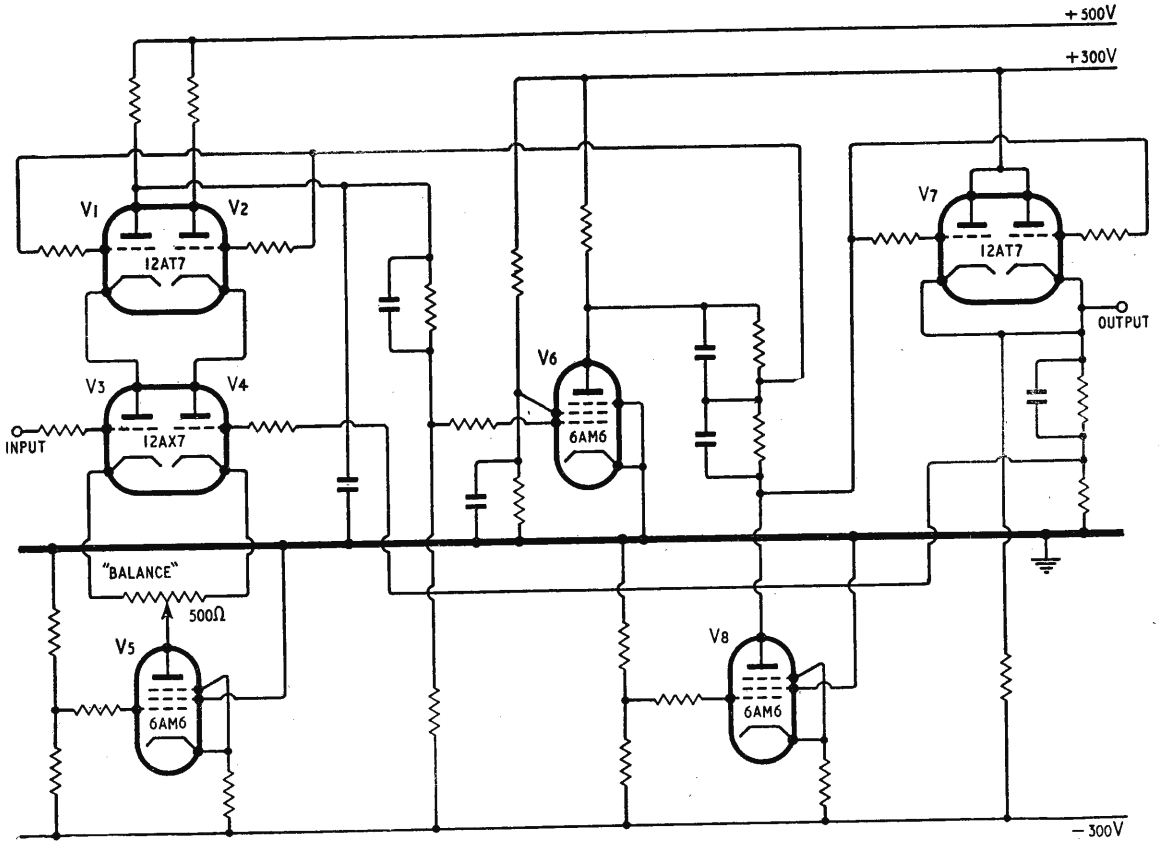


Fig. 12. Multi-stage cathode follower with precision difference circuit.

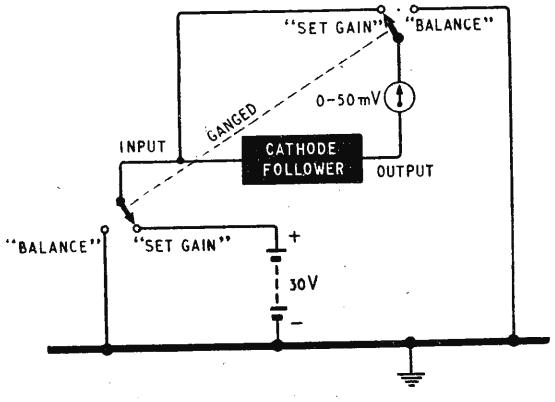
to be set to zero for zero input, and this initial adjustment for V3 and V4 grid-base symmetry once set, should be independent of the varying input voltage. The h.f. gain is about twice the z.f. gain due to the z.f. loss in the coupling network at the grid of V6.

The loop gain is quite high and, as in the circuit of Fig. 10, it is necessary to increase the time constant of one of the lags in order to ensure h.f. stability. The anode load resistor of the second triode is shown padded with the 0.01 μF capacitor, choosing a point in the loop where the signal level is small so that the increased time constant is less likely to cause overloading with high-frequency signals.

It is interesting to note that in the precision long-tailed pair, the triodes V3 and V4 (Figs. 11 and 12) are enabled to give a stage gain of the full value of their amplification factor μ, by virtue of their constant anode-cathode voltages.

Setting-up Procedure for Unity Gain Cathode Followers.—A simple but effective method of setting the "balance" and "set gain" adjustments for a multi-valve cathode follower of the types discussed (except that of Fig. 8 which gives an overall phase reversal) is illustrated in Fig. 13. The 0-50 mV meter is switched as shown to read either output with earthed input ("set balance" position), or the difference between output and input ("set gain") position. Progressive setting of each control alternately until the meter reads zero in both positions is seen to set up the conditions of zero quiescent output voltage simultaneously with exactly unity gain for a 30-V, signal (i.e. about half the overload level). For the circuits with extremely high loop gain (Figs. 10 and 12), a somewhat more sensitive millivoltmeter would be necessary if the setting is required to the utmost accuracy made possible by the precision of the circuits.

Fig. 13. Test circuit for cathode followers.



"Portable Transistor Receiver": An 8-μF electrolytic capacitor (C_{28}) should be inserted in the lead from R_{14} to the earth line in the circuit diagram of this set on page 341 in the July issue. It should be connected with the positive lead to earth.

Limiters and Discriminators for

5.—MEASUREMENT OF A.M. SUPPRESSION RATIO : TYPES OF LIMITER

THE purpose of a limiter stage in a f.m. receiver is to reduce the magnitude of the amplitude-modulation component of an applied signal. The performance of a limiter may be judged by the degree of reduction of the modulation depth which it achieves, and this degree of reduction may be termed the a.m. reduction factor. However, a figure for the reduction of the modulation depth would not be directly applicable to self-limiting detectors such as the ratio detector. Furthermore, many discriminators have some degree of inherent a.m. rejection. For example, with a perfectly balanced Foster-Seeley discriminator there is zero output when the carrier is at the centre frequency and hence no output if the carrier is amplitude modulated. Thus a criterion is required which provides a figure of merit for a combination of limiter and discriminator, and which is applicable to self-limiting discriminators. Such a criterion is obtained by employing a test signal modulated simultaneously in frequency and amplitude, and measuring the ratio of the components of the output signal due to the two components of the signal modulation respectively. This criterion is termed the *a.m. suppression ratio*. If a limiter has a given a.m. reduction factor, it would appear that its effect, in combination with a given discriminator, would be to increase the a.m. suppression ratio by an amount equal to the a.m. reduction factor. However, this is not always true as the limiter may introduce spurious f.m. in the course of its limiting action.

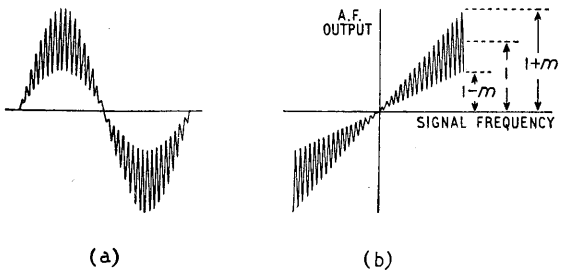


Fig. 1. Oscillograms of a.f. output from perfectly balanced Foster-Seeley discriminator with input signal simultaneously modulated in amplitude and frequency (a) with sawtooth time-base (b) f.m. component applied to X plates as time base.

However, there is general agreement as yet as to the test conditions to be employed in making a measurement of a.m. suppression ratio; the result is that any one device may have a number of values of a.m. suppression ratio, depending on the conditions of measurement. There is also the undesirable result that the minimum figure for the a.m. suppression ratio of a receiver, under given conditions of operation, is subject to a margin of uncertainty, unless the conditions adopted for the measurement of the a.m. suppression ratio are defined. In this article, the definition and measurement of the a.m. suppression ratio is that recommended by the B.B.C. Research Dept. The modulation depth of both a.m. and f.m. components of the test signal is 40 per cent ($\pm$30 kc/s frequency swing for the f.m. component) and the frequencies of the f.m. and a.m. components are 100 c/s and 2 kc/s respectively. The measurement is carried out as follows.

The apparatus under test is fed from a signal generator which can be modulated simultaneously in amplitude and frequency. The a.f. output is fed to a power-measuring instrument, preceded by a standard aural weighting network. (This network has a frequency response substantially flat in the region of 2 kc/s, where measurements are made, and therefore does not appreciably affect the measurements, save in exceptional circumstances, as, for example, when the a.m. component produces a substantial output of high-order harmonic components.) The input signal is set to the required amplitude for the test, and is first modulated by f.m. only to a swing of 35 kc/s by a signal at 2 kc/s. The a.f. power output P_1 is then measured. (If the apparatus under test is a complete receiver, the gain control is adjusted to give the standard power output of 50 mW). The value of 35 kc/s frequency swing is greater than the modulation depth of 40 per cent specified, and is used to allow for the effect of a 50 microsecond de-emphasis network, so that the a.f. power output is the same as that which would be obtained with a signal of $\pm$30 kc/s frequency swing at 100 c/s.

The frequency-modulating signal is then set to 100 c/s, and the frequency swing to $\pm$30 kc/s. The amplitude modulation signal at 2 kc/s is then applied, with a modulation depth of 40 per cent. The fundamental-frequency component in the output due to the frequency modulation is then filtered out by means of a high-pass filter having a cut-off frequency of 250 c/s. The a.f. power output P_2 due to the remainder of the signal is then measured. The a.m. suppression ratio is then the ratio of P_1 to P_2 expressed in decibels.

It was mentioned earlier that the Foster-Seeley discriminator has some degree of inherent a.m. rejection, and its a.m. suppression ratio can be calculated as follows. In an ideal discriminator of this type, the a.f. output is very nearly equal to $I.f$, over a region near the centre frequency, where I is the magnitude of the input signal current, and f is the difference between the signal frequency and the centre frequency. If the input current I is amplitude modulated, its value is given by $(1+m\cos\omega_2 t)$ I, where m is the amplitude modulation depth expressed as a fraction, $\omega_2 = 2\pi f_2$, and f_2 is the frequency of the a.m. component. If the f.m. component has a frequency of f_1, then the a.f. output is proportional to $(1+m\cos\omega_2 t)\cos\omega_1 t$. Such an output gives rise to oscillograms of the type shown in Fig. 1. The expression for the a.f. output

F.M. Receivers

By G. G. JOHNSTONE*, B.Sc.

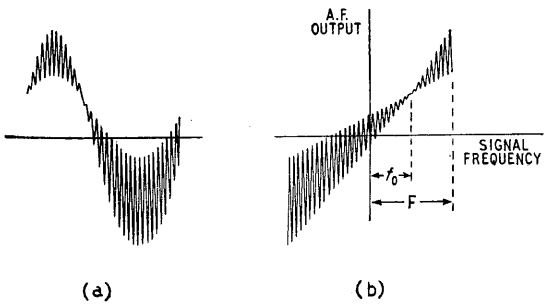
(*Concluded from page 280 of the June 1957 issue*)

waveform is precisely similar to the expression for an amplitude-modulated carrier. It can be resolved into three components, corresponding to the carrier and sidebands of an a.m. signal. However, the " carrier " component in this case is the fundamental frequency component of output due to the frequency modulation, and the power output due to this component alone may be taken as unity. When this component due to the frequency modulation is filtered out, there remains two components due to the amplitude modulation. These are of equal amplitude, $m/2$, and have frequencies $(f_1 - f_2)$ and $(f_1 + f_2)$. With the test frequencies postulated, i.e., 100 c/s for the f.m. component and 2 kc/s for the a.m. component, these two residual components of the a.f. output have frequencies of 1900 c/s and 2100 c/s. The total power output is then proportional to $2(m/2)^2 = m^2/2$. With the value of m postulated, 0.4, this power output is proportional to 0.08. Thus the ratio of the power outputs due to the f.m. component to that due to the a.m. component is 1 : 0.08, i.e., some 11 dB. However, this figure includes no allowance for the effect of the de-emphasis network, which introduces a loss of some 1.5 dB in the region of 2 kc/s; thus the value of the a.m. suppression ratio is some 12.5 dB.

The effect of a change of test conditions upon the value of the a.m. suppression ratio can be judged from the foregoing; if the amplitude modulation depth used had been 30 per cent., the a.m. suppression ratio would be 15 dB.

If the input signal carrier frequency is not precisely at the centre frequency of the discriminator characteristic, the a.m. suppression ratio alters. The output signal, with the input signal simultaneously modulated by a.m. and f.m., is then proportional to $(1 + m \cos \omega_2 t)(\mathrm{F} \cos \omega_1 t - f_0)$, where f_0 is the displacement of the carrier frequency from the centre frequency of the discriminator, and F is the frequency swing of the f.m. component. The types of oscillogram obtained under these conditions are shown in Fig. 2. In addition to the two components, each of amplitude $m/2$ relative to the fundamental frequency f.m. component, discussed previously,

Fig. 2. Carrier frequency displaced by frequency f_0 from centre frequency.



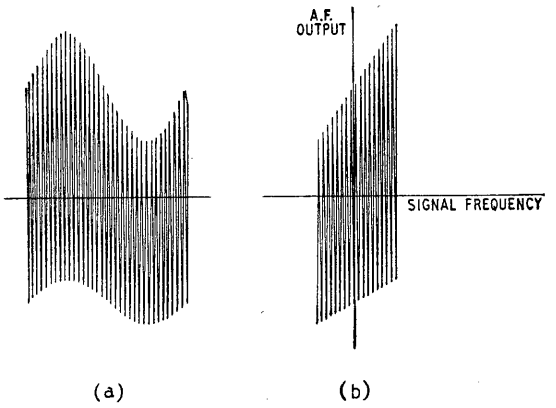


Fig. 3. Oscillograms of a.f. output from a counter-type discriminator with input signal modulated simultaneously in amplitude and frequency (a) with sawtooth time base (b) f.m. component applied to X plates as time base.

there is now a further a.f. component of amplitude mf_0/F at the a.m. modulating frequency f_2. The power output due to the a.m. component is thus increased to $(m^2/2) + (m^2 f_0^2/\mathrm{F}^2)$. If, for example, the carrier frequency is displaced 30 kc/s from the centre frequency, the power output due to the a.m. component rises from 0.08 to 0.24, i.e., the a.m. suppression ratio falls by some 4.8 dB. to 7.7 dB.

This special case was considered because it can be extended to other discriminators. For example, the counter-type discriminator gives zero output at zero frequency, and its output is proportional to the input signal amplitude and the signal frequency. Thus if a counter-type discriminator is operated at a centre frequency of 200 kc/s, a typical figure, the value of f_0 is 200 kc/s. The type of oscillogram obtained with the input signal modulated simultaneously in amplitude and frequency is shown in Fig. 3. Applying the formulae given previously, the a.m. suppression ratio is − 6.1 dB. Thus a counter-type discriminator requires that very careful attention be given to the performance of the preceding limiter.

The minimum desirable value for the a.m. suppression ratio measured in the manner described above, depends upon the type of a.m. interference encountered, and upon the class of service desired. For a broadcasting service, giving a signal output of good quality, a minimum value of 30 dB would seem to be necessary, and it would appear preferable that the ratio should be greater than 35 dB. It is doubtful if any aural change is perceptible if the value is increased beyond 40 dB.

Although the a.m. suppression ratio provides an excellent criterion of performance, another important factor must not be overlooked. This is the range of input signal amplitude over which a.m. rejection is maintained. The test for a.m. suppression ratio

*B.B.C. Engineering Training Dept.

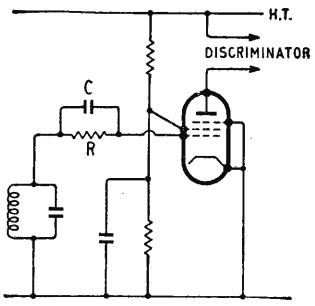


Fig. 4. Basic circuit of grid limiter.

explores limiting performance over a range of 40 per cent. modulation depth, but it is important to know the maximum modulation depth which the limiter can handle. Dependent upon the type of limiter, there may be a minimum signal amplitude below which limiting action fails, or alternatively, there may be a maximum modulation depth which the limiter will handle. In general, limiting action fails when the signal amplitude is decreasing. If the limiter has a minimum value of input signal below which limiting action fails, the limiter is said to have a threshold value. The maximum modulation depth in the " downward " direction then varies with the amount by which the mean signal amplitude exceeds the threshold. With limiters of the type which have a fixed " downward " modulation handling capacity, there is no fixed threshold. However, with such limiters, the a.m. suppression ratio generally falls with mean carrier amplitude, and there is thus a quasi-threshold fixed by the input signal amplitude above which the a.m. suppression ratio is satisfactory.

For most purposes, it would seem desirable that satisfactory limiting action should be maintained for "downward" modulation of 50–70 per cent., although in some locations the depth of amplitude modulation due to reflections may exceed this value. Thus if a limiter has a threshold input of 1 volt for satisfactory limiting, the mean carrier level should normally be greater than 2–3 volts. With a limiter or self-limiting discriminator (e.g., ratio detector), having maximum " downward " modulation handling capacity, this modulation handling capacity is fixed in the course of design and should be in the region 50–70 per cent.

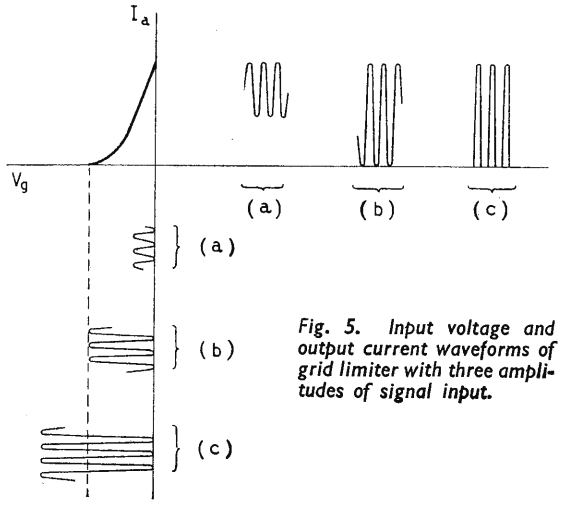


Fig. 5. Input voltage and output current waveforms of grid limiter with three amplitudes of signal input.

Grid Limiter. The grid limiter has been widely used in f.m. receivers, particularly in conjunction with Foster-Seeley discriminators. It comprises a pentode operated with a low screen voltage, fed at the control grid through a self-biasing network, as shown in Fig. 4. No cathode bias is usually employed, and one of the reasons for employing a low screen voltage is to prevent the valve drawing excessive current in the absence of an input signal. The low screen voltage also results in the valve having a short working grid-base, so that the limiting action commences with a relatively small input. The action of the circuit is as follows.

The grid and cathode of the valve function as a diode detector. When the input signal is positive-going, grid current flows at the tip of the cycle, and the capacitor C is charged, biasing the valve. With a reasonably large value grid resistor R (i.e., large compared with the resistance of the grid-cathode path when conducting), the bias so adjusts itself that grid current flows only on the tips of the positive peaks of the input signal. As the input signal amplitude increase from zero, the valve behaves first as a class A amplifier. When, however, the input signal amplitude exceeds half the cut-off bias, the valve is driven beyond cut-off on the negative-going peaks of the signal. As the input signal amplitude increases still further, the periods when the valve conducts become progressively shorter, as shown in Fig. 5.

The resultant anode current waveform may be

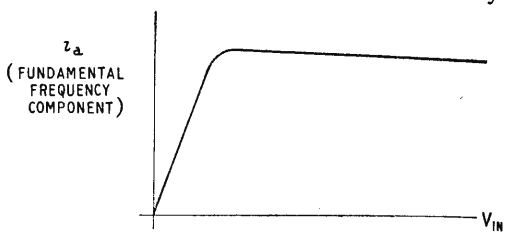


Fig.6. Fundamental frequency component of anode current plotted against input voltage for typical grid limiter.

analysed into components at the input signal frequency, and harmonics of this frequency. We may plot this fundamental-frequency component against input signal amplitude and obtain a curve of the type shown in Fig. 6. It will be seen that this fundamental-frequency component rises linearly at first with increasing input signal amplitude, until a " threshold " is reached, beyond which the output current is substantially independent of input signal amplitude. With a typical circuit of this type, comprising a pentode having a screen voltage of the order of 40–50 volts, the threshold input signal is of the order of 1 volt.

In practice, the portion of the curve above the threshold is not flat, but generally tends to fall slowly. This tendency may be minimized by careful choice of screen feed resistor, anode feed resistor and grid resistor. The selection of these components is usually done on test. A well-designed grid limiter will have an a.m. reduction factor of the order of 20-30 dB.

The grid limiter of the type described above has one major disadvantage. This is bound up with the time constant CR of the grid circuit components.

(Continued on page 381)

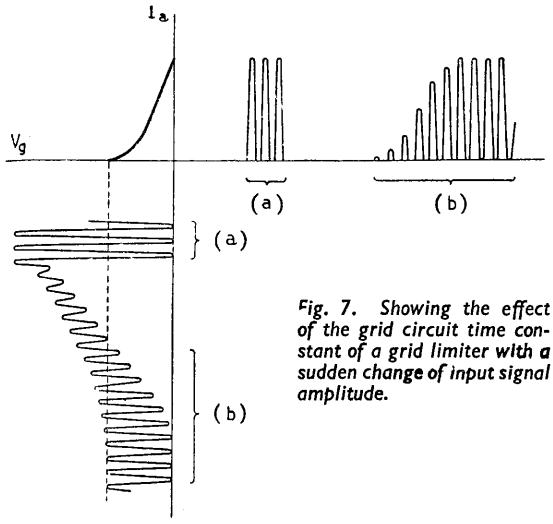


Fig. 7. Showing the effect of the grid circuit time constant of a grid limiter with a sudden change of input signal amplitude.

For satisfactory operation, the bias developed across the capacitor C should change instantaneously with any change of signal amplitude so that the positive-going peaks of the signal are always at zero bias. With an increasing signal amplitude, this condition is very nearly fulfilled, since the capacitor is charged through the relatively low resistance of the grid-cathode path. When, however, the input signal amplitude falls, the capacitor has to discharge through the resistor R, and whilst this is happening, the amplitude of the signal may be insufficient to cause the valve to conduct at all, or only partially. This is shown in Fig. 7. Thus, to ensure rapid discharge of the capacitor when the signal amplitude is decreasing, the time constant CR must be small. The desirable value of the time constant depends upon the maximum rate of change of input signal encountered, and the problem is the same as that of avoiding "tracking" distortion in conventional diode detector. It can be shown that this form of distortion can be avoided if $CR < 1/2\pi f m$, where f is the modulation signal frequency, and m is the maximum modulation depth. To consider the simplest case, co-channel interference, if the wanted signal is at one extreme of the frequency swing, and the unwanted signal is at the other, the wanted signal will be amplitude modulated at a rate of 150 kc/s. If the ratio of wanted to unwanted signal is 2:1, then m is 0.5, and in this case CR must be less than 2.1 microseconds approximately. In practice a value in the region of 2.5 microseconds is frequently adopted.

The choice of values for C and R individually is limited in two ways. If C is made small, a capacitance potential divider with the input capacitance of the valve is formed, and the signal appearing at the grid is materially reduced. Thus there is a lower limit to the value of C which can be tolerated; if the valve input capacitance is 10 pF, this minimum value is of the order of 20 pF. If the value of R is reduced, the damping of the tuned circuit feeding the limiter is increased. Since the grid and cathode of the valve behave as a diode detector, the damping resistance is given by $R/2\eta$, where η is the rectification efficiency of the circuit. Thus if the preceding circuit has a dynamic resistance of 20 kΩ, the minimum value of R would appear to be in the region of 40 kΩ, giving a reduction of approximately one-half in the working Q-value of the tuned circuit feeding the limiter. Values of C and R often adopted for a time constant of 2.5 microseconds are 50 pF and 47 kΩ respectively.

There is one variant of the grid limiter which is worthy of special mention. This is the form of grid limiter in which the valve employed has a high input resistance at the input grid, even when driven positive with respect to the cathode. Valves of this type have been discussed before in the section on gated-beam discriminators. Thus the valve type 6BN6 may be employed, and because of its high input resistance, it may be operated without the grid-current biasing network. The valve is biased to a class A operating condition in the absence of a signal by the cathode components, and when the signal amplitude is sufficiently large, square waves of anode current are generated, the magnitudes of which do not vary appreciably with input signal amplitude above the threshold value. This type of limiter thus has the advantage over the conventional type of grid limiter that its operation is not affected by the action of the grid circuit time constant. The damping presented to the input circuit under operating conditions is of the order of 20 kΩ.

A similar type of action to that described above may be secured with a normal pentode by inserting a resistor in series with the grid as shown in Fig. 8. When the signal drives the grid positive with respect to the cathode, the series resistor limits the flow of grid current, and ensures that the grid is not driven appreciably positive with respect to the cathode. The behaviour of the circuit is thus essentially similar to that of the 6BN6 type of limiter described above, the input signal driving the valve between anode current cut-off and its value at zero bias. However, there is one major disadvantage

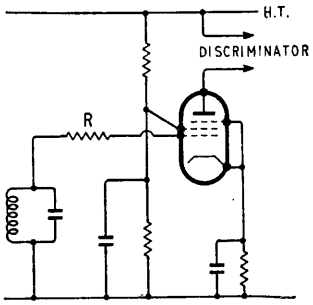


Fig. 8. Series-resistor grid limiter.

of this circuit: it is not suitable for use at high frequencies because of the effect of the grid-cathode capacitance of the valve. This, in conjunction with the series resistor, introduces a loss of signal increasing with increasing frequency. The circuit is thus useful only for maximum frequencies of the order of hundreds of kilocycles per second.

Another form of grid limiter sometimes used has a tuned circuit directly coupled to the grid of a pentode stage operated with a small bias. Grid current then damps the circuit, and gives a limiting action.

Anode Limiter.—The anode limiter relies for its action upon the existence of the "knee" of the I_a-V_a characteristic of a pentode. The valve is operated with a high value of anode load impedance,

so that when the grid voltage is a few volts negative, the anode voltage " bottoms " at the value given by the intersection of the load line and the portion of the I_a-V_a curve below the " knee " of the characteristic, as shown in Fig. 9. The anode-current/grid-voltage characteristic is modified by the "bottoming " action to the form shown in Fig. 9(b). If the valve is biased to the working voltage V_g indicated in Fig. 9(b), symmetrical limiting of the input wave form occurs. Such a limiter was described by Scroggie* for use with a counter-type discriminator with the added refinement that a series grid resistor was used to assist the limiting action when the grid-cathode voltage was driven positive.

Dynamic Limiter—The dynamic limiter operates by presenting a varying impedance to a source of signal, the impedance varying in such a way as to tend to maintain the output signal at a constant amplitude. In its simplest form the circuit is shown in Fig. 10. We shall assume that the diode has a very low forward resistance compared with its load resistance. Then under quiescent conditions, the damping of the tuned circuit by the diode circuit is approximately equivalent to a parallel resistance R/2. This resistance is usually comparable with, or less than, the dynamic resistance of the tuned circuit. The time constant of the load circuit of the diode is made large compared with the period of the a.m. signals it is desired to suppress. Under quiescent conditions the diode load capacitor charges to a voltage just less than the peak signal voltage. If now the signal amplitude tends to increase, the diode will take increasing current on the peaks of the signal, in an attempt to increase the voltage across the capacitor. If the capacitor is large, however, the voltage across it cannot increase appreciably and the damping of the tuned circuit will increase, so that the load presented to the driving valve falls, and the gain from grid to anode decreases. The decrease in gain largely offsets the increase of input signal amplitude, so that there is only a small change in output signal amplitude.

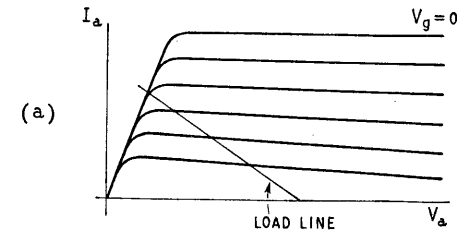
If the input signal amplitude decreases, the opposite effect occurs, the damping decreasing, so that the driving valve gain rises, offsetting the fall in signal amplitude.

However, there is a lower limit below which the limiting action ceases. This occurs when the signal across the tuned circuit falls below the voltage across the diode load capacitor, and the diode fails to conduct on the peaks of the signal. Below this signal amplitude, the driving valve behaves as a linear amplifier. The range over which limiting is maintained can be calculated from the graph of Fig. 11. The curve of $E=R_d i$, where R_d is the dynamic resistance of the tuned circuit, shows the relationship between the output voltage and the current supplied by the driving valve in the absence of the diode circuit. The curve of $E=R'i$ is the curve obtained when diode limiter is connected, R′ being equal to R_d in parallel with R/2, the equivalent damping resistance due to the diode circuit (the diode rectification efficiency is assumed 100 per cent.). In plotting this graph, the input current is assumed to change its amplitude very slowly, so that at each stage the diode load capacitor charges to the peak value of the output voltage.

Under dynamic conditions, when the input signal amplitude decreases from the quiescent value i_0 the charge on the diode load capacitor does not have time to change appreciably, and the output voltage amplitude remains constant until the input current falls to the value i_1, when the diode ceases to conduct; the equivalent damping resistance due to the diode circuit is then infinite. If the input current decreases further, the output voltage falls linearly, following the curve $E=R_d i$. Thus the maximum " downward " modulation depth which the limiter will suppress is given by $(i_0-i_1)/i_0$. From the geometry of the figure, this modulation depth is given by $1-(i_1/i_0) = 1-(R'/R_d)$. But $R' = R_d(R/2)/(R_d + R/2)$, so that this maximum value is given by $R_d/(R_d + R/2)$. Thus for good " downward " modulation handling capacity, R_d must be large compared with R/2. This means that the tuned circuit is heavily damped under quiescent conditions, and hence the gain of the driver stage is low.

Because a diode employed in a practical circuit

* Wireless World (April, 1956)



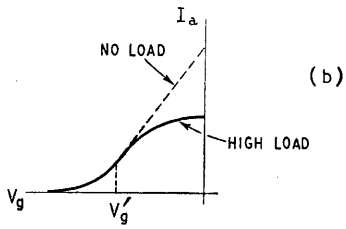


Fig. 9 (a) Showing the " bottoming " effect occurring with an anode limiter with a high-value anode load. (b) Modification of the I_a-V_g curve of the valve by the high-value anode load.

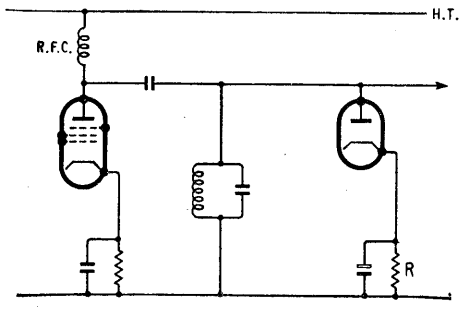


Fig. 10. Basic circuit of dynamic limiter.

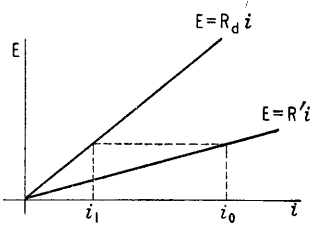


Fig. 11. Showing graphical construction for determining maximum " downward " modulation handling capacity of dynamic limiter.

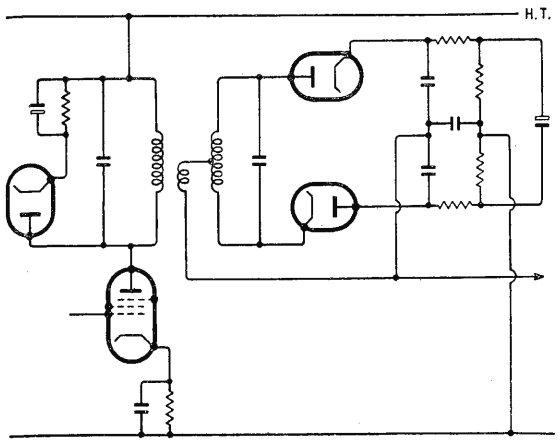
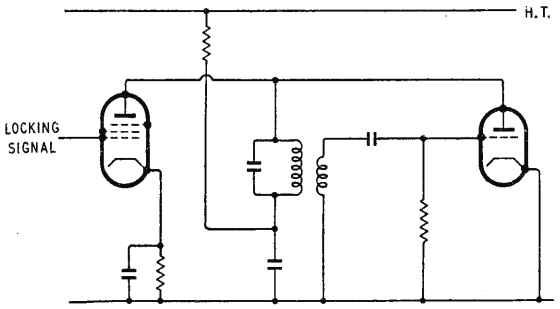


Fig. 12. Ratio detector with added dynamic limiter.

Fig. 13. Basic locked-oscillator circuit.



cannot have 100 per cent. rectification efficiency, the limiting action is not perfect, and the a.m. reduction factor is usually of the order of 10-20 dB. This type of limiter offers no protection against long-term changes of input signal amplitude or slow flutter due to reflections from aircraft, as the diode load capacitor will charge to the mean value of the input signal amplitude. It has, however, the advantage that the limiting action is maintained over a constant range of modulation depth at all levels of input signal amplitude, down to the quasi-threshold value at which the diode efficiency falls to the point where the limiting action is seriously impaired.

The damping imposed on the tuned circuit under operating conditions varies with the amplitude modulation of the input signal, and so, therefore, does the pass band of the tuned circuit.

The dynamic limiter may be employed with advantage in combination with those forms of limiter/discriminator where the a.m. suppression ratio falls somewhat short of the desirable value. In particular, it may be employed with a ratio detector, connected in parallel with the primary circuit, as shown in Fig. 12.

The Locked Oscillator. The type of oscillator used widely in receivers employs grid-current biasing, and in this resembles the grid limiter. The limiting action which takes place stabilizes the oscillation amplitude. Thus if an oscillator of this type can be made to change in frequency in step with an applied signal, the oscillator output amplitude will tend to remain constant independently of changes in the input signal amplitude. A suitable arrangement for locking an oscillator to an applied signal is shown in Fig. 13.

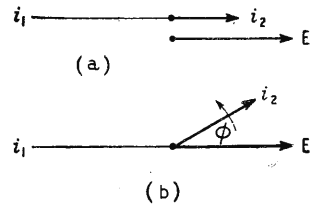


Fig. 14. Vector diagrams for circuit of of Fig. 13.

Consider firstly the conditions of operation when the applied signal frequency is equal to the free-running frequency of the oscillator. The equilibrium relationship between the vectors representing the oscillator valve anode current (i_1), the locking valve anode current (i_2) and the voltage across the tuned circuit (E) are as shown in Fig. 14(a). The current vectors are in anti-phase, and the oscillator valve anode current is also in anti-phase with the tuned circuit voltage, indicating that the oscillator valve is equivalent to a negative resistance in parallel with the tuned circuit. The locking valve current is in phase with the oscillator voltage, corresponding to a damping resistance of magnitude E/i_2. If now the locking signal frequency increases, the locking-valve anode current vector will commence to rotate in a clockwise direction, as shown in Fig. 14(b). There will now be a component of the locking signal current in quadrature with the oscillator voltage, i.e. the locking valve now behaves as a resistor and reactor in parallel. The reactance is equivalent to an inductive component under the conditions postulated, and this equivalent inductance re-tunes the oscillator, circuit to a higher frequency. Equilibrium is restored when the oscillator frequency is equal to that of the locking frequency, i.e. synchronization has been achieved. If the phase angle between the locking valve anode current and the oscillator voltage in this equilibrium condition is θ, then the reactance of the equivalent parallel inductance is $E/i_2\sin\theta$. The range over which locking occurs is limited because when the phase angle between the oscillator voltage and the locking valve anode current is equal to 90 degrees, the equivalent parallel inductance is at its minimum value; any increase of phase angle beyond 90 degrees increases the magnitude of the equivalent parallel inductance. At the minimum value of inductance, the reactance is given by E/i_2. For maximum effect, this reactance should be as small as possible, and hence for locking over a wide frequency range, E should be small, and i_2 large. Further, the main tuning inductance of the oscillator circuit should be as large as possible, for the equivalent parallel inductance to have maximum "pulling" effect.

The argument applied above can be applied also when the locking signal frequency is below that of the oscillator; in this case the locking valve behaves as an equivalent capacitor.

The relationship between the oscillator frequency and the locking frequency is as shown in Fig. 15(a). Outside the locking range, the oscillator frequency tends to swing between wide limits, as the heating effect with the locking signal produces alternately the effect of a parallel capacitance and parallel inductance; the mean frequency tends to follow the curves shown dotted in Fig. 15(a). In practice, however, non-linearity in the oscillator valve causes

the oscillator to lock over a succession of small ranges at fractional multiples of the locking signal frequency (e.g. 10/9, 9/8), as shown in Fig. 15(b).

The greater the amplitude of the locking signal current, the greater is the frequency range over which locking is maintained. When the input signal is amplitude modulated, therefore, the minimum value to which the input current falls must be sufficient to lock the oscillator over the full frequency range of the f.m. signal. The locked oscillator thus resembles the grid limiter, in that there is a threshold limit of signal which must be exceeded for satisfactory performance. The "downward" a.m. modulation handling capacity is determined by the ratio of the mean input signal amplitude to this threshold amplitude.

The locked oscillator limiter may also suffer from the effects of the time constant of the grid-biasing components in the same way as the grid limiter, and the grid components must thus be chosen with care.

Examples of the locked oscillator limiter were given in Part 4 of this series. This type of limiter is not now widely used. One of its principal disadvantages is the feedback of the oscillator signal to early i.f. stages, which can lead to overloading in the i.f. amplifier. A number of schemes have been proposed for locking an oscillator at a submultiple of the intermediate frequency to avoid this effect. Additionally, a single stage locked oscillator limiter-discriminator has been described by Bradley (see references).

The "Clipper." This type of limiter employs two triodes cathode coupled as shown in Fig. 16. It thus comprises a cathode follower driving an earthed-grid triode. Under quiescent conditions, both triodes are conducting, and each is biased approximately to the mid-point of its grid base. If now the input signal at the grid of V1 increases positively, the anode current of V1 increases. The cathode potential therefore rises, and this in turn leads to a decrease of anode current in V2. In fact,

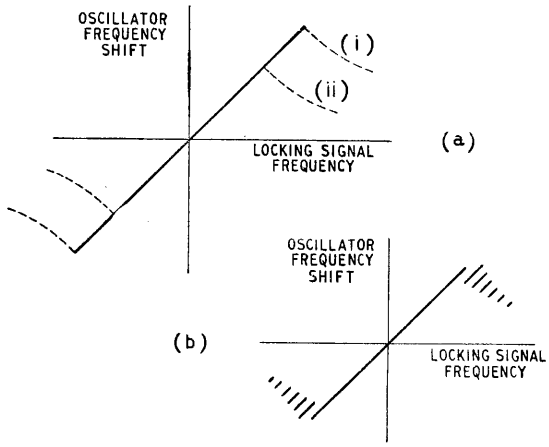


Fig. 15. (a) Locking of oscillator frequency to that of locking signal. The dotted portions of the curves indicate the mean value to which the oscillator frequency tends outside the locking range. Curve (i) is that for a larger locking signal input than curve (ii); (b) Showing locking of the oscillator frequency at fractional multiples of the locking signal frequency over restricted ranges outside the true locking range.

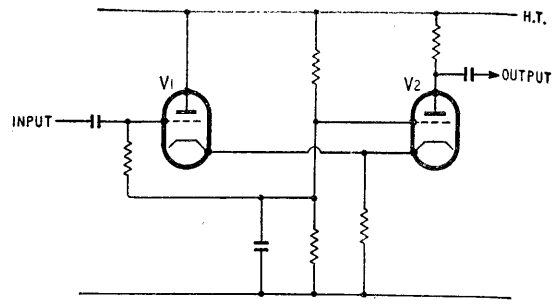


Fig. 16. Basic circuit of the "clipper" type of limiter.

the common cathode potential rises by an amount equal to half the increase of V1 grid potential. If the input to the grid of V1 increases sufficiently, the common cathode potential rise to the point where anode current is cut off in V2. The degree of feedback applied to V1 then increase sharply, and V1 behaves as a true cathode follower. During the rise of common cathode potential the anode of V2 rises to h.t. potential, and when anode current is cut off, it remains at this value, i.e. the output signal is then limited.

When the input signal at the grid of V1 is negative-going, the common cathode potential falls, and the anode current in V2 rises. Whilst both valves are conducting, the change in cathode potential is approximately half that of V1 grid. If the input signal rise to a value sufficiently negative, anode current in V1 is cut off, and there is no further change in common cathode potential. Thus this circuit "clips" the input signal symmetrically, providing a chain of square-wave output pulses.

This form of limiter is very useful at low frequencies, and may be used with input signal frequencies of the order of a few Mc/s. It has a fixed threshold of the order of 5-10 volts above which limiting occurs. As it does not depend for its action upon the charging and discharging of capacitors, it is free from "blocking" effects.

The author wishes to record his thanks to Dr. G. J. Phillips and Mr. J. G. Spencer for helpful discussion.

REFERENCES

"Locked-in Oscillator for TV Sound" by M. S. Corrington, *Electronics*, March, 1951.

"Single-stage F.M. Detector" by W. E. Bradley, *Electronics*, December, 1949.

"A Study of Locking Phenomena in Oscillators" by R. Adler, Proc. I.R.E., June, 1946.

Nickel-Iron Laminations

THE new British Standard BS2857/1957 covers laminations for transformers and chokes of 0.004, 0.008 and 0.015 in thick respectively and containing between 36 per cent and 75 per cent of nickel with the residue mainly or wholly iron.

Measurements of permeability are to be made normally at 50 c/s, but by arrangement between user and manufacturer audio tests can be effected at six frequencies between 300 c/s and 4,000 c/s, or at a single frequency of 800 c/s. Details are given of a method of testing for compliance with the minimum values of permeability laid down in the specification.

Copies of BS2857 are obtainable from the British Standards Institution, 2, Park Street, London, W.1, price 3s (3s 6d by post).

"Rainbow 'Round my Shoulders"

An American Serviceman Faces Up to Colour Television

By JACK DARR*

SOME several years ago, television came over the Arkansas Hills into our little town. It wasn't too far behind the bigger towns, at that. To most of the radiomen it came as no surprise: we'd heard rumours of its existence! We're speaking, of course, of the old-fashioned monochrome, or "B. & W." (black and white) TV, not the multi-hued version. "The papers were full of it," literally. In consequence of this, we felt pretty well at home when TV finally did put in an appearance. At least, we weren't perfect strangers! But we found the inevitable assortment of troubles not mentioned in the books: the normal ratio between "book-larnin'" and practical experience still holds in this, as in every other trade! It was several years before we become as "at home" in the underside of a TV set as we were in radio chassis.

The average American serviceman accepted the advent of television as a challenge, as do servicemen everywhere in the world, whenever a new piece of equipment is introduced. He set out to learn all he could about it, and today, even in the smaller towns such as ours, there are several shops, staffed with well-trained technicians and provided with an astonishing array of modern test equipment. (This does not, of course, include *my* home town, and *my* competitors!)

Literature

We accepted the advent of colour TV with the same aplomb that we had B. & W.: the magazines began to run articles about it, and are still doing so: the set-manufacturers put out study courses on the fundamentals of colour, some of them free, some at a very nominal figure. RCA, for instance, sent out an excellent course, prepared by RCA Institutes, beginning with the wavelength of coloured light and winding up with a detailed description of convergence and setup procedures for the latest sets then available. I obtained mine free by agreeing to buy a few hundred tubes! Other set-makers had similar material: Philco, for instance, published a single-volume course, illustrated in colours, showing test patterns, etc., to be found under certain conditions.

In addition to this, RCA, Philco, Hoffman, and others held "Colour Clinics," schools, in the larger cities, and some servicemen travelled many miles to attend them. Service meetings held by manufacturers and service groups became devoted almost exclusively to colour, and after a while even the most remotely situated serviceman could answer without hesitation when asked, "What angle is Green?" (299.4 degrees, by the way!) Fundamentals and theory came out of our ears: chromaticity diagrams became as familiar to us as our own front lawns. All we needed now was some practical experience!

Came the day when a customer in our town, possessed of more money than most of us, ordered a colour set, and called upon us to set it up. Came also the day when we discovered that all was not going to be multi-chrome beer and skittles! Came also our first experiences with what one of my associates described with some bitterness as "pink trees and purple people!" We made the same discovery all over again, that we'd made with B. & W. TV. Easy as it might sound in the books, actually sitting down on one's haunches before a huge colour TV receiver, confronted with an array of controls bearing such exotic names as "Green Horizontal Dynamic Slant" and "Blue Vertical Static Parallax" was a far cry from sitting at home in an easy chair reading about it!

