

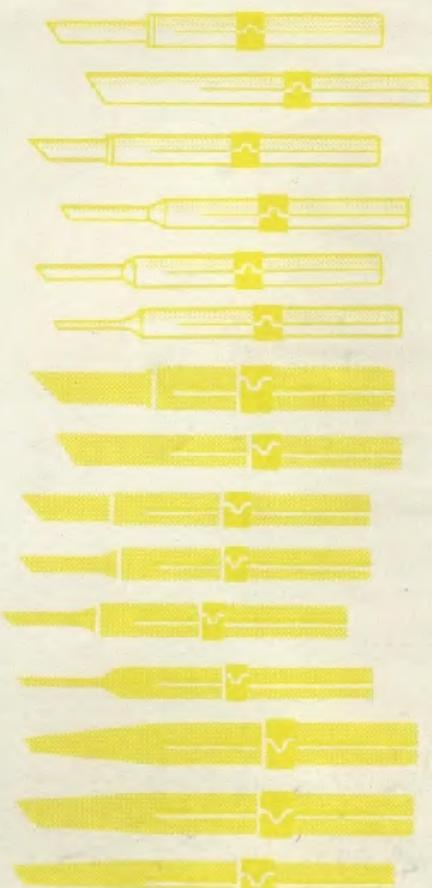
Wireless World

March 1968 Three Shillings

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Wireless World

MARCH 1968

VOLUME 74 NUMBER 1389

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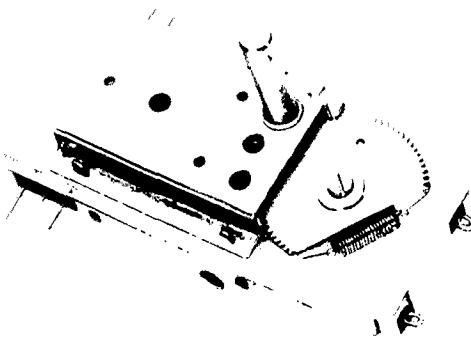
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Wireless World

ELECTRONICS, TELEVISION, RADIO, AUDIO

Trade Balance or Imbalance?

"IF these three requirements [quality, price and delivery dates] are not met the Post Office will be forced to look at the alternatives of procurement abroad and the creation of additional manufacturing capacity by the Post Office itself." This was the tough warning given to the industry by Mr. Edward Short, the Postmaster-General, at the annual dinner of the Telecommunication Engineering and Manufacturing Association in London on February 6th. He had said earlier in his strongly worded speech, "I should like to assure you also that we will do all we can to buy British provided we can get it—in time". This clarion call to buy British is all very well, but how much, or how little, of some products is British? Be that as it may, there certainly seems little justification for many of the imports in the field of radio and electronics.

Although in certain sections of our industry the export record is extremely high the curve for imports tends to rise more steeply. Take for instance the capital equipment side. The total given in the Board of Trade "Overseas Trade Accounts" for telecommunications equipment exported in 1967 is £83.3M compared with the previous year's £79.9M. On the debit side, however, we find the figure of £20.2M, and moreover, this represented a 33½% increase, whereas exports rose by only 4%. It is to be hoped that the telecoms industry will rise to the challenge presented by the P.M.G. to avert a still steeper rise in the imports curve. Incidentally, last year's exports included £13M worth of radio communications equipment, an increase of nearly 50% on the previous year.

The balance of trade in this sector of the industry is still healthy, but this cannot be said of, for instance, the domestic equipment side. Again quoting from B.o.T. figures, exports of radio and television receivers, chassis and parts, declined from £7.6M to £6M, whereas imports increased from £6.8M to £9.3M. Incidentally, the total number of transistor receivers and chassis imported last year was 2,452,000 as against 1,718,000 in 1966. A similar picture can be painted of the active component section; the value of semiconductors imported last year rose 10% to £11.37M and exports fell 4% to £2.7M.

The picture is no brighter for valves, tubes, etc., of which last year £7.3M worth were imported (£5.3 in 1966) and £5.1M exported (£5.6 in 1966); nor for the test and measuring instruments—imports rose by £5.2M and exports by £1M.