Preliminary Adjustments

To set up a colour TV receiver correctly, a series of adjustments must be made. These should be made after the set is installed in the owner's home, as any moving of the set afterwards disturbs them; not from a shifting of the adjustments themselves, but from the changing magnetic fields from metallic objects, such as radiators, etc. This process is known as "convergence," although it covers a great deal more than that. Strictly speaking, the convergence adjustments are those made to enable the beam from each of the three guns in the c.r.t. to strike its own colour dot on the screen, through the same hole in the shadow mask. Improper convergence or, indeed, errors in any of the other adjustments, means that the set will not only not give a good colour picture, or even a good black-and-white picture: such ill effects as colour fringing, tinting, etc., will interfere with the use of the set. This is the "rainbow 'round the shoulder" effect so common in badly adjusted sets.

RCA and most other manufacturers recommended the use of a "dot generator" for alignment, a signal generator which creates a pattern of small dots on the screen. Test equipment makers leaped eagerly into the breach, and assorted pattern generators were soon available at all prices.

After the proper test gear is assembled, then arises the problem of learning how to use it. Fortunately, the distributor sent along his own expert technician, a happy character named Gene, complete with dot generator and other equipment. His main purpose was to check me out on the set. He turned it on, and suggested that I make the first setup on it, to gain experience. Happily I agreed, and sat down in front of the monster. Thoughtfully, the maker had mounted all the adjustments on the front panel of the set, exposed by removing the knobs and a couple of small screws, after which a small panel

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came off, and there they were. These were all plainly labelled, a feature unfortunately sometimes omitted!

Gene handed me the instruction sheets, and stood back, hands in pockets, with a knowing grin on his face. I casually glanced at them, then laid them down, after locating the various controls. After all, hadn't I finished my colour TV correspondence course with honours? I knew all there was to know about it! Deftly I made the initial connections, finally obtaining a pattern of small multi-coloured dots on the screen, about an inch apart. Apparently, none of the blasted things was converged: I didn't see a white dot anywhere! This is one of the charming paradoxes of colour TV work: you must adjust for a complete *lack* of colour!

Dot and Carry Two

Gene mildly suggested that I select a dot in the centre of the screen, since I had to start somewhere! This individual was selected, and I tentatively wiggled one of the adjustments. This resulted in the blue dot taking off wildly for the left side of the screen, winding up about a half-inch away from where I wanted it. Reversing the direction brought it back to the other side, then finally to centre, where it overlapped the red dot, anyhow. The green dots were still about 11 o'clock, high. Adjusting that control brought them down; it also moved the red dots over to about 2 o'clock. Adjusting the red dots brought them back: the blue dots, meanwhile, had apparently found something interesting going on over at the right side of the screen: at any rate they were all wandering off in that direction! Turning their control halted their flight and brought them back toward the centre, at the same time separating the red and green dots, so that I once again had a perfect triad: translated, this means that I was right back where I started!

At this point, we had to stop and revive Gene, who was rolling helplessly on the floor behind me. After we had administered restoratives, and wiped the tears from his eyes, and he had recovered some degree of coherence, we followed the standard American custom in such circumstances: we took a coffee break. Bringing the instruction sheets along, he tactfully explained to me that the main trouble was my complete ignoring of the instruction book! (This is an unusually frequent occurrence among us technicians: I recently read the instruction book on a piece of test equipment I'd owned for ten years, and discovered three things that I didn't know it would do!)

Back at the store we sat down with the instruction sheet, a very detailed and lucid piece of technical literature, and began at the beginning! First, as in B. & W., we made the vertical linearity and size adjustments: once convergence is started, these must never be touched. Next, we measured the high voltage on the tube, using a special test socket provided on the back of the set. After the horizontal size and linearity adjustments were checked, *then* we began the setup procedure.

First, under constant supervision, I made the purity adjustments. This consists of turning the blue and green guns off, through their gain controls, and adjusting pots, etc., for a pure red screen. This was slightly marred by patches of orange and magenta at the edges. Adjustments of small magnets at the tube's rim failed to eliminate these completely, so we went through a mystic rite known as " degaussing " it. This consists of waving a large ring-shaped coil, about 18 inches in diameter, plugged into the mains, before the face of the tube, genuflecting and backing away the while. Appropriate incantations are chanted throughout this process. The coil is then unplugged, and the rites continue. Correctly done, this enables the attainment of a pure red screen. The red is turned off, and the procedure repeated for blue and green.

Now, the fun begins: convergence. A dot is selected in the centre, and it is " converged, " to make a white dot; all three colours must be perfectly overlapped before this will happen. There is a total of four adjustments needed for this: for the blue, a small magnet on the neck of the tube is moved to move the dot sidewise, and the control on the front moves it up and down. The same control for red moves the red dot from 2 o'clock to 7 o'clock: the green dot moves from 10 o'clock to about 4 o'clock. The idea is to find a combination setting which will zero all dots in at a given location! At least fifteen adjustments were provided to accomplish this: vertical and horizontal static convergence, vertical and horizontal dynamic convergence, and vertical " tilt " for each colour: the last named are to correct any bowing in the lines of dots and to enable convergence to be achieved over the entire screen. Adjustment of these controls, I learned, must follow the proper order: failure to do this will upset the whole process and require repeating it from the beginning. (How did I learn this? *Please*!)

The end result of the procedure, after much patient coaching from Gene, was a pattern which was converged over almost the entire area of the screen, with the exception of about eight or ten dots at the corners. Gene assured me that this was very good, and that these would never be noticed in the picture. (This took place a year ago: since then, with perfection of techniques and adjustments, I've seen screens 100% converged!)

Black and White Check

Now, we gave it the acid test; we tuned in a picture! In black and white, of course. Incidentally, this set was connected to a community-antenna system, and one of the things we wanted to check was the ability of the system's amplifiers to carry the colour signals, without clipping colour burst, etc., which they did, perfectly. The black and white picture was perfect. In fact, it appeared to have much better detail than that seen on a B. & W. set nearby. One could view it from a much closer distance, and get a better picture. This was due to the shadow mask inside the colour c.r.t., which broke up the scanning line structure and gave the picture the appearance of a newspaper halftone print, with its multitude of tiny dots.

This all took place in the morning: not until afternoon would we be able to view a colour programme. NBC was running " Howdy-Doody " every afternoon, between 3 and 4 p.m., in full colour. Gene had to leave as he was on his way to an appointment with another hopeful dealer, so he wished us well, and departed, with a few final guffaws at my attempts to converge. Eagerly we awaited the start of the programme. After the inevitable commercials, the familiar kaleidoscope

pattern was seen: this time in colour. But what colours! Instead of the bright rainbow we had expected, they were all washed out, pale and wan looking! We twiddled the various operating controls, with no results, no good ones, that is: the picture retained its weak pastel tones! The signal strength was measured and found to be around 1,000 microvolts: no trouble there, still pastels.

The next day we made further checks. The set still made beautiful B. & W. pictures, but once again the familiar pastels met our eyes. This time there was a great difference, however. The day before, the colours had at least "stayed put"; today, great waves of colour washed back and forth across the face of the tube! Red, green, blue; they waved back and forth like a demented rainbow, resulting in a very picturesque display, but hardly the one intended! Repeated adjustments of the controls had no effect. In desperation we tried to call Gene on the telephone, but he had vanished: no one knew where he was, and they didn't expect him back to his home until the last of the week!

Chromatic Climax

Many alternatives were discussed, including suicide, without result. A careful study of the instruction sheet gave us no help. A glum group of technicians and salesmen watched the remainder of the show in a grim silence, broken only near the close of the show when a fat-faced trumpet player, in a close-up, puffed out his cheeks and blew a mighty blast on a final high note: as he did, his face turned a brilliant purple! It stayed purple until he took the horn from his lips, when it turned a pale blue! This wound up an otherwise dismal performance on a jovial note, and most of the audience departed, leaving the community-antenna technician and myself to further study of the situation.

Another colour show, a short 15-minute musical affair, follow the first. This displayed the same symptoms. We watched it for a few minutes, and then turned to each other and said simultaneously, "Let's try another station!" Fortunately, we had another NBC station on the cable system; one which had been included as a "standby," which was so far away that the signals were usually too weak and snowy to watch. Tuning the set to this station, we watched open-mouthed as the colours suddenly snapped into place with an almost audible "click"! Faces once again became flesh-coloured: dresses were red or green, hair lost its magenta tinge and became brown, etc. The salesmen came running from the back of the store, wanting to know what we were screaming about. We showed them. Turning back to the original station the colours once again wandered; on the weaker station they locked perfectly into place! With this as a clue, we came to the conclusion that the colour bursts were being clipped from the signal at the transmitter! This left us the colour, but no colour sync information, hence the wandering!

With this off our mind, we were free, the next day, to pursue our original problem: Why the pastels? No audience this time. The salesmen had abandoned all hope and disappeared, leaving only two puzzled technicians. Halfway through the show, I decided to attempt another adjustment of the much-adjusted controls, and reached for the "Chroma" knob. Watching the picture, I gave it a slight turn. The scene being televised was brightly coloured, or should have been: gay drapes and costumes abounded, and the whole thing should have been a riot of colour; instead they were all pale and washed out. Suddenly as I turned the control, they leaped into vivid life: reds glowed, blues and greens became deep and rich, and the whole thing came up to the colour standard of a Technicolor movie!

Amid loud shouts of "Hey! Whadja do?" "Boy! Looka that, willya?" and similar exclamations, I investigated. Fortunately, my hand had frozen to the knob, and I discovered that I had turned the *brightness* control, instead of the "Chroma"! Further investigation revealed the horrifying truth: we had simply had the brightness turned up to maximum all the time! This gave our colour picture the same aspect as a black and white under the same conditions: it was just washed out! A few experiments with brightness and contrast controls showed us their proper settings, and the pictures we got were simply beautiful!

As a result of these experiences, we have come to this conclusion: the installing technician is the key man in the success or failure of any colour TV installation. If this worthy has the proper equipment and the "know-how" to use it, and the humility to read and heed the manufacturers' instructions, he will be able to obtain first-class colour pictures! The "know-it-all" type, who assumes that all sets have been constructed by a group of morons far below his technical level, and that he can make setup adjustments alone, using his own version of the procedure, is in for a rude awakening!

One dealer in another city told us that he'd had a new colour set which worked perfectly when unpacked: no adjustment at all! This happy state continued until his serviceman decided to check the convergence adjustments, using only a signal for reference; no dot generator! Ever since then, he moaned, everybody's had rainbows "round their shoulders"!

Ready to Go

The practising TV technician's biggest problem, right now, outside of acquiring the extra cash to buy colour TV test equipment, is the lack of material to practice on! Although colour TV has taken hold to some extent in the larger cities, it is still a case of "few and far between" in the smaller towns, such as ours. In fact, here we have only two colour TV sets, at the moment: both are still on the dealers' floors! This is caused, of course, by one simple fact: the price! Although colour sets have been reduced tremendously during the past two years, from RCA's beginning with a 15-incher at $15,000 down to the latest production of 21-inch sets listing around $450 they are still away out of reach of the average TV buyer, and most especially the mass market. Until colour circuits are simplified enough to enable a price reduction to about $300 we do not look for any drastic increase in colour-TV density! (The preceding statement is entirely the writer's own personal opinion, and is entirely uncluttered by such things as facts, etc.!)

One optimistic note is seen in recent articles in radio and TV magazines, detailing new and simpler circuits for colour matrixing, new colour c.r.t.s, such as Philco's Apple tube, the Lawrence Chromatron now under investigation by Dumont, and others. The last two named are single-gun tubes, and offer

the possibility of simpler convergence adjustments. (Speed the day!) These developments may bring the price down, by allowing elimination of many special tubes now necessary, and bring on an upturn in sales.

The broadcasters are doing everything they can to assist in this project. All of the major networks, and especially NBC, are programming many more hours of colour shows than ever before. NBC stations in this area send out to TV servicemen and dealers a colour TV programme schedule, listing all shows in colour for the coming month. Last year this did not fill a single sheet: this year it fills three sheets, and many of the shows listed are on every day under a single listing, such as NBC's Matinee Theatre, in colour every afternoon from 1 to 2 p.m. However, the future remains doubtful, as far as any drastic upturn in colour TV sales is concerned, especially in this area. We await with optimism new developments, and do whatever we can to further the cause.

So, in conclusion, as far as the average American TV serviceman is concerned, with colour, he regards it mainly as he did black and white TV: as a challenge to his technical skill. He expects no trouble from the sets themselves. (Note: I did *not* say he was going to *have* no trouble; I merely said that he *expected* no trouble!) Just as before, he's in for troubles, and plenty of 'em! He's facing the same situation right now that he did with the B. & W.s. He didn't expect much trouble from those, either. " After all, they're just like radios, only bigger!" (The bitter laughter you hear in the background is from the author and his colleagues!)

However, he has a massive body of help available, in the form of literature, technical information, training courses, manufacturers' literature and schools, and the like, so the chances are he'll be able to attain a degree of proficiency in this, as he did in black and white TV, radio, " hi-fi," and all of the other subjects he's been called upon to cope with. He'll still have plenty of problems, but as the costers sing in the Broadway version of " My Fair Lady," " With a little bit of luck he'll get by!"

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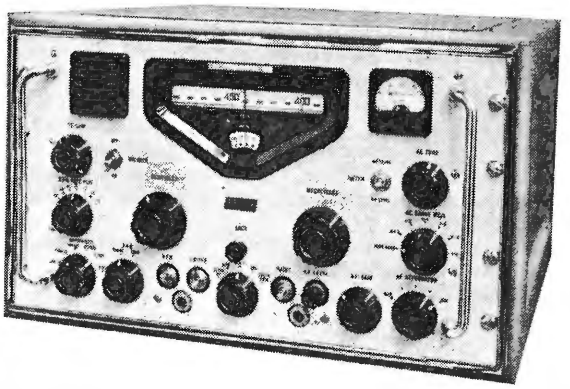
Continuously Variable Crystal Control; Wideband Coverage Without Waveband Switching



VARIOUS systems have been devised to apply the stability of crystal control to wideband communications receivers, the most common being a multiplicity of crystals used in various combinations. These involve complicated switching systems and often restrict the equipment to operation on a number of fixed spot frequencies.

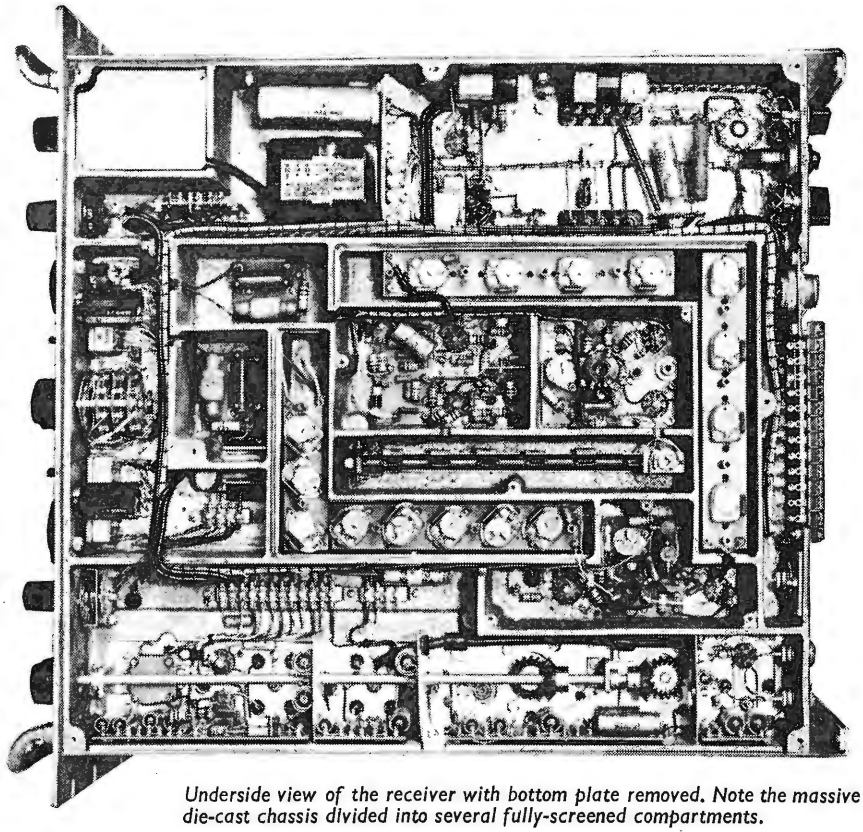
An attractive system which forms the basis of the design of a new communications receiver, Type RA17, being produced by Racal Engineering Ltd., of Bracknell, Berks, makes use of the harmonic spectrum of a single crystal to cover a tuning range of 500 kc/s to 30 Mc/s without gaps of any kind and without any of the conventional forms of waveband switching.

The block schematic diagram shows the basic arrangement, from which it will be seen that the received signal is first amplified by an aperiodic r.f. amplifier covering 0 to 30 Mc/s, then mixed with the output of a variable oscillator covering 40.5 to 69.5 Mc/s in a single range to produce an input to the first i.f. amplifier of 40 Mc/s. This amplifier has a bandwidth of 1.3 Mc/s. At the same time part of the output of the local oscillator is combined in a second mixer with the harmonics, up to the 32nd, of a 1-Mc/s crystal-controlled oscillator and a second i.f. output at 37.5 Mc/s appears at the output of a tuned filter having a bandwidth of $\pm$150 kc/s. In order to obtain the 37.5 Mc/s i.f. the 40.5 to 69.5 Mc/s oscillator (Mc/s scale) must be set to within 500 kc/s, $\pm$150 kc/s tolerance, of a harmonic of the crystal-controlled oscillator. Any change can only be steps of 1 Mc/s, so that for every setting of the variable oscillator a 1-Mc/s panorama of signals, derived from the first mixer, is presented to the 40-Mc/s i.f. amplifier. Its bandwidth must be, therefore, 1.3 Mc/s wide in order to accommodate this band of signals, plus the 300-kc/s tolerance in the setting of the oscillator brought about by the 300-kc/s bandwidth of the 37.5-Mc/s i.f. filter.

The 37.5-Mc/s i.f. and the 1-Mc/s panorama of signals from the 40-Mc/s i.f. amplifier are then combined in a third mixer which gives a " panoramic " output from 2 to 3 Mc/s and this is passed to a conventional form of superheterodyne receiver (interpolation receiver) which selects the wanted signal from the 1-Mc/s panoramic input. Its tuning is linked with the long film scale calibrated in kilocycles.

It will be apparent that with so many r.f. oscillators of one kind or another very great care has had to be given to the screening and filtering of these circuits in order to eliminate set-generated whistles and the effectiveness of this filtering was apparent by the almost entire absence of whistles in the receiver demonstrated to *Wireless World*.

Tuning is effected by two operations, both quite simple. First the megacycle scale (40.5 to 69.5 Mc/s oscillator) is adjusted to the nearest megacycle of the signal frequency, then the fractional part of the frequency is set up on the horizontal film scale (the 2 to 3 Mc/s receiver tuning), which is 60 in long and provides a setting accuracy of 200 c/s. Any drift in the local oscillator is of no consequence as it cancels itself out in the third mixer and the setting of the megacycle scale is, therefore, not critical. By using an unusually high first i.f. and a low-pass filter passing 0 to 30 Mc/s in the r.f. amplifier, conventional tuned r.f. circuits have been dispensed with.



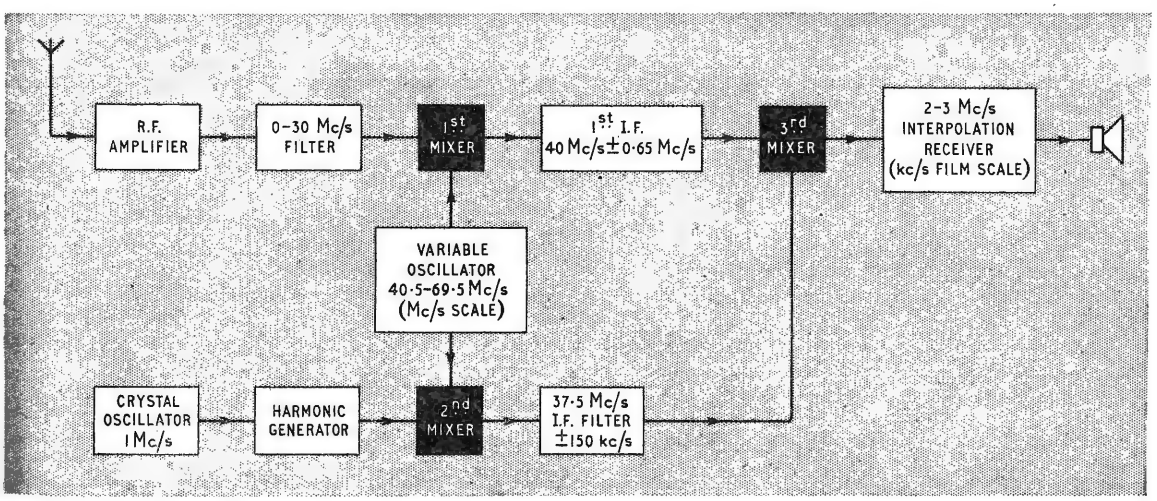
Underside view of the receiver with bottom plate removed. Note the massive die-cast chassis divided into several fully-screened compartments.

The complete absence of mechanical waveband switching in the signal and oscillator circuits contributes significantly to the re-setting accuracy and stability of the receiver over long and short periods of time. To assist further in accurately setting the receiver to a particular frequency there is a built-in 100-kc/s pulse calibrator with pulses derived from the main 1-Mc/s crystal oscillator. This supplies calibration "pips" at every 100 kc/s of the film scale.

A calibrated and stable BFO, adjustable to ± 3 kc/s is included, together with a tone control, a variable selectivity control giving alternative bandwidths of 100 c/s, 350 c/s, 750 c/s, 1.2 kc/s, 3 kc/s and 8 kc/s respectively, noise limiter and "s" meter.

The dimensions of the set are 19 in wide, $10\frac{1}{2}$ in high and 20 in deep; the weight is 56 lb without case and 79 lb in case. The power consumption is about 90 watts from the a.c. supply mains.

Block schematic diagram of the Racal RA17 receiver.



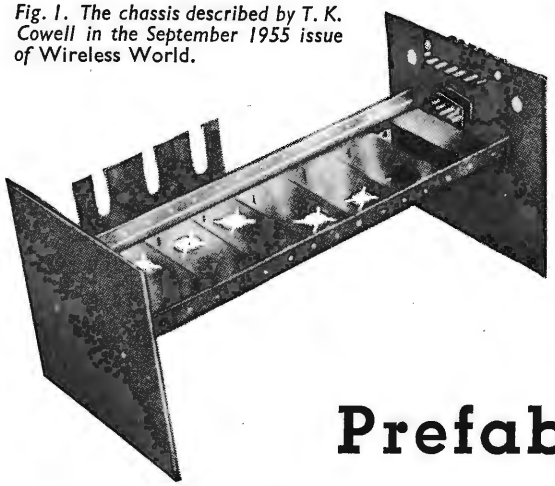


Fig. 1. The chassis described by T. K. Cowell in the September 1955 issue of Wireless World.

DESIGN COMBINING SIMPLICITY WITH VERSATILITY

By D. M. NEALE*, B.Sc., A.M.I.E.E.

Prefabricated Chassis

IN the September 1955 issue of *Wireless World*, T. K. Cowell described a chassis (Fig. 1) for experimental and development work. It was assembled from a number of standard parts so designed that arrangements could be chosen meeting most practical requirements. The system filled a need which had previously been felt in our physics research laboratory and it was disappointing to find that the parts were not being marketed.

Cowell's system was based on the use of eight standard parts. It is accordingly uneconomic for one, relatively small, user to have these parts made to order since the cost of tooling up is prohibitive. The writer has therefore developed the idea further to provide a system more flexible than the original yet requiring only one specially produced component.

It will be seen from Fig. 1 that Cowell's system consisted of valveholder plates and potentiometer brackets bolted to angle-brass runners. These runners were supported at either end by angle brackets bolted to end-plates of which there were four different types. In the modified system, illustrated in Fig. 2, "Meccano" angle girders are used for the runners and angle brackets. These components are already mass produced and readily available. It is therefore unlikely that anything more economical or more convenient can be devised. In fact, the retail price of the finished Meccano parts is about half that of the raw material for parts made in brass. In the original

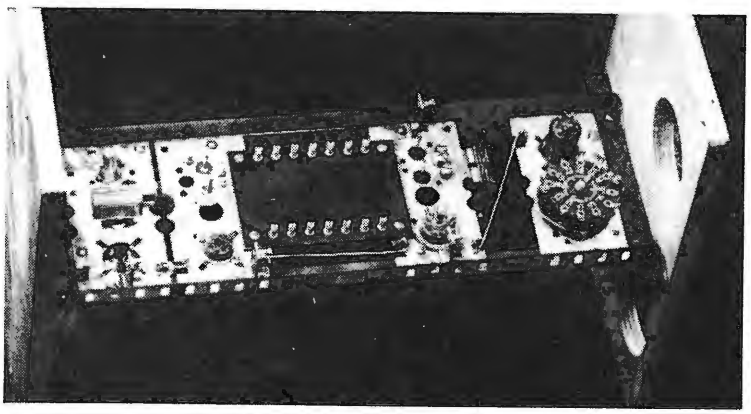


Fig. 2. Underside view of a 12½in × 4in chassis using the new design of plates, Meccano angle girders and wooden end-boards.

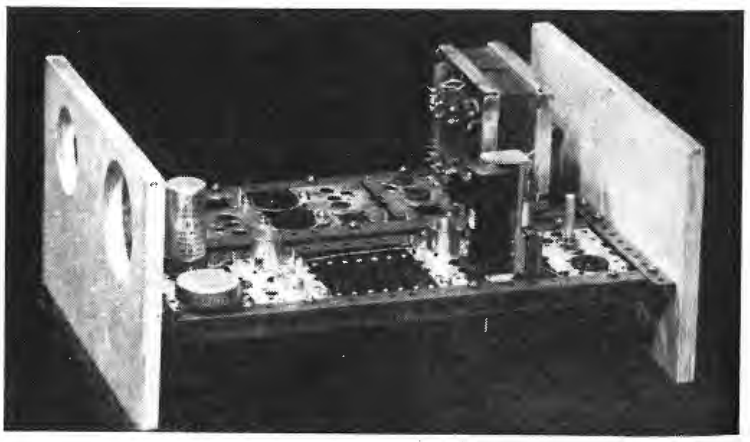


Fig. 3. Top view of a chassis assembled with two 12½in × 4in units using the same wooden end-boards as shown in Fig. 2 but with the long sides horizontal.

*Ilford Limited.

system, the runners were drilled and tapped, but a further economy has been effected by using ¼-in 4-B.A. bolts and nuts in the Meccano perforations.

By using wooden end-boards, the need for four specially produced metal end-plates was eliminated. Only one size is used and this may be produced quickly by unskilled labour. Holes may be cut in some of the end-boards to accommodate 2in and 2½in instruments, but no other components are as a rule mounted on these boards. Figs. 2 and 3 show that the same 10in × 6in end-boards may conveniently be used to support either one or two 12½in × 4in chassis assemblies.

The essence of the new system is a new valveholder plate (Fig. 4) designed to suit the ½-in hole spacing of the Meccano runners. So far as possible, this plate has been made to accommodate all the more common types of component, whilst at the same time keeping to a minimum the number of holes to be formed in the plate. The new type of plate will accept a B7G or B9A valveholder with retaining can and/or a carbon or wirewound potentiometer, several stand-off pillars, rubber grommets, a wafer switch, a toggle switch, two coaxial sockets, a pilot lampholder, an electrolytic capacitor or a Type 3,000 Post Office relay. Fig. 5 shows clearly how provision has been made for various locating spigots and also how rubber grommets are held by semi-circular cut-outs in adjacent plates. Other components may be mounted between one valveholder plate and the next, or between the valveholder plate at one end of the chassis and the cross-bearer supporting the runners. In this way, it is possible to mount terminal boards, Jones plugs and sockets and the larger types of valveholder and electrolytic capacitor without drilling any further holes in the valveholder plates.

Since the potentiometers are mounted in the valveholder plates, rather than at right angles to them, it is a simple matter to transfer successful "breadboard" circuits to rack mounting when required. It is necessary only to remove four nuts and bolts to detach the wooden end-plates and Meccano bearers from the assembled 12½in × 4in chassis. Four of these chassis may be mounted side by side across the width of a 19-in rack with a ½-in space between each. Standard 18½-in Meccano angle girders may be used as horizontal bearers, but it then becomes

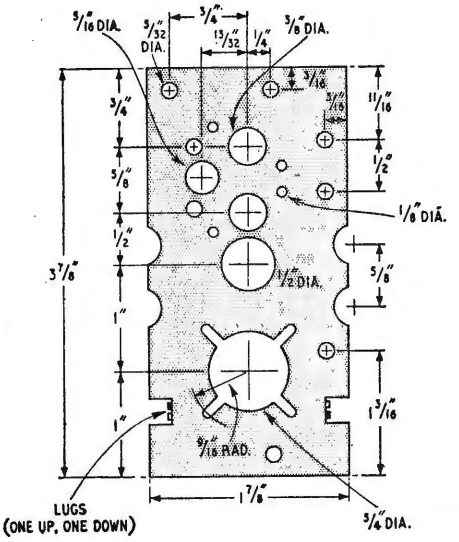


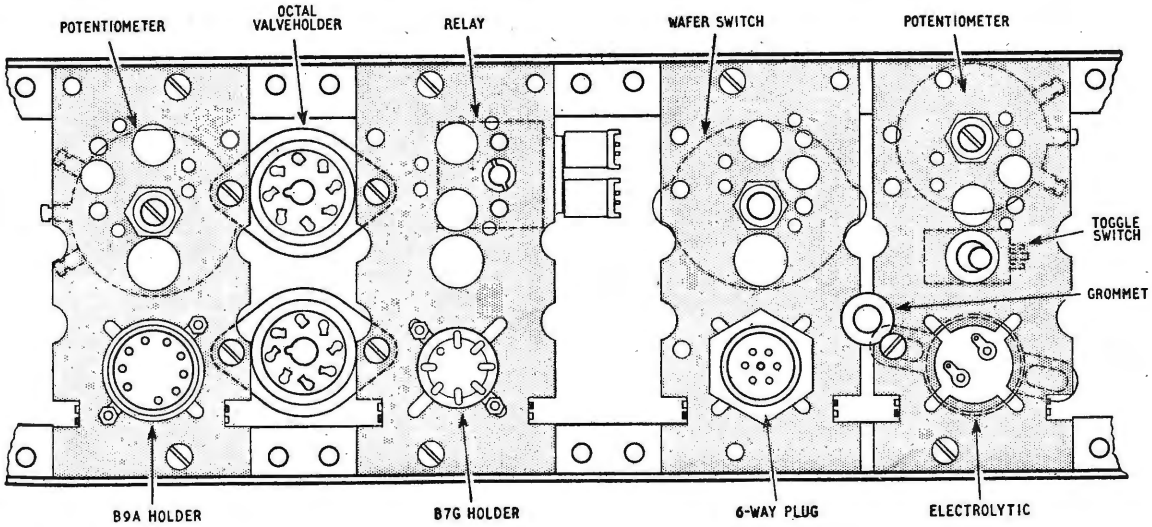
Fig. 4. Dimensions and drilling details of the new valveholder plate.

necessary to drill and tap the rack at non-standard spacings. However, not many such holes are required and these do not conflict with standard hole positions.

Valveholder plates may be made in 22 s.w.g. bright mild steel, electro-tinned after stamping. A cadmium finish may also be used provided it is not passivated. The electro-tinned finish simplifies soldering to the earthing tags on the plates. It is, of course, essential to bond all plates together by a tinned copper wire joining the earthing tags since the enamel finish of the Meccano runners makes earthing through the securing bolts uncertain. It was expected that earthing troubles might arise with r.f. circuits, but a 7-stage video amplifier with 2 Mc/s bandwidth has given no trouble at all.

The above design is proving a very satisfactory

Fig. 5. Showing how components can be mounted between valveholder plates and how rubber grommets are accommodated in semi-circular cut-outs.



compromise between flexibility and economy. By virtue of its asymmetry, each plate may be mounted between runners in four possible orientations. A further four orientations are possible if the valve-holder plate is mounted longitudinally between transverse plates. This is not generally done, however, because it involves flattening or removing one of the earthing tags on each plate.

Normal usage of the plates calls for no cutting, bending or drilling. When a chassis is dismantled, therefore, all plates may be returned to stock as good as new.

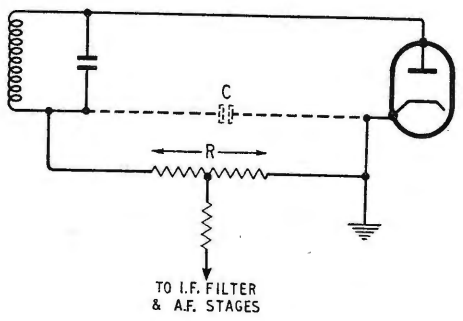
Diode A.M. Detector Circuits

A Note on Reduction of Distortion

IN PRACTICE (though not necessarily in theory), the reception quality attainable from f.m. transmission is better than that from a.m. However, f.m. transmissions have a shorter range than a.m. In the absence of relay systems, long distance transmissions which are thus only available with a.m. may have sufficient programme value to make it worth while to try to receive them with the best quality obtainable.

In a.m. reception it is quite possible for the detector to provide a major part of the total distortion in the system. Thus it is worthwhile trying to reduce the distortion in a.m. detectors. The theory of this is well known†; but two useful practical details seem to have been little mentioned.

In such diode detectors it is usual to have a shunt capacity (C say) across the diode load (R say), in order to fill in the half cycles at r.f. (which would otherwise be the only output from the detector) to the full a.f. envelope, and thus to increase the detection efficiency.



A well-known type of distortion in diode detectors arises at high modulation levels due to shunting of the load R at a.f., so that the resultant a.f. load is less than the d.c. load R. Generally only the unavoidable resistive shunts are considered and the shunting produced by the capacity C is neglected.

The usual method of reducing the a.f. shunting is to take the a.f. output from a tap down the diode load. The shunting can be still further reduced by also putting a resistance in series with the output*, a method which appears to have been seldom mentioned.

By these two methods it is easy to make the equivalent a.f. shunting resistance across the d.c. load R at least 20 R, even at the highest a.f. where high modulation fractions may occur (5 kc/s say). It is particularly easy if the a.f. is fed into a sensitive pre-amplifier; in which case the low-pass filters usually provided can often be useful in combating interference.

Thus, to reduce distortion due to shunting by C at a.f. to the same level as that produced by other a.f. shunts the reactance of C at 5 kc/s should be not less than 20 times the diode load R. This leads to much smaller values of C than those usually used.

The argument in the last paragraph assumes that, as regards this type of distortion, C acts at any one frequency like a resistive shunt of amount equal to the reactance of C at that frequency. Actually, owing to the elliptical loadline produced by C, the equivalent resistive shunt will be only half the reactance of C, so that C should be further reduced by a half. In any case, if the reactance of C at 5 kc/s is 20 R, at the i.f. of 465 kc/s it will still only be about R/5, and it will not properly fill in the half cycles at r.f.

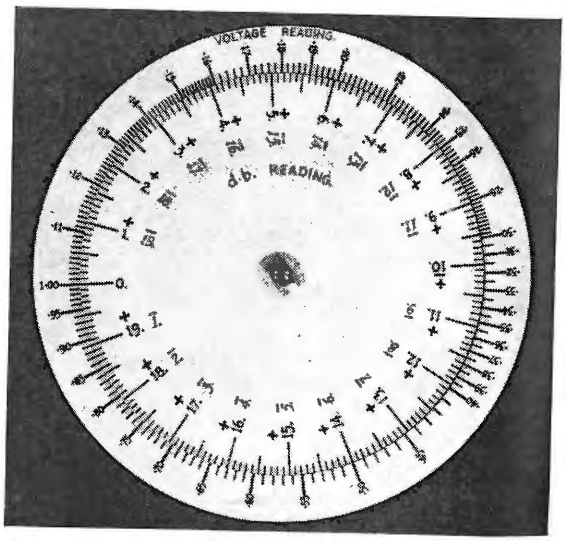
C could thus perhaps best be omitted altogether. This also has the advantage of reducing the damping on the last i.f. transformer secondary by a factor of about four, and thus of increasing the selectivity. A practical test gave a marked decrease in the distortion produced by off-tuning (a way of effectively raising the modulation fraction at high a.f.).

M. G. L.

† See for example, "Radio Receiver Design," by K. R. Sturley; Part 1, Chapter 8. Published by Chapman and Hall.
* D. T. N. Williamson, *Wireless World*, Vol. 55, p. 477, 1949.

Decibel Circular Slide Rule

THE Gerry dB Calculator is virtually a two-scale circular slide rule—one scale being linearly marked in decibels and the other being an antilog scale divided by twenty. Thus voltages or currents into constant impedance on the antilog scale correspond to decibels on the other. The scale is accurately made within the limits of the rather thick lines, but this limitation is unlikely to be of importance in normal radio or audio work. The rule costs 15s and may be obtained from Blundell Rules, Ltd., Lynch Lane, Weymouth, Dorset.



POTENTIAL — MAP READING IS A GREAT HELP

By "CATHODE RAY"

IT is customary for the people who unravel the intricacies of semi-conductor theory to illustrate their remarks with diagrams showing the variations of electrical potential in the material. Fig. 1, for example. This represents a p-n-p junction transistor, and it is pointed out (though probably in more refined language) that if the "holes" shown reposing on the emitter shelf are jerked up the slight hill to the base they are very likely to topple over the potential precipice on the other side and land on the collector.

Assuming it is clear to all why the potential diagram should have this particular shape, fair enough. But is it safe to assume this? If the relative heights of the various parts of the graph corresponded to the voltages imposed from without on the electrodes corresponding to those parts, all would be well. So far as the collector is concerned, all *is* well, for its depressed potential corresponds to the relatively large negative voltage applied by a battery. But on the same principle the base potential ought to be slightly *lower* than that of the emitter, to correspond with the small negative bias applied.

Presumably the instructor will have already dealt with this anomaly by some preliminary work on the simple p-n junction, in which he may well

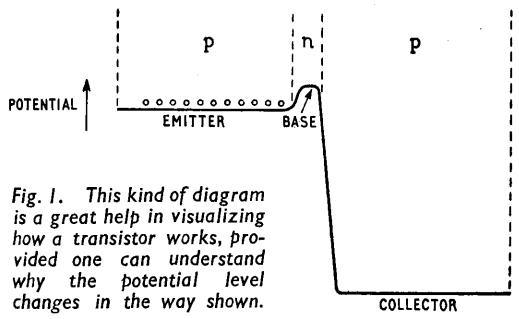


Fig. 1. This kind of diagram is a great help in visualizing how a transistor works, provided one can understand why the potential level changes in the way shown.

have exhibited something like Fig. 2. Here it is supposed that no batteries are connected, the potential changes shown below being a result of the distribution of charges shown above. Now this is the point where I suspect the assumption of obviousness often comes unstuck. I feel that those whose studies have tended towards the practical rather than the theoretical are likely to associate potentials with applied voltages and are not particularly enlightened by potential diagrams derived from vague charges inside a chunk of material. It was for this reason that I carefully avoided potential diagrams when on this semi-conductor subject just a year ago.

But such diagrams do appear, and if it is true that some of us are not too clear how they are arrived at, then it is time we went back to first principles to find out. Is it unkind to suggest that a lot of people who talk about potential would be unable to say what it means?

There are various textbook definitions; for example: "Potential is the quantity whose space rate of change in any direction is the field strength in that direction." That is delightful for people who thrive on textbook definitions, but what does it mean in terms that can easily be visualized?

Potential, Height and Energy

One thing we can hardly have failed to notice at a very early age is that where differences of height occur between two places there is a tendency for things to move from the higher place to the lower. Further observation shows that the greater the gradient between the two places the greater the tendency. This tendency has been named gravitation. To sound more scientific we can call the tendency the force due to a gravitational field—the one in which we happen to be situated. Another name for gradient is rate of change of height. So if we look again at the textbook definition we discover that it defines what we usually call height. Height, in fact, is the particular kind of potential when the field is a gravitational one. A gravitational field manifests itself by the force it exerts on the *mass* of objects. An electric field manifests itself by the force it exerts on the electrical *charge* of objects. But whereas electric potential (which is the one we are supposed to be discussing) is difficult to visualize, gravitational potential in the guise of height is familiar to all. No wonder, then, that it is the favourite analogue for potential. A particularly attractive feature of the analogy is that diagrams like Fig. 1 become more than mere graphs; they are also drawings of working models whose mechanical performance gives quite a good idea of the electrical performance of the thing repre-

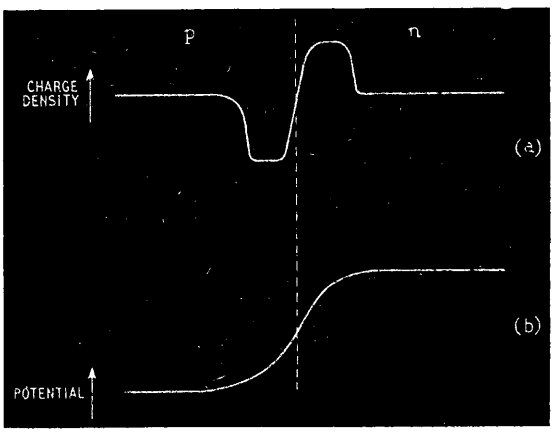


Fig. 2. This is the usual explanation, but is it clear why (b) follows from (a)?

sented. (Like most attractive things, however, this analogy can lead one astray if one doesn't know where to stop.)

If the dimension along the arrow in Fig. 1 represents height, the diagram is a vertical section of the gravitational analogue of the transistor. In the same way Fig. 3(a) is a vertical section across a tract of country. In this form, the information is limited to a single line on the ground, so it is more usual to transfer it to the horizontal plane as shown at (b), forming a contour map. Of course, this one vertical section locates only a row of points along AB; to draw the contour lines it is necessary to plot the heights at many more places. Alternatively, Fig. 3 shows how a contour map can be used to construct a vertical section along any line. It is the same with potentials; given one form of diagram, the other can be derived.

Now although a scale of height is shown in Fig. 3(a), what usually matters most is the relative height. The appearance of this piece of country, and the behaviour of loose objects on it, would not be affected if all the figures in the scale were increased or decreased by some fixed amount. There is really no such thing as absolute height; the figures usually specified are heights relative to mean sea level. In the same way there are only relative potentials. Unless the contrary is stated, " earth " is the " mean sea level " in the electrical world.

The meaning of a contour line is that all points on it are at the same height. It could be called an " equi-height line." Analogous to it on a potential map is an equipotential line. As Fig. 3 illustrates, steepness of gradient can be judged from a map by closeness of contour line spacing. So without looking at (a) we can easily see that there would be a stronger tendency to fall down the right-hand slope of the hill than the left. What we may actually have done by now, however, is to have fallen into a trap. How did we reckon the gradient?

Rolling Stones

The usual procedure is to measure the distance on the map between two contour lines. Take the points x and y on Fig. 3(b). Suppose the distance scale shows them to be 200ft apart. Then, as x is 100ft higher than y, the gradient is said to average 1 in 2, or $\frac{1}{2}$. If somewhere two contour lines were found to touch, the gradient there would be 1 in 0, which is infinity. According to our textbook definition, that ought to mean an infinitely large gravitational force! It would certainly mean an infinitely large electric force if two equipotential lines touched. But we know in fact that even at a vertical precipice, where the gradient is (according to usual reckoning) 1 in 0, the force on a body is no more than equal to its weight. Where is the catch?

No doubt you have already spotted it—the practice of reckoning land gradient in terms of height difference per *horizontal* distance (because that is what one can measure on the map). In applying the textbook definition to a hillside we tacitly assumed that the gravitational field strength is reckoned along the surface of the ground, because that is the only place where stones, etc., can roll; so for that purpose gradient ought to be reckoned as difference of height per distance *along that surface*. The maximum is therefore 1 in 1, or the full vertical gravitational pull. The operative word in the definition is " space rate

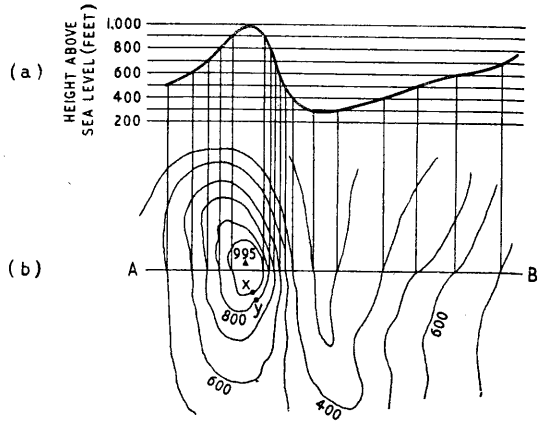


Fig. 3. Vertical section and contour map of a hill. It would be strictly correct to refer to the height scale as a potential scale.

of change." Our interest in electric force is not usually limited to the two dimensions of a surface, but may occupy three-dimensional space. So electric contour maps are not necessarily based on a horizontal plane.