One is tempted to ask why should there be this general imbalance in our import-export trade? Is it because so many of the "British" companies are in fact subsidiaries or associates of overseas concerns and are therefore dependent on importing the parent company's output for their own "production"? Certainly, by far the highest volume of imports of electrical and electronic equipment comes from the U.S.A. whose share increased by 14% to over £65M last year. Germany's exports to this country stood at £21M last year (a slight decrease), and although the Netherlands came third her share went up by some 60% to over £20M. Although much lower in value it is significant that both Italy and Japan increased their supplies to this country by nearly 50% to £9.3M and £6.3M, respectively.

To go back to our question "why?". Is it our industry's inability to compete in the home market with imported foreign products which are often cheaper and better than the equivalents produced in the U.K.? One reason for this often put forward by economists is the inefficient structure of British industry: too many small manufacturing units making it impossible to achieve economies of scale.

Whatever the cause, we must not only think in terms of the Buy British campaign we must also sell British.

New B.B.C. Monitoring Loudspeaker

1. Design of the low frequency unit

by H. D. Harwood, B.Sc.

An outstanding feature of the B.B.C.'s latest studio monitoring loudspeaker is the 12-inch low frequency unit, which has a performance believed to be superior to that of any known commercial product.

THE studio monitoring loudspeaker at present being used by the B.B.C., type LS5/1A, was developed in 1959 and employs a special 380 mm low-frequency unit and two 58 mm high-frequency units. Although some 250 of these have been built, considerable difficulty has been experienced in securing adequate supplies of low-frequency units which meet the tolerances applied. Yet, in spite of the tightness of these tolerances, comments have been made that the sound quality varies from specimen to specimen. Criticism has also been made of the reproduction, although it is conceded to be better than that of any commercially available loudspeaker.

In view of the difficulty in obtaining low-frequency units of adequate quality and reproducibility, an investigation was started in the B.B.C. Research Department into the possibility of producing a thermoplastic cone and these experiments led to the production of the 305 mm unit described in this article (also in a B.B.C. Monograph¹). The listening tests were so successful that in November 1965 it was decided to commission a new loudspeaker incorporating this unit. It was clear that by employing a 305 mm unit an appreciably smaller cabinet than that of the LS5/1A would suffice, and it was intended that the new loudspeaker should serve both for studios and outside broadcasts.

LIMITATIONS OF EXISTING UNITS

Wide-range loudspeakers, such as are employed for quality monitoring, generally consist of low- and high-frequency units mounted in a cabinet together with a crossover network. In the past colouration[†] has been so prominent in the reproduction from low-frequency units

[†] By colouration is meant a characteristic timbre imparted to the reproduced sound by the loudspeaker; it is believed to arise from excitation of mechanical resonances.



H. D. Harwood, who obtained a physics degree at London University in 1941, started his career in 1938 in electro-acoustics at the N.P.L. There he helped on the first Medresco hearing aid and worked on microphone and loudspeaker calibration. Joining the B.B.C. Research Department in 1947, he has since been engaged on loudspeaker development, microphone calibrations, stereophony requirements and the design of a free field room. He has a number of patents and is author of various B.B.C. Engineering Monographs.

that the choice of unit has been made on the basis of comparative freedom from this effect rather than on that of power-handling capacity. As an example, a 15 in. (380 mm) unit is employed in the type LS3/1A‡ loudspeaker when a unit of smaller diameter would have been chosen if one of the necessary quality could have been found. In addition, owing to the restricted working frequency range of the high-frequency units available, it has been necessary to use low-frequency units beyond the frequency range in which the cone and surround behave as a simple piston, i.e. up to about 500Hz, and into the region in which the amplitude/frequency response is irregular and dependent on the modes of cone resonance and their degree of damping. Furthermore, in existing loudspeaker units the frequency range over which the response is smooth appears, for reasons not fully understood, to be almost independent of cone diameter and from this aspect there is therefore no advantage to be obtained from employing units of smaller diameter.

Cones have generally been made of a paper felt material, but in practice the characteristics of this material, especially the damping coefficient, are not accurately reproducible in large-scale manufacture, and therefore the frequency characteristics are variable in the region of resonance modes. In an effort to improve matters some manufacturers have turned to materials having a higher stiffness to weight ratio than is obtainable with felted paper, the idea being to make the cone so stiff and light that the inevitable resonances lie outside the frequency range of interest. For this purpose expanded polystyrene has been employed, generally with a reinforcing skin of some other material such as aluminium. The results are rather disappointing as resonances are found to occur within the middle-frequency band and by its very construction the cone is of such a high mechanical impedance that it is very difficult to secure adequate damping.

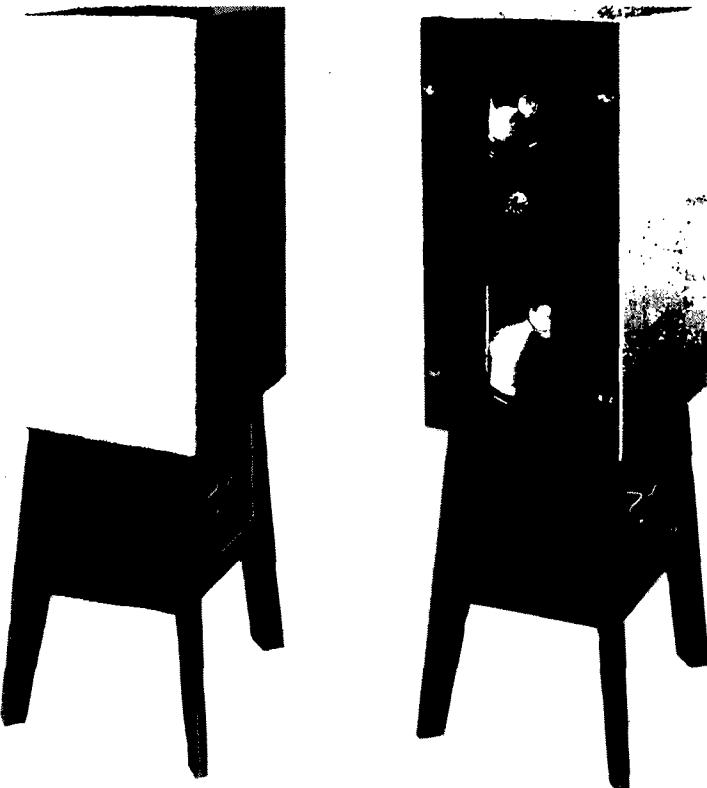
In the B.B.C. the monitoring loudspeakers LS5/1A, LS5/2A,** and LS3/1A all use a special commercial 15 in. (380 mm) diameter low-frequency unit, and have a crossover frequency of about 1,600 Hz, and some difficulty has been found in obtaining units which will meet the B.B.C. test specification in the 500 to 1,600 Hz region where various resonances occur; furthermore, the axial frequency characteristic in this region is not as smooth as could be desired. It was therefore decided to see whether it would be possible to make, for future designs, loudspeaker units which would have more uniform and more reproducible characteristics than those of the type at present in use.

One of the difficulties restricting the development of paper cones has been the fact that the cost of a new mould has been in the region of £200, making experimental procedure very expensive. It was therefore decided to investigate the use of thermoplastic materials which can easily be made into cones by vacuum forming. For this process changes in mould shape and even new moulds can be made quite cheaply and easily; furthermore, as the raw cone material is made in the form of flat sheets, it should be very uniform and repeatable.

It was explained earlier that the existing low-frequency units were chosen on the basis that they were relatively free from colouration

[‡] The LS3/1A is used for outside broadcast monitoring and has a small lightweight cabinet. The design is intended to provide the best compromise between quality and portability.

^{**}The LS5/1A is the normal floor-standing version, while the LS5/2A is designed to hang above picture monitors in television control rooms.



The complete studio monitoring loudspeaker (free-standing version) with and without front cover. It is a three-unit design.

although in fact they were unnecessarily large. It was therefore decided that the new units should be of 12 in. (305 mm) diameter as this size should afford adequate power-handling capacity to meet all requirements. In order to restrict the investigation as much as possible, it was decided to use commercially available chassis and magnet systems, leaving open the choice of voice coil diameter and length, spider constants, and the design of the cone and surround; for the last-mentioned two items, the influence of shape, thickness, and material were to be examined.

CONE MATERIAL

During the period of roughly forty years in which moving-coil loudspeakers have been under development, very little has been published on the various factors which influence the frequency characteristics. One factor which is known,² however, is that cones with straight sides are much more likely to generate subharmonics than those which have curved sides and it was therefore decided to start with a cone shape having slightly curved sides, as shown in Fig. 1(a); the voice coil diameter was 2 in. (50.8 mm).