This shows how careful one must be not to swallow an analogy whole without making sure that there are no differences in custom regarding method of reckoning.

An advantage of a contour map over a vertical section is that it shows not only the amount of gravitational pull (when correctly reckoned!) but also its direction. Obviously the gravitational force is a maximum in the direction of steepest downhill gradient. And the steepest gradient between two parallel contour lines is at right angles to them, because that gives the shortest distance from one level to the other. So a ball will tend to roll in that direction, along what we might call a line of gravitational force. In the same way, the so-called lines of electric force are everywhere at right angles to the equipotential lines.

We mustn't jump to the conclusion that the lines of force (gravitational or electric) are the paths that would actually be taken by a freely rolling ball or a freely moving charge. Fig. 4 shows a succession of contour lines, and we can plot a line of force beginning at A by drawing it at right angles to them (and to all the intermediate ones, not shown but estimated). It arrives at B. But a ball released at A would depart from this line directly it began to turn the corner, because its own inertia would tend to carry it on in a straight line (Newton's first law of motion). The ball's path—probably something like the dotted line—would be determined by the resultant of its movement in the direction of the line of force and its previously acquired movement in another direction. Roughly the same is true of a charged body in an electric field; even an electron has some inertia, minute though it is. But here there is another slight flaw in the analogy, for the ball rolling under the influence of gravity is rather a special case, in that the gravitational force tending to deflect it from its original direction is proportional to its mass and therefore to its inertia, so that (apart from secondary effects such as friction) balls of every weight would

follow the same path*. Charged bodies are not so; the force brought to bear on them by an electric field is proportional to their charge, which is quite a different thing from their mass or inertia. This distinction is not merely academic; it has an important bearing on the design of the domestic television tube. When an electron is knocked off an atom, it and the damaged atom (or *ion*) have equal though opposite electric charges, so have equal forces acting on them in a given electric field. But the mass of the ion is enormously greater than that of the electron, so the field deflects the ion far less. Advantage is taken of this fact in devising ion traps to prevent negative ions from bombarding the screen.

A very important part of the subject of potential concerns work and energy. Rolling a ball or anything else uphill is work in the strictly technical sense, and can only be done at the cost of energy. If a 10-lb weight is raised 50 feet, measured vertically, 500 ft-lbs of work have to be done (not counting friction); and the weight gains 500 ft-lbs in potential energy. Its potential is increased by 50 feet. So another way of defining height could be as the amount of work that had to be done on a standard weight—say 1 lb—in order to lift it from the lower to the upper level.

If a weight is allowed to go downhill, its potential energy is (neglecting friction) converted into kinetic energy—energy of motion—which is capable of doing work. For instance, it could carry the weight some way up a hill. So alternatively height could be defined as the amount of energy acquired by a standard weight in falling from the upper level to the lower. This amount could be judged by the velocity it has acquired.

It happens that height can usually be much more conveniently and accurately measured as vertical distance. But one cannot measure difference of potential in any such simple and direct way, so reckoning it in terms of work is of practical as well as theoretical importance. In fact, potential is commonly defined as the amount of work required to transport unit charge from one place to the other—a definition apparently quite different from the one quoted at the beginning, but amounting to the same thing.

Of course it is necessary to be consistent with the units. If you want the potential difference to be in volts, the unit charge must be taken from the same set of units, viz., one coulomb, and the work must be reckoned in joules (=watt-seconds). In electronics one is so often concerned with the very minute amount of work required to push a charge of one electron up a potential hill reckoned in volts that a semi-official unit of work or energy—the electron-volt (eV)—is commonly used. It is about 1.6×10^{-19} joule.

It is also necessary to get the signs right. Saying the difference in height between A and B is 50 feet is not much help unless one knows whether A is higher or lower than B. If work has to be done on the standard weight to move it from A to B, that implies at once that B is higher than A. But it is really meaningless to ask which of two points has the higher electric potential because, in relation to potential, " height " is only metaphorical. It has however been generally agreed to describe the potential at A as higher than at B if (relative to B) A has a surplus charge of the kind arbitrarily called positive. (This is the same thing as B having a surplus of the other kind of charge, called negative). Now it is an experimental fact that charges of the same kind repel one another, so one of them has to have work done on it to make it move nearer the other. It follows that if a positive charge needs an external effort to make it go in a certain direction, then that direction is towards a higher potential. The natural tendency of a positive charge, then, is to run " downhill," so it is the analogue of the rolling stone on a hillside. A negative charge, on the contrary, tends to move " uphill " towards points of higher potential.

For the purpose of this explanation I attributed the high potential at A to a positive charge there, but it is not necessary to have any charges at either point between which there is a difference of potential. In the arrangement shown in Fig. 5(a) the battery transfers electrons from plate P_1 to P_2, charging P_2 negatively and P_1 positively. This establishes a difference of potential (equal to the voltage of the battery) between the plates, and there will be a potential gradient from one to the other, A being at a higher potential than B; see Fig. 5(b). An electron in the space between them would tend to move towards A and would have to be forced to move towards B. An analogue of this could be constructed of a large sheet of thin rubber stretched on a horizontal frame, with a horizontal rod to represent P_1 pushed up from below to raise the rubber into a ridge, and another one (P_2) pushing it down. Bearing balls could represent loose positive charges. If the space beneath the rubber were filled with liquid, electrons could be represented by small air bubbles, which would tend to run towards P_1.

All this may be simply underlining what I began by assuming everyone understood—the potential patterns due to batteries and other sources of volts. But when tackling the potential gradients inside semi-conductors, next month, it will be an advantage to have some definite ideas about the meaning of the word " potential."

* It was this curious fact that led Einstein to his General Theory of Relativity.

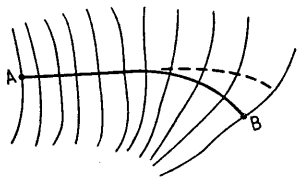


Fig. 4. The curve AB is a line of force, but a body acted upon by the force might take the dotted path.

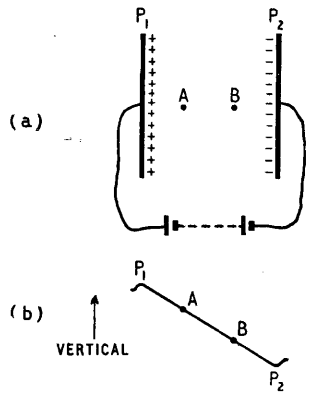


Fig. 5. Points AB are situated on a potential slope, as indicated by the model (b).

Doppler Navaid for Civil Aircraft

Self-contained Air Navigational System Entirely Independent of Ground Station Co-operation

MILITARY aircraft of the Royal Air Force have been using the Marconi Doppler Navigator for the past three years, but so far nothing quite comparable to it has been available for civil aircraft. All the existing airborne radio navaids require the co-operation of one or more ground stations and failing this navigation in the air hitherto had to rely on old-fashioned systems. More important than this the pilots of civil aircraft flying to-day have no accurate knowledge of the actual ground speed, drift or prevailing wind velocity.

These points serve to underline the importance of the new Doppler Navigator, Type AD2300, specially designed for commercial aircraft and recently introduced by Marconi's Wireless Telegraph Company. The equipment operates as a self-contained system in the 8,000-Mc/s band and is entirely independent of any ground station.

The AD2300 provides the airline pilot with accurate indication of ground speed, drift-angle and distance flown, and used in conjunction with a computer, gives instantaneous and continuous information of the aircraft's immediate position in latitude and longitude, wind direction and wind speed. The distance to go along a " leg " of a predetermined flight plan, or the distance to fly along a composite track to reach a destination, and also more accurate computation of ETA (expected time of arrival), than hitherto, comprise some, but by no means all, of the navigational information available with this new navaid.

Theory of Operation

The full equipment comprises an aerial system, a transmitter-receiver, a tracking unit, computer and display unit. The system is based on the phenomenon of the displacement in frequency which occurs at the receiving position when the transmitter and receiver are in relative motion to a fixed point of reflection of the waves. The basic principles were described in *Wireless World* recently.* Two c.w. beams are radiated from the aerial one projecting forward and the other backward and both are depressed towards the ground. A small amount of the radiated energy is returned, by ground reflection, to the aircraft where analysis is made of the difference in frequency existing between the transmitted and received waves. This difference is directly related to the speed of the aircraft relative to the ground.

By displacing one beam to starboard and the other to port, and alternately switching their positions, the drift angle of the aircraft is found by comparing the Doppler frequency when the forward beam is displaced to starboard and the backward beam displaced to port, to the frequency derived when the beam positions are reversed. The aerial is then rotated until the two frequencies are equal and it is then aligned along the aircraft track.

*" Airborne Doppler Navigation " by G. E. Beck, *Wireless World* May 1957, p. 225.

The aerial system comprises four slotted linear arrays lying parallel to one another in a directional horn assembly with the axis of the aerial horizontal. The forward and backward beams are obtained by feeding from each slotted unit in turn, two waveguides being used for transmission and two for reception. At the half-power points the beam width is $3\frac{1}{2}°$. A sample of the transmitted signal is extracted in a directional coupler and mixed with the received signal.

Airborne Computer

The transmitter and receiver units and their associated power supplies are housed in a single unpressurized case with cooling complying with the American ARINC standard. The carrier wave is generated by a klystron and the transmitter output is one watt. The output from the receiver is fed to the tracking unit, which contains the frequency measuring circuits for determination of ground speed and drift angle, a.g.c. and automatic search circuits. Frequency measuring is effected in a discriminator, where the Doppler signal is compared with the tone generated by a phonic wheel. The resultant frequency is used to control integrator and azimuth drive circuits, the former controlling the speed of the phonic-wheel motor and the latter a motor situated in the aerial system which rotates the aerial for drift-angle measurement. The phonic-wheel speed is a measurement of aircraft ground speed.

The resultant speed and drift information is fed to the computer, an electro-mechanical type using analogue methods for solution of the trigonometrical equations concerned in the navigational problem. Inputs of compass heading and true air speed are also fed to the computer.

The display is capable of considerable variation to suit individual requirements. It may be embodied in the computer, or if the only information required is ground speed, drift angle and distance flown, these can be displayed by a small indicator unit which will in such cases replace the computer unit.

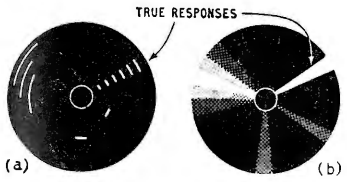
The Marconi AD2300 operates over an altitude range of 150 ft to 50,000 ft, at ground speeds of 80 to 900 knots, at drift angles up to $\pm 45°$, up to 10° climb or descent and up to 20° of bank. The equipment will function in steeper angles of climb, descent and bank than given, but the accuracy may be degraded slightly.

A pilot's left-right indicator for steering the aircraft on a desired rhumb line, or great-circle course, can be included, also information of distance to destination and visual indication when the end of a " leg " of a pre-determined course has been reached. In addition the left-right course indication is available as a signal for feeding into an auto-pilot.

All units are for standard ARINC rack mounting and all valves have American equivalents. The total weight, including aerial system and computer, is 130 lb.

Technical Notebook

Helical-Scan E.E.G. display described by H. W. Shipton in Vol. 7, No. 2, of the *Proceedings of The Electro Physiological Technologists' Association* uses a number of small c.r. tubes to give a topographic presentation of brain potentials picked up simultaneously from various parts of the patient's head. In an earlier "electrotoposcope" the c.r. tubes had a p.p.i. type of rotating radial timebase, as shown in (b), a stationary pattern being obtained when the rotational speed of the timebase was related to the frequency of the e.e.g. signal. When, however, a photographic record was taken, the light



integration made it difficult to distinguish the true responses, related to the timebase rotation (at "2 o'clock"), from others of short duration (4 and 6 o'clock), and those formed by overlapping when a signal was drifting slowly round the tube (at about 9 o'clock). With the helical scan, however, which increases in diameter during the camera exposure, the different types of responses can be clearly distinguished, as shown at (a). Signals related to the rotational speed appear at the same bearing on successive sweeps but with changing radius. Where there is not an exact relationship, a progressive displacement occurs on successive sweeps from which an estimate of frequency can be made.

Grown Infra-Red Crystals, for use as windows, lenses and prisms in this not-quite-optical part of the electromagnetic spectrum, are now being produced on a commercial scale with a purity and crystalline perfection superior to that of the natural material. Hilger and Watts, for example, are growing rocksalt (sodium chloride) crystals about 8 inches in diameter by 4 inches thick from which optical components can be cut. The polished surfaces can be aluminized if necessary. Rocksalt is transparent over the wavelength range 0.2 to 15 microns, but potassium bromide crystals of similar size can be grown to extend this to about 26 microns and caesium bromide crystals to go up to 40 microns. Where the infra-red components have to be used in extremes of temperature or with rapid heating and cooling rates, silicon crystals offer distinct advantages. These are being grown by the American firm Texas Instruments with impurities of less than 1 part in 10^8. A silicon component 3mm thick will transmit over 50% of the incident radiation between 1.3 and 9 microns, but transmissions greater than 90% can be achieved at particular wavelengths within this range by applying a low-reflection coating to the material.

Information-Theory Servicing of electronic equipment is discussed by R. B. Miller, J. D. Folley and P. R. Smith in D.S.I.R. unpublished report PB118038. Methods of fault diagnosis using the "half-split" technique for eliminating alternatives leads to a consideration of the relationship between fault-finding, information theory and probability data.

New Storage Ferroelectric called triglycine sulphate has the same kind of rectangular voltage hysteresis loop as the well-known barium titanate but with a much lower coercive field, allowing it to be switched from one state to the other with potentials of only about 20 volts. This means that transistors can be used for driving purposes. Discovered by B. T. Matthias of Bell Telephone Laboratories, the new material is stable chemically and does not decompose when exposed to moisture or to the atmosphere. Large single crystals can be grown quite easily (see picture), and a number of large-area slices can be cut from each crystal. Repeated switching does not cause any fatigue in this material, as it does in barium titanate, and a given area will retain a given polarization in-

definitely without any deterioration. Although heating beyond 47°C (the Curie point) causes the material to lose its ferroelectric properties, these properties are regained in full when it is cooled. By replacing some of the hydrogen atoms with deuterium the Curie point can be raised to 60°C. Switching times of the order of 1-2 μsecs can easily be attained. A matrix store can be constructed with 30 or more electrodes to the inch evaporated on to each side of a thin slice of crystal. This means that 900 or more binary digits can be stored on a square inch of the material—a very compact form of storage compared with most other methods.

Function Generator Tube designed by L. S. Allard of G.E.C. Research Laboratories is a self-contained c.r.t. device which depends for its operation on the equal division of beam current between two target electrodes. Conventional c.r. tubes have been used as Function generators in the past—the spot being made to follow the profile of an opaque mask stuck on the tube face—but these suffer from the disadvantages that the screen phosphor is very readily

burnt and that voltage fluctuations are introduced into the output by the granular structure of the screen. In the G.E.C. tube one of the two target electrodes is cut to give a profile of the required function while the other is a planar disc. As the electron beam is scanned across this assembly in the X direction it is constrained to follow the profile by a feedback voltage derived from the target electrodes, which is applied to the Y deflection plates so as to maintain the equal division of beam current between the electrodes. The voltage applied to the Y plates varies in accordance with the y ordinates of the profile electrode and so provides the required output.

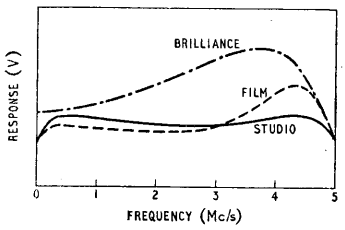
Fast Kerr Cell, using nitrobenzene, is being developed as a light shutter to give extremely short light pulses of the order of micro-microseconds. Some parts of the work are described in D.S.I.R. unpublished report PB118714, by G. L. Clark, D. K. Holshouser and H. M. Von Foester.

Square-Law Thermocouple. — A method of compensating a thermocouple to make it accurately follow a square law was shown at the recent N.P.L. Open Day. By joining a platinum wire of high tempera-

ture coefficient of resistance in series with the thermocouple an opposite deviation can be added to that of the thermocouple. In this way power measurements to within 0.25% can be obtained.

C.R.T. Chronograph has been built for measuring and recording a large number of consecutive time intervals. The signals appear as lines on a c.r. tube raster and are recorded photographically. Circuitry and possible extensions are discussed in D.S.I.R. unpublished report PB114757 by H. G. McGuire and K. A. Yamakawa.

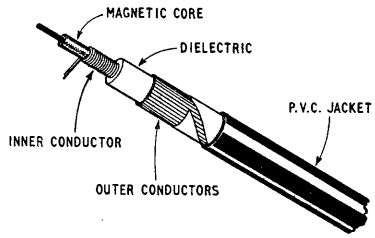
Video Response Control, equivalent to the tone control of a sound broadcast receiver, is used in a recent German television receiver, the Nordmende "Diplomat 58." Three conditions are available, "Studio," "Film" and "Brilliance," as shown in the accompanying sketch, and the circuit corrections to obtain them are selected by a piano-key switch. Appropriate compensation is applied automatically to the picture contrast as each key is depressed. A full description of the receiver appeared in the issue for the second half of March, 1957, (No. 6) of *Funk-Technik.*



High-Power Microwave Frequency Doubling in ferrites is reported by J. L. Melchor *et al.* in *Proc. I.R.E.* for May 1957. The frequency doubling arises from the generation of a double frequency component of magnetization along the direction of the d.c. magnetizing field. The efficiency depends markedly and in a complicated manner on the ferrite geometry. By careful attention to this point a conversion loss of only 6 dB has been achieved for doubling from 9 to 18 kMc/s. Peak and mean power levels can be as high as roughly 32 kW and 20 watts (at 9 kMc/s) respectively.

Coaxial-Line Monitor Diodes for the S, X and Q microwave bands are available from Elliott's. These consist of a length of evacuated coaxial line terminated in a dissipative load (iron-loaded resin). When an electromagnetic wave is propagated along the line the potential difference produced by the r.f. energy between the inner cathode and outer anode causes electrons to flow between them. Owing to the short response time (less than 0.01μsec), r.f. pulse envelopes can be directly viewed on a c.r.o.; the high output (of the order of 50 volts) being also useful for this purpose. Mixing and demodulation are, of course, also possible. High maximum mean and peak power inputs of at least 10 watts and 50 kW respectively can be accepted. Reflection coefficients of less than 0.09 over the band can be obtained in the tunable holders provided.

Magnetic-Core Delay Cable, produced by the Columbia Technical Corporation of New York, contains, inside the inductive winding, a continuous, flexible, low-loss magnetic core which serves to increase the impedance and the unit delay of the line. This kind of delay element is,



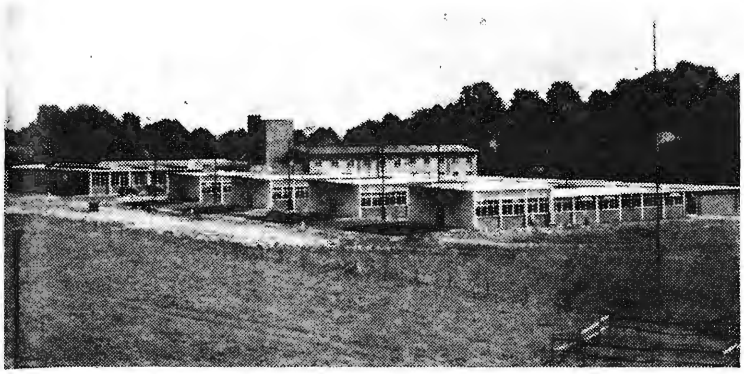
of course, a distributed-parameter type, and does not have the same sort of cut-off frequency as lumped-parameter lines. Rather the attenuation increases gradually with increasing frequency. Cables are available with delays ranging from 0.08 to 1.0 microsecond per foot and with impedances between 1,500 Ω and 3,900 Ω. They are intended mainly for pulse work in a frequency spectrum up to 30 Mc/s and have bandwidths ranging from 6 to 15 Mc/s. Any delay can be obtained by cutting off the appropriate length of cable, and the makers will supply calibrated lengths complete with terminations.

R.F. Power Transistor, capable of providing an output of 5 watts at 10 Mc/s either as an oscillator or an amplifier, has been developed at Bell Telephone Laboratories. Normally, of course, it is difficult to make power transistors work at even high audio frequencies because of their necessarily large dimensions. The Bell device, however, which is made from silicon, achieves the high frequency performance by using the diffusion method of forming, together with a p-n-i-p type of structure in which a "neutral" layer of silicon separates the collector from the other elements. Alpha cut-off frequency is about 100 Mc/s and some laboratory samples have apparently provided as much as 1 watt output in oscillation at this frequency. Another silicon power transistor of high performance has now been put into commercial production by Texas Instruments in the U.S.A. This is the 2N389, with a power dissipation of 37.5 watts at 25°C and 15 watts at 100°C, and it is made by a diffusion process similar to that of the Bell Laboratories. It is intended for use in power circuits which have to operate at high temperatures.

Transistors in Parallel for obtaining greater power output from pulse amplifiers are used in a technique described in D.S.I.R. unpublished report PB111665 by J. F. Spades and A. W. Carlson. Parallel operation of the transistor regenerative pulse amplifier is achieved by means of common-base and common-emitter connections, but with each emitter returned through a separate path.

Microwave Pulse Powers can be measured from the perturbation of electron beams in a new technique described by H. Thomas in *Proc. I.R.E.* for February 1957. The beam is accelerated transversely through an evacuated section of waveguide carrying power in the TE_{10} mode. To a first approximation, the electrons gain energy in one half cycle of the r.f. (when they are in phase with the r.f.), and lose it in the next (when they are out of phase). Thus, if the transit time is an odd number of half cycles, there will be a net gain or loss in the odd half cycle. The accelerating potential is adjusted so that the transit time is such that there is a maximum net gain. This gain is measured by a d.c. cut-off potential. It can be theoretically related to the Poynting vector of power flow. It is necessary to correct for the perturbations in the r.f. field produced by the holes in the waveguide through which the beam passes. This also can be done theoretically. Corrections due to standing waves in the guide can be made either from measurements of the phase and amplitude of these waves, or by using three separated beams. The thermal distribution of the electron's energy produces an uncertainty in the true current cut-off point which can lead to serious errors at low powers. However, by subtracting the apparent cut-off voltage without power flow from that with power flow, this uncertainty is eliminated. The directness of this method is of particular advantage in the measurement of peak pulse powers where the errors are normally about 30% or more. The fact that the power flow is not disturbed by the measurement may also be useful.

Unpublished Reports mentioned above come from various sources but can be obtained from the Technical Information and Documents Unit of the Department of Scientific and Industrial Research, 15, Regent Street, London, S.W.1.



Radio Research Station's new building at Ditton Park, showing the four laboratory units and the administration block in the background.

New Building for Radio Research Station

IT is perhaps appropriate that the formal opening of the new building at Ditton Park for the Radio Research Station of the D.S.I.R. should take place on the eve of the International Geophysical Year, during which over 1,000 research stations throughout the world will be participating, with the Radio Research Station taking a leading part. The opening ceremony was performed by Sir Edward Appleton, F.R.S.

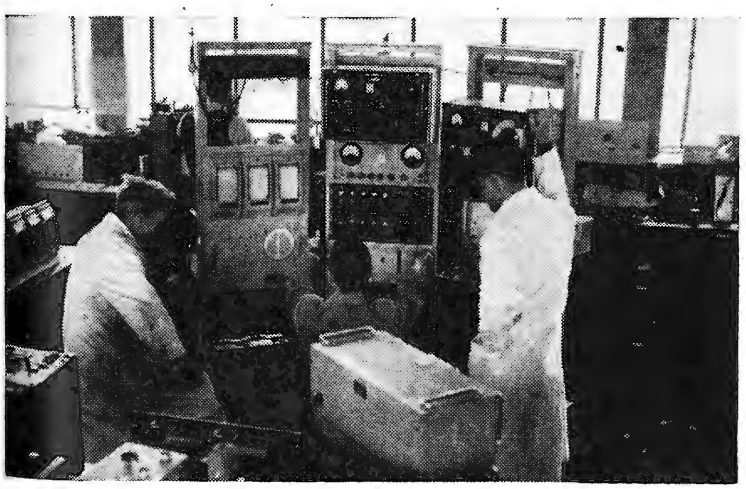
The new building has accommodation for a staff of 300 and much of the work hitherto carried out in wooden hutments scattered throughout the park, and at the N.P.L., will now be concentrated under one roof. The building consists of a central two-storey administration block with two single-storey wings, one containing laboratories and the other workshops and stores. The laboratories jut out into the field area of the park and have easy access for aerial lead-ins from the many diverse kinds of aerials on which much of the work at the station depends.

Radio wave propagation has always been one of the principal subjects for study at the station and a new development in this field is the utilization of back-scatter for determining skip distances on the short waves. Back scatter results where r.f. waves strike the ground after refraction in the ionosphere and some travel back to the transmitter over the same path as the waves that originated the echoes. Radar technique is used to plot, on a p.p.i. display, echoes from one- two- and sometimes three-hop transmission paths.

Study of the ionosphere has enabled D.S.I.R. to issue long-term forecasts, enabling all users of radio channels to plan their communications some six months in advance. Investigation into the causes of errors in radio direction finding at h.f., v.h.f. and u.h.f. occupies much of the time of the station.

Among the activities at the new laboratories is the study of the properties of ferrites and of semi-conductors.

Interior of one of the laboratories in the new Radio Research Station's Building.



RANDOM RADIATIONS

By "DIALLIST"

Sound Sense About Aerials

THERE'S good sound sense in the recommendations on TV aerial and feeder installation recently issued by the R.E.C.M.F. From my window, for instance, I can see a horizontal array so erected that it overhangs a chimney pot and is less than a foot above it. One hates to think of the devastation when the sweep comes to do his stuff! Very rightly, this sort of thing is frowned on, as is the all-too-common practice of letting feeders straggle over roofs without tile clips to anchor them. As I watch some of these blowing about over slates and tiles I can't help wondering that breakages of feeder "inners" isn't a whole lot commoner than it is. Another useful point made is that feeders must not be taken over the outer edge of gutterspouts unless stand-off brackets are used. I wonder whether some of the makers of TV aerials could re-institute short courses for erectors. It would be a jolly good thing if they did, for careless, slovenly erection is often responsible for breakdowns for which the aerial makers are quite unjustly blamed.

FM/DX

THE ranges at which reception from the B.B.C.'s f.m. stations has been reported are quite uncanny. Writing from Sidcot Heaton, near Bolton in Lancashire, a reader tells me that before the Holme Moss service started he had no trouble about getting Wrotham, though it is well over 200 miles from him. It was receivable with an improvised single dipole (lengths of brass wire fixed to a thin board with paper clips!). The signal was so strong at night-time that it came in loud and clear in no matter what direction the dipole was pointed —and even if it was turned from horizontal to vertical. Wrotham seems, for some reason which eludes me, to be pushing out the most far flung of the Band II transmissions. I've had reports of it from many parts of the country. In my East Anglian home town we normally get our v.h.f. programmes from Norwich. But these are the Midland programmes in the Home Service. If there's an item from London that we want to hear there's not the least difficulty about doing so if you have an indoor aerial and can reorient it. Our friend has separate outdoor aerials for Norwich and Wrotham and can take his choice.

Timeo Danaos

"I'VE my doubts about those Greeks though they come with gifts in their hands," as the Trojans had good cause to feel when they were offered the fatal wooden horse. Now it's the Irish Republic which is scratching its head over the offers made to it to put up a television transmitter free of charge in return for the sole use of it for some hours every day. As those hours would, one imagines, be used for advertising, it must be plain that the object of the would-be-benefactors can hardly be to serve only Southern Ireland with its rather small population. One feels that they'd like to build a station with a very high e.r.p. and capable of reaching Northern Ireland as well as considerable portions of this country. Mutual interference between TV transmitters has already become quite a big problem. The Irish station, if built, would presumably have to occupy a channel on Band I or Band III and those available are already pretty well booked up. It's quite understandable that such offers must be very tempting to a country which is anxious to have a television service, but whose government has not the money to build the transmitter and run the programmes. If, though, any such offer is accepted, I hope there will be very strict provisions that no interference with other stations shall be caused.

Matters of E.H.T.

IT has often puzzled me that it's almost (if not quite) universal practice to use miniature types for that hard-worked valve, the e.h.t. rectifier. In some cases it may be necessary for space-saving reasons; but there certainly are receivers with heaps of room for a full-sized valve, yet fitted with tiny e.h.t. rectifiers. These little valves are apt to break down more quickly than bigger types would. I know, in fact, of one case in which e.h.t. rectifiers seldom much outlasted their three months' guarantee until an expert friend installed one of larger size. Since then there's been no trouble. Another point which calls for attention is the regulation in some e.h.t. circuits. It can be very poor. You adjust, for example, height, width and focus on Test-card C and get them just to your liking. Now, the test-card contains a good deal more white than the average TV picture and the drain on the source of the e.h.t. can cause

a voltage drop if the regulation is poor and increase the size of the image. Hence the test-card on which you've so carefully adjusted height and width is actually oversize on the screen and when an ordinary picture comes on you may find it adorned with unwelcome dark borders.

The Two-in-one Valve

THE use of "compound" valves, such as double-triodes, triode-pentodes, diode-triodes and the like, has become so much standard practice nowadays that you find them in almost every kind of electronic apparatus except the very simplest affairs, or those using transistors throughout. They have many advantages, but those who benefit most largely from these are probably the manufacturers of such apparatus, to whom they mean smaller costs, reduced space requirements and things of that sort. But I'm not so sure that their user benefits to the same extent, particularly in the case of domestic equipment. Thanks to them this may be less bulky than it otherwise would be and the purchase price isn't so high, but when it comes to replacements he feels the draught. If one part of a double valve gives out, the whole thing becomes useless and must be renewed. And that costs more—sometimes a great deal more—than the replacement of the faulty one would come to, if they were two separate valves.

Are You Earthed?

IT doesn't always pay to take earth connections for granted. I once buried a large biscuit tin with the idea of using it as a first-rate earth for a wireless set. Some months later I dug it up to see how it was getting on and found the whole thing destroyed by the action of acid soil. Not long ago a friend found his set "earthed" in a different way. He was using an indoor aerial in an upstairs room and had taken his earth wire through the floor to an ascending water main in a large cupboard below. It occurred to him one day to see that the connection to the pipe was as it should be: so down he went to have a look at it. He got a bit of a surprise when he found the wire cut and the two ends neatly rolled up. What had happened was that some weeks before the painters had been at work and that the one who was doing the cupboard found that the wire was in his way and took what seemed to him the best way out of the difficulty.

UNBIASED

By FREE GRID

Telephilanderers' Troubles

JUST lately we have read a lot in the press about telephone tapping and many of us who are not indulging in what the prayer book calls "seditious and privy conspiracy" cannot help feeling uncomfortable when using the phone to fix up a date with our respective blondes.

After all, even though we are not plotting to overthrow Queen and Parliament we do perhaps say some things to our blondes which sound unconvincing and even a little foolish when set down in cold print. Few of us can rise to the heights of Homer when we try to express our feelings over the phone, and even fewer of us attain to the simple dignity of Barkis when he sent his famous three-word proposal of marriage to Peggotty. Perhaps it is well we do not, for I feel sure that the stolid policeman licking his pencil at the phone-tapping table might easily read something sinister into such a cryptic phrase as "Barkis is Willing".

Naturally I have been hard at work trying to work out an electronic speech scrambler on the lines of the one used in the transoceanic radiotelephone. The difficulties that confront me are economic rather than technical. Each subscriber who desired to be immune from telephone tapping would have to have a scrambling and descrambling unit. But the cost of these devices puts them out of court and their absence is apt to put telephilanderers into one even if only the divorce court.

The simplest and cheapest form of "scrambler" is the one the Germans used so successfully in the *first* World War to convey information and instructions to their agents in certain nearby neutral countries. In those far-off days anybody tuning in to Norddeich heard the station transmitting what appeared to be a continuous high note which in reality was a "scrambled" message.

The *modus operandi* was simple. In Berlin messages were recorded in the ordinary way on a wax cylinder of the type used on the old-fashioned cylinder phonograph and also, of course, on a well-known office dictating machine of those days. The record was then put on a special reproducer having a mandrel rotating at high speed. A primitive mike picked up the resultant high-pitched noise which, at the receiving end, was recorded on another high-speed machine. It was then only necessary for the record to be transferred to an ordinary cylinder reproducer and its message read in the ordinary way.

Surely one of your technological tycoons can think of a workable system lying somewhere between the crudities of the Germans' 1918 device and the prohibitively expensive transoceanic arrangement. At present my blonde and I are both learning Swahili but at any moment it may occur to the authorities to use a tape machine and send the record for translation to one of the big missionary societies, the officials of which might think it their duty to phone the Queen's Proctor at once.

A Photoarchic Camera

I WAS delighted to see an advertisement in *W.W.'s* sister journal, *Amateur Photographer* (19.6.57) describing a 16mm cine camera in which a photocell is used to operate the iris diaphragm of the camera so that it is always opened to the correct aperture according to the varying conditions of light. Thus the lens is always opened to the correct aperture according to the varying conditions of light available even if a cloud momentarily passes over the sun while shooting.

This is indeed a praiseworthy application of electronics and the reason for my delight is the fact that I first described this type of photoarchic cine camera in this journal some twenty years ago (20.6.34). It is gratifying to learn that all the big manufacturers of scientific apparatus keep a wary eye on these columns.

In the advertisement it is described as the *first* cine camera of this type. I have little doubt that the maker of this camera honestly believes this to be the case. After all, we all used to believe that Harvey discovered the circulation of the blood until it was revealed that he was anticipated, several centuries earlier, by an Arabic medical man. But this oriental sage's discovery was forgotten and Harvey made the discovery independently long afterwards. No doubt the camera has been re-invented and its progenitors owe nothing to my former description.

Is Ernie Radioactive?

I AM very sorry to say that my attempt to use electronic techniques to influence Ernie in my favour, about which I wrote in June, proved a complete flop. At the same time I must take off my hat to the Post Office engineers for their very successful effort to outwit me and others like me. I was unaware of their precautions at the time and thought that my pulse generator had developed a fault.

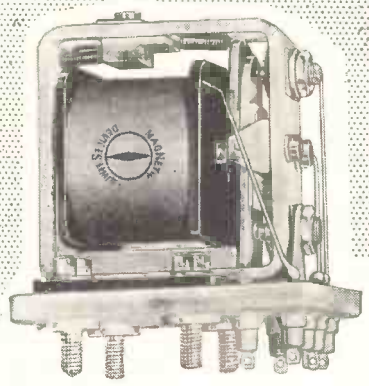
However, the Editor has solved the mystery by forwarding to me a communication he has received from the Lead Development Association in which it is stated that the whole of Ernie's innards were encased in lead. This would, of course, effectively prevent any outside influence affecting his distributions of largesse.

I am astonished to realize from the wording of the bulletin sent out by the Lead Development Association that its public relations officer obviously does not realize the real reason for Ernie being provided with a lead casing. The P.O. engineering department seems to have informed him that the purpose of the lead casing is to contain the radiations from Ernie's neon tubes and so prevent interference with other parts of his anatomy.

If this be true I cannot for the life of me see why the screening metal had to be of lead and not of some non-plumbeous metal such as we use for screening in our radio sets. Could it be that the P.M.G. has not been as truthful as he might have been and that the real reason for Ernie's lead waistcoat is to shield his audience from harmful radioactivity? That would at least explain the presence of lead. Perhaps the P.M.G.'s technologists will write to the Editor and explain, and maybe the Lead Development Association will join me in this request for enlightenment.

"Barkis is Willing"

Voltage Regulating Relay



ZA44704
ZA44706

25·5

23·5

ZA44705
ZA44707

12·75

11·75

Two forms of the relay are available, either fully hermetically sealed or enclosed and tropicalised but unsealed. The inter-service reference numbers are as follows:—

Unsealed
ZA 44706 25.5V. make 23.5V. break
ZA 44707 12.75V. make 11.75V. break

Sealed
ZA 44704 25.5V. make 23.5V. break
ZA 44705 12.75V. make 11.75V. break

The Voltage Regulating Relay was designed in co-operation with S.R.D.E., to reduce voltage variations in certain essential circuits of radio sets and has many other applications of a similar nature.

This is particularly necessary in the case of vehicle-borne equipment, with power supplies consisting of lead acid batteries and a small charging generator.

The armature is balanced to withstand vibration, and the complete relay has been subjected to severe vibration testing.

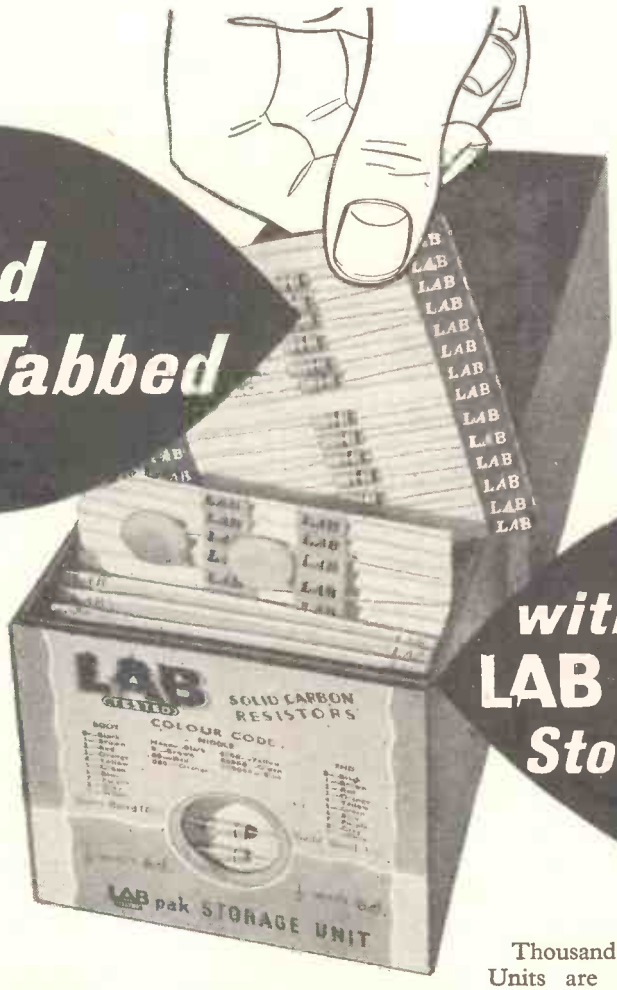
Magnetic shielding is achieved by the iron case, enabling the relay to be used within reasonable proximity of transformers, chokes, etc.

The Voltage Regulating Relay complies with the stringent Ministry of Supply specification No. 166/1, to operate within tolerance, over a temperature range of −40°C. to +85°C.

MAGNETIC DEVICES LIMITED

MAGNETIC DEVICES LIMITED
A.I.D. & A.R.B. approved
EXNING ROAD, NEWMARKET, SUFFOLK
Telephone: Newmarket 3181/2/3 Telegrams: Magnetic Newmarket

MD20A



Typed and Tabbed with LAB Continuous Storage Units

REF.	WATTS	MAX. VOLTS	OHMS	MIN. ORDER FOR FREE UNIT	UNIT STORAGE CAPACITY
RESISTORS					
T	½	250	10 to 10M	240	720
R	1	500	10 to 10M	180	500
Tolerances available ±20% 10% 5%					
HIGH STABILITY RESISTORS					
HS3	½	750	1 to 500M	93	500
Tolerances available ±5% 2% 1%					
WIREWOUND RESISTORS					
LM	5 & 10	—	5 to 100K	72	300
LP	5 & 10	—	5 to 100K	72	300
CERAMICAPS					
CER	Tubular	500	3 to 470pf	141	500
HK	Tubular	500	470 to 5000pf	141	500
HKD	Disc	500	470 to 5000pf	141	500
Tolerances available ±2% 10%					

Thousands of LAB Continuous Storage Units are daily solving the problem of control and storage of the great range of resistors. Compact, and capable of storing up to 720 separate resistors, LABpak make selection positive, simple and speedy. Now that Ceramicaps, Histabs and Wirewound resistors have been added to the carded range the usefulness of LABpak storage units is enhanced.

FREE with any purchase of the LABpak range, these units are the complete answer to the storage problems of small production units, laboratories, etc.

MAKE UP YOUR ORDER TODAY — DELIVERY EX-STOCK

All LABpak resistors are carded in ohmic value, rating and tolerance, colour indexed and tabbed for easy selection.

The LAB Continuous Storage Units are available from your normal source of supply, but more detailed information and literature can be obtained from

THE RADIO RESISTOR COMPANY LIMITED

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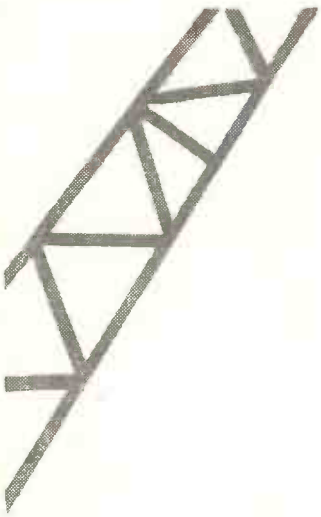

It is gratifying to know that in a world of rising prices our policy of maintaining and, in many instances, reducing prices has resulted over the years, and especially at this period, in ever increasing sales.

We carry a stock of 2,000 types of receiving, transmitting and special purpose tubes, and invite your enquiries not only for commercial grade tubes but also for those tested to C.V., JAN and MIL specifications.

Our Organisation is A.R.B. Approved.

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Acos × 500 tested Replacement Styli

are shortly to appear in new containers.

Sapphire styli in silver packs, diamond styli in golden packs.

These sealed envelopes will give added protection to the styli.

Also, their striking design will catch your eye

in the shop to remind you: for your records' sake,

fit Acos styli, and fit them in time.

acos ARE DOING THINGS IN STYLI

COSMOCORD LTD WALTHAM CROSS HERTS. TEL. WALTHAM CROSS 5206 (London subscribers please dial WA4 5206)

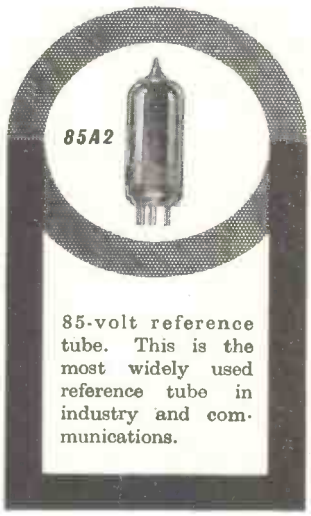
Voltage Reference and

This comprehensive range of Mullard gas-filled voltage reference and stabiliser tubes fulfils the needs of a variety of applications—both civilian and military.

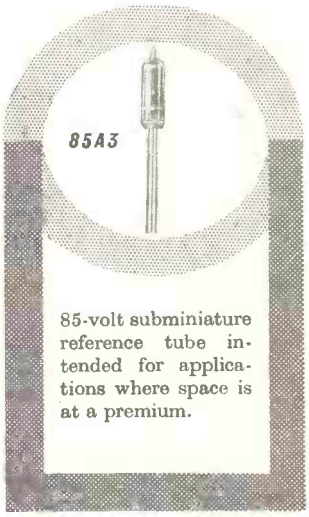
The tubes are highly stable and mechanically strong. They have a long life and their operating characteristics are well defined.

Most of them are available to British Services CV Specifications and in Special Quality versions—both pinned and flying lead—for operation under rigorous conditions of shock and vibration.

Further information and data are readily available upon request at the address below.



85-volt reference tube. This is the most widely used reference tube in industry and communications.



85-volt subminiature reference tube intended for applications where space is at a premium.

Voltage Reference Tubes

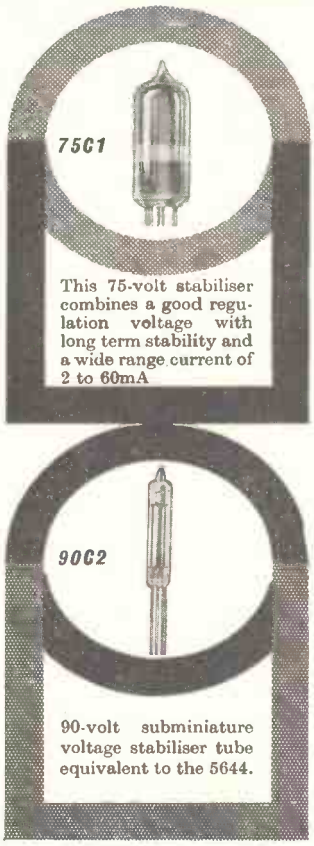
These tubes provide a constant voltage standard of extreme accuracy. They are normally operated at the optimum constant current.