The primary criterion which was applied to the choice of material was that it should possess a high degree of mechanical damping, for it was argued that since resonance modes were almost certain to occur in the frequency range of interest it was essential that they should be well damped if a uniform frequency characteristic was to be obtained.

The first material to be tried was expanded polythene, which is available in sheet form in various thicknesses from $\frac{1}{16}$ in. (1.6 mm) upwards. This material is very light and is characterized by an extremely high damping coefficient. The first experimental models showed axial frequency characteristics which fell off above 500 Hz owing to insufficient stiffness of the material; this result was not altogether unexpected and steps were taken to stiffen the cone. A coat of polyurethane varnish was applied to each side of the material and as a result the frequency characteristic was extended to about 1 kHz. It will be noted from Fig. 1(a) that there is a sharp bend in the cone shape near the voice coil, and it was thought likely that flexure was taking place at this point. A further mould was therefore made, Fig. 1(b), in which the sharp bend was replaced by a gradual curve, and this resulted in a wider frequency range but the frequency characteristic was rather irregular. Coating the cone again with polyurethane would have improved matters, but as more promising results had in the meantime been obtained with other materials further experiments with this material were abandoned.

Concurrently with the experiments described above, tests were carried out on cones made of 0.02 in. (0.6 mm) thick unplasticized polyvinylchloride (p.v.c.), which is a horny type of material and also with a polystyrene material (Bextrene) of the same thickness which had been toughened by the addition of a synthetic rubber and possessed a higher degree of damping than did the p.v.c. Cones were made with the mould shown in Fig. 1(a), and the frequency characteristics were measured with the units mounted in an enclosed cabinet similar in volume to that of the type LS5/1A loudspeaker. These characteristics are shown in Figs. 2 and 3 respectively. It is evident that the high-frequency range covered was in both cases adequate for the purpose in hand and that the additional damping in the polystyrene was advantageous; further experiments were therefore confined to this material.

All the experiments so far described were made on cones having a surround made of the same material as that of the cone and the irregularities which are seen in Fig. 3 above 500 Hz are due to the presence of resonance modes. The cone can be regarded as a transmission line and resonance modes can occur with the wave motion either in a radial or circumferential direction if it is not properly terminated in a resistive surround. As the required impedance for these two directions is different and the termination must occupy a distance small compared with a wavelength, it will be seen that the problem of designing a good termination is difficult.

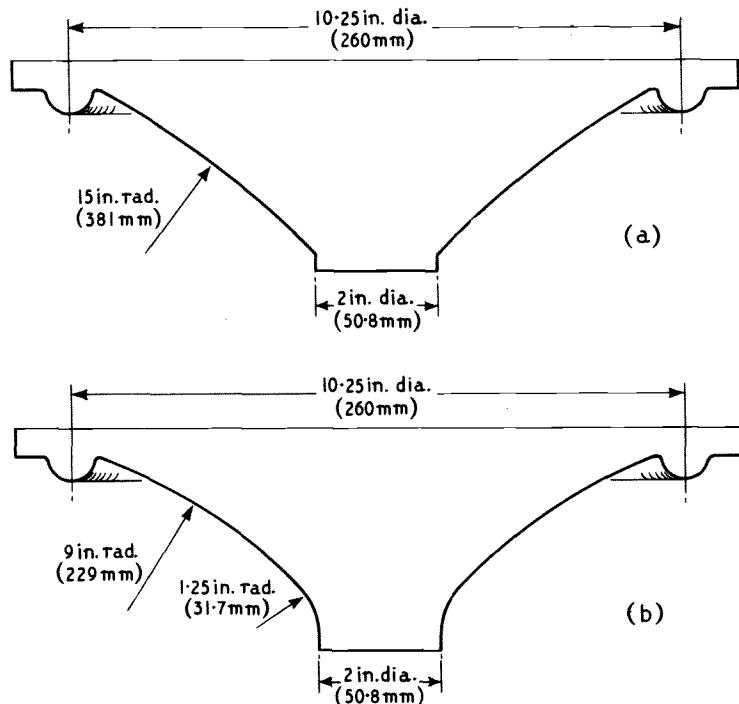
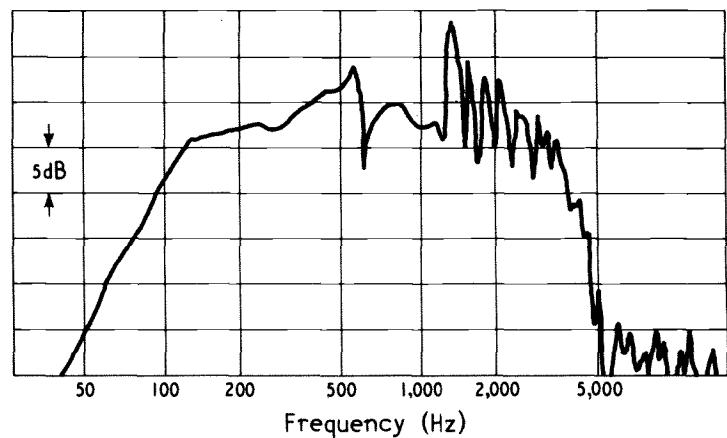


Fig. 1. (a) Shape of first mould; (b) shape of second mould.

Fig. 2. Axial frequency characteristic of unplasticized p.v.c. cone from first mould.



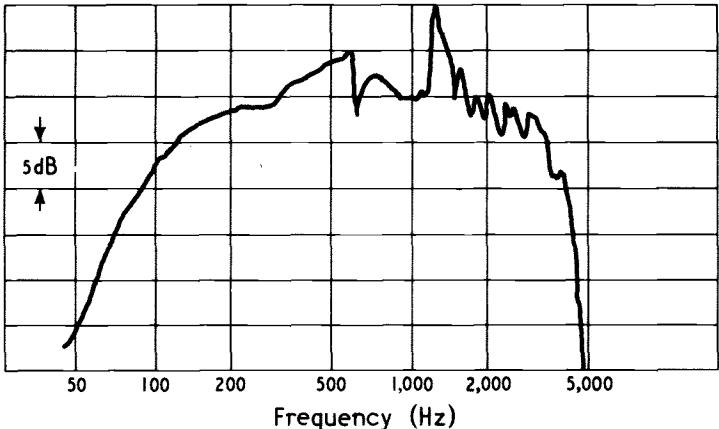


Fig. 3. Axial frequency characteristic of Bextrene cone from first mould.

Fig. 4. Shape of first p.v.c. surround.

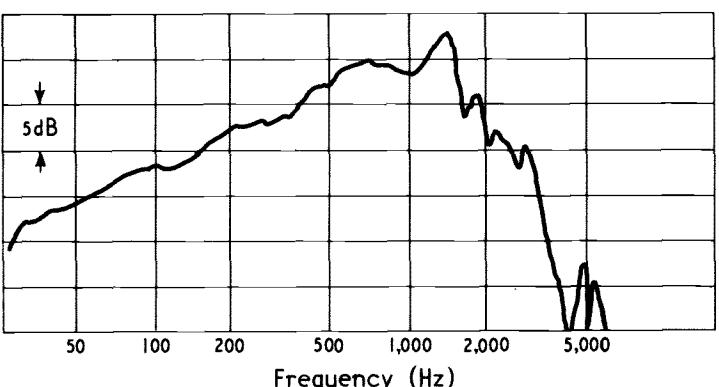
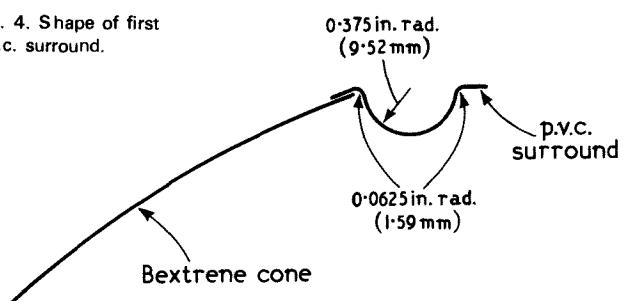


Fig. 5. Axial frequency characteristic of Bextrene cone from first mould. Fig. 1 (a). fitted with p.v.c. surround of shape shown in Fig. 4.