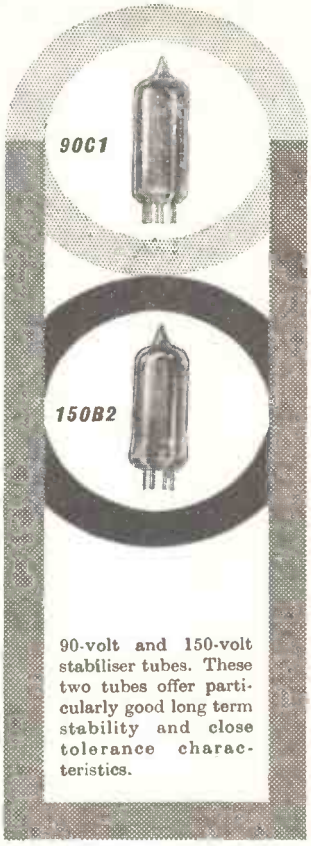
Abridged Data for Reference Tubes

(Please send for details of Special Quality Versions)

Type No.	Equivalent U.S. Type	CV No.	Construction	Preferred Operating Current (mA)	Burning Voltage Range at Preferred Operating Current (V)	Min. Voltage for Ignition (V)	Max. Incremental Resistance (ohms)	Typical Drift in Burning Voltage per 1000 hrs. (%)	Max. Voltage jump of typical tube at preferred operating current (mV)
85A2	—	CV449	B7G	6.0	83 to 87	115	450	0.1	5
85A3 *	5783	—	Sub-min. flying lead	1.5 to 2.0	84 to 88	130	1000	0.5	5

Stabiliser Tubes





Voltage Stabiliser Tubes

These tubes are designed to give a constant output voltage despite wide variations of input supply. They have a wide current range and good regulation.

Abridged Data for Stabiliser Tubes (Please send for details of Special Quality Versions)

Type No.	Equivalent U.S. Type	CV No.	Construction	Nom. Burning Voltage (V)	Min. Ignition Voltage (V)	Current Range (mA)	Max. Regulation Voltage ** (V)
75C1	—	—	B7G	75	115 †	2.0 to 60	8.0
90C1	—	—	B7G	90	115 †	1.0 to 40	14
90C2 *	5644	CV3987	Submin. flying lead	90	125 §	5.0 to 25	5.0
108C1	0B2	CV1833	B7G	108	133 §	5.0 to 30	4.0
150B2	—	CV2225	B7G	150	180 †	5.0 to 15	5.0
150C4	0A2	CV1832	B7G	150	185 §	5.0 to 30	8.0

* Preliminary information only.

** Measured over the range Imin. to Imax., where I = Operating Current.

† This voltage covers operation in daylight or complete darkness.

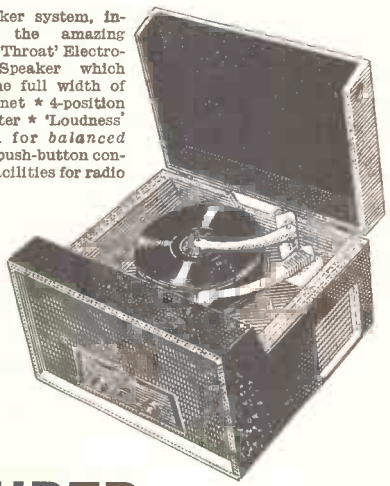
§ In total darkness a somewhat higher voltage is required for ignition.

MV306a

VIVACE

"*Vivace*". . . *with life* . . . so vital to a musical performance. An ordinary record played on the Super Black Box becomes a thrilling musical experience . . . springing to life with all the feeling and beauty of the original performance. The Super Black Box gives a standard of performance unequalled by any other table record player (for the technical this means only 0.5% distortion at 8 watts output). Ask your Pye dealer for a demonstration.

* 3-speaker system, including the amazing 'Infinite Throat' Electrostatic Speaker which spans the full width of the cabinet * 4-position noise filter * 'Loudness' control for *balanced* sound * push-button controls * facilities for radio tuner



4-speed record player for automatic or manual operation. In gay Contemporary or Traditional mahogany-veneered cabinets. A.C. Mains. 59 gns. tax paid

SUPER BLACK BOX

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This superb instrument is an impressive addition to the famous Pye "Black Box" range of high-fidelity record reproducers. For full details, fill in and post this coupon to PYE LTD., HI FI DIVISION, CAMBRIDGE.

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PYE LIMITED OF CAMBRIDGE

MINIATURE OSCILLOSCOPE

Type CT84

Type CT52

Weight—approx. 15 lb. Size—13½″ × 8″ × 5½″ approx. Finish—Dark Battleship Grey.

Designed as a general-purpose instrument, the Metrovick miniature oscilloscope is particularly useful for radar servicing. Its light weight and compact construction result in a portable and robust instrument designed to withstand rough use, so that it has now become standard equipment for the fighting services.

SPECIFICATION

SUPPLY: With A.C. Power Pack (CT52)—100/125 v., 200/250 v., 50/60 c/s.; 180 v., 500 c/s. With D.C. Power Pack (CT84) —28 volts D.C. Power consumption 50 VA approx.

CATHODE RAY TUBE: Hard tube—2¾in. diameter screen. Standard tube fitted has Green screen with medium afterglow. Alternative tubes can be fitted.

TIME BASE: Free-running linear time base, paraphase amplifier and synchronising. Repetition range 10 c/s. to 40 Kc/s. Single-sweep linear time base with paraphase amplifier, triggered by 30-volt pulse. Repetition range—50 c/s. to 3,000 c/s. Sweep range—50 milliseconds to 3 microseconds.

Y PLATE ATTENUATOR: Resistance attenuator, capacitance compensated. Flat response—3 db. from D.C. to 100 kc/s. Fixed attenuation of 14 db. (5 times).

Y PLATE CONNECTION: Direct or series capacitor connection. Input resistance—2.5 megohms. Input capacitance—50 pf. approx.

Y PLATE AMPLIFIER: 1. Max. gain of 38 db. (80 times) flat to 3 db from 25 c/s. to 150 Kc/s. 2. Max. gain of 28 db. (25 times) flat to 3 db. from 25 c/s. to 1 Mc/s.

CALIBRATION: An internal supply of 50-volt peak ± 10%, sine wave, at the supply or vibrator frequency.

DELAY LINE: A delay network brought to the Y plate switch, and the displayed signal is delayed by approximately 0.5 microseconds, having its source impedance of 75 ohms.

RATING: Continuous operation at ambient temperatures between—32° C. and + 50° C.

Write for leaflet 652/14-1 for technical details

METROPOLITAN-VICKERS

ELECTRICAL CO LTD · TRAFFORD PARK · MANCHESTER 17

An A.E.I. Company

R/E603

A NEW A.C. MILLIVOLTMETER
BY
BRITISH PHYSICAL LABORATORIES

MODEL NO. : VM 348D MK II.

POINTS TO NOTE.

- ★ 2mV F.S.D. at 10 MC/S, ± 0.5 dB.
- ★ ±3dB AT 15 MC/S.
- ★ OPERATES UP TO 20 MC/S WITHIN ± 6dB.
- ★ EIGHT RANGES UP TO 6 VOLTS. UP TO 00 VOLTS WITH PLUG IN MULTIPLIER.
- ★ 5 INCH SCALE METER, MIRROR SCALE, KNIFE EDGE POINTER.
- ★ INPUT VIA TERMINALS OR COAXIAL SOCKET.
- ★ ALTERNATIVE USE AS HIGH GAIN AMPLIFIER (X1000) FOR SINE, SQUARE AND PULSE WAVE-FORMS.
- ★ IMMEDIATE DELIVERY— ASK FOR DEMONSTRATION.

FOR FURTHER INFORMATION ON THIS INSTRUMENT OR ANY OTHER ITEMS IN OUR RANGE OF INSTRUMENTS OR METERS, PLEASE CONTACT THE ADDRESS BELOW.

BRITISH PHYSICAL LABORATORIES, RADLETT, HERTS.

TELEPHONE : RADLETT 5674.

UNQUESTIONABLY . . .

" The variable oscillator employs a triode in a modified Colpitts circuit comprising a split-stator capacitor and an appropriate tuning inductor which is selected by means of a range switch, the oscillator output being monitored by a crystal rectifier and indicating meter which are coupled to an 80dB resistive step attenuator."

WHEN schoolboys are as interested in square-wave techniques as they are in square-leg tactics, it is advisable to know all about Marconi instruments.

It's not difficult. Take the Marconi TF 982A, for example, about which our young friend is so obviously well-informed. Here is a Marconi instrument that provides complete test facilities for mobile radio telephone sets. It combines, in one compact unit, a signal generator, a crystal-controlled auxiliary oscillator, a.f. and r.f. power meters, a local r.f. field detector, and an a.c./d.c. multi-range test meter.

Details of all this apparatus are given in a leaflet, full of technicalities, so that you, too, can discuss the V.H.F. Test Set authoritatively. You really should send for a copy.

MARCONI V.H.F. TEST SET
Type TF 982A

Signal Generator Section: 60 to 200 Mc/s; also eight bands centred on common i.f. values from 1·6 to 8·5 Mc/s; fixed depth 30% a.m. can be applied internally. Output 2μV to 2 mV at 52 and 75 ohms; higher outputs at 37·5 ohms. *A.F. Power Meter:* 30 mW full scale at 600 ohms; 1 watt full scale at 3 ohms. *R.F. Power Meter:* 20 watts full scale at 75 ohms. *Test Meter:* Five ranges covering from 100μA d.c. to 200 volts a.c. full scale.

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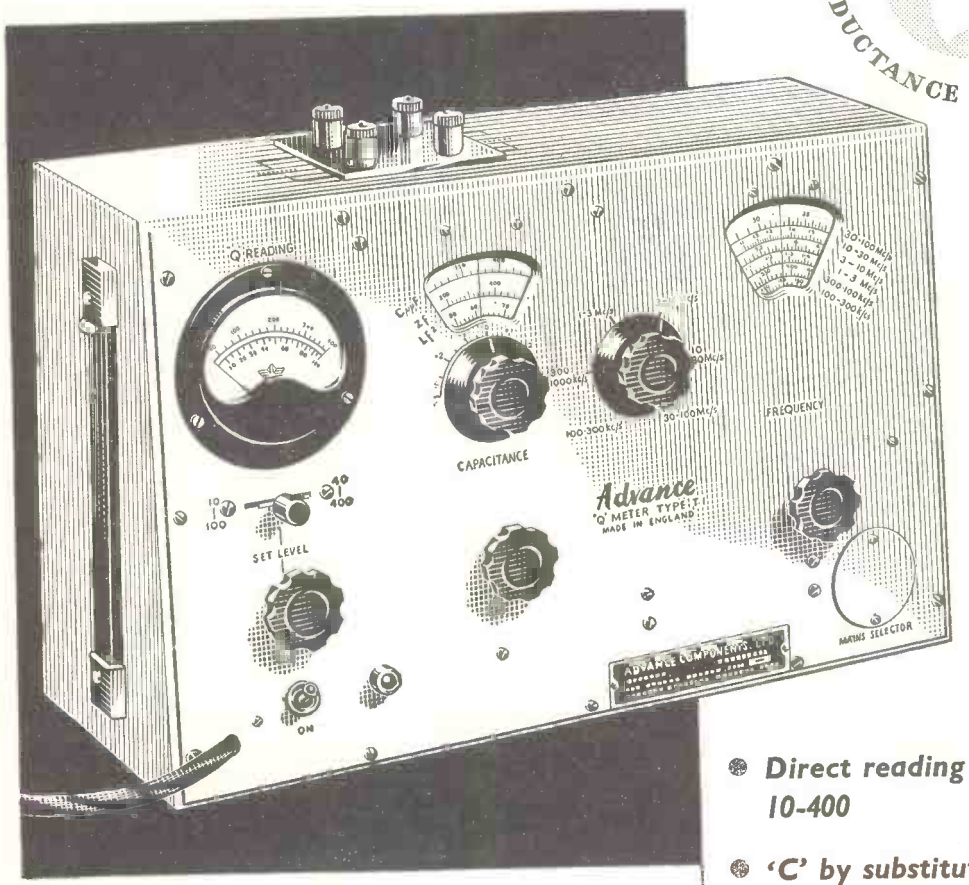
WORLD-WIDE REPRESENTATION

TC 105

Advance

CIRCUIT MAGNIFICATION METER

Q INDUCTANCE CAPACITANCE



- *Direct reading of 'Q' Range 10-400*
- *'C' by substitution*
- *Rapid calculation of 'L' and 'Z'*
- *No 'Set-Zero' problems*
- *Small and portable (15½ x 10¼ x 6½ - 14lb)*

MODEL T1 NETT PRICE IN U.K. **£55**

The "T1" is an easily operated and convenient instrument for making R.F. measurements of circuit magnification ('Q'), inductance, capacitance and power factor at frequencies between 100 kc/s and 100 Mc/s. Its portability and excellent specification make it a valuable addition to the electronic laboratory as well as for production testing.

Full technical details in Leaflet W31 available on request

The MODEL T/2

A new version of the Model T1 providing additional facilities for comparing 'Q,' Inductance and Capacitance, and is most suitable for the production testing of coils.
Full technical details in Leaflet W44. **£70** Nett Price in U.K.

Export enquiries welcomed.

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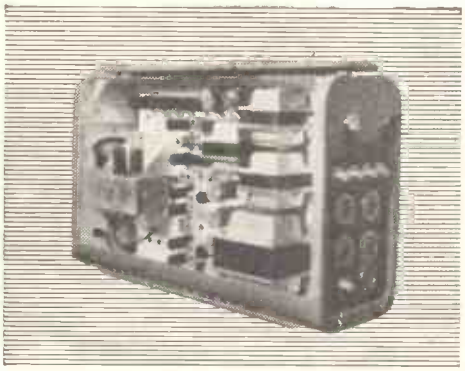

Mobile sound and vision receiver designed and produced by P.A.M. for Marconi's Wireless Telegraph Company Limited. It is primarily intended for use in studio and mobile control rooms.

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and you want it Designed and Developed or produced to your specification*

Consult

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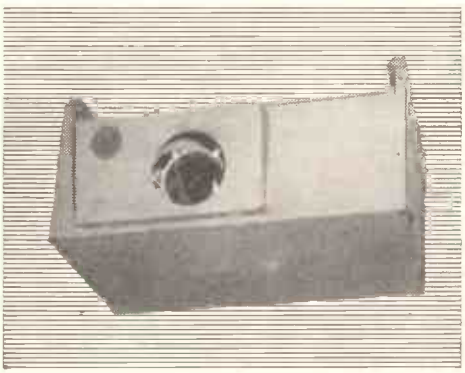
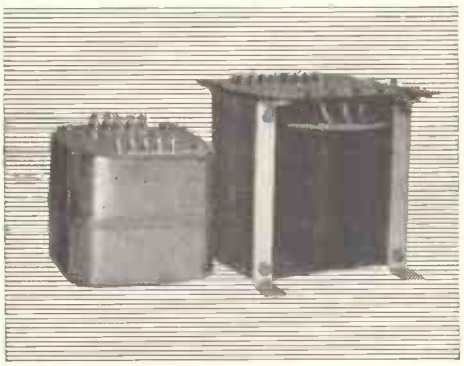
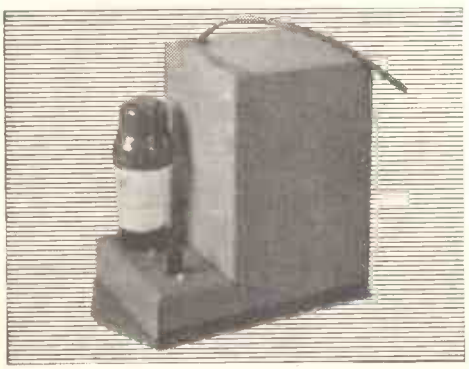


Model P.48 Projection Receiver for closed circuit Television for Industrial use giving a picture up to 4ft. x 3ft.



Open and Shrouded types of Transformers for general use in electronic equipment. Designed and manufactured to individual requirements.



R.F., E.H.T. Unit. A safe, D.C. high voltage unit specially designed to meet the need for a reliable source of supply for all Television C.R. Tubes including the new wide angle and aluminised types. Also satisfactory for flash testing where a D.C. supply is necessary.

P.A.M. Electronics Department combines the technique of several companies, long-established in the Electronic field, with the extensive modern production resources of P.A.M. Ltd.

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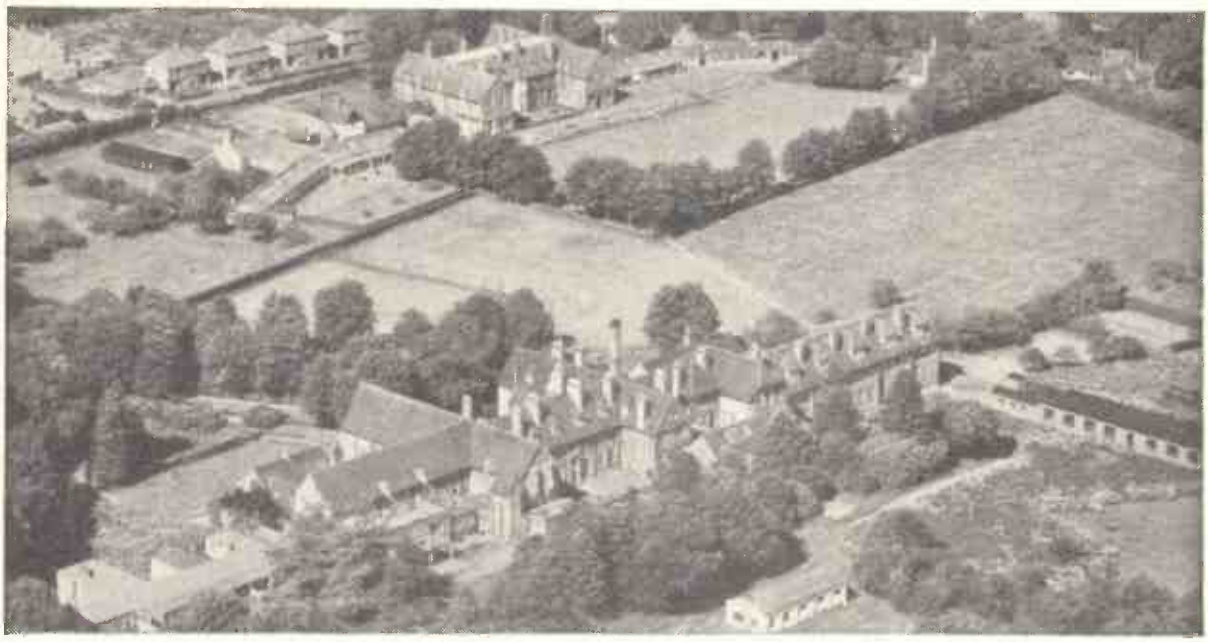
Telephone: Guildford 2211.

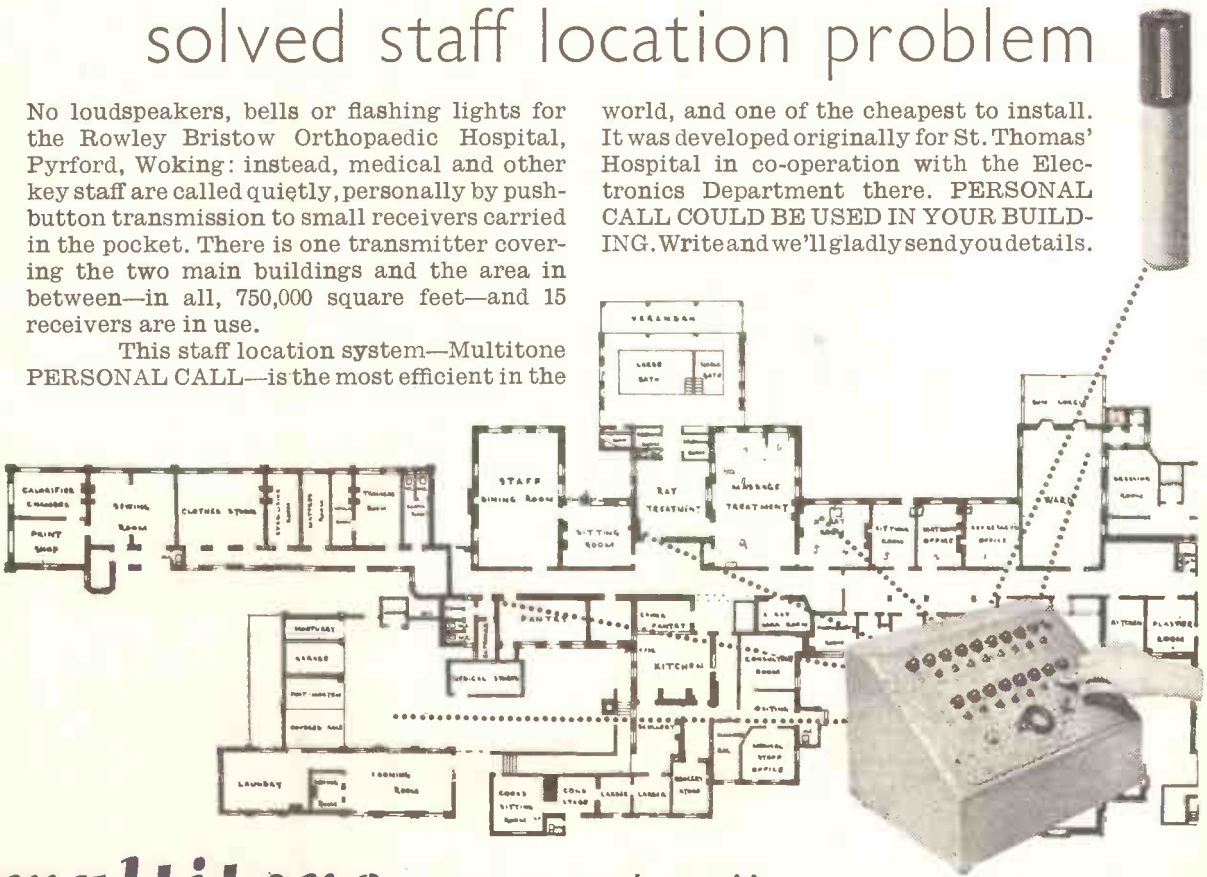
**Whichever stage of the struggle you've reached, we can save you time and trouble—maybe money too—write or 'phone without delay.*



how Rowley Bristow Hospital solved staff location problem

No loudspeakers, bells or flashing lights for the Rowley Bristow Orthopaedic Hospital, Pyrford, Woking: instead, medical and other key staff are called quietly, personally by push-button transmission to small receivers carried in the pocket. There is one transmitter covering the two main buildings and the area in between—in all, 750,000 square feet—and 15 receivers are in use.

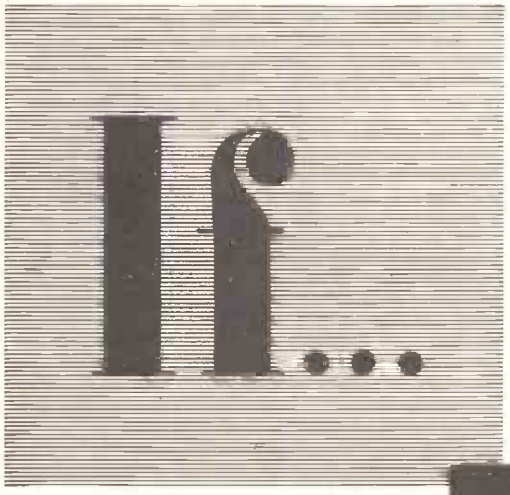
This staff location system—Multitone PERSONAL CALL—is the most efficient in the world, and one of the cheapest to install. It was developed originally for St. Thomas' Hospital in co-operation with the Electronics Department there. PERSONAL CALL COULD BE USED IN YOUR BUILDING. Write and we'll gladly send you details.



multitone personal call **STAFF LOCATION SYSTEM**

Multitone Electric Company Ltd., 12-20 Underwood Street, London, N.1. Tel: Clerkenwell 8022

CRC 12M



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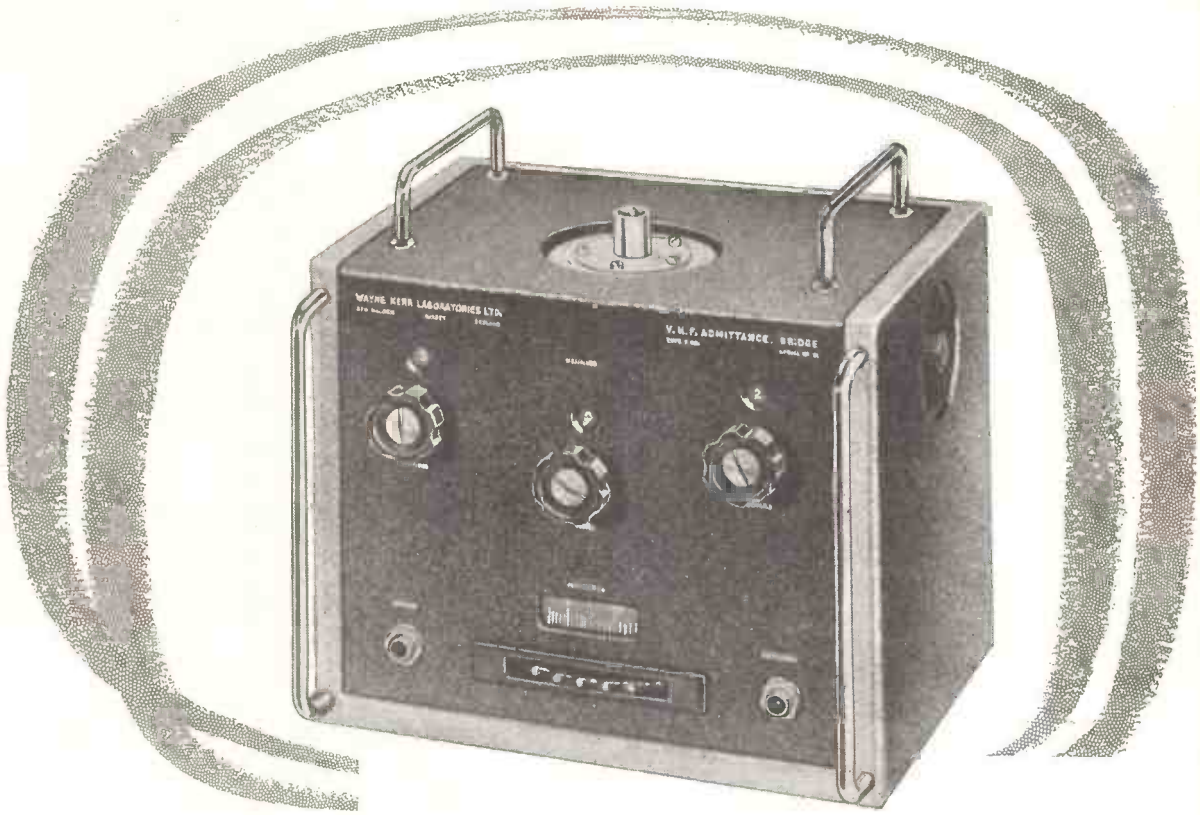

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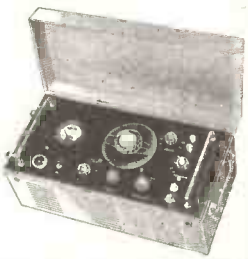

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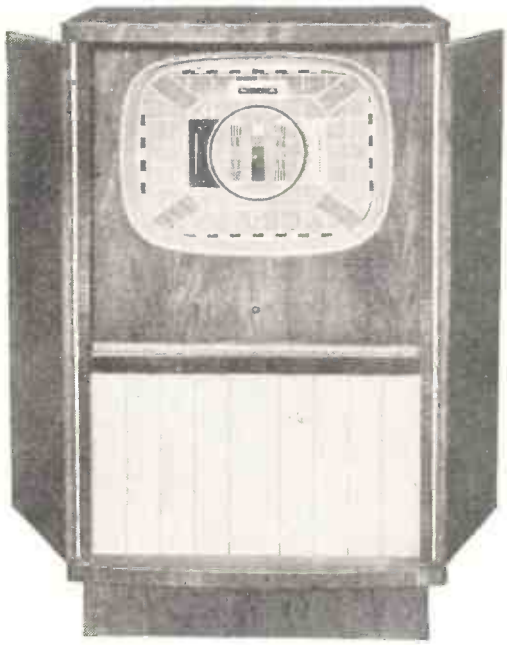

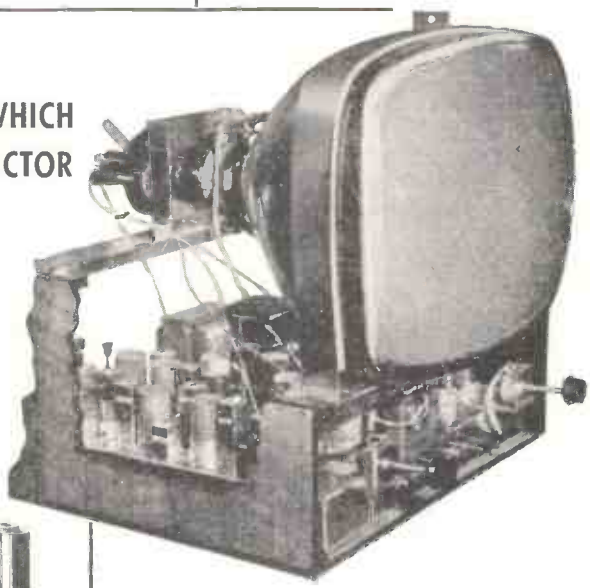

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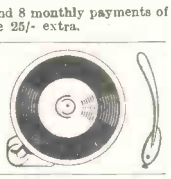

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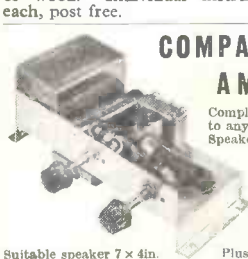

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Managing Editor: HUGH S. POCOCK, M.I.E.E.
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AUGUST 1957

In This Issue

VOLUME 63 No. 8

PRICE: TWO SHILLINGS

FORTY-SEVENTH YEAR OF PUBLICATION

Offices: Dorset House, Stamford Street, London, S.E.1

Please address to Editor, Advertisement Manager or Publisher, as appropriate.

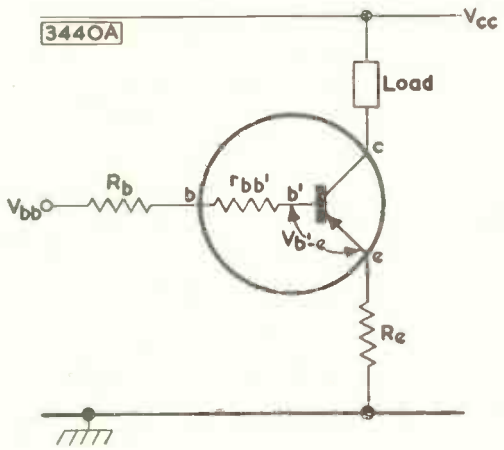
Telephone: WATerloo 3333 (60 lines)

Telegraphic Address: "Ethaworld, Sedist, London".

PUBLISHED MONTHLY (4th Tuesday of preceding month) by ILIFFE & SONS LTD., Dorset House, Stamford Street, London, S.E.1. *Telephone:* Waterloo 3333 (60 lines). *Telegrams:* "Iliffepres, Sedist, London." *Annual Subscription:* Home and Overseas, £1 12s. 6d. U.S.A. and Canada $5.00. BRANCH OFFICES: *BIRMINGHAM:* King Edward House, New Street, 2. *Telephone:* Midland 7191. *COVENTRY:* 8-10, Corporation Street. *Telephone:* Coventry 5210. *GLASGOW:* 26B Renfield Street, C.2. *Telephone:* Central 1265. *MANCHESTER:* 260, Deansgate, 3. *Telephone:* Blackfriars 4412. OVERSEAS OFFICES: *U.S.A.:* 111, Broadway, New York, 6, N.Y. *Telephone:* Digby 9-1197. *CANADA:* 67, Yonge Street, Toronto, 1, Ontario. *Telephone:* Empire 6-0873.

Transistor Base-to-Emitter Voltage Compensation

It is well known that satisfactory transistor performance can only be obtained by restricting the variation of collector current with temperature. Under the worst conditions of operation, stabilisation of the working point is also essential to prevent thermal runaway. The most widely used method of d.c. stabilisation consists in deriving the base bias from a potential divider connected across the base in conjunction with an emitter resistor. One possible refinement is to give the emitter resistor a positive temperature coefficient. This method is of particular importance in circuits using power transistors, such as the OC16, with low impedance bias supplies.



Temperature Dependence of Base-to-Emitter Voltage

The increase in collector current with temperature arises in part from the temperature dependence of the base to emitter voltage. Under certain conditions, and particularly with power transistors, this increase may become more important than that produced by the temperature dependence of the collector leakage current. Referring to the figure, the base to emitter voltage which can be measured on an actual transistor exists between b and e, and itself depends on the internal base resistance, $r_{bb'}$, and the voltage between b' and e. This latter voltage, $V_{b'-e}$, changes with temperature at a rate which is theoretically the same for all transistors, and is equal to —2·5mV/°C. The minus sign indicates that $V_{b'-e}$ decreases with temperature.

Emitter Resistors of Pure Metal

The change of $V_{b'-e}$ with temperature can be compensated by using temperature sensitive elements in the circuit. Thermistors having a negative temperature coefficient can be used in the bias circuit, but as their temperature coefficient varies with temperature, it is not possible to obtain exact compensation.

On the other hand, if the emitter resistor is wound from wire made of some pure metal, such as copper or nickel, it will have a positive temperature coefficient and compensation for changes in $V_{b'-e}$ can be obtained over the entire temperature range.

For exact compensation, the voltage across R_e should have an equal and opposite coefficient to $V_{b'-e}$, that is, the voltage across R_e should increase by 2·5mV/°C. Pure metals such as copper and nickel have temperature coefficients of about +0·004/°C. If the value of R_e is chosen to give a voltage drop of about 630mV, this voltage drop will increase by about $630 \times 0{\cdot}004 = 2{\cdot}5$mV/°C as required.

If the drop is higher, or if in fact $V_{b'-e}$ decreases by less than 2·5mV/°C, the circuit will be overcompensated. However, overcompensation is not a disadvantage as it helps to stabilise against the collector current changes produced by the temperature dependence of the collector leakage current.

Advantages

In general, an emitter resistor having a positive temperature coefficient reduces variations in collector current but does not directly improve the stability of the circuit with respect to thermal runaway, because the emitter resistor reacts to changes in ambient temperature, not junction temperature.

Signal handling capacity is reduced to a smaller extent by any rise in ambient temperature.

The collector dissipation does not rise so much with temperature. It is therefore possible to increase the dissipation by 10 or 15%, or to permit a higher ambient temperature, with any given heat sink: under these conditions the runaway stability remains unaltered. Alternatively, a somewhat smaller heat sink suffices: the runaway stability then deteriorates somewhat and better circuit stabilisation is required.

Mounting the positive temperature coefficient resistor on the heat sink makes only a negligible improvement to the runaway stability and may actually be inadvisable because of the heat dissipated in the emitter resistor itself. It would, however, reduce the current changes which occur when first switching on.

Heat Sinks

Transistors with higher dissipation ratings, such as the OC72 and OC16, have to be fitted with some sort of metal cooling fin or mounting plate which serves to conduct away, and radiate away, heat generated in the transistor itself.

Although these heat sinks operate on such a simple principle, it becomes necessary at the power rating of the OC16 to specify the dimensions, material, and the gauge and finish of the metal plate rather exactly. Usually the chassis can be designed to be the heat sink, but, if the chassis gets hot because of the presence of valves or other heat generating components, a separate sub-chassis may be necessary.

It is regretted that the circuit shown in Fig. 2 on this page of the July issue was incorrect. The electrolytic capacitor C should be omitted. There should be a single load resistance Z as shown in Fig. 1 and the top of the resistor R1' should be connected to the collector of Tr1 (point X).

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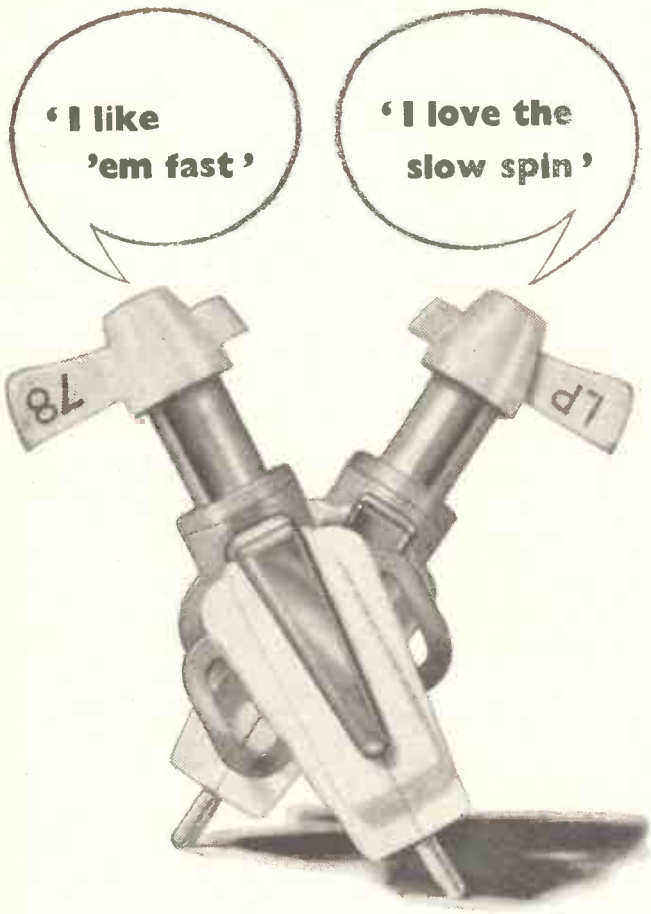

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"BELLING-LEE" NOTES

A CASE FOR THE INDOOR AERIAL

As far as we know, the first indoor television aerial ever invented, manufactured and sold, was the "Doorod." Even within the firm, the inventor had great difficulty in persuading the Directors and the Technical Manager to market his idea, because at that time it was known that to use an indoor aerial was bad technical practice. There were too many variables, beyond the control of the user. Hidden metal objects built into the wall such as girders, conduits, water pipes, etc., and in the case of semi-detached properties, portable metallic objects such as standard lamps, pianos, etc., just at the other side of a parting wall, which, to a radio signal, might as well not be there.

Individuals at the B.B.C. and the Post Office blamed us for setting a bad example, but, as we saw it, in the case of a difficult landlord, and a fairly strong signal, it was a case of an indoor aerial or no television.

The outcome is well known, "Belling-Lee" have sold nearly a million "Doorods," and competitors must have sold an additional number amounting to many tens of thousands.

There is little doubt that if it were possible to erect a well-situated outdoor aerial, still better results would be obtained in practically every case. But only too often there are already four multi-element aerials on the only available chimney.

In the meantime receiver manufacturers have improved the sensitivity and automatic gain control of their sets, and the B.B.C. have increased the power of their transmitters.

Not to be outdone, I.T.A. are using very high power to overcome the propagational difficulties associated with the higher frequencies and so in a great many cases it is found that less sensitive aerials are required.

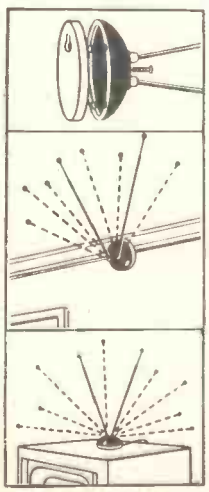
Many American viewers have several transmitters close to their homes and with high sensitivity receivers and high A.G.C. they have, for some time, had a choice of entertainment on much less efficient aerials than we have needed here.

Today, however, in this country, with increased transmitter powers, improved receiver sensitivity and better automatic gain control it can, in our opinion, now be regarded as reasonable technical practice to introduce a *broad band aerial* into the same room as the receiver, if signal strength is realistically high, interference levels low, and receivers reasonably modern.

The outcome is the "Golden V" for bands I, II and III. True, all is not gold that glitters, but the telescopic elements are genuine gold plated—and look it. Standing up from their highly polished black base and gilt bezel, overall appearance is one of quality. There is nothing cheap about it, although it is very good value for two guineas.

The "Golden V" is designed to stand on top of the receiver, which it cannot damage, because ot its non-scratch, non-slip base, or on the corner of a nearby mantleshelf or table, or to hang on the wall.

"Wireless World" readers will appreciate that it would be unreasonable to expect such an aerial to give optimum results just by setting it up anywhere, anyhow. It should be moved about, and the angles and length of the elements should be adjusted until the best possible picture is obtained. If the signal is strong enough and the location relatively free of interference, there should be a combination of element lengths and angles and position to provide a reasonable reception from both B.B.C. and I.T.A.



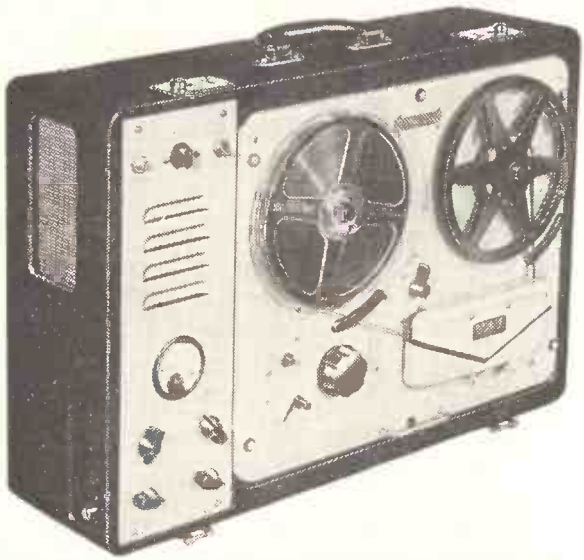
A keyhole slot enables the "Golden V" to be hung on wall or picture-rail. Elements are extendible, and can be moved in any direction.

Advertisement of
BELLING & LEE LTD.
Great Cambridge Rd., Enfield, Middx.
Written 24th June, 1957

G

Vortexion

TAPE RECORDERS and AMPLIFIERS



The above recorder uses a synchronous capstan motor and for use on 12 volt car battery a 50 c/s ±1 cycle 230 v., 120 w. power supply unit is available.

T.R.G.10 MINIATURE AMPLIFIER AND VERSATILE PRE-AMPLIFIER. A modern miniature amplifier, measuring only 4½ x 5in. over front panel and projecting 10½in. to the rear. Uses C core transformer material to obtain low external magnetic field and has less than 0.1% harmonic distortion at 10 watts output. The amplifier response is level 15 c/s. to 50,000 c/s. within 0.2 db. The 3-valve pre-amplifier will operate direct from recorder heads with correction networks for difficult tape speeds and switched inputs are provided for radio, microphone and gram. with correction for all recording characteristics.

"SUPER FIFTY WATT" AMPLIFIER. This heavy duty amplifier is available for long life under arduous conditions. The normal life being 5,000 hours without valve change.

★ The total hum and noise at 7½ inches per second 50-12,000 c.p.s. unweighted is better than 50 dbs.

★ The meter fitted for reading signal level will also read bias voltage to enable a level response to be obtained under all circumstances. A control is provided for bias adjustment to compensate low mains or ageing valves.

★ A lower bias lifts the treble response and increases distortion. A high bias attenuates the treble and reduces distortion. The normal setting is inscribed for each instrument.

★ The distortion of the recording amplifier under recording conditions is too low to be accurately measured and is negligible.

★ A heavy mu-metal shielded microphone transformer is built in for 15-30 ohms balanced and screened line, and requires only 7 micro-volts approximately to fully load. This is equivalent to 20ft. from a ribbon microphone and the cable may be extended 440 yds. without appreciable loss.

★ The 0.5 megohm input is fully loaded by 18 millivolts and is suitable for crystal P.U.s, microphone or radio inputs.

★ A power plug is provided for a radio feeder unit, etc. Variable bass and treble controls are fitted for control of the play back signal.

★ The power output is 4 watts heavily damped by negative feedback and an oval internal speaker is built in for monitoring purposes.

★ The play back amplifier may be used as a microphone or gramophone amplifier separately or whilst recording is being made.

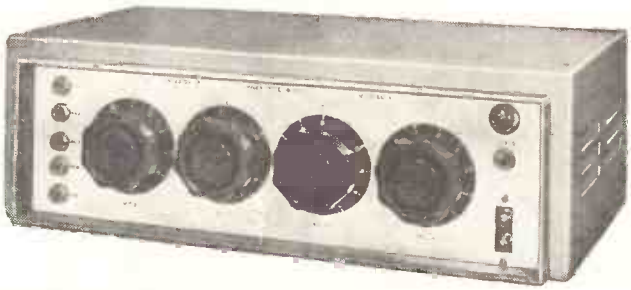
★ The unit may be left running on record or play back, even with 1,750ft. reels, with the lid closed.