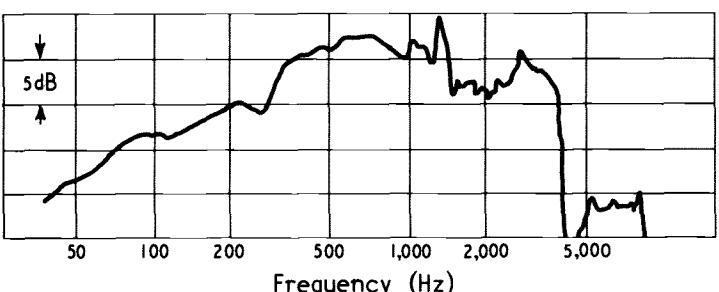
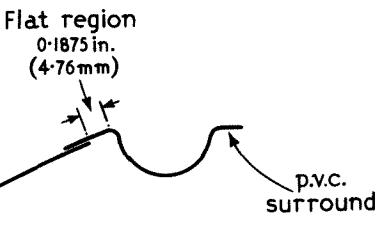


Fig. 6. Axial frequency characteristic of Bextrene cone from second mould. fitted with p.v.c. surround of shape shown in Fig. 4.

Fig. 7. Shape of second p.v.c. surround showing flat region.



The first surround tried was of plasticized p.v.c. 0.02 in. (0.5 mm) thick of the shape shown in Fig. 4, this profile being chosen to allow for fairly large excursions of the cone at low frequencies. The surround was substituted for the integral surround on the polystyrene cone previously used to obtain the curve in Fig. 3 and the resulting axial frequency characteristic is shown in Fig. 5. It will be seen that the curve is considerably smoother than that of Fig. 3 but that the high-frequency response is reduced, probably due to the surround damping out resonance modes; on the other hand, as would be expected, the bass range is extended to lower frequencies. The fact that the axial characteristic rises with frequency is largely due to the directivity increasing with frequency and the concentration of more of the sound energy on the axis. Experiments with a cone material of twice the thickness, i.e. 0.04 in. (1.0 mm), showed that it was possible to recover the high frequency response, but the response was more irregular and the sensitivity lower owing to the greater mass. Cones were then made with 0.02 in. (0.5 mm) material to the second shape mould, Fig. 1(b). As with the polythene material, the change in shape resulted in an increase in the high frequency response, as shown in Fig. 6. The dip in the curve at 250 Hz was thought to be partly due to a circumferential mode and this was checked by stroboscopic examination. Further evidence was obtained by making a cone with a small turnover at the edge; this had the effect of stiffening the cone edge, thereby increasing the Q and producing an increase in the depth of the dip.

The effects of small changes in the shape of the cone and in the diameter of the voice coil were investigated and it was found that neither of these two factors was critical.

A large number of experiments were then carried out, using surrounds of differing materials, thickness, and profile in an attempt to damp out the mode at 250 Hz. It was finally discovered that with a suitable surround material better damping could be obtained if, as shown in Fig. 7, a small flat region was left before the turnover of the surround commenced. This flat region has the effect of introducing a shunt arm, as indicated in Fig. 8, consisting of a resistance and compliance, in parallel with the mass, compliance and resistance of the surround proper. The axial characteristic with this surround, shown in Fig. 9, is appreciably smoother than that obtained from commercial 12 in. (305 mm) units, especially in the region above 500 Hz; the sensitivity is about the same as that of the 15 in. (380 mm) unit referred to earlier. The power-handling capacity and transient response were then tested. Mounted in a closed cabinet, the unit was able to take the full output of a 25-watt amplifier down to 70 Hz without obvious amplitude distortion when the waveform was observed on an oscilloscope. Chopped-tone transient response tests³ showed the unit to be free from serious resonances below 3 kHz.

Four units were then made to check the reproducibility of this form of construction; the axial frequency characteristics did not differ from one another by more than $\pm \frac{1}{2}$ dB from 75 Hz to 1,250 Hz and ± 1 dB from 30 Hz to 2 kHz. It was therefore decided to design a complete loudspeaker employing a unit of this type for the low frequencies and to carry out listening tests.

The cost of materials for the cone and surround is only a few shillings, while the cost of production of these parts is only a small fraction of that of the magnet system. The price of the complete low-frequency unit should be no greater than that of corresponding commercial products.

TESTS

LS5/1A (studio-type loudspeaker).—The 15 in. (380 mm) unit in an LS5/1A loudspeaker was replaced directly by the new 12 in. (305 mm) unit. A slight excess of output in the middle frequencies was corrected by means of a resistor which was originally designed to be adjustable for this purpose. A small dip in the axial response at 1,750 Hz was traced to the effect of the 7 in. (178 mm) wide slot in front of the unit.