CP20A AMPLIFIER. This standard amplifier for extreme tropical use will operate from 230 v. A.C. mains or 12 v. car battery and give 15 w. output for a consumption of 5.5a. Inputs for 30Ω balanced microphones, M.I. P.U. and Cr. P.U.

FOUR CHANNEL ELECTRONIC MIXER

An Electronic Mixer for four 30-50Ω balanced line microphones or special to order. Normal output 0.5 v. on 20,000Ω but 1 mW., 600Ω balanced or unbalanced is available as an alternative.

The 3-CHANNEL MIXER and PEAK PROGRAMME METER is similar to the above but is fitted with a meter reading peak signals with 1 second decay time and calibrated in dbs from zero level 1 mW., 600Ω to +12 and −20 balanced or unbalanced output by means of switch.



Full details and prices of the above on request

VORTEXION LIMITED, 257-263, The Broadway, Wimbledon, London, S.W.19

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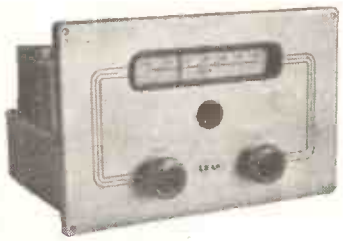
High engineering ideals have guided our efforts, and Leak Amplifiers have been the choice of the B.B.C., Commonwealth and foreign broadcasting authorities and Recording Studios. This acceptance by professional audio engineers has led to a demand for Leak equipment from music lovers throughout the world.

On the important question of prices it is appropriate to mention one of the basic principles of Leak design. From long experience and by extreme attention to design details during development work on the pre-production models, we enable our craftsmen to achieve a high output per man-hour. The labour costs thus saved offset the increased cost incurred for high-grade materials, components and finishes, and this, together with quantity production (made possible only by a world-wide market), explains how quality products may be sold at reasonable prices.

An important Test Report . . .

Independent laboratory tests of the Garrard 301 transcription turntable were recently carried out by Audio Instrument Company Inc., New York, U.S.A., under the direction of Mr. C. J. Lebel (Chairman of one of the groups which prepared the NARTB Standards). It was necessary that the pick-up and amplifier system should conform in response to the RIAA-New AES-new NARTB response curve within ± 1db, and in the tests of this excellent transcription unit ***the components selected for use as complying with this requirement were a Leak tone arm fitted with Leak cartridge and a complete Leak pre-amplifier and power amplifier Model TL/10.***

The full test report appeared in the February, 1957 issue of "Wireless World," pages 22 and 23.



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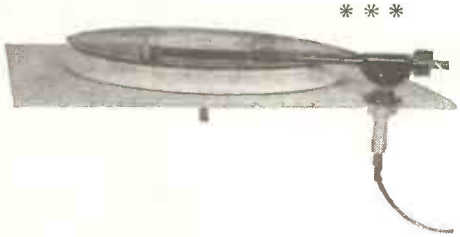

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S.3. **Rectifier Unit.** Ex Electric Supply Co. for working d.c. instruments, motorised equipment, etc. from a.c. mains. Input 200/240v. Output 200/240v. ·3 amp. 35/-, carriage 7/6.

S.4. **Rectifier Unit,** as item S.3. but ·2 amp. 25/-, carriage 6/6.

S.5. **Rectifier Unit,** as item S.3. but 40 m.a. 20/-, carriage 5/6.

S.6. **Filament Transformer, 2v. 5** amp. High voltage output. Secondary winding, so OK for tube isolation. 4/6.

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S.8. **Transistor new,** tested. OK for LF 6/6.

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S.22. **Moving coil meter.** 2½in. flush mounting. Scaled 0-30 m.a. 7/6 **each.**

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S.24. **Mullard 510. Mains transformer.** 29/6, plus 2/6 post and packing.

S.25. **D.C. Rotary Converter.** Doubles or halves voltage, e.g. 24v. to 12v. or vice versa. 45/-, plus 3/6 carriage and insurance.

S.26. **R.F. 25 Tuning Unit.** New, unused and complete with valves. 9/6, post 2/6.

S.27. **Hand magneto generator,** as used on telephones. 9/6.

S.28. **Powerful Blower** with motor, 24v. D.C. but can be operated off mains with rectifier. 15/-, post and packing 2/-.

S.29. **As item S.28,** but with larger motor for 220v. 25/-, post and packing 3/6.

S.30. **400 watt Step Down Transformer** tapped output, 110-155v. 37/6, carriage 6/6.

S.31. **500 watt Isolation Transformer.** Mains in, mains out. (Make servicing safe.) 69/6, post 6/6.

S.32. **Coil pack** for superhet 465 Kc/s I.F. Medium and 2 short waves. 9/6.

S.33. **Fluorescent Tube 80 watt.** Standard in all respects. Callers only. **8/6 each.**

S.34. **Fluorescent Tube 40 watt.** See item S.33. 7/6 **each.**

S.35. **Fluorescent Tubes 20 watt.** Standard in all respects. Callers only. **6/6 each.**

S.36. **Cathode Ray Tube.** VCR 97. Instrument type. 7/6 **each,** carriage 3/6.

S.37. **Cathode Ray Tube.** VCR 517. **8/6 each,** carriage 2/6.

Where the value of your order for small articles exceeds £2, these are post free. Under £2 add sufficient to cover, and where carriage or postage specifically mentioned add this in any case.

S.38. **.1 mfd. 350v.** small tubular metal cased type, made by Dubilier. **2/6 per doz.**

S.39. **Loudspeaker.** 5in. energised field 600 ohm. 9/6, carriage 3/6.

S.40. **Loudspeaker.** 8in. energised field 500 ohm. 12/6, carriage 3/6.

S.41. **Welding Transformer.** 12v. 50 amp. Continuous rating. Intermittent rating for spot welding 500 amps. **Price 45/-,** carriage and packing 5/-.

S.42. **Mains Lead.** Metal screened to stop interference. **9d. per yard.**

S.43. **10 core flexible cable.** 230v. cores. **Price 1/6 per yard.**

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S.46. **3-valve superhet chassis.** Long and medium. Complete with valves. Unused but may need servicing. 25/-, post and insurance 3/6.

S.47. **Thermometer Capillary Type.** 0-100°C. **Price 9/6.**

Many more bargains at all our branches. Please telephone before calling to pick up something special in case stocks have been cleared.

S.48. **Mains Transformer** 250-0-250. 60-80 m.a. 6-3v. Standard mains input. Half shrouded. **12/6.** post and insurance 2/6.

S.49. **Precision Potentiometer** 20k. ohms 10 watt, with large instrument knob. **Price** 8/6.

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S.59. **Rotary switch,** as used for hair dryers, etc., 10 amp. **1/9 each.**

S.60. **Bakelite 5 amp electric wall switch.** "Hicraft". **9d. each** or 8/- **per dozen.**

S.61. **As item S.60,** but two-way. **Price 11d. each,** or **10/- per doz.**

S.62. **Series,** parallel and off-electric wall switch made by Crabtree. **Price 1/3 each** or **13/6 per doz.**

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S.71. **Head-phones,** lightweight American type HS 30. **22/6 pair.**

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S.73. **Midget push-pull** input transformer, and push-pull output transformer to match. **8/- the pair.**

S.74. **Octagonal speaker enclosure** as specified by the G.E.C. for the metal cone, also suits any 8in. speaker, beautifully made but not polished. £5. Carriage and insurance 10/-.

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Input 0–230/250 v. Output 240–0–240 v., 1.5 amps RMS, 5 v. 1.75 amps, and 5 v. 12.5 amps. 7 x 7½ x 10½in. high. Wt. 50 lbs. Potted, oil-filled, by Gresham. Gives 2.1 amp. D.C. when rectified, OR, as ISOLATING TRANSFORMER, to obtain two 240 v. 360 w. lines. Brand new. **£3/10/-.** Carr. 10/-. Input 0–110/120–200/250 v. Output 275–0–275 v. 100 mA, 6.5 v. 7 amps, 5 v. 3 amps (Govt. ratings). 4 x 4¾ x 4in. high. Upright mounting. Brand new. **32/6.** Postage 2/6.

U.S.A. potted type, input 210/220/230 v. 5 secondaries, 7.5 v. 4 a., 7.5 v. 4 a., 7.5 v. 8 a. and 2.5 v. 5 a., ALL centre tapped, and 6.3 v. 4a. These can be connected to give many useful voltages up to 31 v. 4 a. Size 6in. x 5in. x 4in. Wt. 16lb., price **35/-.**

HEAVY DUTY SLIDER RESISTORS 0.4 ohm, 25 amps, 250 watts, worm drive, **7/6**. 10 ohms, 3.5 amps, worm drive, **10/6.** 1 ohm' 12 amps, 150 watts, **7/6.** 14 ohms, graded 1–4 amps, **7/6.**

MINIATURE STC RELAYS. 250 ohm coil. DP C/O (double-contacts). 1¼ x ⅝ x ¾in. **7/6.**

OUTPUT POWER METERS. Ex-W.D. No. 3, Mk. 2 (Windsor 150 A.). Impedance ranges 2.5 to 20,000 ohms in 40 steps. Power ranges 0–5, 50, 500 milliwatts, and 0–5 watts. Also scaled in dB, 3½in. M/C meter. In oak case, 10½in. x 8in. x 5½in. In good condition. Tested. **£15.**

INSULATION TESTERS by Record Electric. 0–50 Megohms. Test voltage 500. In perfect working order. Complete in leather carrying case. **£9/19/6.**

AVO VALVE TESTERS. Roller panel type, with cut-out. New purchase enables us to offer these in very good condition, in transit case and full working order for ONLY **£7/19/6** carriage paid.

JACK BOXES. A small metal box fitted with 9 miniature insulated Igranic jack sockets. Brand new. SNIP. **12/6.**

HEAVY DUTY BLOWERS. For 200-250 v. A.C./D.C. mains, 300 watts. With 1½inch diam. twin "V" shape outlets. 2 lengths of hose, 4 spare filters, and brushes. Suitable for industrial use, forges, etc. Brand new, **£4/19/6.**

VIBRATOR PACKS. Input 6 v.D.C., Output approx. 100 v. D.C. at 30 m/Amps, fully smoothed and R.F. filtered. Size 6½ x 5 x 2in. Fitted with Mallory 629C vibrator. Brand new. Boxed. **12/6.**

MOTOR ALTERNATORS. Input 80 volt D.C. at 16 amps. Output 80 volt A.C. 2,000 c/s, at 8 amps (650 V.A.). Built-in voltage regulator. Brand new. Crated. **79/6.** Carriage 15/-.

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50 Microamp.	D.C. M/C	2½in.	Flush circ., scaled 0-100	59/6
100 Microamp.	D.C. M/C	2½in.	Flush circ., scaled 0-1,500	39/6
500 Microamp.	D.C. M/C	2in.	Flush circular	17/6
500-0-500 Micro-amp.	D.C. M/C	2½in.	Flush circular, scaled 100-0-100 V.	25/-
1 Milliamp.	D.C. M/C	2in.	Flush square, Fe/NFe	22/6
150 Milliamp.	D.C. M/C	2in.	Flush square	7/6
200 Milliamp.	D.C. M/C	2½in.	Flush circular	10/6
1 Amp.	Thermo-couple	2½in.	Projecting circular	6/9
4 Amp.	Thermo-couple	2in.	Flush square	6/9
30-0-30 Amp.	D.C. M/I	2in.	Proj. circ., ear type	5/-
15 Volts	A.C. M/I	2½in.	Flush circular	8/6
300 Volts	D.C. M/C	2in.	Flush square	10/6

METER RECTIFIERS. Full wave bridge. **Brand** new, Salford 1/mA. 6/6. 5 m/A., 6/6. STC 2 m/A., 5/6.

WIRELESS SET No. 19, Mk. 2.
Two transmitter-receivers and an intercom. amplifier in one case. "A" set covers 2–8 Mc/s R/T and CW, and "B" set 240 Mc/s R/T only. Complete with dynamotor for 21 v. D.C. operation, 6 K7G, 2 6K8G, 2 6V6G, 6B8G, 807, EF50, EB34, and 500 microamp check and tuning meter. S.A.E. full specification. Technical data supplied. Made in U.S.A. First-class condition. AIR TESTED **£5/10/-** plus 15/- carr. and pkg. Or less dynamotor, **£4/19/6.**

RCA AMPLIFIER MI-11220. Employs 2 6L6G, 4 6J7, 1 5U4G. Output 12 watts at 5, 7.5, 15, or 600 ohms. For 190–250 v. A.C. mains. In umber-grey crackled case, 17 x 11 x 9in. Wt. 38lbs. Brand new, boxed, less valves, **£9/19/6.** Circuit supplied. Set of new valves, **59/6.** Converted for use with pick-up or microphone, with tone control, **£2** extra. Spare O/P transformer for above, with NFB tertiary winding. BRAND NEW, **27/6,** including amplifier circuit.

HIGH VOLTAGE POWER UNITS Input 200–250 v. A.C. mains. Output 1200v. D.C., 200 milliamps. Fully smoothed, Metal rectifiers, **£5/10/-,** plus 15/- carriage.

RI09A RECEIVERS. 8 valve superhet using 5 x ARP12's and 3 x AR8's covering 2–12 Mc/s. Contains vibrator pack and 3½in. speaker and operates from 6 volt battery, consumption 1¼ amps. Housed in metal case 13 x 12 x 11in. Complete with valves and circuit. Very good condition. Tested. **£4/7/6,** carr. pd.

SCR522 TRANSMITTER/RECEIVERS. 100–150 Mc/s. Comprises BC624A rec., and BC625 trans. All complete with valves, and in first-class condition. BC624A, less relay, **39/6.** With relay, **49/6.** BC625, **49/6.**

RT37/PPN2 BEACON TRANSMITTER-RECEIVER. 214–234 Mc/s. Size 13in. x 10in. x 5in. Contains 5 3A5, 3 1S5, 1 1R5 and 2 2 v. synchronous vibrators. Operates from 2 v. accumulator via 2 built-in vibrapacks. Complete with telescopic mast antenna system (9½ft.), lightweight headphones. Technical Manual, super quality carrying haversack, cords, co-ax cables, plugs, etc. Total wt. 28lb. BRAND NEW, boxed. American equipment, **72/6.**

PYE 45 Mc/s. IF STRIPS. Complete with 7 valves and CIRCUIT. New. ONLY **39/6.**
RF UNITS. ALL BRAND NEW AND BOXED. RF24 **7/6,** RF 26 **25/-.** Post 2/6.

Two-Way MORSE TRAINING SETS, W/T Mk. 3. Consists of 2 valve oscillators (ARP12's) (one with pitch control), for 1 or 2 operators. Has provision for creating "atmospherics." In polished oak case 12½in. x 10in. x 8in., wt. 16 lb. Complete with valves, leads, 2 keys, 7-way terminal board, circuit and instructions, but less batteries and phones. Ideal for Cadets, Scouts, etc. SNIP, **19/6,** carr. 7/6.

VARIAC TRANSFORMERS. Semi-variable input 200–240 v. 50 c/s. Output 7.5 amps., 1.65 KVA. 8 x 4½ x 4 inches. Wt. 14lb., **89/6.**

MAINS DIMMERS. 300 ohms, 1 amp, 300 watts, twin ceramic formers, **15/-.**

FIELD TELEPHONES. Army type D, Mk. 5. Buzzer calling. Ideal for building sites, farms, workshops, etc. Complete with handset and batteries. Tested, **39/6** each.

CRYSTALS. 200 Kc/s American GEC, **10/-** each. 100 Kc/s R.C.A. bars, **19/6** each.

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ASSEMBLED CHARGER
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Fitted Ammeter and selector plug for 6 v. or 12 v. Louvred metal case, finished attractive hammer blue. Ready for use with mains and output leads, Double Fused. Only **47/9**

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6 v. or 12 v. 2 amps. .. 38/9
6 v. or 12 v. 4 amps. .. 59/9
Above ready for use. Carr. 2/9.

MISC. SPARES.
Bakelite Fuses 15a 1/9. Bakelite Terminals, 6d. ea. Multi-Position 15a Switches with Knobs 4/9. Rheostats 25μ 0.4 ohms. with worm drive 6/9.
Heavy Duty rectifiers can be supplied to customers specification. Please let us Quote you for your requirements.

BATTERY CHARGER KITS
Consisting of Mains Transformer F.W. Bridge. Metal Rectifier, well ventilated steel case, Fuses, Fuse-holders, Grommets, panels and circuit. Carr. 2/6 extra.
6 v. or 12 v. 1 amp..... 22/9
6 v. 2 amps..... 25/9
6 v. or 12 v. 2 amps. .. 31/6
6 v. or 12 v. 4 amps. .. 53/9

BATTERY CHARGER KIT
Consisting of F.W. Bridge Rectifier 6/12 v. 5 a. Mains Trans., 0-9-15 v. 6 a. output, and ammeter. Only 49/9. Post 3/-.

All for A.C. MAINS 200-250v., 50 c/s. Guaranteed 12 months
Assembled 6v. or 12v. 4 amps.

Fitted Ammeter and variable charge selector. Also selector plug for 6 v. or 12 v. charging. Double fused. Well ventilated steel case with blue hammer finish. Ready for use with mains and output leads. Carr. 3/9. Or Deposit 13/9 and five monthly payments 13/9. **75/-**

SELENIUM RECTIFIERS

L.T. Types		6/12 v. 6 a. ..	19/9
2/6 v. ½ a.h.w.	1/9	6/12 v. 10 a. ..	25/9
6/12 v. ½ a.h.w.	2/9	**H.T. Type H.W.**	
F.W. Bridge Types		120 v. 40 mA.	3/9
6/12 v. 1 a. ..	4/11	250 v. 50 mA.	5/9
6/12 v. 2 a. ..	8/9	250 v. 80 mA.	7/9
6/12 v. 3 a. ..	11/9	250 v. 150 mA.	9/9
6/12 v. 4 a. ..	14/9	300 v 250 mA.	12/11

CO-AXIAL CABLE. 75 ohms. ¼in., 8d. yard Twin screened feeder 11d. yard.

5 CORE FLEX. Henleys circular rubber 14/36. Each lead colour coded. 1/6 yard.

DIAL BULBS. M.E.S., 8 v. 0.2 a., 6/9 doz. 6.5 v. 0.3 a., 5/9 doz. 2.5 v. 0.3 a. 3/9 doz.

ELECTROLYTICS (current production). NOT Ex Govt.

Tubular Types		Can Types	
8 mfd. 450 v...	1/9	16μF 450 v. ..	2/9
8 mfd. 500 v...	2/6	16 mfd. 500 v.	3/9
16μF 350 v...	1/11	32μF 350 v. ..	2/11
16μF 450 v. ..	2/9	32 mfd. 450 v.	4/9
16μF 500 v. ..	3/9	100 mfd. 450 v.	4/9
8-16μF 500 v.	4/11	8-8μF 450 v...	2/9
25μF 25 v.....	1/3	8-16μF 450 v.	3/11
50μF 12 v.....	1/3	16-16μF 450 v.	3/11
50 mfd. 25 v...	1/9	32-32μF 350 v.	4/9
50μF 50 v.....	1/9	32-32μF 450 v.	5/9
100 mfd. 12 v.	1/9	100-100 mfd. 350 v.	5/9
100 mfd. 25 v.	2/3	64-120 mfd. 350 v.	7/6
3,000 mfd. 6 v.	3/9	100-200 mfd. 275 v.	6/11
6,000 mfd. 6 v.	3/11		

Many others in stock.

VOLUME CONTROLS with long spindles, all values, less switch, 2/9; with S.P. switch, 3/9.

EX GOVT. STEP UP/STEP DOWN TRANSFORMERS. Double wound 80/100 watts. 10-0-100-200-220-240 v. to 5-0-75-115-125-135 v. or Reverse. Only 11/9, plus 2/9 post. 10-0-100-200-220-240 v. to 9-0-110-122-136-148 v. or Reverse. 200 watts, 35/9 plus 7/6 carr.

EX GOVT. METAL BLOCK PAPER CONDENSERS

4 mfd. 500 v.....	2/3	8 mfd. 500 v.....	4/6
4 mfd. 1,000 v...	3/9	10 mfd. 500 v. ..	3/9

EX GOVT. VALVES. VR137, EA50, EB34, 11d.; SP61 2/3; VS110 1/11; 6J5 3/9; 6V6G, 5U4G 7/9; 35Z4, 6X4 5/9; EF80 7/9.

EX GOVT. UNITS, type RDF1 in original sealed cartons with 14 valves including 5Z4G, etc., trans., L.F. choke, Rectifier, etc., etc. We cannot enter into correspondence regarding these units which represent a really exceptional bargain at 29/9. Carr. 7/6.

OIL FILLED BLOCK CONDENSERS
Bryce 11-7 mfd. 500 v. New unused Govt. surplus, only 5/9 each.

THE SKY FOUR T.R.F. RECEIVER

A design of a 3 valve 200-250 v. A.C. Mains L. & M. wave T.R.F. receiver with selenium rectifier. For inclusion in cabinet illustrated above or walnut veneered type. It employs valves 6K7, SP61, 6F6G, and is specially designed for simplicity in wiring. Sensitivity and quality is well up to standard. Point-to-Point wiring diagrams, instructions and parts list, 1/9. This receiver can be built for a maximum of £4/19/6 including cabinet. Available in brown or cream bakelite, or veneered walnut.

EX GOVT. MAINS TRANSFORMERS
All 230 v. 50 c/s. input

120-0-120 v. 40 mA.	5/9
250-0-250 v. 60 mA., 6.3 v. 3 a., 6.3 v. 1 a. Potted 4½-3½-3in.	11/9

HEAVY DUTY OIL FILLED MAINS TRANSFORMERS
Suitable welding or soil heating. With input of 200-250 v. 50 c.p.s., output is 12 v. 80-100 amps. Only £6/19/6, carr. 7/6.

MANUFACTURERS SURPLUS TRANSFORMERS
Primary 200-240-250 v. Drop through type 250-0-250 v. 70 mA. 6.3 v. 3 a., 11/9. Postage 2/9.

EX GOVT. SMOOTHING CHOKES
250 mA., 5 H., 50 ohms. 12/9
150 mA., 10 H., 50 ohms. 10/11
100 mA., 5 H., 100 ohms., Tropicalised 3/11
50 mA., 50 H., 1,000 ohms. 6/9

EX-GOVT. CASES. Well ventilated, black crackle finished, undrilled cover. Size 14—10—8½ins high IDEAL FOR BATTERY CHARGER OR INSTRUMENT CASE. COVER COULD BE USED FOR AMPLIFIER. Only 9/9, plus 2/9 post. Size 13½in. × 8in. × 6½in. with undrilled perforated cover finished in stoved grey enamel, 7/9, plus 2/9 post.
SPECIAL OFFERS. Small 2 gangs .0005 mfd., 4/9. Electrolytics 32-32-32 mfd. 250 v., 2/9 each or in lots of six, 2/3 each.

EX-GOVT. VIBRATOR UNITS. 12 v. input 200 v. output. Suitable for car radio, etc. 16/6.

R.S.C. BATTERY TO MAINS CONVERSION UNITS

Type BM1. An all dry battery eliminator. Size 5½ × 4½ × 2in. approx. Completely replaces batteries supplying 1.4 v. and 90 v. where A.C. mains 200-250 v. 50 c/s. is available. **Suitable for all battery portable receivers requiring 1.4 v. and 90 v.** This includes latest low consumption types. Complete kit with diagrams, 39/9, or ready for use, 46/9.

Type BM2. Size 8 × 5½ × 2½in. Supplies 120 v., 90 v., and 60 v., 40 mA. and 2 v. 0.4 a. to 1 amp. fully smoothed **THEREBY COMPLETELY REPLACING BOTH H.T. BATTERIES AND L.T. 2v. ACCUMULATORS** when connected to A.C. mains supply 200-250 v. 50 c/s. SUITABLE FOR ALL BATTERY RECEIVERS normally using 2 v. accumulator. Complete kit with diagrams and instructions 49/9 or ready for use 59/6.

JUNCTION TRANSISTORS for Audio stages. Only 7/6.
MINIATURE MOTORS. 24/28 v. D.C. or A.C. Size only 2½ × 1½ins. Spindle 1½ins. long, ¼in. diam. Made by Hoover Ltd., Canada. Price only 9/9.
VIBRATORS. Oak 2 v. 7 pin. synchronous, 7/9.
M.E. SPEAKERS. 2—3 ohms R.A. 8in. Field 600 ohms, 11/9.

T.V. CABINETS. For 15 16 or 17in. tube. Table model with doors. 79/6 carr. 7/6.

R.S.C. TRANSFORMERS

FULLY GUARANTEED. INTERLEAVED AND IMPREGNATED.

MAINS TRANSFORMERS
Primaries 200-230-250 v. 50 c/s.

FULLY SHROUDED UPRIGHT MOUNTING

350-0-350 v. 70 mA., 6.3 v. 2 a., 5 v. 2 a.	19/9
250-0-250 v. 100 mA., 6.3 v.-4 v. 4 a., c.t., 0-4-5 v. 3 a.	25/9
250-0-250 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a.	23/9
250-0-250 v. 100 mA., 6.3 v. 6 a., 5 v. 3 a., for R1355 conversion	31/-
300-0-300 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a.	25/9
300-0-300 v. 100 mA., 6.3 v. 4 v. 4 a. c.t., 0-4-5 v. 3 a.	26/9
350-0-350 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a.	23/9
300-0-300v. 130 mA., 6.3v. 4 a., c.t., 6.3v. 1 a., suitable for Mullard 510 Amplifier	33/9
350-0-350 v. 100 mA., 6.3 v.-4 v., 4 a., c.t. 0-4-5 v. 3 a.	26/9
350-0-350 v. 150 mA., 6.3 v. 4 a., 5 v. 3 a.	33/9
350-0-350 v. 150 mA., 6.3 v. 2 a., 6.3 v. 2 a., 5 v. 3 a.	33/9
425-0-425 v. 200 mA., 6.3 v. 4 a., c.t., 6.3 v. 4 a., c.t., 5 v. 3 a., suitable Williamson Amplifier, etc.	49/9
450-0-450 v. 250 mA., 6.3 v. 6 a., 6.3 v. 6 a., 5 v. 3 a.	69/6

TOP SHROUDED DROP-THROUGH TYPE

260-0-260 v. 70 mA., 6.3 v. 2 a., 5 v. 2 a.	16/9
350-0-350 v. 80 mA., 6.3 v. 2 a., 5 v. 2 a.	18/9
250-0-250 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a.	22/9
300-0-300 v. 100 mA., 6.3 v.-4 v. 4 a., c.t., 0-4-5 v. 3 a.	23/9
350-0-350 v. 100 mA., 6.3 v. 4 a., c.t., 5 v. 3 a.	22/9
350-0-350 v. 100 mA., 6.3 v.-4 a. 4 a. c.t., 0-4-5 v. 3 a.	23/9
350-0-350 v. 150 mA., 6.3 v. 4 a., 5 v. 3 a.	29/9
E.H.T. TRANSFORMERS, 2,500 v. 5 mA., 2-0-2 v. 1.1 a., 2-0-2 v. 1.1 a., for VCR97, VCR517	36/6

FILAMENT TRANSFORMERS
Primaries 200-250 v. 50 c/s.

6.3 v. 1.5 a. ..	5/9	12 v. 1 a.	7/9
6.3 v. 2 a.	7/6	6.3 v. 6 a.	17/6
0-4-6.3 v. 2 a.	7/9	12 v. 3 a. or	
6.3 v. 3 a.	8/11	25 v. 1.5 a...	17/6

CHARGER TRANSFORMERS
All with 200-230-250 v. 50 c/s. Primaries:
0-9-15 v. 1½ a., 11/9; 0-9-15 v. 3 a., 16/9; 0-3.5-9-17 v. 3 a., 17/9; 0-9-15 v. 5 a., 19/9; 0-9-15 v. 6 a., 23/9.

ELIMINATOR TRANSFORMERS
Primaries 200-250 v. 50 c/s.
120 v. 40 mA., 5-0-5 v. 1 a. 14/9
90 v. 15 mA., 6-0-6 v. 250 mA. 9/11

OUTPUT TRANSFORMERS

Midget Battery Pentode 66:1 for 3S4, etc.	3/6
Small Pentode 5,000Ω to 3Ω	3/9
Standard Pentode, 5,000Ω to 3Ω	4/9
Standard Pentode, 8,000Ω to 3Ω	4/9
Push-Pull 8 Watts 6V6 to 5 ohms.	8/9
Push-Pull 10-12 Watts 6V6 to 3Ω or 15Ω	15/9
Push-Pull 10-12 Watts to match 6V6 to 3-5-8 or 15Ω	16/9
Push Pull EL84 to 3 or 15 ohms.....	16/9
Push Pull 15-18 Watts, sectionally wound, 6L6, KT66, etc., to 3 or 15 ohms	21/9
Push-Pull 20 Watt high-quality sectionally wound, 6L6, KT66, etc., to 3 or 15Ω	47/9

SMOOTHING CHOKES

250 mA., 5 H., 100 ohms.	11/9
150 mA., 7-10 H., 250 ohms.	11/9
100 mA., 10 H., 200 ohms	8/9
80 mA., 10 H., 350 ohms.	5/6
60 mA., 10 H., 400 ohms.	4/11
1 amp. 0.5 ohm. L.T. type	6/6

R.S.C. A10 ULTRA LINEAR 30 WATT AMPLIFIER

NEW 1957 DESIGN. HIGH FIDELITY PUSH-PULL UNIT EMPLOYING SIX VALVES. EF86, EF86, ECC83, 807, 807, GZ34. Tone Control Pre-amp stages are incorporated. Sensitivity is extremely high. Only 12 millivolts minimum input is required for full output. **THIS ENSURES THE SUITABILITY OF ANY TYPE OR MAKE OF MICROPHONE OR PICK-UP.** Separate Bass and Treble controls give both "lift" and "cut" with ample tone correction for long playing records. An extra input with associated vol. control is provided so that two separate inputs such as "mike" and gram, etc. etc., can be simultaneously applied for mixing purposes. **AN OUTPUT SOCKET WITH PLUG IS INCLUDED FOR SUPPLY OF 300 v. 20 mA. and 6.3 v. 1.5 a. FOR A RADIO FEEDER UNIT.** Price in kit form with easy-to-follow wiring diagrams. Cover as illustrated 17/6 extra. Only **10** GNS. car. 10/-. Or Factory built with 12 months' guarantee. **£12/19/6. TERMS ON ASSEMBLED UNITS. DEPOSIT 28/11** and 9 monthly payments of 28/11.

Type 807 output valves are used with High Quality Sectionally wound output transformer specially designed for Ultra Linear operation. Negative feedback of 20 D.B. in main loop. **CERTIFIED PERFORMANCE FIGURES ARE EQUAL TO MOST EXPENSIVE UNITS AVAILABLE.** Frequency response ± 3 D.B., 30-20,000 c/cs., Tone Controls ± 12 D.B. at 50 c/cs., + 12 D.B. to −6 D.B. at 12,000 c/cs., Hum and noise 70 D.B. down. Good quality reliable components used. Chassis finish blue hammer. Overall size 12 × 9 × 9in. approx. Power consumption 150 watts. For A.C. mains 200-230-250 v. 50 c/cs. Outputs for 3 and 15 ohm speakers. **EQUALLY SUITABLE FOR THE CONNOISSEUR OR FOR LARGE HALLS, CLUBS, or OUTSIDE FUNCTIONS. IDEAL FOR USE WITH MUSICAL INSTRUMENTS SUCH AS STRING BASS, ELECTRONIC ORGAN, GUITAR, etc. FOR DANCE BANDS, GARRISON THEATRES, etc. etc.**

We can supply Microphones, Speakers, 12 v. Rotary Converters, etc., at keen cash prices or on terms with amplifiers.

EXPORT ENQUIRIES INVITED

LT/45 HIGH QUALITY TAPE DECK AMPLIFIER

COMPLETE with POWER PACK and OSC. STAGE. Suitable for Collaro, Lane, Truvox, Aspden, Brennel, etc. etc. State make of Deck when ordering. Chassis size 12-7-3in. Overall size 12-7-6¼in. For 200-250 v. 50 c/cs. A.C. mains. Output for standard 2-3 ohm speaker. Only 15 millivolts input required for full recording. Only 2 millivolts minimum input required from recording head. Magic Eye recording level indicator. Provision for feeding P.A. amplifier. Negative feed-back equalisation. Linear frequency response ± 3 D.B. 50-11,000 c/cs. Facilities for recordings at 15in., 7½in. or 3¾in. per second. Automatic equalisation at the turn of a knob. When switching from record to playback position automatic demagnetisation of heads is assured. Separate gain and output controls. Mullard valves ECC83, ECC83, EL84, EZ80, EM34. Output 4 watts. Unit supplied with makers' 12 months' guarantee. We know of no other make which represents the same exceptional value. We can supply Decks and microphones with above at a special inclusive price.

12 Ready for use GNS. Carr. 7/6.

LINEAR LG3 MINIATURE 3 WATT GRAM. AMPLIFIER

For 200-250 v. 50 c.p.s. A.C. Mains. Chassis and P.U. connections fully isolated. Fitted vol. (with mains switch) and Tone Control. Designed for use with any kind of single player or record changing unit. Output for 2-3 ohm speaker. Guaranteed 12 months (valves 3 months). Only 69/9 carr. 3/9.

R.S.C. 4-5 WATT HIGH GAIN AMPLIFIER TYPE A5

A highly sensitive 4-valve quality amplifier for the home, small club, etc. Only 50 millivolts input is required for full output so that it is suitable for use with the latest high-fidelity pick-up heads in addition to all other types of pick-ups and practically all mikes. Separate Bass and Treble controls are provided. These give full long playing record equalisation. Hum level is negligible being 71 D.B. down 15 D.B. of negative feedback is used. H.T. of 300 v. 26 mA. and L.T. of 6.3 v. 1.5 a. is available for the supply of a Radio Feeder Unit or Tape Deck pre-amplifier. For A.C. mains input of 200-230-250 v., 50 c/s. Output for 2-3 ohm speaker. Chassis is not alive. Kit is complete in every detail and includes fully punched chassis (with baseplate) with the blue hammer finish, and point-to-point wiring diagrams and instructions. Exceptional value at only £4/15/-, or assembled ready for use 25/- extra, plus 3/6 carriage. Or Deposit 22/- and five monthly payments of 22/- for assembled unit.

R.S.C. A7 3-4 WATT QUALITY AMPLIFIER

A highly sensitive 4-valve amplifier using negative feedback and having an excellent frequency response. Pre-amplifier and Tone Control stages are incorporated with separate Bass and Treble controls giving full tone compensation for Long Playing records. Suitable for any kind of pick-up including latest high fidelity types. H.T. of 250 v. 20 mA. and L.T. 6.3 v. 1 a. available for supply of Radio Feeder Unit, etc. ONLY 40 millivolts input required for full output. Fully isolated chassis with baseplate. For A.C. mains 200-250 v. 50 cycles. Output for 2-3 ohm speaker. Complete kit of parts with point-to-point wiring diagrams and instructions. Only £3/15/-, carr. 3/6 or factory built 22/6 extra. Or Deposit 18/6 and five monthly payments of 18/6 for assembled unit.

P.M. Speakers recommended for use with A7, A5 or L45 amplifiers.

Plessey 12in. 3 ohm, 29/11. 6½in. Celestion and Goodmans with high flux density magnet 19/9.

COLLARO RC456 4 SPEED AUTO-CHANGERS

With studio pick-up with turnover head. BRAND NEW. Cartoned, latest model. For 200-250 v. 50 c.p.s. A.C. mains. Very limited number at only £8/19/6. Carr. 5/6.

COLLARO RC54 3 SPEED AUTO-CHANGERS

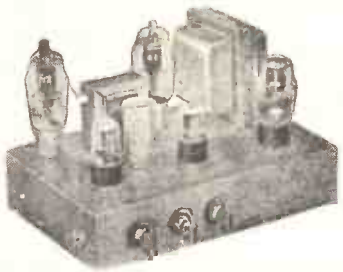
As above unit but for normal 3 speed requirements. Brand new cartoned but for 110 v. 50 c.p.s. A.C. mains. So that the unit can be operated from normal, 200-250 v. A.C. mains we are supplying free with every changer a suitable auto-transformer with input and output voltages clearly marked. Limited number only. £7/19/6. Carr. 5/6.

LINEAR L45 MINIATURE 4/5 W. QUALITY AMPLIFIER. Suitable for use with Garrard, B.S.R. or any other record playing unit, and most microphones. Total negative feedback 12 db. Separate Bass and Treble Controls. For convenience when mounted in cabinet, mains switch is incorporated in control. For A.C. mains input of 200-250 v. 50 c.p.s. Output for 2/3 ohm speaker. Three miniature Mullard valves used. Size of unit only 6 × 5 × 5¼in. high. Chassis is fully isolated from mains. Guaranteed 12 months. Only £5/19/6. Or Deposit 22/- and five monthly payments of 22/-. Send S.A.E. for leaflet.

PLESSEY DUAL CONCENTRIC 12 in. P.M. SPEAKERS

(15 ohms), consisting of a high quality 12in. speaker, of orthodox design, supporting a small elliptical speaker ready wired with choke and condensers to act as tweeter. This high fidelity unit is highly recommended for use with our A8 or any similar amplifier. Rating is 10 watts. Price only £5/17/6. Or Deposit 13/- and nine monthly payments of 13/-.

R.S.C. ULTRA LINEAR 12-WATT AMPLIFIER



NEW 1957 MODEL A8 HIGH-FIDELITY PUSH-PULL AMPLIFIER WITH "BUILT-IN" TONE CONTROL, PRE-AMP. STAGES

High sensitivity. Includes 5 valves (807 outputs), High Quality sectionally wound output transformer, specially designed for Ultra Linear operation, and reliable small condensers of current manufacture. **INDIVIDUAL CONTROLS FOR BASS AND TREBLE "Lift" and "Cut" Frequency response ±3db. 30-30,000 c/cs. Six negative feedback loops. Hum level 71 db. down. ONLY 70 millivolts INPUT required for FULL OUTPUT. Suitable for use with all makes and types of pick-ups and practically all microphones. Comparable with the very best designs. For STANDARD or LONG PLAYING RECORDS. For MUSICAL INSTRUMENTS such as STRING BASS, GUITARS, etc. OUTPUT SOCKET** with plug provides 300 v. 20 mA. and 6.3 v. 1.5 a. For supply of a **RADIO FEEDER UNIT.** Size approx 12-9-7in. For A.C. mains 200-230-250 v. 50 c/cs. Output for 3 and 15 ohm speakers. Kit is complete to last nut. Chassis is fully punched. Full instructions and point-to-point wiring diagrams supplied.

Unapproachable value at **£7/15/-** or factory built 45/- extra. Carriage 10/-. If required louvred metal cover with 2 carrying handles can be supplied for 17/6. Where an extra input socket with associated volume control is required for mixing purposes this can be provided for 13/- extra. **TERMS OF ASSEMBLED UNITS with extra input as mentioned above. DEPOSIT 25/6 and nine monthly payments of 23/4.**

LINEAR "DIATONIC" 10-WATT HIGH FIDELITY AMPLIFIER. Incorporating pre-amp. For A.C. Mains input 200-230-250 v. 50 c.p.s. A compact attractively finished unit with two separately controlled inputs, and outputs for 3 and 15 ohm speakers. Separate Bass and Treble controls. Five latest type miniature Mullard valves. Only 12 Gns. Send S.A.E. for leaflet and credit terms.

W.B. "STENTORIAN" HIGH FIDELITY P.M. SPEAKERS. HF1012, 10 watts, 15 ohm (or 3 ohm) speech coil. Where a really good quality speaker at a low price is required, we highly recommend this unit with an amazing performance. £4/10/9. Please state whether 3 ohm or 15 ohm required.

P.M. SPEAKERS. 2-3 ohm 5in. Goodmans 17/9. 7 × 4in. Elliptical, 19/6, 6½in. Rola, 19/9. 8in. Rola, 19/9. 10in. R.A., 29/9. 12in. Plessey 3 ohms, 10 watts, 59/6.

SUPERHET RADIO FEEDER UNIT

Design of a high quality Radio Tuner Unit (specially suitable for use with any of our Amplifiers). A Triode Heptode F/changer is used. Pentode I.F., and double Diode Second Detector. Delayed A.V.C. is arranged so that A.V.C. distortion is avoided. The W. Ch. Sw. incorporates Gram. position. Controls are Tuning, W., Ch., and Vol. Output will load most Amplifiers requiring 500 M.V. input depending on Ae. location. Only 250 v. 15 mA. H.T. and L.T. of 6.3 v. 1 amp. required from amplifier. Size of unit approx. 9-6-7in. high. Send S.A.E. for illustrated leaflet. Total building cost is £4/15/-. Point-to-point wiring diagrams and instructions, 2/6.

RECORDING TAPE. 1,200 ft. Reels, Puretone, Medium Coercitivity, 15/9.

Radio Supply Co. (LEEDS) LTD.

32 THE CALLS. — LEEDS, 2.

Terms: C.W.O. or C.O.D. No C.O.D. under £1. Postage 1/9 extra on all orders under £2, 2/9 extra under £5 unless carriage charge stated. Full Price List 6d. Trade List 5d. Open to Callers: 9 a.m. to 5.30 p.m. Saturday until 1 p.m, S.A.E. please with all enquiries.

Stern's introduce...

A "fidelity" TAPE RECORDER

WITH EVERYTHING — EXCEPT A HIGH PRICE

TESTED AND APPROVED AT THE TRUVOX LABORATORIES

IT INCORPORATES: The NEW TRUVOX Mk. IV TAPE DECK together with the "fidelity" MODEL HF/TR2 TAPE AMPLIFIER (both fully described on this page), and a Rola 10×6in. P.M. speaker.

PRICE . . . Including CRYSTAL MIKE and 1,200ft. reel of PLASTIC TAPE.

£49.10.0. (OR £3 EXTRA WITH REV. COUNTER.)

(Plus £1/10/- carriage and insurance, of which £1 is refunded on return of Packing Case.)

● BEFORE CHOOSING YOUR TAPE RECORDER YOU SHOULD HEAR THIS MODEL—TRULY "Hi-Fi" RECORDINGS ARE OBTAINABLE and it is comparable to much higher priced Recorders.

Alternatively send S.A.E. for ILLUSTRATED LEAFLET.

CREDIT SALE: Deposit £12/8/- and 9 monthly payments of £4/10/8.

HIRE PURCHASE: Deposit £24/15/- and 12 monthly payments of £2/5/11.

Home Constructors!

YOU CAN BUILD A PORTABLE TAPE RECORDER OR INCORPORATE "TAPE" IN YOUR RADIOGRAM.

WE MAKE SPECIAL PRICES TO PURCHASERS OF TAPE EQUIPMENT (i.e. buyers of Deck and Amplifier together, etc.). SEND YOUR ENQUIRY TO US. H.P. and CREDIT SALE TERMS ARE AVAILABLE.

A COMPLETE KIT OF PARTS TO BUILD

The "fidelity" TAPE AMPLIFIER Model HF/TR2 including POWER SUPPLY UNIT

FOR ONLY **£12.0.0.** (Plus 5/- carr. and ins.)

This amplifier has been expressly designed to meet the requirements of the enthusiasts for High Fidelity reproduction. It is based on a new design, completed by the Mullard Technicians and only really high grade components are incorporated, truly HIGH FIDELITY Recordings are obtainable whilst "Hi-Fi" reproduction is assured by use of a high quality Output Transformer by Gilson. It incorporates a "magic eye" Recording Level indicator, a two position equaliser for 3¾in. and 7½in. speeds, and an effective Tone Control arrangement. Monitoring and Extension Speaker Socket are incorporated and in addition a position is provided to enable it to be used as an independent Amplifier for Gramophone Records or Radio Tuning Unit. Overall size: 11in.×6in.×6in. high. Suitable for nearly all makes of Tape Decks. When ordering, please advise make of deck in use.

THE ASSEMBLY MANUAL, PRACTICAL DIAGRAMS, etc., are available for 2/9 or send S.A.E. brief details.

WE ALSO SUPPLY THE HF/TR2 ASSEMBLED and READY FOR USE FOR £16.0.0. (Plus 6/- carr. & ins.) **H.P. TERMS.** Deposit £8 and 9 monthly payments of £1. **CREDIT TERMS:** Deposit £4 and 9 monthly payments of £1/9/4.

THE NEW TRUVOX MkIV TAPE DECK

THIS IS UNDOUBTEDLY ONE OF THE BEST TAPE DECKS ON THE MARKET. WE HAVE A FEW ONLY AVAILABLE

PRICE £27.6.0 (Plus 10/- carr. and ins.)

CREDIT TERMS: Deposit £6/17/- and 9 monthly payments of £2/10/-.

H.P. TERMS: Deposit £13/13/- and 12 monthly payments of £1/5/4.

SPECIFICATION:— ● 3 B.T.H. shaded pole motors with silent friction drive eliminating wow and flutter. ● Push button controls, electrically and mechanically interlocked (patented). ● Patented electric type push button controlled brake. ● Inching to assist editing; tape loading on the drop-in principal accommodation for reels of 7in. diameter. ● Tracking sense. To British and American standards. ● Playing times: Up to 3 hours with L.P. Tape or 2 hours with Standard Tapes. ● Two tracks side by side, with safety gap. ● Playing time indication by precision revolution counter or large visual type indicator plate, according to choice. Positive Azimuth adjustment of Record/Player Head. ● High Impedance Heads. ● The metal work is Gold Hammered finish. ● Overall size 14½in. × 12$\frac{13}{16}$in., from top of face of panel, overall depth 5in.

The Mk. IV DECK CAN ALSO BE SUPPLIED INCORPORATING PRECISION REV. COUNTER for £30/9/-. H.P. TERMS: Deposit £15/4/6 and 12 months of £1/8/3

CREDIT SALE: Deposit £7/12/3 and 9 months of £2/15/-.

STERN'S "COMPACT 5" AMPLIFIERS

The "Compact 5-2"

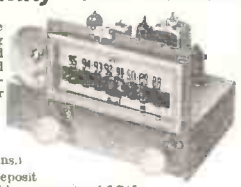
EXPRESSLY DEVELOPED FOR VERY HIGH QUALITY REPRODUCTION OF GRAM. RECORDS AND PARTICULARLY SUITABLE FOR HIGH QUALITY REPRODUCTION OF THE F.M. TRANSMISSIONS.

A 2-stage high sensitivity amplifier having SEPARATE BASS and TREBLE CONTROLS and designed to give up to approx. 5 watts with very pleasing quality. PRICE £6/6/-.

The "Compact 5-3" A 3-stage version of the "5-2" model but in this case having an additional stage and incorporating negative feedback. PRICE £6/16/-.

POWER SUPPLY. Is obtainable from a small separate Unit which apart from supplying power to either Amplifier, also has additional supply available for a Radio Tuning Unit. **PRICE** (additional to above), £2/10/-.

Stern's "fidelity" F.M. TUNING UNIT



A 5-Valve Tuner incorporating the latest Mullard Permeability Tuned Unit. Price assembled less Power Supply:

£14.10.0

(Plus 7/6 carr. and ins.)

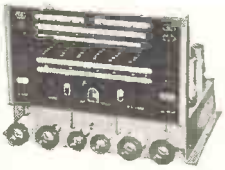
TERMS: (a) **H.P.** Deposit £7/5/- and 9 monthly payments of 18/4: (b) Credit Deposit £3/12/6 and 9 monthly payments of £1/6/7. Provides "Hi-Fi" reproduction with any make of Amplifier and many Radio Receivers. It incorporates: ● The latest Valve line-up—ECC85, 2 type EF85, EF91 and EM80. ● A "Magic Eye" Indicator. ● Power consumption is 1.7 amps at 6.3 volts and 25 m/a at 250 volts.

STERN'S "fidelity" COMBINED A.M. and F.M. TUNING UNIT

This is IDENTICAL to the Stern's F.M. Tuner illustrated above, but in addition incorporates the MEDIUM WAVEBAND and thereby also provides a selection of foreign stations. Price **£18.18.0.** (Plus 7/6 carr. and ins.)

TERMS:—(a) **H.P.** Deposit £9/9/- and 10 monthly payments of £1/1/-; (b) Credit Deposit £4/15/- and 9 monthly payments of £1/14/7. Send S.A.E. if further data required.

THE ARMSTRONG MODEL AF105 AM/FM RADIOGRAM CHASSIS



Developed to meet the needs of those who require really high quality radio and record reproduction but who, for reasons of expense or lack of room in existing or proposed cabinets, cannot consider the normal high-fidelity system. The A.F.105 is as good as, or better than, all but the most expensive Amplifiers, and Associated units. Independent and continuously variable Bass and Treble controls give a wide range of control. **SEND S.A.E. FOR DETAILS.**

PRICE £37 (Plus 7/6 Carr and Ins.)

CREDIT SALE TERMS: Deposit £9/5/- and 9 monthly payments of £3/7/10.

HIRE PURCHASE TERMS: Deposit £18/10/- and 12 monthly payments of £1/14/4.

Open Monday to Friday 9 a.m.—6 p.m.
Saturday 9 a.m.—1 p.m.

STERN RADIO LIMITED

AMPLIFIERS
PRE-AMPLIFIERS

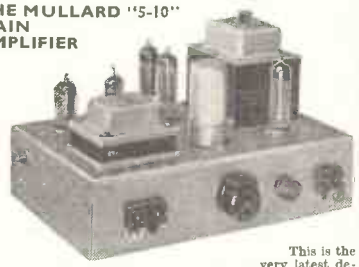
HIGH FIDELITY FOR THE HOME CONSTRUCTOR

TUNING UNITS
RADIO RECEIVERS

—COMPLETE KITS OF PARTS FOR THE "Hi-Fi" ENTHUSIAST—

QUALITY OF THIS NATURE HAS NEVER BEFORE BEEN OFFERED AT SUCH LOW COST.

THE MULLARD "5-10" MAIN AMPLIFIER



This is the very latest design and needs no recommendation from us. Our Kit is complete to Mullard's specification, including the latest GILSON ULTRA LINEAR OUTPUT TRANSFORMER and the entire MULLARD Valve line up. ALL SPECIFIED COMPONENTS are supplied.

PRICE OF COMPLETE KIT OF PARTS (Plus 5/- carr. and ins.). **£11/11/0**

THE full SPECIFICATION and BUILDING INSTRUCTIONS for these two Units are available for 1/6 each. THEY include COMPONENT PRICE LISTS and simple "wire-to-wire" PRACTICAL DIAGRAMS.

STERN'S "fidelity" PRE-AMPLIFIER TONE CONTROL UNIT

"A design for the music lover"

Briefly it has inputs for all types of MICROPHONES, HIGH and LOW GAIN PICK UPS and a RADIO TUNING UNIT. It incorporates (a) GRAM EQUALISING CONTROL: (b) STEEPCUT FILTER: (c) Continuously variable BASS and TREBLE CONTROLS and a variable OUTPUT CONTROL which enables its use with any type of Amplifier.

PRICE OF COMPLETE KIT OF PARTS
WE ALSO OFFER IT ASSEMBLED READY FOR USE, £8/-/- (Plus 5/- carr and ins.). **£6/6/0**

A COMPLETE KIT OF PARTS, STERN'S "HIGH QUALITY" 8-10 WATT AMPLIFIER

Has power supply available for Radio Tuning Unit.
Price of COMPLETE KIT OF PARTS (plus 5/- carr. and ins.). **£7/10/0**

WE ALSO OFFER IT ASSEMBLED and READY FOR USE for (plus 5/- carr. and ins.). **£9/10/0**

This amplifier has proved one of the most popular models yet offered to the HOME CONSTRUCTOR. It provides really excellent reproduction up to 8 watts, employing 6V6's in push-pull and incorporating negative feedback. Provides for the use of both 3 and 15 ohm Speakers. The Complete SPECIFICATION and BUILDING INSTRUCTIONS are available for 1/6.
"Wire-to-Wire Diagrams are included and all Components are available separately.

SPECIAL PRICE REDUCTIONS . . . FOR PURCHASERS OF A COMPLETE "Hi-Fi" AMPLIFIER

WE WILL SUPPLY (a) COMPLETE KIT OF PARTS to build THE MULLARD "5-10" MAIN AMPLIFIER and the STERN'S "fidelity" PRE-AMPLIFIER-TONE CONTROL UNIT for £16/16/- or we will supply THE TWO UNITS MADE UP and READY FOR USE for £19/19/-. Terms: Deposit £3/19/6 and 12 monthly payments of 18/7, or £5 Deposit and 9 monthly payments of £1/16/7.

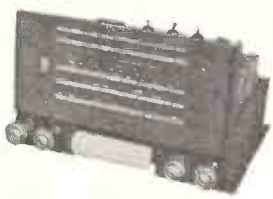
"MODERNISE YOUR OLD RADIOGRAM"

IT IS MUCH CHEAPER THIS WAY!!

THE LATEST DESIGN OF COMBINED AM/FM REPLACEMENT RADIOGRAM CHASSIS and a NEW 4-SPEED RECORD PLAYER

STERN'S NEW "Fidelity" COMBINED AM/FM RADIOGRAM CHASSIS

A genuinely hand-made chassis providing really high quality on both Radio and Gram.



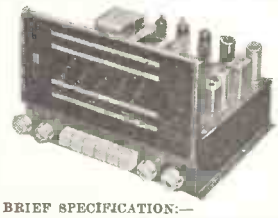
PRICE **£26/15/0** (Plus 7/6 carr. and ins.).

TERMS: Credit Deposit £6/14/- and 9 monthly payments from £2/9/-. H.P. Deposit £13/7/6 and 12 monthly payments of £1/4/10.

BRIEFLY IT HAS:—
An 8 valve line up incorporating the latest MULLARD preferred-type valves. ● Provides complete coverage of the VHF/FM waveband plus the SHORT, MEDIUM and LONG waves. ● Has EL84's in Push-Pull, with negative feedback of 6 watts output. ● Employs "Piano Key" Selector Switch and a Variable Tone Control. ● Contains Gram input socket for both Crystal and Magnetic Pick-ups ● Provides for use of either 3 or 15 ohm Speakers. ● Has "Magic Eye" Tuning Indicator. ● Dimensions 13in. × 9¼in. × 8in. high, Dial size 11¼in. × 5¼in.

THE NEW ARMSTRONG P.B.409 AM/FM RADIOGRAM CHASSIS

A "de luxe" Chassis for those who want the highest possible quality



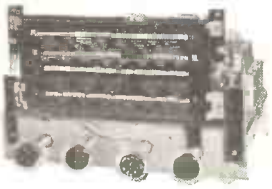
PRICE **£29/8/0** (Plus 7/6 carr. and ins.)

TERMS: Credit Deposit £7/7/- and 9 monthly payments of £2/14/-. H.P Dep. £14/14/- and 12 monthly payments of £1/7/3.

BRIEF SPECIFICATION:—
A 9 valve line up employing the latest MULLARD preferred-type valves. ● Provides complete coverage of the VHF/FM Transmissions, plus the SHORT, MEDIUM and LONG waves. ● Has Push-Pull output, with negative feedback, for 6 watts Peak output. ● Quick action "Piano Key" Selectors and separate Bass and Treble Controls. ● Has "Magic Eye" Tuning Indicator. ● Two Gram Inputs are provided, one for Crystal Pick-ups and the other for Magnetic types. ● Dimensions 13in. × 9¼in. × 8in. high, Dial size 11¼in × 5¼in.

STERN'S 'SUPER SIX'

6 Valve 3 Waveband Superhet



Provides good selection of stations and really good reproduction on both RADIO & GRAM

PRICE ONLY **£14/0/0** (*Plus 7/6 carriage and ins.*)

CREDIT TERMS: Deposit £3/10/- and 9 monthly payments of £1/5/8. H.P. TERMS: Deposit £7 and 10 monthly payments of 16/-.

BRIEF SPECIFICATION
★ Delayed AVC on all wavebands
★ Preselection feedback
★ Modern valve line-up: 12AH8, 6BA6, 6AT6, two 6AQ5 and 5Z4 (or OCTAL VALVE equivalents)
★ Push-pull output gives approx. 6 watts
★ Connections on chassis for extension speaker, gram and mains supply to gram
★ Coverage 18-50 metres, 190-560 and 800-2,000
★ Overall size 11 × 7¾ × 8¼in high, dial 8¼ × 4¼in
★ A bronze dial escutcheon is available for 4/6.

SEND S.A.E. IF FURTHER INFORMATION IS REQUIRED ON THESE CHASSIS.

To complete a GENUINELY HIGH QUALITY RADIOGRAM . . . we recommend THE NEW COLLARO MODEL 456 4-speed Autochanger and if a LOUDSPEAKER is required we recommend THE 8- or 10-inch W.B. STENTORIAN "Hi-Fi" MODELS. We have SPECIALLY REDUCED PRICES for purchasers of a CHASSIS and RECORD PLAYER (and SPEAKER if required). SEND S.A.E. FOR DETAILS.

CASH ONLY OFFER!!

This latest B.S.R. MONARCH 4-SPEED AUTOCHANGER

£7/19/6 (Plus 5/- carr. and ins.).

● These units will autochange on all four speeds, 7in. and 12 in.

● They play MIXED 7in., 10in and 12in. records of same speed.
● They have separate sapphires for L.P. and 78 r.p.m. which are moved into position by a single switch.
● Minimum baseboard size required 14 × 12½in. with height above 5½in., and height below baseboard 2½in. A bulk purchase enables us to offer these BRAND NEW UNITS at this exceptional price.

WE HAVE THE FULL RANGE OF DULCI CHASSIS IN STOCK

THE MODEL H.4 is illustrated but all Chassis and Tuners are similar—send S.A.E. for leaflets. H.P. and CREDIT SALE TERMS are available.

RADIOGRAM CHASSIS

These two Chassis are really well designed and reproduce most excellent quality on both Radio and Gram.
Model H.3—A 3 Waveband AM/FM chassis **£20/17/0**
Model H.4—A 4 Waveband AM/FM chassis **£24/6/6**

TUNER UNIT CHASSIS

The FM/VHF TUNER CHASSIS with self-contained Power Supply. **£17/10/3**

MODEL H4/T—A 4-Waveband AM/FM TUNER with self-contained Power Supply. **£20/17/0**

MODEL H.11—A combined 4-Waveband AM/FM Tuner incorporating a "Hi-Fi" Control Unit—Audio Pre-amplifier which has switching and connections for Tape Replay, Gram equalising, Bass and Treble Controls, etc. **£29/3/10**

"Hi-Fi" AUDIO AMPLIFIERS

MODEL G.A.4—A self-contained 4 watt Amplifier with adjustable Tone Control Box. **£9/9/0**

MODEL D.P.A.LO—A 10 watt Amplifier with separate Tone-Preamplifier Unit incorporating Bass and Treble Controls and Gram. equalising. **£19/19/0**

RECORD PLAYERS

THE VERY LATEST MODELS ARE OFFERED AT GREATLY REDUCED PRICES

Send S.A.E. for ILLUSTRATED and DESCRIPTIVE LEAFLET which also contains details of:—
(a) A PORTABLE CASE to accommodate an Amplifier—Speaker and autochanger. **£3/17/6**
(b) A 2-STAGE GRAM. AMPLIFIER having separate BASS and TREBLE CONTROLS. Suitable for use with all modern Record Players. **£4/0/0**

109-115 FLEET ST., LONDON, E.C.4.
Phone: FLEet Street 5812-3-4.

FOR CALLERS ONLY We have in stock various KITS OF PARTS including F.M. Tuners, AM/FM Tuners, Midget Battery Portable and Mains Units, etc. etc. . . . We also have the most comprehensive stock of WIRELESS and ELECTRICAL COMPONENTS.

CLYNE RADIO LTD.

18, TOTTENHAM COURT ROAD, LONDON, W.1

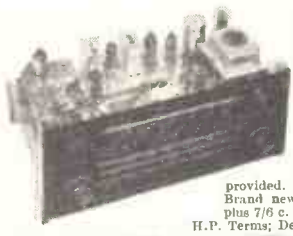
MUSeum 5929/0095
(50 yards only from Tottenham Court Road Tube)
All post orders please to:—24-26, HAMPSTEAD RD., LONDON, N.W.1
EUSton 5533/4/5

TRANSISTORS!!!

SURPLUS——P.N.P.
RED SPOT (Audio/Experimental Applications) ..... 10/- ea.
BLUE SPOT, R.F. up to 1.6 Mc/s. ..... 15/- ea.
WHITE SPOT, R.F. up to 2.5 Mc/s. ..... 20/- ea.

STANDARD — BRIMAR
T.S.I ..... 18/- ea.

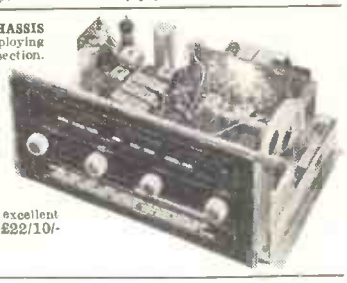
MULLARD
OC70 ..... 21/- ea.
OC71 ..... 24/- ea.
OC72 ..... 30/- ea.
(ALL POST FREE)



RC7, FAM. A most attractive AM/FM chassis employing 9 valves with Push-Pull output. Covers Long, Medium, Short and F.M. wavebands. Valve line-up: 5Y3, 2-6BW6, 12AU7, EABC80, EF89, ECH81, ECC85 and EM81. Built-in Ferrite Rod Aerial for A.M. reception. Controls; 2 dual, Tuning/Wavechange and Volume ON/OFF/Tone. 6-8 watts output. Very attractive easily read dial in BLACK and GOLD. Size (overall) 15in. × 6in. Chassis dimensions; (overall) 15in. × 6in. × 7¼in. Indoor Aerial for F.M. provided. For use on A.C. mains 200/250 v. 50 cycles. Brand new and fully guaranteed. PRICE 26 gns., plus 7/6 c. & p.
H.P. Terms; Deposit £13/13/- and 12 months at £1/3/4.

RC5 FAM. AM/FM CHASSIS. This is a most attractive chassis employing the very latest circuitry and highly efficient miniature valves. Waveband selection is by means of a piano-keyboard type push-button control—separate bass and treble controls are provided also a built-in Ferrite Aerial which automatically comes into operation on all A.M. Bands and is rotatable by means of a knob situated on the front panel. This Chassis is supplied complete with two dermo-dynamic 10in. × 7in. elliptical speakers and one high-frequency tweeter unit (cross-over network is incorporated in Chassis wiring). Valve line-up: ECC85, ECH81, EF89, EABC80, EL84, EM80 and C100 metal rectifier. Overall dimensions: 20¾in. × 8in. × 6¼in. high. For use on A.C. Mains 110/250 v. PRICE: £25, plus 7/6 carr. and pkg. H.P. terms: £12/10/- deposit and 12 monthly payments of £1/2/11.

RC4.FAM AM/FM RADIOGRAM CHASSIS
A new style AM/FM Chassis employing a printed circuit F.M. Tuner section. Valve line-up: 8 valves: ECC85, 6BA6, 12AH8, 6BA6, 6AL5, 6AT6, EL84, 5Y3. Most attractive dial 12×5¼in. fully illuminated, with figures in green, red and white on black background. Four controls: Tuning, Volume, Wavechange and Tone/On/Off. Dimensions (overall): 13×9×6in. Frequency coverage (four wavebands). 1,000-2,000 m., 200-550 m., 15-50 m., 88-100 mc/s. This is an excellent and very efficient chassis. Price £22/10/- plus 5/- P. & P.



SWITCH TUNED FOUR STATION RECEIVER CHASSIS (Manufacturers' Surplus). A most attractive unit covering 4 pre-set stations in the medium waveband. A complete receiver (less cabinet) including built-in good quality 5in. loudspeaker, and frame aerial. Employs Universal Superhet circuit and miniature valves:—UCH42, UAF42, UL41, UY41. Dimensions (overall):—5×9×5in. For use on AC/DC mains 200/250 v. Absolutely brand new. Few only at £5/5/- plus 2/6 P. & P.

SPECIAL PURCHASE ' MANUFACTURER'S SURPLUS

Owing to favourable purchase we can offer strictly limited quantity of these handsome chassis. AC/DC 200/250 v. for Medium and Long Waves, plus gram position. Incorporates own frame aerial. Valve line up: U107, N108, DH107, W107 and X109. Overall chassis size 12 × 5¾ × 7¼in. high. Attractive bronze dial with gold and cream lettering. Dial size 11¼ × 4¼in. Scale length 7¼in. Logging scale provided. Price £7/19/6 only, tax paid, plus 3/6 P. & P. H.P terms. £4 deposit plus four monthly payments of 22/-

DULCI F.3 RADIOGRAM CHASSIS.
Last few of these fine chassis. 3 waveband, 5 valve superhet with built-in ferrite aerial. Brand new, fully guaranteed only, £10/5/- plus 3/6 P & P.

DULCI
All Dulci products available ex stock. Illustrated leaflets and H.P. terms available.
Dulci F.M. Tuner at £16/16/-.
AM/FM Tuner type H4T at £20/17/.
AM/FM Chassis H4 at £24/6/6.
Each plus 5/- p. & p.
Demonstrating at Tottenham Court Road!

TELEVISION TURRET TUNERS 12 CHANNEL—" BRAYHEAD "
We have five types now available from stock, to cover Bands I and III—fully illustrated and descriptive leaflet available on request. Each unit is fully aligned and thoroughly tested before despatch. Valves employed are PCF80, PCC84 for AC/DC and ECF80 and ECC84 for A.C. Price complete £7/7/- 2/6 P. & P. All channels available.

Type	Sound M/Cs	Vision MC/s	Heater
358	38.0	34.5	Series
168	19.5	16.0	Series
16P	19.5	16.0	Parallel
108	10.5	14.0	Series
10P	10.5	14.0	Parallel

We have a large selection of in-built converters for all areas from 92/6; also aerials, low-loss co-axial cable at 10d. per yd. Are you on our mailing list?

JUST RELEASED ! ! !
THE NEW R.C. TRANSISTOR/RECEIVER KIT

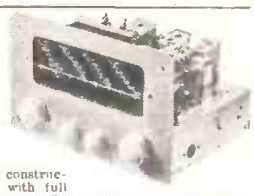
This receiver, covering medium waveband, which can be assembled in about 1 hour, will give amazing volume and tonal quality when used in conjunction with a good aerial and earth. Incorporating PNP Transistor and Germanium Diode. For headphone reception.
Included with the kit of parts is a handsome plastic case in black and white, measuring 4½ ×2¾ × 1¾in. This case accommodates the complete receiver, including battery.
PRICE OF COMPLETE KIT: 25/- plus 1/3 P. & P.
Lightweight high resistance headphones can be supplied separately at 15/- pair. If, however, the kit is purchased complete with headphones this will be supplied at a SPECIAL INCLUSIVE PRICE OF 37/6 plus 1/6 P. & P. Optional extra. 100ft. coil single 7/36 coloured P.V.C. covered wire, suitable for both aerial and earth. 2/6 only.

THE JASON FM TUNER

Based on the booklet by Data Publications Ltd., 2/- post free, including our individually priced Parts List. Highly sensitive, free from drift. Incorporates 4 valves 6AM6 and 2 specially graded G.E.C. Crystals. The kit supplied includes drilled chassis with tuning condenser, scale calibrated in mc/s., and attractive bronze stove-enamelled front plate already mounted (illustrated). Front plate size 8in. × 5in. Chassis 7in. × 4½in. × 1¼in. Complete standard kit £6/15/- plus 2/6 P. & P. Fringe area kit £7/15/- plus P. & P.

FM POWER PACK KIT. We can now supply complete kit for power pack suitable for the above F.M. tuner or any other similar type. Price for the complete kit is 37/6 only or 52/6 for ready assembled unit. This pack is extremely small, incorporating valve rectifier type 6X4 and built on chassis size only 6 × 4 × 1¼in. Optional extra for power pack. Bulgin Octal Plug 2/3.

AM/FM KIT

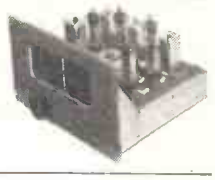


Introducing the JASON AM/FM KIT of medium waves and F.M.!
As illustrated this is a very high quality chassis incorporating 8 of the latest miniature valves, plus DM70 magic eye. Kits are available for chassis complete with output stage at £15/5/-. Also less output stage but with own built-in power pack at £13/19/6 only. These are high fidelity units and exceptional value at these prices which include all required components and full constructional details. Fully Illustrated Data Booklet with full construction details, plus individually priced component list, available per return of post 2/- post free. Both plus 3/6 P. & P.

THE T.S.L. FM TUNER !

We can now supply this FM/VHF adaptor either in kit form or fully assembled, wired and tested. Our price for the ready-built unit, which incorporates its own power supply, is £13/15/- only, tax paid, plus 5/- P. & P. or H.P. terms. Magic eye tuning indicator, 19/- extra. Or the kit complete as specified £10/19/6 plus 3/6 P. & P. The booklet " FM TUNER CONSTRUCTION " (32 pages) with full technical data and point-to-point wiring diagrams, together with our separately priced parts list, is available at 2/6, post free.

ANNOUNCING OUR NEW F.M. TUNER KIT (printed circuit). This is our printed circuit version of the Osram 912 F.M. Tuner—using T.C.C. printed circuit and condensers, incorporating 5 valves and two germanium diodes. Attractive black and gold dial, with gold escutcheon plate. Dial aperture only 5 × 2in. Osram F.M. booklet plus our additional instructions and individually priced components list—2/6 post free or the Kit absolutely complete at £8/8/- plus 2/6 P. & P. Alignment service available if required. We are demonstrating at 18 Tottenham Court Road.



SPEAKERS & ENCLOSURES
Full range in stock by
WHARFEDALE, W.B., T.S.L., etc.
Your enquiries welcomed.

JUST ARRIVED. Further limited stocks of Acos HGP37 crystal pick-up insert complete with sapphire stylii, suitable for B.S.R. Monarch, etc. Brand new, only 18/6 and 9d. P. & P.

VALRADIO T/V TUNER
Limited stocks of this well-known unit available at much reduced price.—An ideal pre-fabricated front end for any superhet T/V receiver with 16 mc/s I.F. Continuously variable tuning covering ALL bands, from 40-100 mc/s and 170-225 mc/s. Valve line-up: PCC84, PCF80 (series heaters). Whilst stocks last only £3/19/6 plus 2/- P. & P.

Our advantageous H.P. terms are available on any single item over £5. Let us have your enquiries.

Please add postage under £1, or Cash with order. C.O.D. charge extra—open 9 a.m. to 6 p.m. Monday to Friday. Sorry but we close 1 p.m. on Saturday.

THE FIRST AND STILL THE BEST !!

THE "SUPERIOR FOUR" KIT Our superior four-valve receiver A.C. mains, 200/250 v. M. and Long waves. As with our very successful "Economy Four" all required components as supplied. Valve line-up: 2 68G7, 6 X5GT and 6 V6GT. Chassis ready drilled. Cabinet size 10½in. × 10in. wide. Maximum depth at base 5in. tapering to 3½in. at top. Sloping front. Very attractively finished in light walnut and peach. Each component brand new and tested prior to packing. Complete instruction booklet with practical and theoretical diagrams is provided. Booklet available at 1/6 post free. Our price for complete kit, £8/9/6. Please add 2/6 P. & C. If preferred, we can supply Cabinet Assembly only, comprising Cabinet and bracket wave-change switch; dial, pointer, drum pulleys drive spindle, drive spring and knobs, at 45/-, plus 2/6 P. & C. N.B.—Our kits are even supplied with sufficient solder for the job.

CONSTRUCTORS NOTE ! !
RADIO DATA BOOKS AVAILABLE, i.e. Valve guide, Colour code, etc. Send stamp for list.

VALVES. We have perhaps the most up-to-date valve stocks in the trade. A stamp will bring complete list of brand new imported valve types, fully guaranteed. P.T. paid. Also all usual surplus types available such as 6V6GT, etc.

THE R.C. RAMBLER ALL-DRY PORTABLE KIT Full assembly details with practical and theoretical diagrams, 1/6 post free. This is a truly professional 4-valve superhet—all dry—for medium and long waves. Cream plastic top panel, with dial engraved in red and green adds to the very imposing appearance of this model which is housed in attractive cream and grey leatherette covered attache-case type cabinet, measuring only 9in. × 7in. × 5½in. Weight less batteries 4½lb., with batteries 6½lb This set really has everything. Built-in frame aerial, high quality, extremely sensitive, and very adequate volume from the 5in. speaker. Valve line-up 3V4, 1R5, 1S5, 1T4. The required components, exactly as specified, including cabinet can be supplied from stock at the special inclusive price of £7/7/- plus 2/6 p. and p. (less batteries). Uses Ever-Ready 90 v. H.T. type B126 at 1/-. Also L.T. 1.5 v. A.D. 35 at 1/6.

RAMBLER MAINS UNIT. For using our popular all-dry "Rambler" on A.C. Mains. Complete kit, when assembled fits snugly into battery compartment, supplied at 47/6 plus 1/6 packing and postage. Includes all required components, and full assembly instructions. **N.B.—This unit is completely self-contained in a metal box measuring 7in. × 2½in. × 1½in and is ideally suitable for ANY all-dry battery portable requiring 90 v. H.T. and 1.5 L.T.**

N.B.—All our T.R.F. Kit circuits include specially wound Denco "Max Q" coils on polystyrene formers, improved performance. Price remains the same.

THE R.C. 2 AMP. BATTERY CHARGER KIT. Includes handsome well-ventilated black stove-enamelled steel box, size: 7½in. × 3½in. × 3½in. Fully shrouded first quality transformer, brand new G.E.C. rectifier. Mains fuse, etc., for charging 6 or 12 v. batteries at 2 amp. Absolutely complete kit with full practical and theoretical instructions. Price 33/6 plus 2/6 P. & P. Can be supplied assembled and tested at 41/6 plus P. & P. Heavy duty crocodile clips suitable for car battery lugs, optional extra at 1/6 per pair.

THE R.E.P. 1-Valve RECEIVER. All dry battery operation, for use with head phones. The complete kit is available at 42/-, less batteries plus 2/- P. & P. or full instructions at 9d. post free.

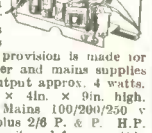
RC2.A. Small Portable Gram Amplifier. This little Amplifier is built around a Printed Circuit and employs the very latest highly efficient valve type ECL82. It is ideal for use where space is limited. Although of such small size 7in. × 5½in. × 2in. (overall) with a control panel 3½in. × 1½in., reproduction is excellent. A wide range tone control is provided. Output approx. 3 watts max. For use on A.C. Mains 200/250 v. NOTE THE PRICE 59/6, plus 2/- P. & P.

RC1.A. AMPLIFIER. A small high quality gramophone amplifier employing the latest circuitry and highly efficient miniature valves. Very neat chassis finished in bronze stove enamel. Size (overall) 5½ × 4 × 5in. Valves, 6X4, ECL82. Output 3 watts max. Controls: Volume, Tone/On/Off. For use on AC mains 200/250 v.

Price £3/19/6 plus 2/- P. & P.

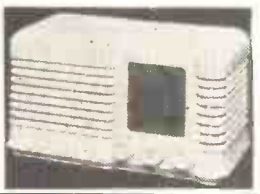
RC3.A. Small 3-Valve Portable Gram Amplifier. An excellent little amplifier for portable gram, giving high quality output. Separate Bass and Treble controls. 2-3 watts output. Valve line-up: EZ80, EL84, ECC83. Provision for mounting 6½in. loudspeaker. Fully isolated from mains 200/250 v. A.C. Overall size: 6½in. L. × 5½in. H. × 2½in. D. PRICE £3/19/6 (less Speaker and Output Transformer), plus 2/6 P. & P.

RC4.A. (STALLION). This is supplied complete with high flux 8in. P.M. Speaker and Baffle. Incorporating three octal type valves 6Q7, 6V6 and 6X5, this robust and well-made unit is ideal for use in the larger type of record player and is equally suitable for use in conjunction with a radio feeder unit. Separate bass and treble controls are provided; also provision is made for an extension speaker and mains supplies to gram. motor. Output approx. 4 watts. Size overall 13in. × 4in. × 9in. high. For use on A.C. Mains 100/200/250 v PRICE £5/19/6, plus 2/6 P. & P. H.P. terms £2/19/6 deposit and four monthly payments of 16/6 per month. Fits our portable cabinet "G" at 85/- without modification.



RECORD PLAYER CABINETS—to suit all types of single record and auto-changer units. Priced from 45/-. Send stamp for fully illustrated list.

THE "ECONOMY FOUR" T.R.F. KIT. A three-valve plus metal rectifier receiver. A.C. mains 200/250 v. Medium and Long waves. We can supply all required components right down to the last nut and bolt. Valve line-up 6K7, 6J7, and 6V6 Chassis ready drilled. Cabinet size 12in long by 6in. high by 5in. deep—Choice of ivory or brown Bakelite, or wooden walnut finish cabinet. Complete instruction booklet with practical and theoretical diagrams. Each component brand new and tested prior to packing. Our price £5/10/- complete—Remember this set is being demonstrated at our shop premises! We proudly claim that our fully illustrated instruction booklet is the most comprehensive available for this type of receiver—Booklet available at 1/6 post free. This is allowed if kit is purchased later. Plus 2/6 packing and carriage for complete kit.



GRAMOPHONE MOTORS are in SHORT SUPPLY!

COLLARO AC 3/554: Three speed, single player for A.C. mains 200/250 v., cream finish, complete with turnover crystal pick-up incorporating the well-known high output "T" type head. Strictly limited quantity at £6/19/6 plus 3/6 p. and p.

FOUR-SPEED CHANGERS
Collaro RC456 Mixer Auto-Changer in cream with Studio "O" insert. £9/15/-. B.S.R. Monarch Mixer Auto-Changer, in cream and gold. £8/15/-. Both plus 3/6 p. and p. H.P. Terms available. Stocks rapidly diminishing.

RECORDER AMPLIFIER
(Well known manufacturer's surplus.) This is a brand new amplifier designed for use with a famous wire recorder. A simple modification is all that is required to make this unit ideal for use with any Tape Deck. Specifications: Valve line-up 7C5, 12AU7, 6BR7, 6BR7, 6X4. Neon Record Level Indicator. Controls; Volume/Record Level, Tone Control, Record/Playback Switch. High and Low level inputs for Mike and Radio. External Speaker Socket. Built-in 5in. Loudspeaker with High Flux magnet. Separate Power Pack. Dimensions; Amplifier 5½in. H. × 11½in. W. × 2½in. D. Power Pack; 6½in. × 6in. × 5in. High (overall). Full modification details are supplied. Price £8/19/6, P. & P. 3/6.

10in. CABINET SPEAKER. Ideal for P.A. etc. Comprises solid wood cabinet complete with carrying handle. Painted dark brown; with built-in good quality 10in. P.M. speaker, 3 ohm speech coil, complete with lead and Igranic Jack plug. Brand new. Price only 45/-. plus 3/6 P. & P.

SURPLUS BARGAINS—METERS

F.S.D.	Size	Type	Fitting	Price
50 microamp	D.C. 4in.	M.C.	Rectangular	110/-
50 microamp	D.C. 3½in.	M.C.	F.R.	95/-
100 microamp	D.C. 2½in.	M.C.	F.R.	45/-
200 microamp	D.C. 3½in.	M.C.	F.R.	65/-
500 microamp	D.C. 2in.	M.C.	F.R.	18/6
1 mA.	D.C. 2in.	M.C.	F.R.	17/6
1 mA.	D.C. 2in.	M.C.	F.Sq.	22/6
1 mA.	D.C. 2in.	M.C.	F. Sq. (1954 by Elliott)	25/-
1 mA.	D.C. 2½in.	M.C.	Desk Type	30/-
50 mA.	D.C. 2in.	M.C.	F. Sq.	8/6
100 mA.	D.C. 2½in.	M.C.	F.R.	10/6
.5 amp.	R.F. 2in.	Thermo	F. Sq.	6/6
1 amp.	R.F. 2½in.	M.C.	F.R.	10/-
120-0-120 amp.	D.C. 2in.	M.C.	F. Sq. (shunt required)	15/-
150 amp.	A.C. 4in.	M.I.	R.P.	45/-
1 amp.	R.F. 2½in.	Thermo	R.P.	7/6
3 amp.	R.F. 2in.	Thermo	F. Sq.	6/-
20 amp.	D.C. 2in.	—	R.P. (with shunt)	10/6
30 amp.	D.C. 2½in.	M.I.	F.R.	12/6
15 volt	A.C. 2½in.	M.I.	F.R.	10/-
15-0-15 volt	D.C. 2½in.	M.C.	F.R.	17/6
300 volt	A.C. 2½in.	M.C.	F.R.	35/-

SPECIAL U.S. 0-1 mA. 2½in. taken from equipment but perfect, 22/6 each. R.P. = Round Projection. M.C. = Moving Coil. Thermo = Thermo-coupled. F. Sq. = Flush Square. F.R. = Flush Round. M.I. = Moving Iron.

METER RECTIFIERS. 1 mA. by G.E.C. at 6/6, also 5 mA. by G.E.C. at 6/6.

THE R.C.3/4 WATT AMPLIFIER KIT. Compare the advantages. Treble, bass AND middle controls. For crystal or magnetic pick-up. A.C. Mains 200/250 v. Valve line-up: 6V6GT, 6SG7 metal 6X5GT. Negative feedback. Built on stove enamelled steel chassis, measuring only 8in. × 4in. × 1½in. Four engraved cream knobs are included in the price of the complete kit with all necessary practical and theoretical diagrams at £4/5/- only, plus 2/6 packing and post or Instruction Book fully illustrated for 1/-. Post free. This amplifier can be supplied assembled, tested, and ready for use at £5/5/- plus P. and P. Hearing is believing.

PRE-SET TUNER UNIT. (Manufacturers surplus). A two valve (TH41. VP41). superhet tuner unit covering two pre-set stations: Light and Home services, for feeding direct into any suitable amplifier. Power requirements: 200 volt at 20 ma. D.C. and 4 v. at 2 amps. Built-in power supplies may be added if required. Dimensions: 9in. × 3½in. × 7½in. overall). Unit only, 45/- plus 2/6 P. & P. All components for built-in power supplies with full modification details available for 20/- extra.

SPECIAL PURCHASE from Ministry
BRAND NEW No. 17 Mk. II TRANSMITTER/RECEIVER

Built into strong wooden cabinet 15in. × 14in. × 9in Complete with headphones and microphone. Range 5-8 miles with simple aerial. Frequency coverage, 44-61 mc/s. (5-7 metres). Uses standard 120 v. H.T., and 2 volt L.T. batteries. Complete with full operating instructions. 59/6, plus 3/6 C. & P. No. 17 Mk. II, as above, but secondhand, in good condition and complete, 45/- plus 3/6 C. & P.

MAINS TRANSFORMER—SPECIAL
Removed from chassis but clean and guaranteed. 200/240 v. input. 350-0-350 at 250 m/a. 6.3V. 3 amps. 6.3V. at .6 amps., 5 at 3 amps. Only 30/- plus 1/6 P. & P.

BEACON TX/RX. (Mint condition.)
Comprising: Transmitter/receiver unit, telescopic antenna, pair lightweight headphones, co-ax. cable, connecting leads, plugs, etc., contained in excellent quality haversack. Supplied complete with valves 6-3A5, 3-1R5, 1-1R5, 2-2v. vibrator packs, also comprehensive illustrated manual. Frequency coverage: 214-234 Mc/s. Size: 13in. × 10in. × 5in. Weight: 28lb. Limited quantity only at 72/6, plus 2/6 C. & P

CLYNE RADIO LTD.
18, Tottenham Court Road, London, W.1

WANTED. ALL TYPES OF COMMUNICATION RECEIVERS, TEST EQUIPMENT AND VALVES. HIGHEST CASH PRICES PAID.

MINIATURE REVERSIBLE MODEL MOTORS

Size only 2in.×¾in. Will operate from 4.5 to 24 volts D.C. Ideal for launches etc., 8/6 each. P.P. 1/-.

6FT. POST OFFICE RACKS. Standard 19in. U channel type, 79/6 each. P.P. 12/6.

CHARGING AND MODEL TRANSFORMERS

1. Pri. 200/250 v. Sec. 3.5, 9 or 17 v. 1 amp., 9/9.
2. Pri. 200/250 v. Sec. 3.5, 9 of 17 v. 2 amp., 14/3
3. Pri. 200/250 v. Sec. 3.5, 9 or 17 v. 4 amp., 16/6
4. Pri. 200/250 v. Sec. 6.3 v. 3 amp., 8 v. 1.5 amp., 9/6.
5. Pri. 200/250 v. Sec. tapped, 3, 4, 5, 6, 8, 10, 12, 15, 18, 20, 24 or 30 v. 2 amp., 18/6. P.P. 1/6 all types.

PANORAMIC ADAPTORS

Brand new and boxed Ex-U.S.A. For use with receivers having an I.F. of 455/475 kc/s., giving a bandwidth of 200 kc/s. 110/230 volt A.C. operation. Price £30 each. P.P. £1.

ELECTROLYTIC CONDENSER BARGAINS

All new stock.

8 m. 450 v. 1/9	30 m. 450 v. 3/3	16×16 m.	
8 m. 500 v. 2/-	40 m. 450 v. 3/9	450 v. ..	3/6
16 m. 450 v. 2/9	8×8 m. 450v.	3/6	16×16 m.
16 m. 500 v. 3/3	8×16 m.	500 v. ..	4/3
32×32 m.	450 v. ..	3/6	32×32 m.
450 v. ..	4/6	50×50 m. ..	350 v. .. 4/3
25 m. 25 v. 1/9	275 v. ..	3/9	100 m. 25 v. 1/3
250×250 m.	50 m. 50 v.	1/9	6000 m. 6 v. 3/6
6 v. ..	2/6	500 m. 12 v.	1/3
1000×2000m.	8×16 m.	6d. P/P. on all	
6 v. ..	3/6	500 v. ..	4/3 types.

ADMIRALTY REFLEX RE-ENTRANT P.A. LOUDSPEAKERS

Twin units. Impedance 3 ohms. Extremely sensitive and directional. Ideal for all outdoor work. Complete with 600 ohm line transformer. Price 32/6 each. P.P. 5/-.

MINIATURE SLOW MOTION DRIVES

Dia. 1¾in. Scale 0-100, for ¼in. spindle. Complete with locking device. Brand new, 7/6. P.P. 1/-. Large type available as above 7/6.

L.T. METAL RECTIFIERS

Full wave and bridged. 12 v. 1 amp., 6/3; 12 v. 2 amp., 9/3; 12 v. 4 amp., 13/9; 24 v. 4 amp., 22/6; 1/- P.P. all types.

METER BARGAINS

0/50μ amp. 2½in. Pj. MC	49/6
0/100μ amp. 2½in. F.M.M.C.	39/6
0/150 M/amps. 2in. F.M.M.C.	6/9
0/200 M/amps. 2½in. F.M.M.C.	9/6
0/1 amp. RF. 2½in. Pj. T.C.	5/-
0/4 amp. R.F. 2in. F.M.T.C.	5/-
0/300 volt A.C. 2½in. F.M.M.I. ...	25/-
0/1.5 amp. A.C./D.C. 2in. F.M.M.I.	6/6
20/0/20 amp. Lucas arc type	8/6
500/0/500μ amp. 2½in. F.M.M.C. ...	25/-

ALL NEW AND UNUSED

2 m/a meter rectifiers S.T.C. 5/6

R.1155 COMMUNICATION RECEIVERS, MODEL L

Latest issue by the Ministry. Similar to the model N, incorporating the trawler band. Frequency coverage, 200-500 kc/s., 600-1,500 kc/s., 1.5.3 mc/s., 3-7.5 mc/s., 7.5-18.5 mc/s. Supplied as new, aerial tested and complete with illustrated descriptive leaflet. Price £12/19/6 each. P.P. 10/-.

R.1155 SUPER SLOW MOTION DRIVES

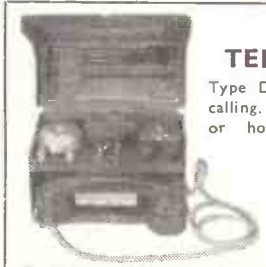
Improved version as fitted to model L and N. Supplied brand new and boxed, 12/6 each. P.P. 1/6.

POWER UNIT TYPE 3

A complete A.C. mains power pack, input 200/250 volts. Output 250 volts D.C. 100 m/a, and 6.3 volts 4 amps. Fitted with H.T. voltmeter and current meter. Fully smoothed, choke and paper condensers. Housed in grey case for 19in. rack mounting. Supplied in brand new condition. 72/6 each. P.P. 7/6.

L.T. TRANSFORMER BARGAIN

Input 200/250 volts. Output 12 volts 5 amps. Brand new 12/6 each. P.P. 2/6.



FIELD TELEPHONES

Type Don Mk. 5. Buzzer calling. Ideal for inter office or house communication. Supplied complete with two 1.5 volt cells, tested and ready to operate. Price only 39/6 each. P.P. 3/-.

RCA AR.88 COMMUNICATION RECEIVERS

Model L.F. Frequency coverage 75-550 kc/s. and 1.5-30 mc/s. on 6 bands. Operation 110/230 volt A.C. Supplied in perfect condition, aerial tested, £45 each. P.P. 30/-.

RCA OUTPUT TRANSFORMERS

Completely potted. Centre tapped primary, 10,000 ohms. Secondary tapped. 3. 7.5, 15, 500 or 600 ohms. Supplied brand new.

MARCONI CRYSTAL CALIBRATORS

Frequency coverage 170/240 mc/s. Directly calibrated, accuracy .001%. Operation 200/250 volts A.C. Supplied complete with 5 mc/s. crystal and spare set of 5 valves in original transit case, brand new with instructions. £4/19/6 each. P.P. 10/-.

TRANSMITTER/RECEIVER No. 19, Mk. II

Equipment comprises 3 separate units built into one chassis and separate power pack.
Specification: "A" set. Transmitter/receiver. Frequency coverage 2-4.5 mc/s. and 4.5-8 mc/s. For R.T., C.W. or M.C.W. Range on R.T. 15 miles, C.W. 50 miles. Superhet receiver, 465 kc/s. I.F., B.F.O., etc. Rx., Valve line-up: 6K7, RF, 6K8 mixer, 2 6K7 I.F., 6B8 det. A.F. phone output. Tx: 6K8 mixer, VFO, EF50 buffer, EB34 ADC. 807 P.A. "B" set. Transmitter/receiver 229/241 mc/s. Local use up to 1 mile. Valve line-up: CV6, 2 6K7 and 6V6. Inter Com. set, 2 valve A.F. amplifier for vehicle crew inter-communication. Valve line-up: 6K7 and 6V6.
A 2½in. meter is built in reading L.T. and H.T. voltages, drive, etc. POWER UNIT. 12 volt D.C. input. Output 275 volts 110 m/a., and 500 volts 50 m/a.
Equipment is of American manufacture and is supplied in good condition. Price, complete with power pack only £5/10/- each. P.P. 15/-. Less power pack, £4/19/6 each.

POWER UNIT 234

A complete A.C. mains power unit in grey metal case for 19in. rack mounting. Input 200/250 volts A.C. Output 250 volts 150 m/a. and 6.3 volts 6 amps Double choke and condenser smoothed. Fitted with 2½in. moving iron meter for measuring A.C. input and D.C. output volts. Price 69/6 each. P.P. 8/6.

VARIAC TRANSFORMERS. Input 220 volts 50 cycles. Output variable from 200-240 volts 7.5 amps. Price 87/6 each. P.P. 5/-.

SOUND POWERED EARPIECES. Can be used as a two-way communication, no batteries required. New, 3/6 each. P.P. 1/-. Inserts only, 1/9. P.P. 6d. Brand new sound powered handsets, 19/6 each. P.P. 1/6.

DYNAMO EXPLODER UNITS

Used for detonating explosive charges. Operation is by hand generator, giving 1,800 volts D.C. across output terminals. Ideal also for use as photo flash generator. Supplied brand new only £3/19/6 each. P.P. 5/-.

HEATER TRANSFORMERS. Brand new. 230 volt input. 6.3 volt output 1.5 amps. 5/9 each. P.P. 1/-.

SURPLUS SPEAKER BARGAINS

All new and unused

Elac 5in. 3 ohm, 17/6; Elac 6½in. 3 ohm, 17/6; Elac 8in. 3 ohm, 19/6; Elac 10in. 3 ohm, 27/6; ROLA 7X4 elliptical 3 ohm, 18/6; Plessey 2½in. 3 ohm, 16/6; Plessey 10X7 elliptical 3 ohm, 27/6; Goodmans 3½in. 3 ohm, 17/6; Std. pentode o/p transformer, 4/6.

SMOOTHING CHOKES

ALL NEW AND UNUSED

G.B. 20h 175 m/a., 10/6; Parmeko 9H. 100 m/a., 7/6; Parmeko 8H, 50 m/a., 5/6; Parmeko C core, 4H. 22.5 m/a., 4/6; Collins 8H. 100 m/a., 8/6; Parmeko swinging choke, 3.6-4.2H. 250 m/a. 20H. no D.C., 10/6; 15H. 60 m/a., 5/6; STC 10H. 60 m/a., 4/6; 20H. 120 m/a., 10/6; 15H. 300 m/a., 10/6; Rich/Bundy 50H. 120 m/a., 15/6.

"C" CORE E.H.T. TRANSFORMER. Input 230 v. Output 3,850 volts 5 m/a. 4 v. 2.5 amps., 4 v. 1 amp. Supplied brand new and boxed, 52/6 each. P.P. 3/-.

H.T. TRANSFORMER BARGAIN. Input 200/250 v. Output 250/0/250 v. 200 m/a. 6.3 v. 4 a. 5 v. 2 a. Brand new, 27/6 each. P.P. 2/6.

G.P.O. BELL UNITS No. 1

Supplied brand new in wooden box, complete with two bells, induction coil and condenser, 7/6 each. P.P. 2/6.

ROTARY CONVERTORS. Input 24 volts D.C. Output 50 volts A.C. 50 watts. Brand new, 29/6 each. P.P. 3/-.

MIDGET RECORDER MOTORS. Size only 2¼in.×1¼in.×¾in. Will operate from 4.5 to 24 volt D.C Fitted with reduction gear. Supplied brand new, 12/6 each. P.P. 1/-.

VALVE BARGAINS

Large stocks held. Few examples:
5V4 8/6, 6AG5 3/6, DK96 9/6, EY51, 10/6, EF86 12/6, 6V6 6/6, DL96 9/6, EF80 9/6, EL84 12/6, 5U4 8/6, 6X5 7/6, PX25 15/6, DF96 9/6, ECF80 12/6, EZ81 10/6, 6H6 1/9, 6SN7 5/11, DAF96 9/6, ECF82 12/6, ECC83 9/-, 6J6 3/6, KT66 12/6. DF91 7/6, ECC84 12/6, ECL80 11/6, 2D21 8/6, VU111 1/9, EF39 5/6, ECH42 10/6, ECH81 10/6, EF37A 10/6.
ALL NEW AND GUARANTEED

G.W. SMITH & CO (RADIO) LIMITED

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RADIO-GRAM CHASSIS

5 VALVE SUPERHET, LATEST B.V.A. MIDGET SERIES VALVES

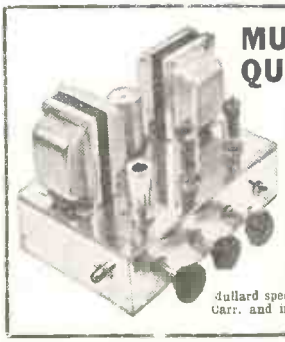
3-WAVEBANDS:—L.W. 800*m*-2000*m*, M.W. 200*m*-550*m*, S.W. 16*m*-50*m*. Chassis size 13½×5½×2½in. Attractive Glass Dial 10×4½in. edge lit by 2 pilot lamps. Horizontal or Vertical Station Names and 4 control knobs, walnut or ivory to choice, 4 position W/C switch, L.M.S. and Gram. P.U. sockets. Modern circuitry, all coils adjustable, dust cored and only quality components used throughout. Delayed A.V.C. and neg. feedback. A.C. mains 200-250 v. Double wound trans. isolates chassis from mains. Aligned and calibrated ready for use.

BRAND NEW & GUARANTEED £9.19.6 Carr. and ins. 4/6

8" and 10" speakers suitable for this chassis available.

7-Valve De Luxe, push-pull version 7 watt output £12.10.0. Carr. & ins. 5/-

MULLARD "3—3" QUALITY AMPLIFIER



An ideal companion unit to the JASON Tuner. A really first-class 3-valve 3-watt Amplifier giving Hi-Fi quality at a reasonable cost. Mullard's latest circuit. Valve line up: EF86, EL84, EZ81. Extra HT and LT available for Tuner Unit addition.

Variable treble cut and bass boost controls, sensitivity 100 MV for 3-watt output. Frequency response + or — 1 db. 40 o/s to 25 kc/s.

Complete amplifier wired and tested with quality sectionalised output transformer to Mullard specification (less speaker) **£8.8.0**

Carr. and ins. 4/6.

ELECTROLYTICS *Leading Makes New Stock*

TUBULAR		CAN TYPES	
25/25 v., 50/12 v.	1/9	8+8/450 v.	4/6
50/50 v. 4/500 v.	2/-	8+16/450 v.	5/-
100/250 v.	1/9	8+16/500 v.	5/6
8/450 v.	2/3	16+16/450 v.	5/6
8/500 v.	2/9	16+16/500 v.	6/-
8+8/500 v.	4/6	16+8/350 v.	5/6
8+16/450 v.	5/-	32+32/275 v.	5/6
16/450 v.	3/6	32+32/350 v.	5/6
16+16/450 v.	5/6	50+50/350 v.	4/8
32/350 v.	4/-	80/350 v.	6/6
32/500 v.	5/-	60+250/275 v.	12/6
32+32/350 v.	5/6	64+120/275 v.	11/6
32+32/450 v.	6/6	100+200/275 v.	12/6
		32+32/450 v.	6/6
		100/270 v.	6/6

CONDENSERS.—Mica, Silver Mica. All pref. values, 3 pf. to 1,000. 6d. each. Ditto ceramics 9d. each. Tubulars, 450 v. Hunts and T.C.C. .001 mfd.-.01 and .1/350 v., 9d. each. .02-1/500 v., 1/- each .25 Hunts, 1/6. .5 Hunts, 1/9.

80 ohm CABLE CO-AXIAL

SPECIAL.—Semi-air spaced polythene standard ¼in. diam. Stranded core. Feeder losses cut 50%, 9d. yard.
Standard ¼in. Grade A, 8d. yard.
COAX PLUGS 1/2. SOCKETS 1/-.
COUPLERS 1/3. OUTLET BOXES 4/6.
BALANCED TWIN FEEDER per yd., 6d.
Special 300 ohm. TWIN FEEDER 8d.
TWIN SCREENED FEEDER per yd., 1/3.
50 OHM COAX CABLE 8d. per yd., ¼in.
ATTENUATORS 6db, 12do, etc., from 4/6. Band 1-3 Cross-over filter unit from 7/6.

SPEAKER FRET.—Expanded Bronze anodised metal 8×8in., 2/3; 12×8in., 3/-; 12×12in., 4/3; 12×16in., 6/-; 24×12in., 8/6, etc.
TYGAN FRET (Murphy pattern) 12in.×12in., 2/-; 12×18in., 3/-; 12×24in. 4/-, etc.

JASON F.M. TUNER UNIT 87-105 m/cs

Kit of parts to build this modern and highly successful unit complete with drilled chassis and J.B. dial, wound coils and screening cans. 4BVA miniature valves and all necessary quality components, etc., for only £6/10/- post free. Superior dial calibrated mc/s. edge lit by 2 pilot lamps, 12/6 extra, as illustrated. Power Pack components kit including double wound mains transformer, £2/5/- extra.
Tested and approved by "Radio Constructor," etc. Illustrated handbook with full details, 2/-, post free.

RESISTORS

Carbon type. Pref. values 10 ohms-10 megohm, 20% Tol. ½ w. 3d.; ¼ w. 5d.; 1 w. 6d.; 2 w. 9d.; 10% Tol. ½ w. 9d.; 5% Tol. ½ w. 1/-; 1% Hi-stab. ½ w. 2/-.

WIRE WOUND TYPES

Wire ends. Silicone coated. 25 ohms-10,000 ohms, 5 w., 1/3. 10 w., 1/6. 15 w. 2/-.
LINE CORD .3a. 60 ohms per ft., .2a. 100 ohms per ft., 2 way 6d. per ft., 3 way 7d. per ft.

LOUDSPEAKERS

P.M. 3 OHM. 5in. Celes., 17/6; 6in. Celes., 18/6; 7×4in. Goodmans Elliptical 18/6; 8in. Elac, 20/-; 10in. R. and A. 25/-; 12in. Plessey, 35/-; 2½in. Plessey, 16/6; Goodmans 12in. Audiom 50, 15 ohms, £4/15/-.

S.T.C. RECTIFIERS

E.H.T. types. K3/25 2 kV., 5/-; K3/40 3.2 kV., 6/9; K3/45 3.6 kV., 7/3; K3/50 4 kV., 7/9; K3/100 8 kV., 12/9; etc. Mains types. RM1 125 v. 60 mA., 4/6; RM2 125 v. 100 mA., 4/9; RM3 125 v. 120 mA., 6/9; RM4 250 v. 250 mA., 16/-. RM4B type 250 v. 275 mA., 17/6. LT types F/W bridge 6-12 v. 1½ a., 8/9; 3 a., 15/6; 4 a., 18/6; 6 a. 24/6 each.

PRE-SET W/W POTS

T.V. knurled slotted knob type. 25 ohms to 30,000 ohms, 3/-; 50,000 ohms, 4/-; 50,000 ohms to 2 Meghohms (carbon), 3/-.

VOLUME CONTROLS

Midget log type, long spindles, all values 10,000 ohms to 2 Megohms. Less sw., 3/-; S.P. sw., 4/-; D.P. sq., 4/9. Linear types all values 10,000 ohms to 2 Megohms, less switch 4/-. Guaranteed 12 months.

TRS RADIO COMPONENT SPECIALISTS

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70 BRIGSTOCK RD., THORNTON HEATH, SURREY

Phone: THO 2188. Hours 9 a.m.—6 p.m., 1 p.m. Wed. Open all day Saturday. By THORNTON HEATH STATION. Buses 130A, 133, 166, 169, 190.

Terms: C.W.O. or C.O.D. Kindly make cheques, P.O.s, etc., payable to T.R.S. Post and Packing up to ¼lb 7d., 1lb. 1/1, 3lb. 1/6, 5lb. 2/-, 10lb. 2/9. Bargain Lists 3½.

CHAS. H. YOUNG, LTD.

SPECIAL OFFER

D.104 CRYSTAL HAND MIKES

List £6. Complete with 6ft. of cord and plug.
VERY LIMITED QUANTITY AVAILABLE
ONLY **£3.10.0** each *DON'T BE TOO LATE*

AMERICAN 807 VALVES. New, boxed, 7/6 each; 4 for 25/-.
ELECTRON MULTIPLIERS. Type 931A. Only 50/- each, or 2 for £4/10/-. Holders available at 2/- each.
3IN. AERIAL INSULATORS. Ribbed glass. 1/6 each or 6 for 7/6. 12 or more post free.
CONDENSERS. TCC type III, 8 mfd. 1,000 v. List over £3. Only 10/6. Post 1/9. 8 mfd. 750 v. 5/6 each. Post 1/6.
COPPER AERIAL WIRE. 14 g. H/D 140ft. 17/-. 70ft. 8/6. P. & P. 2/-. Stranded 7/25, 140ft. 10/-. 70ft. 5/-. P. & P. 2/-.
RACK MOUNTING PANELS, all 19in. long by 5¼in., 7in., 8¾in., or 10½in., 5/9, 6/6, 7/6, 9/- respectively. Post 2/-.
ABSORPTION WAVEMETERS. 3 to 35 mc/s. in 3 switched bands, complete with indicator bulb. 17/6. Post free.
TRANSMITTER TUNING CONDS., by Johnson, U.S.A., 500 pf. 1,550 v. rating, ceramic insulation. 15/- each. Post free.
HEADPHONES. High resistance (4,000 ohms), very sensitive. Bargain price only 12/6 pair. P. & P. 1/6.
AMERICAN BREAST MIKES. Swivel head. Push to talk and lock on switch. Beautiful job. Only 12/6. P. & P. 1/6.
BRITISH BREAST MIKE UNIT, complete with pair of 4,000-ohm phones in strong wooden carrying case, 8¼ × 4½ × 7½. Ideal for mobile operators. Only 17/6. P. & P. 2/-.
LOW RESISTANCE HEADPHONES. New ex-W.D. stock. C.L.R. types. Only 8/6 pair. P. & P. 1/6. Special Terms Quantities.

Most comprehensive stock of HiFi equipment in the Midlands, including QUAD, LEAK, W.B., RCA, ROGERS, WHARFEDALE, GOODMANS, etc. Details and demonstrations with pleasure.

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1A68

C.R.T. ISOLATION TRANSFORMERS

For Cathode Ray Tubes having Heater/Cathode short circuit for C.R. Tubes with falling emission.
Type A. Low leakage windings. Ratio 1:1.25 giving a 25% boost on Secondary.

2 volt	10/6 each	
4 volt	10/6 each	with Tag
6.3 volt	10/6 each	Panel and
10.8 volt	10/6 each	Solder Tags
13.3 volt	10/6 each	
Ditto with mains primaries	12/6 each	

Type B. Mains input 220/240 volts. Low Capacity. Multi Output 2, 4, 6.3, 7.3, 10 and 13 volts. Input has two taps which increase output volts by 25% and 50% respectively. This transformer is suitable for all Cathode Ray Tubes. With Tag Panel 21/- each.
Type C. Low capacity wound transformer for use with 2 volt Tubes with falling emission. Input 220/240 volts. Output 2-2½-2½-2½-3 volts at 2 amps. With Tag Panel 17/6 each.
All Isolation Transformers are individually boxed, labelled and clearly marked with relevant data.
NOTE:—It is essential to use mains primary types with T.V. receivers having series connected heaters.

RESISTORS. All values. 10 ohms to 10 meg., ¼ w. 4d.; ½ w., 6d.; 1 w., 8d.; 2 w., 1/-.
HIGH STABILITY. ½ w. 1%, 2/-. All preferred values 100 ohms to 10 meg.
WIRE-WOUND RESISTORS: 5 watt, 10 watt, 15 watt } 25 ohms—10,000 ohms 1/3, 1/6, 2/-
15,000 ohms—50,000 ohms, 5 w., 1/9; 10 w. 2/3
WIRE-WOUND POTS. 3 WATT LAB. COLVERN, ETC.
Pre-set Min. T.V. Type Knurled Slotted Knob. All values 25 ohms to 30 K., 3/- ea. 50 K., 4/-. Ditto Carbon Track 50 K. to 2 Meg., 3/-.
Standard size Pots., 2½in. Spindle High Grade. All Values, 100 ohms to 50 K., 5/6; 100 K., 6/6. W/W EXT. SPEAKER CONTROL 10Ω, 3/-.
O/P TRANSFORMERS. Heavy Duty 50 mA., 4/6. Multi-ratio push-pull, 6/6. Tapped small pentode, 3/9. Hygrade Push-Pull 7 watts, 15/6.
L.F. CHOKES 15/10 H. 60/65 mA., 5/-; 25/20 H. 100/120 mA., 11/6; 20/15 H., 120/150 mA., 12/6; 5 H. 250 mA., 15/-.
MAINS TRANS. 350-0-350, 80 mA., 6.3 v. tapped 4 v. 4 a. 5 v. tapped 4 v. 2 a., ditto 250-0-250 80 mA., etc., 21/-. Bargain 300-0-300 v. 65 mA., 6 v. 4 a., 4 v. 2 a., 15/-.

I.F. TRANSFORMERS 7/6 pair

465 Kc/s Slug tuning Miniature Can 2½ × 1 × 1in. High Q and good band width. By Pye Radio. Data sheet supplied.
Wearite M800 IF Transformers 465 Kc/s, 12/6 pair.

HEATER TRANS. Tapped 200/250 v. 6.3 v. 1½ amp., 7/6.
ALADDIN FORMERS and cores. ¼in., 8d.; ½in., 10d. .3in. FORMERS 5937/8 and Cans TV1/2. ¼in. sq. × 2¾in. and ½in. sq. × 1¾in., 2/- complete with cores.
SLOW MOTION DRIVES. Epicyclic ratio 6 : 1, 2/3.
TYANA. Midget Soldering Iron. 200/220 v. or 230/250 v., 16/9. SOLON MIDGET IRON. 25 w., 24/-.
MAINS DROPPERS. 3 × 1½in. Three Adj. Sliders, .3 amp. 750 ohms, 4/3. .2 amp., 1,000 ohms, 4/3.
LINE CORD. .3 amp., 60 ohms, per foot, .2 amp., 100 ohms, per foot, 2 way, 6d. per foot, 3 way, 7d. per foot.

CRYSTAL MIKE INSERT by Acos

Precision engineered. Size only 1⅛ × 3/16in. Bargain. Price 6/6. No transformer required.

MIKE TRANSF. Ratio 50 : 1, 3/9 ea.; 190 : 1, 10/6.
LOUDSPEAKERS P.M. 3 OHM. 2½in. square 17/6
5in. R.A. 17/6 7in. × 4in. Goodmans 21/-
3½in. Square Elac, 21/- 8in. Elac, 22/6
6½in. Goodmans, 18/6 10in. R.A. 30/-
TEL TWEETER LSH75, 8/6 12in. Plessey 30/-
8in. M.E. 2.5 k. field tapped O.P. transformer, 24/6
CRYSTAL DIODE. G.E.C., 2/-. GEX34, 4/-. 40 Circuits, 3/-.
CRYSTAL SET CONSTRUCTION. Kit 12/6. Book 1/-.
H.R. HEADPHONES. 4,000 ohms, brand new. 16/6 pair.
SWITCH CLEANER Fluid, squirt spout, 4/3 tin.
TWIN GANG CONDENSERS. 365 pf. Miniature, 1in. × 1½in. × 1½in., 10/-. .0005 Standard with trimmers, 9/-; less trimmers, 8/-. Midget, 7/6; 3-gang 500 pf., 7/6.

SUPERHET COIL PACK 27/6

Miniature size 2½ × 2½ × 1½in. High Q dust cored coils. SHORT, MED., LONG. GRAM switching with connection diagram and circuit. 475 Kc/s I.F.

VALVE HOLDERS. Pax int. Oct., 4d. EF50, EA50, 6d. B12A, CRT, 1/3. Eng. and Amer. 4, 5, 6, 7 and 9 pin. 1/-.
MOULDED Mazda and Int. Oct., 6d.; B7G, B8A, B8G, B9A, 9d. B7G with can, 1/6, VCR97, 2/6. B9A with can, 2/6.
CERAMIC, EF50, B7G, Int. Oct., 1/-. B7G with can, 1/9.
SPEAKER FRET. Gold Cloth 18in. × 25in., 5/-. 25in. × 36in., 10/-. Expanded metal, Silver 15½ × 9½in., 2/- each. 14½in. × 12in., 3/- each.
Tygan 4ft. 6in. wide, 10/- ft.; 2ft. 3in. wide, 5/- ft.
WAVECHANGE SWITCHES.
2 p. 2-way 3 p. 2-way, short spindle 2/6
5 p. 4-way 2 wafer, long spindle 6/6
2 p. 6-way, 4 p. 2-way, 4 p. 3-way, long spindle 3/6
3 p. 4-way, 1 p., 12-way, long spindle 3/6
Wave change "MAKITS," 1 wafer 8/6; 2 wafer 12/6; 3 wafer 16/-; 4 wafer 19/6; 5 wafer 23/-; 6 wafer 26/6.
TOGGLE SWITCHES. S.P., 2/-; D.P. 3/6; D.P.D.T. 4/-.
NUTS, BOLTS. 12 of each, 2, 4, 6, or 8 B.A. ..... 1/-.

KNOBS GOLD ENGRAVED. Walnut or Ivory. 1¼in. diam., 1/6 each. "Focus," "Contrast," "Brilliance," "Brilliance—On/Off," "On-Off," "Volume," "Volt-On-Off," "Tone," "Tuning," "Treble," "Bass," "Wavechange," "Radio Gram," "S.M.L. Gram," "Record-Play," "Brightness," ditto, not engraved, 1/-.

1957 RADIOGRAM CHASSIS

THREE WAVEBANDS — FIVE VALVES
S.W. 16 m.—50 m. — LATEST MULLARD
M.W. 200 m.—550 m. — ECH42, EF41, EBC41,
L.W. 800 m.—2,000 m. — EL41, ELZ40
12 month Guarantee. A.C. 200/250 v., 4-way switch. Short-Medium-Long-Gram. A.V.C. and Negative feedback. 4.2 watts. Chassis 13½in. × 5½in. × 2½in. Glass Dial 10 × 4½in. horizontal or vertical available. 2 Pilot Lamps. Four Knobs, Walnut or Ivory, aligned and calibrated. Chassis isolated from mains.

BRAND NEW £10.10.0 Carr. 4/6.
TERMS: Deposit £5/5/- and 6 monthly payments of £1.
MATCHED SPEAKERS FOR ABOVE CHASSIS: 8in., 19/6; 10in., 25/-; 12in., 30/-.

RECOMMENDED FOR ABOVE CHASSIS

★ R.C.S. SCOOP ★
HIGH FIDELITY AUTOCHANGER
1957 MODEL RC456
For 7", 10", 12" Records 16, 33, 45, 78 r.p.m.
4 SPEEDS — 10 RECORDS
WITH STUDIO "O" PICK-UP
BRAND NEW IN MAKER'S BOXES
OUR PRICE £9.15.0 Post free.
TERMS: Deposit £5/5/- and 6 monthly payments of £1.

B.S.R. MONARCH 4-SPEED AUTOMATIC RECORD CHANGERS
1957 MODELS
Brand new and fully guaranteed 12 months.
NOT JOB LINE REJECT STOCK
Designed to play 13, 33, 45, 78 r.p.m. Records 7in., 10in., 12in. Lightweight Xtal pick-up, turnover head, two separate sapphire styli, for Standard and L.P. Each plays 2,000 records. Voltage 200/250 A.C.
OUR PRICE £8.15.0 each. Post free.
Terms: Deposit £5 and 5 monthly payments of £1. Space required 14in. × 12½in. 5in. above and 3in. below.

GARRARD. 4-speed Single Record Player with GC2 Turnover Head for 78 r.p.m. and L.P. Space required 14in. × 12½in., 2¾in. above 2 1/16in. below Model 4 SP —BARGAIN £8.

B.S.R. MONARCH. 3-speed Motor and Turntable with selecting switch for 33, 45 and 78 r.p.m. records. 100-120 v. and 200-250 v. A.C. 50 c.p.s. Also B.S.R. MONARCH Lightweight Pick-up with Acos Xtal turnover head, separate Sapphire stylus for L.P. and standard records. SPECIAL OFFER, THE TWO £4/12/6, post 2/6. 14 × 12½in. Cut Out board 6/-.

AMPLIFIER PORTABLE RECORD PLAYER CABINETS. Size 18½in. × 13½in. × Ht. 8¼in., with motor board 14in. × 12½in., £3/3/-.

4-WATT GRAM. AMPLIFIER. For 200-250 v. 50 c.p.s. A.C. mains. Chassis fully isolated. Fitted vol. (with mains switch) and Tone Control. Designed for use with any kind of single player or record changing unit. With 6½in. loudspeaker and output transformer. Fits our portable cabinet without modification. Post 3/-. **£4-15-0**

GARRARD RC 80m 3 speed Autochange Universal AC-DC 100-250 volts. List price £27/10/-.
OUR PRICE **£15.15.0** carr. & ins. 5/-.

Teletron Band III Converter
London, Midland and Northern for all T.V. Makes. T.R.F. or Superhet
Ready wound coils, two EF80 valves, all components, punched chassis, wiring plans. COMPLETE KIT mains operation. 200-250 V. A.C. £3/10/-.
AS ABOVE less POWER PACK. Requires 200 v 20 mA. H.T. 6.3 v. 0.6 a. L.T. £2/5/-.

THE TELETRON "COMPANION"
Size 4in. × 3in. × 1in. A three-transistor pocket receiver. Two waveband—medium and long. Permeability tuning for sensitivity. Ferrite aerial, internal speaker. Designer specified kit. £4/10/-. Plans only, 6d. Teletron Coil, FX25, 15/-; Teletron Cabinet, 8/6; Ardente transformers D240, D239, 10/- each. R.F. Transistors, 21/-; Audio 10/- each.

Volume Controls
Midget size
Long spindles. Guaranteed 1 year. All values 10,000 ohms to 2 Meg. No. Sw. S.P.Sw. D.P.Sw.
3/- 4/- 4/9
Lin or Log Tracks

80 ohm CABLE Coaxial
Semi-air spaced Polythene insulated ¼in. dia. Stranded core. Ideal Band III. 9d. yd. Losses cut 50%.
STANDARD QUALITY
¼in. Coaxial ..... 8d. yd.

COAXIAL PLUGS 1/- — DOUBLE SOCKET 1/3
SOCKETS 1/- — OUTLET BOXES 4/6
BALANCED TWIN FEEDER per yd., 6d. 80Ω or 300Ω.
TWIN SCREENED BALANCED FEEDER 1/- yd., 80 ohms.
TRIMMERS, Ceramic, 30, 50, 70 pf., 9d. 100 pf., 150 pf., 1/3. 250 pf., 1/6. 600 pf., 750 pf., 1/9. Philips 1/- ea.

ALUMINIUM CHASSIS. 18 s.w.g. Plan, undrilled, with 4 sides, riveted corners and lattice fixing holes, with 2½in. sides. 7 × 4in., 4/6; 9 × 6in., 5/9; 11 × 7in., 6/9; 13 × 9in., 8/6; 14 × 11in., 10/6; 15 × 14in., 12/6; and 18 × 16 × 3in., 16/6.

BLACK CRACKLE PAINT. Air drying, 3/- tin.
P.V.C. CONN. WIRE, 10 colours, single or stranded, 2d. yd.
5in. RADIO SCREWDRIVERS, 6d. each.
NEON MAINS TESTER SCREWDRIVERS, 5/6.
MULTICORE SOLDER 60/40, 18 s.w.g., 3d., 16 s.w.g., 4d. yd.

12/6 PURETONE RECORDING TAPE
1,200 ft. on standard fitting 7" Plastic reels. Brand new, boxed, 12/6.
Spools 5" metal, 1/6, 7" plastic, 4/3.
FERROVOICE 1,200ft. Plastic Tape 25/-

SENTERCEL RECTIFIERS. E.H.T. TYPE FLY-BACK. VOLTAGES. K3/25 2 kV., 5/-; K3/40 3.2 kV., 7/-; K3/45, 3.6 kV., 7/6; K3/50 v. 4 kV., 8/-; K3/100 8 Kv., 14/6. MAINS TYPE, RM1, 125 v.; 60 mA., 5/-; RM2, 100 mA., 6/-; RM3, 120 mA., 8/-; RM4, 250 v. 275 mA., 16/-.
MINIATURE CONTACT COOLED RECTIFIERS. 250 v. 50 ma., 8/6; 250 v. 85 ma., 9/6.
COILS. Wearite "P" type, 3/- each. Osmor Midget "Q" type adj. dust core, 4/- each. All ranges.
TELETRON. L. & Med. T.R.F., with reaction, 3/6.
FERRITE ROD AERIALS. M.W., 8/9; M. & L., 12/6.
T.R.F. COILS A/HF, 7/- pair. H.F. CHOKES, 2/6.

JASON F.M. TUNER COIL SET. 26/-. H.F. coil, aerial coil, Oscillator coil, two I.F. Transformers 10.7 Mc/s., Detector transformer and heater choke. Circuit and component book using four 6AM6, 2/-. J.B. Chassis and Dial, 19/6. Complete Kit, £5/18/6. With Jason superior calibrated dial, £6/15/-.

CONDENSERS. New stock. .001 mfd. 7 kV. T.C.C., 5/6. Ditto 20 kV., 9/6; 100 pf. to 500 pf. Micas. 6d.; Tubular 500 v. .001 to .01 mfd., 9d.; .05, .1, 1/-; .25, 1/6; .5, 1/9; .1/350 v., 9d.; 0.1 mfd. 2,000 v.; 1 mfd., 2,000 v., 4/-.
CERAMIC CONDS. 500 v., 3 pf. to .01 mfd., 10d.
SILVER MICA CONDENSERS. 10% 5 pf. to 500 pf., 1/-; 600 pf. to 3,000 pf., 1/3. DITTO 1% 1.5 pf. to 500 pf. 1/9; 515 pf. to 5,000 pf., 2/-.

NEW ELECTROLYTICS. FAMOUS MAKES.

TUBULAR		TUBULAR		CAN TYPES	
1/350 v.	2/-	100/25 v.	3/-	8+16/450 v.	5/-
2/450 v.	2/3	8+8/500 v.	4/6	16+16/500 v.	6/-
4/450 v.	2/-	16+16/500 v.	6/-	6,000 mfd. 6 v.	6/6
8/450 v.	2/3	CAN TYPES		32+32/350 v.	4/6
8/500 v.	2/9	Clips	3d.	32+32/450 v.	6/6
16/450 v.	3/6	16/450 v.	3/6	64+120/275 v.	7/6
16/500 v.	4/-	32/350 v.	4/-	60+100/350 v.	11/6
32/450 v.	5/6	64/350 v.	5/6	100+200/257 v.	
25/25 v.	1/9	100/275 v.	5/6		12/6
50/25 v.	1/9	50+50/350 v.	7/-	1,000+1,000/6 v.	
50/50 v.	2/-	500/12 v.	3/-		6/6

FULL WAVE BRIDGE SELENIUM RECTIFIERS. 2, 6 or 12 v. 1½ amp., 8/9; 2 a., 11/3; 4 a., 17/6.
CHARGER TRANSFORMERS. Tapped input 200/250 v for charging at 2, 6 or 12 v. 1½ amp. 13/6; 4 amp., 21/-

VALVES

	All Boxed				New & Guaranteed
1R5	8/6	6K8	8/6	EABC80	8/6 EZ81 11/6
1S5	8/6	6L6	10/6	EB91	6/6 KT41 1/6
1T4	8/6	6Q7	10/6	EBC33	8/6 HABC80 12/6
3S4	8/6	6SA7	7/6	EBC41	10/6 HVR2A 7/6
3V4	8/6	6SN7	8/6	EBF80	8/6 MU14 10/6
5U4	8/6	6V6G	7/6	ECC84	12/6 PCC84 12/6
5Y3	8/6	6V6GT	8/6	ECF80	10/6 PCF80 10/6
5Z4	10/6	6X4	7/6	ECF82	10/6 PCF82 10/6
6AM6	8/6	6X5	7/6	ECH42	10/6 PCL82 10/6
6B8	5/6	787	8/6	ECL80	8/6 PL81 11/6
6BE6	7/6	12A6	7/6	ECL82	12/6 PL82 10/6
6BH6	10/6	12AH8	10/6	EF39	7/6 PY80 10/6
6BW6	8/6	12AT7	10/6	EF41	10/6 PY81 10/6
6BW7	8/6	12AU7	10/6	EF50	5/6 PY82 10/6
6CH6	10/6	12AX7	10/6	Equip	8P61 5/6
6D6	7/6	12BE6	10/6	EF50	8/6 UBC41 8/6
6F6	7/6	12BH7	10/6	Sylv.	UCH42 8/6
6H6	3/6	12K7	8/6	EF80	10/6 UF41 8/6
6J5	6/6	12Q7	8/6	EF92	5/6 UL41 8/6
6J6	7/6	3524	10/6	EL32	5/6 UY41 8/6
6J7	8/6	80	8/6	EL84	10/6 U22 10/6
6K6	6/6	954	1/6	EY51	11/6 U25 11/6
6K7	5/6	EA50	1/6	EZ40	10/6 X79 10/6

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Rate 7/- for 2 lines or less and 3/6 for every additional line or part thereof, average lines 6 words. Box Numbers 2 words plus 1/-. (Address replies: Box 0000 c/o "Wireless World" Dorset House, Stamford St., London, S.E.1.) Trade discount details available on application. Press Day September 1957 issue, Wednesday July 31st. No responsibility accepted for errors.

WARNING

Readers are warned that Government surplus components and valves which may be offered for sale through our displayed or classified columns carry no manufacturers' guarantee: Many of these items will have been designed for special purposes making them unsuitable for civilian use, or may have deteriorated as a result of the conditions under which they have been stored. We cannot undertake to deal with any complaints regarding any such items purchased.

NEW RECEIVERS AND AMPLIFIERS

SHIRLEY LABORATORIES, Ltd., 3, Prospect Place, Worthing, Sussex. Tel. 30536
THE TWA/1515 stereosonic tape recording and replay amplifier, separate meter monitoring on record and playback on both channels, 15watts O/P each channel, 96gns; TWA/15 tape recording and reproducing amplifier, 13watts O/P, for Wearite and Collaro decks, 45gns; TW/PA recording and replay pre-amplifier, 30gns; both with valve voltmeter monitoring; type SB/1-15E high-fidelity amplifier, exceptionally wide tone-control system, 40mv sensitivity, 20gns; with two inputs and 3-position gram filter, 22gns; specialized amplifiers for the musical and scientific industries including the Mullard 20watt. [0095

RECEIVERS AND AMPLIFIERS—SURPLUS AND SECONDHAND

HRO Rx's and coils in stock, also AR88, BC348R, CR100, etc.—Requirements please to R. T. & I. Service, 254, Grove Green Rd., London, E.11. Ley. 4986 [0053

UNUSED amplifier Pye Hi Fi PF91 with control unit, list 40gns, two only, 25gns, less control unit, list 20gns; Cantata Hi Fi Pye Corner speaker, list 35gns, one only, 20gns.—S.E.S., Ltd., 429, Staniforth Rd., Sheffield, 9. [7154

TWO large output cinema amplifiers, never been used but deteriorated through storage; these are high quality, high output amplifiers designed for cinema use; one by pamphonic; £50 each; also four loudspeakers for above.—Tel. Gladstone 6373 between 9 a.m. and 5.30 p.m. [7183

R.109A receivers, covers 2 to 12m/cs in two bands, fully mobile; built in 3½in P.M. speakers and 6-volt vibrator power pack; these sets are brand new and include full circuit diagram, but are not fitted with valves or vibrator (1.SP61, 3.AR8 and 4.ARP 12 used); cost many pounds to manufacture; our special price 35/- and 7/6 part cost of carriage and packing.—Walton's Wireless Stores, 46, 47 & 48, Stafford St., Wolverhampton. [0146

RECEIVERS AND AMPLIFIERS WANTED

AEROMAGIC receiver, 1935/36 vintage, urgently required; cash available; also servicing manual.—Box 8437. [7088

DYNAMOS, MOTORS, ETC.—SURPLUS AND SECONDHAND

LARGE Bridge connected rectifier units, H.D. charging cut-outs, H.D starter relays & starter pushes complete vaporiser equipment for Villiers Mark 10, 20 & 25 petrol engines, to run on paraffin, ex stock
T.W. PEARCE, 66, Great Percy St., W.C.1.

TEST EQUIPMENT—SURPLUS AND SECONDHAND

SIGNAL generators, oscilloscopes, output meters, valve voltmeters, frequency meters, multi-range meters in stock; your enquiries are invited.—Requirements to R. T. & I. Service, 254, Grove Green Rd., London, E.11. Ley. 4986.

NEW COMPONENTS

TRANSISTORS, Audio 10/- R.F. (2.8Mcs), 21/-; interstage P.P. transformer, 8/-; output trans., 7/6; full range of components; list.—Osmabet, Ltd., 14, Hillside Rd., Tottenham, London, N.15. [0020

CRYSTAL microphone inserts (Cosmocord Mic 6/4), in steady demand by hams and sound engineers, guaranteed newly made and boxed; 15/6, post free.—Radio-Aids, Ltd., 29, Market St., Watford, Herts. [0170

COMPONENTS—SURPLUS AND SECOND-HAND

SOUTHERN RADIO SUPPLY, Ltd., 11, Little Newport St., London, W.C.2. See our displayed advertisement page 155.

ILLUSTRATED Catalogue No. 13 containing over 450 items of Government surplus and model radio control equipment, 2/2, refunded on purchase of goods, 2/6 overseas sea mail.—Arthur Sallis Radio Control, Ltd., Department W.W., 93 North Rd., Brighton. [0193

COMPONENTS—SURPLUS AND SECONDHAND

RADIO CLEARANCE, Ltd., 27, Tottenham Court Rd., London, W.1. Tel. Museum 9188.
MAINS transformers, pri. 110v, 200-240v, sec. 300-0-300v, 4v 2amp, 6.3v 2.5amp, 11/-; 2-gang condenser, .0005 var. size, 2¼in×2in×1⅝in. ⅜in spindle, 4/-. P.M. focus rings.
WIDE-ANGLE tetrode tube, fully adjustable, 7/6; T.V. metal rectifiers, 250v 250ma, size 2¼in×4in, 12.6; C.T.V. I.F.S. 34mc/s, 2nd, 3rd, 4th vision cans, 1¹³/₁₆in×1¹³/₁₆in×2¼in, slug tuned, set of 3, 5/6; 2-gang var. 15pf, size 2¼in×1¹⁵/₁₆in×1¼in, 2/-.
VIBRATORS, 6v synchronous 7-pin. 7/6; vibrator trans., 6v, 7/6
WIRE-WOUND pots, 100Ω, 1in spindle, 2/6; speakers, P.M., 5in 5Ω speech coil, 16/6; sheet aluminium, large variety of sizes in stock.
SUB-MINIATURE electrolytics for transistor circuits, 6mfd, 8mfd, 3v and 6v, size ⅛in×⅞in, 2/9; 16mfd, 30mfd, 3v and 6v, size ⅜in×½in, 2/9.
ELECTROLYTICS capacity, voltage, size, type of mounting: 50mfd, 25v, 1¾in×½in, tag, 1/6; 100mfd, 12v, 1⅝in×½in, tag, 1/6; 500mfd, 12v, 1¾in×⅝in, tag, 2/-; 10mfd, 25v, ¼in×½in, W/E, 1/3; 4mfd, 150v, 1¼in×⅝in, tag, 1/3; 8mfd, 150v, 1¼in×⅝in, tag, 1/3; 8mfd, 350v, 2in×⅝in, tag, 1/9; 8mfd, 500v, 3in×1⅜in, clip, 2/6; 16mfd, 350v. 2in×⅝in, prong, 1/9; 20mfd, 450v, 2in×⅞in, clip, 2/-; 24mfd, 275-350v, 2in×⅞in clip, 2/-, 32mfd, 275-350v, 2in×1in, 2/-; 32mfd, 350v, 2in×1in, clip, 2/6; 32mfd, 450v, 2in×1in, W/E, 2/9; 40mfd, 150v, 2in×1in, prong, 1/6; 40mfd, 350v, 2in×1in, prong, 2/-; 40mfd, 450-525v, 2in×1in, 2/9; 50mfd, 350v, 2in×1in, W/E, 3/-; 100mfd, 270-350v, 2in×1½in, clip, 3/3; 100mfd, 350-425v, 3in×1⅜in, prong, 3/6; 125mfd, 350-425v, 3in×1⅜in, prong, 3/6; 200mfd, 35v, 1½in×1in., tag, 1/-; 200mfd, 250-325v, 3in×1⅜, 2/6; 200mfd, 275-350v, 3in×1⅜in prong, 3/-; 250mfd, 25v, 2¾in×1⅜in, 1/-; 250mfd, 150v, 3in×1⅜in, prong, 2/-; 500mfd, 6v. 2in×1in, clip, 1/3; 500mfd, 25v, 2in×1in, clip, 2/6; 1,000mfd, 6v, 2in×1in, clip, 2/-, 1,000mfd, 25v, 3in×1in, clip, 1/6; 2,000mfd, 12v, 2in×1⅜in, W/E, 3/6; 2,000mfd, 25v, 3in×1⅜in, clip, 3/6; 2,000mfd, 50v, 4½in×2in, clip, 5/-; 2,500mfd, 50v, 4½in×1⅜in, clip, 5/6; 3,000mfd, 25v, 4½in×1⅜in, clip. 5/-; 4,000mfd, 6v, 3in×1⅜in, clip. 5,000mfd, 25v, 4½in×1⅜in, clip, 5/6;8+8mfd, 450v, 2in×1in, W/E, 4/-; 15+15mfd, 450v+20mfd, 25v, 3in×1in, prong, 4/-; 16+16mfd, 275v, 2in×1in, clip, 3/-; 20+10mfd, 450-525v, 3in×1in. clip, 3/6, 20+20mfd, 350-425v, 2in×1in, prong, 4/-; 20+20mfd, 150v, 2in×1in, clip. 2/-; 20+20mfd, 150v, 2in×1in, W/E, 2/3; 20+20mfd, 350-425v, 2in×1in, W/E, 3/9; 20+20mfd, 450v, 3in×1in, prong, 3/9; 30+30mfd, 150v, 2in×1in, clip, 2/6; 32+16mfd, 200v, 2in×1in, prong, 1/6; 32+16mfd, 275-350v, 2in×1in, clip, 3/-; 32+32mfd, 275-350v, 3in×1in, prong, 3/9; 32+32mfd, 350-425v+50mfd, 25v, 2in×1⅜in, prong, 4/3; 40+40mfd, 150v, 2in×1in, clip, 2/6; 40+40mfd, 350v, 3in×1in, clip, 3/6; 40+40mfd, 450v, 3in×1⅜in, prong, 4/-; 50+20mfd, 150v, 2in×1in, clip, 2/-; 50+30mfd, 450-525v, 3in×1⅜in, clip, 4/6; 50+50mfd, 150v, 2in×1¼in, W/E, 2/6; 50+50mfd, 275-350v, 3in×1⅜in, clip, 3/6; 50+50mfd, 300-350v, 2in×1⅜in, clip, 4/-; 50+50mfd, 350-425v, 3in×1⅜in, prong, 5/-; 60+100mfd, 275-350v, 3in×1⅜in, clip, 4/6; 60+200mfd, 275-350v, 4½in×1⅜in, clip 5/-; 60+250mfd, 250-325v, 4½in×1⅜in, clip 4/6; 60+250mfd, 275-350v, 4½in×1¼in, clip, 5/-; 100+65mfd, 250-325v, 3in×1⅜in, prong, 4/6; 100+200mfd, 250-325v, 4½in×1⅜in clip 5/6; 150+200mfd, 350-425v, 4½in×1⅜in clip 7/-; 200+100mfd, 275-350v, 4½in×1½in, clip, 6/6, 200+200mfd, 275-350v, 4½in×1⅜in, clip, 7/6; 1,000mfd+1,000mfd, 6v, 3in×1in, clip, 3/6; 12+12+24mfd, 275-350v, 2in×1in prong, 3/6; 16+8+4mfd, 275-350v, 2in×1in, prong, 3/6; 16+24+8mfd, 2in×1⅜in, clip, 5/-; 20+20+10mfd, 275-350v, 2in×1in, prong, 3/6; 20+20+20mfd, 150v, 2in×1in, prong, 2/9; 30+25+20mfd, 150v, 2in×1⅜in, clip, 2/9; 32+32+2mfd, 275-350v, 3/-; 32+32+8mfd, 275-350v, 2in×1⅜in, clip, 3/-; 32+32+8mfd, 350-425v, 2in×1⅜in, clip, 3/6; 40+30+20mfd, 275-350v, 3in×1in, prong, 3/6; 40+30+20mfd, 275-350v+25mfd 25v, 3in×1⅜in, prong, 4/-; 50+50+8mfd, 275-350v, 3in×1⅜in, prong 4/6; 50+50+50mfd, 350v, 3in×1⅜in, prong 5/6; 200+250+250mfd, 275-350v, 4½in×2in, clip, 8/-; 40+20+10+10mfd, 350-425v, 2in×1⅜in, clip 5/-.
ALL prices include packing and postage.
RADIO CLEARANCE, LTD., 27, Tottenham Court Rd., London, W.1 Tel Museum 9188.

MAGSLIPS at low prices, fully guaranteed, 3 in Resolver No 5 (AP 10861), 50v, 50c/s, unused, each in tin, 35/-, post 2/1; large stocks of these and other types.—P. B. Crawshay, 94, Pixmore Way, Letchworth, Herts. Tel. 1851 [0087

NEW GRAMOPHONE AND SOUND EQUIPMENT

RECORDERS by Ferrograph, M.S.S., Leevers Rich and the new Brenell Mark IV; unrivalled Mastertape, as used in our studio; extra-play tape, mics., including the "Cadenza" mic., disk recorders, blank disks, defluxers.
TAPE/DISK service, especially L.P.; full studio and mobile facilities.
"EROICA" RECORDING SERVICES (1949), Recorder House, Peel St., Eccles, Manchester. Eccles 1624. Director: Thurlow Smith, A.R.M.C.M [0122

NEW GRAMOPHONE AND SOUND EQUIPMENT

GLASGOW.—Recorders bought, sold, exchanged, cameras, etc., exchanged for recorders or vice versa.—Victor Morris, 406, Argyle St., Glasgow, C.2. [0201

FOR details of the new "Miteeamp" tape record/playback amplifier see our displayed advertisement on page 54.—Harding Electronics, 120a, Mora Rd., Cricklewood, London, N.W.2. [0032

TRUE Hi-fidelity: have you heard Vortexion tape recording equipment in use with the latest Wharfedale and Goodman's Hi-Fi speakers? Why not arrange a personal demonstration, when we can give you our undivided attention and help you with your Hi-Fi problems? Write or 'phone for appointment. GRIFFITHS HANSEN (RECORDINGS), Ltd., 32-3, Gosfield St., Langham St., W.1. Mus. 2771/0642. [0293

TAPE Recorders, Ferrograph, 76gns; Reflectograph, £87; Brenell, 48 gns; tape decks, Wearite, Collaro, Truvox; microphones, Reslo, S.T.C., Acos; amplifiers, Leak, 27gns; Quad, £42; hire purchase facilities available; high fidelity tape to disc service.—Lambda Record Co., 4, Kimberley Ave., Liverpool, 23. [6884

ATTENTION! Our famous "Adaptatape" pre amp is now fitted to the Collaro Mk. IV tape deck and now incorporates push-pull oscillator, complete with power pack 40gns. Easy terms and full specification on request.—Sound Tape Vision, the tape recorder and Hi-Fi specialists, 71, Praed St., London, W.2. Pad. 2807. [7112

CINE-VOX disc recording equipments, type C7J, for high-quality recordings from existing microphone equipment; price from 28gns; also available as a complete channel inclusive of mic., amplifier and playback equipment, at 70gns; type C7 for highest quality professional requirements—recorder mechanism at 48gns, or complete channel at 110gns; demonstrations arranged in London.
PLEASE write for details to K.T.S., Ltd., "Coplow," Park Rd., Braunton, N. Devon. Tel Braunton 224. Callers by appointment only

GRAMOPHONE AND SOUND EQUIPMENT—SURPLUS AND SECONDHAND

FERROGRAPH 2 A/N, little used, also accessories, tapes available; £65.—Box 8829. [0199

D.C./A.C. Valradio converter, type 230/110A, £6.—20, Beverley Court, Chiswick, W.4. [7192

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LEWIS RADIO have the best selection and finest finish.—See page 145. [0224

CABINETS, radiogram and television, 25 models.—157, Bromsgrove St., B'ham. Mid. 1054. [7140

VALVES WANTED

ALL types of valves British or American, transmitting and receiving; keenest cash prices paid. What have you to offer?—Write or call Lowe Bros., 9a, Diana Place, Euston Rd., N.W.1. [6985

WANTED, EXCHANGE, ETC.

WANTED, receivers A.P.R.4, also T.N.16, 17, 18, 19, etc., and any radio test gear.—LESLIE DIXON & Co., 214, Queenstown Rd., Battersea, S.W.8. Macaulay 2159. [0176

WANTED, HRO coils, Rxs., etc., A.R.88s, BS348s, S27s, etc.—Details to R. T. & I. Service, 254, Grove Green Rd., London, E.11. Ley. 4986. [0163

VALVES (new), tape recorders, test equipment, any quantity.—Stan Willetts, 43, Spon Lane, West Bromwich, Staffs. Tel. Wes. 2392. [7079

SPOT cash ready for purchase of surplus and bankrupt stocks of new valves and components; we sell plain valve cartons; list on request.—R. H. S. Ltd., 155, Swan Arcade, Bradford. [0190

CASH on the spot for second-hand tape recorders, amplifiers and Hi-Fi equipment, top prices paid.—Sound Tape Vision (Dept. W.W.), 71, Praed St., London, W.2. Paddington 2807. [0214

WANTED, BC610 Hallicrafters, E.T.4336 transmitters, BC312 receivers, BC221 frequency meters and spare parts for all above; best cash prices.—P.C.A. Radio, Beavor Lane, Hammersmith, W.6. [0079

URGENTLY required, scrap platinum wire, contacts, etc.; spot cash for any quantity; £30 per oz troy.—The Scientific Metal Co., 50, Old Brompton Rd., London, S.W.7. Tel. Kni. 2534 [7009

URGENTLY wanted, manuals or instruction books, data, etc., on American or British Army, Navy or Air Force radio and electrical equipment.—Harris, 93, Wardour St., W.1. Gerrard 2504. [6993

WANTED.—Surplus and redundant stocks of aircraft radio, electrical and instrument equipment; details to—Stewart Aeronautical Supply, Co., Ltd., Adastral House, Lowfield Heath, Crawley, Sussex. [6997

WANTED, tape recorders, domestic radios, amplifiers, record players, communications receivers; also the above taken in part exchange for new equipment; call, send or 'phone Gerrard 2613.—Radio Exchange, Newport Place (car park), Leicester Square, W.C.2. [0189

ALL U.S.A. V.H.F. test and communication equipment; TS174, TS175, TS47, B.C.221 freq. meters; receivers 1294, 1359; Hallicrafters S.27, S27CA U.S.A.; APR4 and tuning units TN16, 17, 18 and 19, RCA AR88D-LF, Hallicrafters SX28; valves 707A-707B, 2K28, 2K39, 2K33, 2K41; highest offers given by return.—Ger. 8410 and 4447.—Universal Electronics, 22, Lisle St., Leicester Sq., London, W.C.2. [0229

WANTED, EXCHANGE, ETC.

WANTED, good quality communication RYS tape recorders, test equipment, domestic radios, record players, amplifiers, valves, components, etc., estb. 18 years.—Call, send or 'phone Ger. 4638, Miller's Radio, 38a, Newport Court, Leicester Sq., W.C.2. [7074

VALVES

VALVES, all new, to clear at rock bottom prices, ACTH1, ACVP1, PEN45, TH41, ECH35, EF39, TP2620, PEN383, and many obsolete types.—M. Jones, 21a, Globe Rd., E.1. Ste. 4071. [7198

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USE Jefco coil winder, cheapest machine on the market.—Details, 170, London Rd., Southend-on-Sea. [0174

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MISCELLANEOUS

TAPE to disc: 12/6.—Mobile Recording Services, 5, New Brown St., Manchester [6555

TAPE to disc, Queensway Recording Studios, 123, Queensway, W.2. Bay 4992. Recorders serviced and for hire. [6994

REFRIGERATOR spares of every description. —Farron Refrigeration, Station Approach, Sanderstead. Tel. 3655. [7221

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150 G.P.O. type telephones, internal bells, not ex-Govt., listed £12 each; sample 25/-.—Messrs. K.E.P., 17, Ashmead Rd., London, S.E.8. [D7142

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METALWORK, all types cabinets, chassis, racks, etc., to your own specification; capacity available for small milling and capstan work up to 1in bar. PHILPOTT'S METAL WORKS, Ltd., Chapman St., Loughborough. [0208

AERIALS I.T.A. Channels 8, 9 and 10 wide-spaced 5-element with mast bracket, 3 yds cable, extra cable 9d yd; 33/- plus 2/- p.p.—Suprasonics, 70, Newbridge Rd., Bath. Money back guarantee. [7143

NOTICES

BRITISH SOUND RECORDING ASSOCIATION. Details of membership, open to the professional sound recording engineer and all others interested in recording high quality reproduction and other branches of audio engineering, together with details of the London lecture programme and the Manchester, Portsmouth and Cardiff Centres, may be obtained from the Hon. Membership Secretary, H. J. Houlgate, A.M.I.E.E., 12, Strongbow Rd., Eltham, S.E.9. [0031

BUSINESS OPPORTUNITIES

ITALIAN firm interested in importing English radios, televisions, tape recorders and related electronic equipment.—Please send literature and prices to C. A. Posnansky, Casella Postale No. 38, Bari, Italy. [7169

WELL-KNOWN firm of precision engineers and instrument makers (London area) are desirous of entering into a licence agreement or purchasing outright, patents relating to electrical and/or mechanical devices of a precision instrument character, or of a consumer goods nature; adequate capital and production facilities are available to develop, produce and market suitable devices.—Communications should be addressed, in the first instance, to Box 7247. [7146

BUSINESS AND PROPERTY WANTED

PREMISES central London sought by small private recording service, sharing partnership consid.—Box 8828. [0194

CAPACITY AVAILABLE

SUB-CONTRACT specialists for 25 years; A.I.D. approved.—Radio-Aids, Ltd., 29, Market St., Watford. Tel. 5988. [0189

CUT wires, pins, special rivets, formed wires, manufactured to specification by Wire Products & Machine Design, Ltd., No. 18, Bridge Rd., Haywards Heath, Sussex. Tel. 1990.

CHASSIS work, instrument cases, embossed panels, in all usual metals. Special groundboards in S.R.B.P., etc. Long or short runs. Precision work at keen prices. Extensive range of stock tools for radio and electronics industry; special tooling at favourable rates.—Metalwork Dept., Unitelex (London), Ltd., Pagnell St., London, S.E.14. Tedway 5842. [0200

WORK WANTED

PTFE supplies and machining; Polysterene, nylon, moulding; coilwinding, assembly capacity; A.I.D. approved.—Bel Sound Products Co., Marlborough Yard, London Archway, N.19. Arc. 5078. [0187

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SCIENTIFIC Assistant (Ionospheric) required by the Falkland Islands Dependencies Survey for the operation and maintenance of special electronic ionospheric recording apparatus at an Antarctic base for two years; commencing salary according to age in scale £400 rising to £540 a year with all found including food, clothing and canteen stores; free passages; liberal leave on full salary; candidates, preferably single and aged 21-28 years, must be of good education, of high physical standard, and experienced in the servicing of radio or radar equipment; genuine interest in life at an Antarctic base essential.—Write to the Crown Agents, 4, Millbank, London, S.W.1. State age, name in block letters, full qualifications and experience and quote M3B/44014/WF. [7164

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CANDIDATES for these interesting and progressive positions should be capable of projection from orthographic drawings and should preferably have experience of similar work; they should write, in confidence, to the Personnel Manager (Ref. 19c),
DE HAVILLAND PROPELLERS, LIMITED.
Manor Rd., Hatfield, Herts. [7173

CIRCUIT Draughtsman (Electronics).

A FULLY experienced man is required by The British Tabulating Machine Co., Ltd., Letchworth, Herts to lead a small section preparing circuit diagrams of electronic computers and the like at their Stevenage premises.
Much more than a knowledge of symbols and first-class draughtsmanship is required; the successful applicant should be able to prepare lucid circuit diagrams from engineers' rough drawings, in which cause and effect are immediately apparent. The opening is likely to interest those with experience in circuit delineation.
WRITE, giving full particulars, to the Personnel Officer, quoting reference W/783. [7171

YORKSHIRE ELECTRICITY BOARD.

NO. 6 (Hull) Sub-Area.
THIRD Assistant Engineer (Radio and Television).
APPLICANTS must have had a sound training and practical experience in the installation, maintenance and repair of various makes of radio and television sets.
THE duties will include responsibility for the purchase and sale of radio and television apparatus, the installation and maintenance thereof and also the training of Radio and Television Mechanics.
CANDIDATES should be Members, or Associate Members of the British Institution of Radio Engineers, hold the Final Certificate of the Radio Trades Examination Board for Television and the City and Guilds Certificate in Radio and Television Service.
SALARY—N.J.B. Class K.Grade 10. £935/20/995 per annum.
APPLICATIONS, giving full details of age, qualifications and experience, together with the names of two referees, should be forwarded to the Manager, No. 6 (Hull) Sub-Area, Yorkshire Electricity Board, Ferensway, Kingston-upon-Hull, not later than August 6th, 1957. [7193

ASSISTANT Controllers of Telecommunications.
(ENGINEERING) Federation of Malaya.
DUTIES include staff management and responsibility for maintenance, installation and operation of telecommunications equipment including exchanges, carrier equipment, telegraph and railway signalling equipment and minor radio stations.
APPOINTMENTS on contract/gratuity terms with salary according to qualifications and experience in the range $818 to $1,699 (£1,145 to £2,378 per annum). Variable Cost of Living Allowance. Single candidates, minimum gross emoluments £1,218 maximum £2,120; married, no children, minimum £1,440 maximum £2,499; married with children, minimum £1,531 maximum £2,730. Substantial gratuity; free passages; quarters if available, at reasonable rentals; generous leave.
CANDIDATES under 40 years of age must be Corporate or Graduate Members of the I.E.E. or hold a degree or diploma acceptable by the Institution for Corporate Membership; two years' experience in practical telecommunications work is necessary.
WRITE Director of Recruitment, Colonial Office, London, S.W.1, giving age, qualifications and experience, quoting BCD 133/23/03. [7161

REQUIRED for Domestic Television Production.
MAN with some experience of television testing for work in our Weybridge factory.
ALSO: Wiring Inspectors (female): 44-hour, 5-day week; top rates of pay; clean and pleasant working conditions; canteen, social club, etc.
APPLY:—Personnel Officer, Peto Scott Electrical Instruments, Ltd., Addlestone Rd, Weybridge, Surrey. [7158

THE Research Laboratories of the General Electric Co., Ltd., North Wembley, Middlesex, have several vacancies for technical assistants.—Please apply in writing to the Staff Manager (Ref. RLB/137), giving full details of qualifications, experience and age. [7153

SITUATIONS VACANT

CENTRAL ELECTRICITY AUTHORITY.

YORKSHIRE Division.

APPLICATIONS are invited for the following appointments in the Technical Department (Communications Section):—

THIRD Assistant Engineer—based near Leeds. COMMENCING salary within the range £1,055-£1,180 per annum, Grade 3, Class AX, National Joint Board Agreement (Schedule "B"), according to qualifications and experience, rising to an ultimate maximum of £1,320 per annum (Class EX).

THIRD Assistant Engineers—based on various locations in the Division. COMMENCING salary within the range £895-£1,020 per annum, Grade 4, Class AX, National Joint Board Agreement (Schedule "B"), according to qualifications and experience, rising to an ultimate maximum of £1,140 per annum (Class EX).

APPLICANTS should possess technical qualifications leading to Corporate Membership of the Institution of Electrical Engineers and have had experience in various applications of communication and electronic technique, e.g., telemetering, supervisory control and automatic exchanges.

FOURTH ASSISTANT ENGINEER—based near Leeds. COMMENCING salary within the range £810-£935 per annum, Grade 5, Class AX, National Joint Board Agreement (Schedule "B"), according to qualifications and experience, rising to an ultimate maximum of £1,035 per annum (Class EX).

FOURTH Assistant Engineers—based on various locations in the Division. COMMENCING salary within the range £710-£835 per annum, Grade 6, Class AX, National Joint Board Agreement (Schedule "B"), according to qualifications and experience, rising to an ultimate maximum of £935 per annum (Class EX).

APPLICANTS should possess or be completing technical qualifications as above and should have some experience in applications of communications and electronic technique.

APPLICATION forms obtainable from the Divisional Secretary (Establishments), Central Electricity House, St. Mary's Road, Leeds 7 to be returned within 14 days of the appearance of this advertisement. [7168

DIRECTOR of Electricity and Telephones Department, Antigua, Leeward Islands. TO undertake general administrative control of the Department, advise the Government on electrical and telecommunications matters, and be responsible for the operation of the public electricity and telephone service in the Colony. CONTRACT appointment for three years in first instance; salary £1,500 p.a.; contract gratuity—12½% of salary; free passages for officer, wife and up to three children; unfurnished quarters at rental of 10% of salary; generous leave.

CANDIDATES must be A.M.I.E.E., under 45 and have had considerable experience in installation and running of diesel-operated generating stations, construction and maintenance of both overhead and underground H.V. and L.V. lines, the installation and maintenance of distribution transformers, the testing and maintenance of consumers' meters, the installation and maintenance of C.B. and magneto telephone exchanges including subscribers' P.B.Xs, the construction and maintenance of overhead and underground telephone lines, the installation and maintenance of subscribers' services, etc.: knowledge of refrigerating plants desirable. WRITE Director of Recruitment, Colonial Office, London, S.W.1, giving age, qualifications and experience, quoting BCD 145/34/01. [7170

NORTHERN POLYTECHNIC, Holloway, London, N.7.

THE Governing Body invite immediate applications for appointment as full-time Assistant Lecturer Grade "B" in the Department of Telecommunications; the duties will include teaching in telecommunications engineering and in radio and television servicing; a knowledge of electronic instrumentation is desirable; salary scale: £650×£25—£1,025, together with allowances in accordance with the Burnham Award; commencing salary according to age, qualifications and experience.

PARTICULARS and form of application from the Clerk to the Governors. [7160

REQUIRED for interesting research development work on electro-acoustic devices, an Engineer up to B.Sc. standard.—Apply Box 8273.

OPPORTUNITY occurs to acquire an interest in old-established business, coil winding experience essential; nominal investment, salary and small share of profits.—Box 8716. [7113

RADIO Engineer, first-class required for approx. 12 months service overseas; large firm engineers; excellent opportunity; write experience, age, references.—Box 8576. [7098

AUDIO and television engineer required by leading manufacturer, applicants to submit full details of qualifications and experience; all applications treated as strictly confidential.—Box 0303. [7187

TRANSFORMERS. — Small manufacturer, Oxford, seeks young man with good theoretical knowledge as design engineer for coupling transformers; salaried superannuated appointment with good prospects.—Box 0140. [7166

SALESMAN required with ability to sell television aerials and components to the wholesale trade in the North-West; preferably resident in Manchester or Liverpool.—Applications in strict confidence to: General Sales Manager, Labgear (Cambridge), Ltd., Willow Place, Cambridge. [7182

SITUATIONS VACANT

RESEARCH and Development. Vacancies exist in the Research Department of a large manufacturing organisation in South-East Essex for
GRADUATE Physicists or
ELECTRICAL Engineers
OF merit and some years of industrial experience for the investigation of long-term problems associated with Echo-Sounding and Non-Destructive Testing.
THE work embraces acoustics and electronics and involves the application of the basic physical principles underlying ultrasonics, telecommunications and computers. Some knowledge of these fields would be an advantage.
THE initial salary will be in accordance with experience and qualifications within a scale which allows ample scope for future development. A contributory pension scheme is available and assistance in housing or removal expenses may be given in suitable cases.
APPLICATIONS, which may be made in strictest confidence, should give full details of qualifications, previous experience, age and salary required, and be addressed to Box 0353.

A.B.C. television require experienced television studio engineers for their Manchester studios.—Application should be made in writing to A.B.C. Television Studios, Manchester. 20. [7185

SUPERVISOR required by leading manufacturer of high-quality loudspeakers and microphones; experience in this field and ability to control female staff essential. Full particulars and wages required.—Box 8847. [7139

EXPANDING electronics laboratory seeks development engineers with audio experience, H.N.C. or equivalent qualifications; pleasant working conditions.—Pamphonic Reproducers, Ltd., Dalston Gdns., Stanmore, Middx. Wor. 4014. [7103

SKILLED radio tradesmen are offered interesting and progressive employment with car radio firm in N.W. London area; 5-day week; above average rates.—Write Box 2F.A.8503, A.K. Advg., 212a, Shaftesbury Ave., London, W.C.2. [7089

DRAUGHTSMEN.—E. K. Cole, Ltd., Southend-on-Sea, have vacancies for draughtsmen for the design and production drawing of electronic apparatus or radio and television for mass production.—Write, stating age, qualifications and experience, to Personnel Manager

RADIO engineer.—A vacancy occurs in small, active manufacturing company in the Home Counties for a man with a sound knowledge of L.F. amplifiers to undertake development work on sub-miniature units; first class progressive appointment for young man with suitable experience; write details.—Box 0141.

ENGINEER required, able to drive and experienced all makes, for leading firm in South Wales holding all main agencies; good conditions, permanent position; willing to pay top wages.—Apply, stating particulars of experience and wages required, and whether accommodation wanted, to Box 0227. [7178

ELECTRONIC Engineers required for work on Transistor circuitry and other projects. The minimum qualification for senior post H.N.C. or equivalent. For junior post, O.N.C., but consideration would be given to advanced student of special ability. North London district.—Box 8120 [7043

KELVIN & HUGHES (AVIATION) require Field Service Engineers for work on introduction of new aircraft instrumentation systems. Practical work on aircraft, instrument and electronic equipment is essential and applicants should possess Higher National Certificate in Electrical or Mechanical Engineering or equivalent.
SALARY will be paid according to qualifications, experience and ability, but is based on generous scales, and adequate payment during illness and contributory pension scheme, etc., are in operation. Canteen, medical services, sports and social facilities are also provided.
APPLICATIONS should be made in writing giving full details of age, qualifications, experience, etc., to the Personnel Manager, Kelvin & Hughes, Ltd., Winchester Road, Basingstoke. [7200

MARINE Radar Instructor required at Leicester factory for instructing ships officers and servicing personnel in the operation and maintenance of Marine Radar equipment; occasional visits to ship are a part of the duties; previous radar servicing experience desirable.—Apply Construction Department, The British Thomson-Houston Co., Ltd., Rugby.

AN experienced inspector with considerable practical knowledge, mechanical and/or electrical, is required for site work; applicants must be prepared to travel and be away from home for periods of several months at a time.—Letters of application to be addressed to Chief Inspector, Scanners, Ltd., Woodskinners Yard, Bill Quay, Gateshead, 10. [7151

ELECTRONIC engineers required at N.C.B.'s Mining Research Establishment, Worton Hall, Isleworth, Middlesex, to assist in the design and development of mechanical, electromechanical and electronic instruments used in mines and laboratories. Occasional visits underground may be necessary. O.N.C. or H.N.C. in Applied Physics or Electrical Engineering is required.
APPOINTMENTS (superannuable), variously graded, within inclusive scales from £492-£1,069, according to qualifications and experience; 5-day week, staff canteen and good prospects of promotion; for junior grades there are facilities for further education.
WRITE, stating age, education, qualifications and experience, to the Personnel Officer at the above address, marking envelope X.784/C.

SITUATIONS VACANT

ASSISTANT to Chief Inspector required for work in quality control laboratory of Electronic Component Manufacturer (E. London); applicant should be interested in electrical measurements.—Write Box 0334. [7191

COSSOR RADIO & TELEVISION, Ltd., require Development Engineers for Commercial Television projects; senior and junior positions available; previous experience essential for senior positions; excellent salaries and usual large company advantages, pension scheme, etc.—Write to the Technical Director, Cossor Radio & Television, Ltd., Cossor House, Highbury Grove, N.5. [7190

INSTRUCTORS required by Posts and Telegraphs Department, Nigeria Federal Government on contract for one tour of 12/24 months in the first instance. Commencing salary according to experience in scales set out below. Outfit allowance £60. Gratuity at rate of £150 a year. Free passages for officer and wife. Assistance towards children's passages and grant up to £150 annually towards maintenance in U.K. Liberal leave on full salary.
INSTRUCTOR, Grade I (M2C/42120/WF). Candidates, preferably under 40 years of age, should have had experience in the installation or maintenance of multi-channel radio telephone systems and be conversant with V.H.F. and F.M. techniques. They should have had at least 5 years' teaching experience and possess C. & G. certs. in Telecomms. Principles III and Radio III or equiv. Salary scale (including Inducement Addition) £1,536 rising to £1,674 a year.
INSTRUCTOR, Grade II (M2C/42145/WF). Candidates preferably under 35 years of age, should have had practical experience in the installation and maintenance of radio telephone systems. They should have had recent teaching experience and possess appropriate C. & G. certs. or equiv. Salary scale (including Inducement Addition) £1,170 rising to £1,488 a year.
WRITE to the Crown Agents, 4, Millbank, London, S.W.1. State age, name in block letters, full qualifications and experience, and quote the reference number shown against the post applied for. [7180

CHIEF of Test required for the Weapons Research Division (Guided Missiles) of A. V. Roe & Co., Ltd., Woodford; applicants should have experience of testing prototype and production electronic apparatus and instruments; familiarity with A.I.D. requirements would be an advantage.—Applications to: Personnel Manager, A. V. Roe & Co., Ltd., Greengate, Middleton, Manchester, quoting reference WRD/MJC/R.1/W. [7177

RADIO technicians required by International Aeradio, Ltd., for overseas service; permanent and pensionable positions; inclusive salary from £894 per annum to £1,373 per annum, tax free, according to marital status; free accommodation; kit allowance; free air fares; generous U.K. leave.—Qualified candidates, to whom replies only will be sent, please write, quoting RT to Personnel Officer, 40, Park St., W.1. [0262

TEST engineer; we have a number of vacancies in our final test room, which offers a prospect of interesting jobs in this rapidly expanding company; candidates should either have had considerable previous experience in the electronic industry or to be at least O.N.C. standard, 5-day week, contributory pension scheme, staff clubroom.—Call or 'phone Electronic Instruments, Ltd., Lower Mortlake Rd., Richmond, Richmond 5656. [7186

SKYWAYS, Ltd., require the following experienced radio mechanics: 1, at Lympne airport, to work on ground and aircraft equipment; 2, at Stansted airport, for employment in workshops and on maintenance of equipment in aircraft; applicants must be fully experienced particularly in workshop practice; good rates of pay and conditions of service.—Apply with full details to Personnel Manager, Skyways, Ltd., Stansted Airport, Essex. [7159

ELECTRONIC inspector required for site work; experience on centimetric radar equipment is necessary, and applications will be considered from ex-service technicians or men with similar experience who are prepared to travel and be away from home for periods of several months at a time.—Letters of application to be addressed to Chief Inspector, Scanners, Ltd., Woodskinners Yard, Bill Quay, Gateshead, 10. [7150

ENGINEERS with experience of Gyroscopes are offered careers by a leading company in the field of Guided Weapons; applicants will find that experience is just as valuable as academic qualifications; the work concerns the design, development and testing of weapon components; please write, in confidence, for further details, to the Personnel Manager (ref. 20B), De Havilland Propellers, Ltd., Manor Rd., Hatfield, Herts. [7174

SIGNAL Technician required by Kenya Government Police Force on probation for pensionable employment, salary scale (including inducement addition) £813 rising to £1,341 a year, commencing salary according to age and experience; outfit allowance £40, free passages for officer and wife and assistance towards cost of children's passages, liberal leave on full salary; candidates, preferably not over 40 years of age, must have a wide knowledge of the installation, running and maintenance of H.F. communications equipment, fixed and mobile V.H.F. equipment and installation and maintenance of ancillary equipment; experience with V.H.F. multi-channel equipment, teleprinters, facsimile equipment would be an advantage.—Write to the Crown Agents, 4, Millbank, London, S.W.1. State age, name in block letters, full qualifications and experience and quote M2C/42335/WF. [7188

SITUATIONS VACANT

DRAUGHTSMAN required to join a team working on the design and development of high-power audio amplifiers for specialised applications; enthusiasm, initiative and a sound appreciation of practical problems are more important than formal qualifications; experience on electronic equipment is highly desirable. —Write, in confidence, giving brief details of qualifications and experience, to Goodmans Industries, Ltd., Axiom Works, Wembley, Middlesex. [7148

ELECTRONICS Technician.—Department of Biochemistry, University of Oxford, require an electronics technician to construct and maintain electronic apparatus for research; the post requires a man who is keen and willing to use his initiative; some knowledge of workshops practice an advantage but not essential; salary on University scale according to age and experience; 5½–6 weeks' paid holiday per year.—Applications in writing to Administrator, Department of Biochemistry, South Parks Rd., Oxford. [7156

AN interesting position for an electronic development engineer occurs in a laboratory engaged in a large variety of original work. The field covered includes: industrial instrumentation, servo, audio circuits, pulse work; experience in one of these is desirable. An academic qualification up to H.N.C. would be an advantage, but the relevant experience will be taken into account.—The replies should be addressed to: Chief Engineer, Winston Electronics, Ltd., Govett Ave., Shepperton, Middlesex. [7152

AN engineer with sound knowledge of light electro-mechanical engineering materials and/or finishes required to advise on existing and new materials and processes, and to assist with general engineering development and the preparation of specifications. Interesting work, good salary and conditions with an A.E.I. company. Opportunity for responsibility and progress for the right man.—State qualifications, experience and salary required, to Staff Officer, ref. 744/80, Siemens Brothers & Co., Ltd., Woolwich, S.E.18. [7145

SENIOR Mechanical Design Draughtsmen are required by the Design Department of Murphy Radio, Limited, to work on radio and television; experience of similar work is essential and preference will be given to applicants between the ages of 25 and 35; this affords an opportunity to join a successful and expanding design team providing excellent scope to men of initiative and originality; Welwyn Garden City is most pleasantly situated within easy reach of London, and applicants from the London area would be eligible for housing after a period; apply by letter initially, giving details of age, experience, and qualifications, to Personnel Department (R.9), Murphy Radio, Ltd., Welwyn Garden City, Herts. [7162

SENIOR Assistants (Scientific).—The Civil Service Commissioners invite applications for pensionable posts (a) Admiralty, 20; (b) Royal Mint, 1; (c) Department of Scientific and Industrial Research, 5; (d) War Office, 5 (men only); (e) Ministry of Supply, 10. Age at least 27 on 31st December, 1957. Candidates must have reached school certificate credit standard in mathematics or a science subject or have other approved qualifications (e.g., O.N.C.), but candidates otherwise well qualified by experience may be admitted. Every candidate must have had thorough experience in the duties of the class, and appropriate to the type of vacancy, gained by service in a Government department or elsewhere.

UNDER (a) 10 posts are for electrical engineers, including communication engineers, 2 mechanical engineers, 1 marine engineer, 2 mathematicians, 2 chemists, 1 physicist, and 2 for general duties. The posts are at naval establishments in London, and the South of England.

THE post under (b) requires knowledge of the processes of producing metallic silver.

UNDER (c) 1 post is at the National Physical Laboratory and calls for a good knowledge of thermometry; 2 posts are for electronic engineers at the Mathematical Engineering Research Laboratory, East Kilbride, near Glasgow; 1 post is at the Building Research Station, Garston, near Watford, Herts; 1 post is at the Pest Infestation Laboratory, Slough, Bucks, for work on problems of grain storage.

UNDER (d) 2 posts are at the David Bruce Laboratories, East Everleigh, near Marlborough, Wilts—1 for a bacteriologist and 1 in the Media Department; 3 posts at the Royal Army Medical College, Millbank, London, S.W.1—1 in the Serological Department, 1 in the Pathological Museum and 1 in the Virology Laboratory.

UNDER (e) the posts are classified: Glass blowing (1), Mathematics and Physics (4), Electronics (3), Engineering (1), Chemistry (1).

FULLER information about the duties and the kind of experience expected is given in the memorandum.

SALARY (London) minimum £715 (women £655). Men's scale maximum £950. Exceptionally, starting pay above minimum. Somewhat lower outside London. Women's scale is being raised to reach equality with men's by 1961.

APPLICATION forms and memorandum from Civil Service Commission, Scientific Branch, 30, Old Burlington Street, London, W.1, quoting S 4712/57/13. Applications to be returned by 12th August, 1957. [7172

SITUATIONS VACANT

TELECOMMUNICATIONS engineers and laboratory assistants required, preferably H.N.C. standard, familiar with development of, or measurements on, capacitors, transformers or telecommunications components. Interesting work, good salaries and conditions with an A.E.I. company.—Write stating training, experience and salary required, to Staff Officer, ref. 744/79, Siemens Brothers & Co., Ltd., Woolwich, S.E.18. [7144

THE General Post Office has vacancies for Radio Operators at its coast radio stations and applications are invited from men between 21 and 35 years of age who hold the Postmaster General's First Class Certificate of Proficiency in Radiotelegraphy or an equivalent certificate issued by an Administration of the Commonwealth or of the Irish Republic; selected candidates will be considered later for permanent pensionable posts.—Applications should be made to the Inspector of Wireless Telegraphy, Radio Services Department, Wireless Telegraphy Section, Union House, St. Martins-le-Grand, London, E.C.1. [7100

RADIO Technicians required for the Ocean Weather Service; duties include maintenance of radio and radar equipment and radar operation; experience in servicing radio and/or radar required; technicians spend from 30 to 36 days at sea followed by 9 to 22 days in harbour (Greenock); leave, 82 days a year, granted during harbour periods; pay, including additional allowances, at age 25 or over, £606 10s rising by annual increments to £716; food and accommodation free on board ship; prospects of promotion and pensionable employment.—Apply to Shore Captain, Ocean Weather Ship Base, Air Ministry (W.S. 12), Great Harbour, Greenock. [7163

ELECTRONIC engineers, senior and junior, required for design and development work on high-power audio amplifiers for specialised applications; necessary qualifications for the senior position are a University Degree, City & Guilds Technological Certificate, or equivalent qualifications, together with experience on high-power amplifiers at the design stage. The junior post requires inter-B.Sc. or equivalent qualifications. Suitable applicants should have enthusiasm and initiative with a keen appreciation of the importance of the practical aspect of their work.—Write in confidence, giving brief details of qualifications and experience, to Goodmans Industries, Ltd., Axiom Works, Wembley, Middlesex. [7149

WIRELESS operator mechanics required by Falkland Islands Dependencies Survey for service at isolated British bases in Antarctic: must be able transmit and receive morse at 20 words a minute and be capable elementary maintenance wireless transmitting and receiving equipment. Salary according to age in scale £330 rising to £420 a year with all found, including clothing and canteen stores. Keen young men between 20 and 30 years required, preferably single, of good education and high physical standard, with genuine interest in polar research and travel and willing to spend 30 months under conditions testing character and resource.—Write to the Crown Agents, 4, Millbank, London, S.W.1. State age, name in block letters, full qualifications and experience and quote M2C/42227/WF. [7165

RADIO engineer required by Trinidad Government Wireless Branch, Works and Hydraulics Department for one tour of two years in first instance. Salary scale (including present temporary allowance of £30) equivalent to £780, rising to £1,250 a year. Commencing salary according to qualifications and experience up to maximum of scale. Gratuity at rate equivalent £100/£150 a year. Outfit allowance £60. Free passages. Liberal leave on full salary. Candidates should be A.M.(Brit.), I.R.E. by examination or possess C. & G. Full Technological Cert. in Telecomms, Engineering. They should have had experience in wireless station management and maintenance and in the organization and operation of communication services. Write to the Crown Agents, 4, Millbank, London, S.W.1. State age, name in block letters, full qualifications and experience, and quote M2C/41953/WF. [7184

TELECOMMUNICATIONS Research Staff (Engineers and Technicians) are required at our London Research Centre (Blackheath, S.E.18) for interesting and important new work in well-equipped and up-to-date laboratories; opportunities for original thinkers seeking experience, advancement and responsibility exist in the following fields: (a) Electronic switching and computer techniques. (b) Telecommunications transmission. (c) Transistor circuit applications: candidates expressing a preference may also be considered for engineering vacancies on closely allied development projects; engineers should have a degree, or H.N.C., plus previous practical experience in industry or research; technicians should have O.N.C., or G.C.E. at advanced level, and a definite interest in this type of work; as the research laboratories and main works are in London, technical staff can participate in the activities of professional institutions and attend a wide range of lectures and courses; attractive salaries, liberal pension scheme; assistance with housing difficulties, if required, may be available in approved cases; excellent sports club and canteen facilities; applications giving preliminary outline of qualifications should be sent to the—Staff Officer, ref. 744/77, Siemens Brothers & Co., Ltd., Woolwich, S.E.18 (an A.E.I. company). [7070

SITUATIONS VACANT

WEST SUSSEX COUNTY COUNCIL.

BOGNOR Regis Technical Institute. Engineering Department.
ASSISTANT Grade A teacher required to teach radio and telecommunications subjects up to City & Guilds level. Teaching experience desirable and preference will be given to a candidate who has had a sound practical training. Duties to commence in September, 1957, or January, 1958. Salaries in accordance with Burnham Scale. Application forms obtainable on receipt of stamped addressed foolscap envelope from Director of Education, County Hall, Chichester, Sussex, and should be returned completed to the Principal, Bognor Regis Technical Institute, Southway, Bognor Regis, Sussex, within 14 days of the appearance of this notice. [7199

THE SYSTEMS GROUP of Elliott Bros. (London), Ltd., has vacancies for two Junior Electronics Engineers; this Group is concerned with system engineering and automatic process control and covers a very wide field of activities involving process instrumentation, telemetering, computing, data handling and control engineering; successful applicants will be required to carry out experimental investigations under the direction of senior engineers and will be given a first-class opportunity to gain experience in this new and vital field; in addition to work carried out in the laboratory, opportunities will arise for gaining experience on process plant, both in this country and abroad.—Applications giving details of qualifications and experience should be addressed to: Personnel Officer, Century Works, Conington Rd., Lewisham, S.E.13.

THE DECCA NAVIGATOR COMPANY, Ltd., has vacancies for Project Engineers and Installation Engineers for work in connection with low frequency transmitting stations. Applicants for the post of project engineer should have received training in electrical and radio theory and have obtained extensive practical experience. The duties will cover all aspects of the planning of complete installations and will demand some travelling both at home and abroad. Applicants for the post of installation engineer must have experience of the installation and commissioning of electrical and radio equipment and preferably should have received some technical training. Vacancies will arise for senior installation engineers to take charge of teams. Considerable travelling at home and abroad will be required.—Applications, giving brief details of experience, training and salary required, should be addressed to:—
THE DECCA NAVIGATOR Co., Ltd., 247, Burlington Rd., New Malden, Surrey. [7179

WIRELESS technicians, grade II, required by Tanganyika Government Police Force for one tour of 30/36 months in first instance; salary scale (including inducement pay) £1,056 rising to £1,341 a year, and £1 at rate of 13⅓% of total substantive salary drawn; free passages; liberal leave on full salary; candidates preferably not over 40 years of age should be of good education and be able to carry out complete installation of medium and low-powered HF and VHF radio stations together with the installation and erection of lattice masts and installation of low-power diesel and petrol generating sets; they should also be capable of running a small workshop and store and supervising work of junior staff; previous experience in telephone and teleprinter practice in relation to HF and VHF systems would be an added qualification.—Write to the Crown Agents 4, Millbank, London, S.W.1. State age, name in block letters, full qualifications and experience and quote M2C/42313/WF. [7155

SITUATIONS WANTED

RADIO Television Engineer (31), wide experience, seeks post with accommodation.—Box 0066. [7157

EX radio officer, A.M.I.P.R.E. 1st class P.M.G. radar certificate, seeks position as part-time instructor in postal tuition from advertiser's home.—Box 0304. [7189

TECHNICAL TRAINING

LEARN it as you do it—we provide practical equipment combined with instruction in radio, television, electricity, mechanics, chemistry, photography, etc.—Write for full details to E.M.I. Institutes, Dept. WW47, London, W.4. [0006

CITY and Guilds (Electrical, etc.) on "No Pass—No Fee" terms, over 95% successes. For full details of modern courses in all branches of Electrical Technology send for our 144-page handbook, free and post free. B. I. E.T. (Dept. 388A), 29, Wright's Lane, London, W.8 [0117

TUITION

WIRELESS operating; attendance and postal courses.—Stamp for reply to Manager, The Wireless School, Manor Gdns., London, N.7. [0104

TV & Radio.—A.M.Brit.I.R.E., City & Guilds, R.T.E.B. Cert., etc., on "No Pass—No Fee" terms; over 95% successes—Details of Exams and Home Training Courses in all branches of Radio and T/V, write for 144-page Handbook—Free. B.I.E.T. (Dept. 397A), 29, Wright's Lane, London, W.8. [0116

TUITION

NOTHING succeeds like success! What we have done a thousand times we can do again for you—see the B.N.R.S. advt. page 70. [C172

FULL-TIME courses for P.M.G. Certs., G.G.L.I., Telecommunications, Radar Maintenance Cert. and B.Sc.(Eng.); prospectus free.—Technical College, Hull. [0111

WIRELESS.—See the world as a radio officer in the Merchant Navy; short training period; low fees, scholarships, etc., available; boarding and day students; stamp for prospectus.—Wireless College, Colwyn Bay. [0018

A.M.I Mech E., A.M.Brit.I.R.E., City and Guilds, etc., on "No Pass—No Fee" terms, over 95% successes—or details of Exams and courses in all branches of Engineering, Building, etc., write for 144-page Handbook—Free: B.I.E.T. (Dept. 387B), 29, Wright's Lane, London, W.8 [0118

TRAIN at home for a better position or a new hobby—We offer comprehensive modern home tuition courses covering over 100 careers and hobbies, practical equipment supplied with many courses.—Write for free brochure stating subject of interest, to: E.M.I. Institutes, Dept. WW 39, London, W.4. (Associated with H.M.V.) [0180

FREE! Brochure giving details of Home Study Training in radio, television and all branches of electronics. Courses for the hobby enthusiast, or for those aiming at the A.M.Brit.I.R.E., City and Guilds, R.T.E.B., and other professional examinations. Train with the College operated by Britain's largest electronics organization; moderate fees.—Write to E.M.I. Institutes, Dept. WW28, London, W.4. [0179

COURSES in Electronics, covering practical and theoretical aspects, basic principles, industrial applications, electronic apparatus, etc. Also courses in Radio and TV Engineering and Frequency Modulation. Guaranteed coaching for Brit.I.R.E., City & Guilds, etc. Study at home under highly qualified tutors. Write for free book: International Correspondence Schools, Ltd., Dept. CL.42, Kingsway, London, W.C.2. [0033

INCORPORATED Practical Radio Engineers' home study courses of radio and TV engineering are recognized by the trade as outstanding and authoritative. Moderate fees to a limited number of students only. Syllabus of Instructional Text is free. "The Practical Radio Engineer" journal, sample copy, 2/-; 6,000 Alignment Peaks for Superhets, 5/9.—Membership and entry conditions booklet, 1/- all post free from the Secretary, I.P.R.E., 20, Fairfield Rd., London, N.8. [0088

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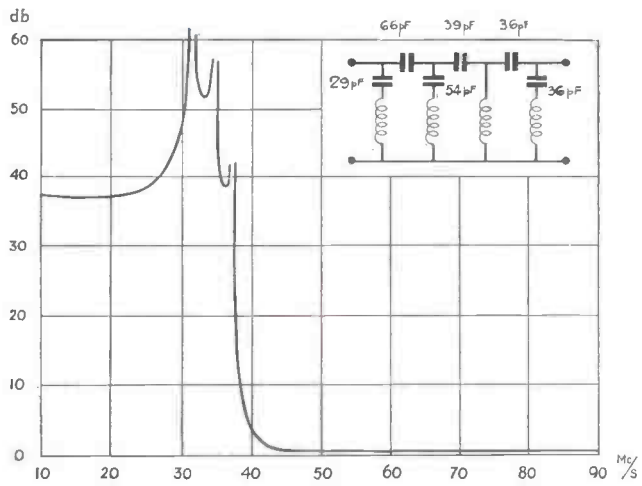

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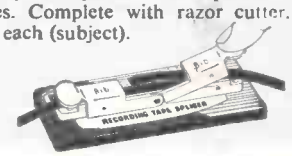

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