LS3/1A (outside-broadcast loudspeaker).—When the 15 in. (380 mm) unit in an LS3/1A loudspeaker was replaced by the new 12 in. (305 mm) unit, the response in the region 400 Hz to 800 Hz was found to be somewhat excessive as with the LS5/1A cabinet. To overcome this, it was found necessary to change the values of several components in the crossover network.

The two loudspeakers described were given listening tests in a listening room at the B.B.C. Research Department using recordings of

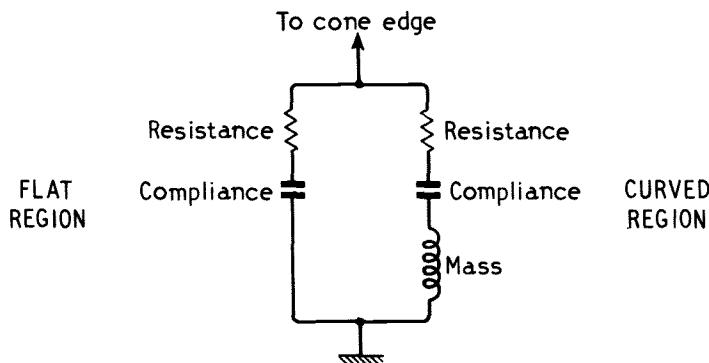


Fig. 8. Mechanical circuit diagram of surround.

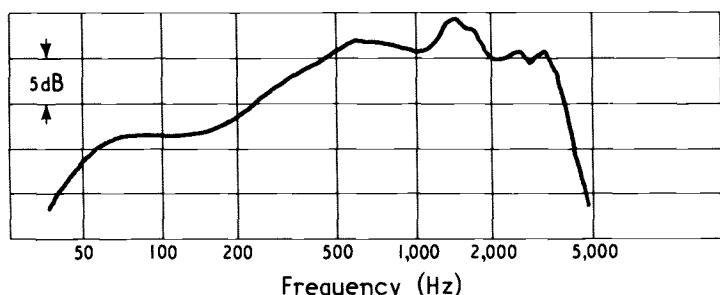


Fig. 9. Axial frequency characteristic of Bextrene cone fitted with p.v.c. surround of the type shown in Fig. 7.

speech from dead surroundings and recorded orchestral items. They were judged to be significantly superior to their LS5/1A and LS3/1A counterparts and were therefore offered for an extended field trial. Reports have been very favourable and in particular comments have been made regarding the freedom from colouration of the bass response compared with the corresponding loudspeakers employing the 15 in. (380 mm) unit.

(Next month: bass equalization and the cabinet).

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1. "The design of a low-frequency unit for monitoring loudspeakers" by H. D. Harwood. B.B.C. Engineering Division Monograph, No. 68, July 1967.
2. "Speaker Design" by J. Q. Tiedje. *Radio Engineering*, N.Y., 16, No. 1, p. 11, 1936.
3. "A Survey of Performance Criteria and Design Considerations for High Quality Monitoring Loudspeakers" by D. E. L. Shorter. *Proc. I.E.E.*, 105, Pt. B, No. 24, Nov. 1958, pp. 607-625.

We understand that KEF Electronics Ltd., who have made B.B.C. monitoring speakers under licence for several years, are arranging to manufacture the new model when field trials are completed and various technical details have been settled. The company say that production of earlier models will also continue.—Ed.

Books Received

Principles of Television Reception by W. Wharton and D. Howorth. A step-by-step tour through a television set in which basic principles are expanded into block diagrams and these into circuit diagrams that are discussed in detail. After dealing with black and white, colour television is then discussed in its various forms (N.T.S.C., PAL, SECAM). This book should be of value to anyone with some knowledge of electronics who wishes to know more about this particular branch. Pp. 296. Price 40s. Sir Isaac Pitman & Sons Ltd., Pitman House, Parker Street, London, W.C.2.

Measuring Hi-Fi Amplifiers by M. Horowitz. Explains the basic principles of high-fidelity amplification and the meanings behind manufacturers' data. A comparison of the various instruments available for measuring performance is made and test set-ups for determining various circuit parameters are described. Pp. 159. Price 25s. W. Foulsham & Co. Ltd., Slough, Bucks.

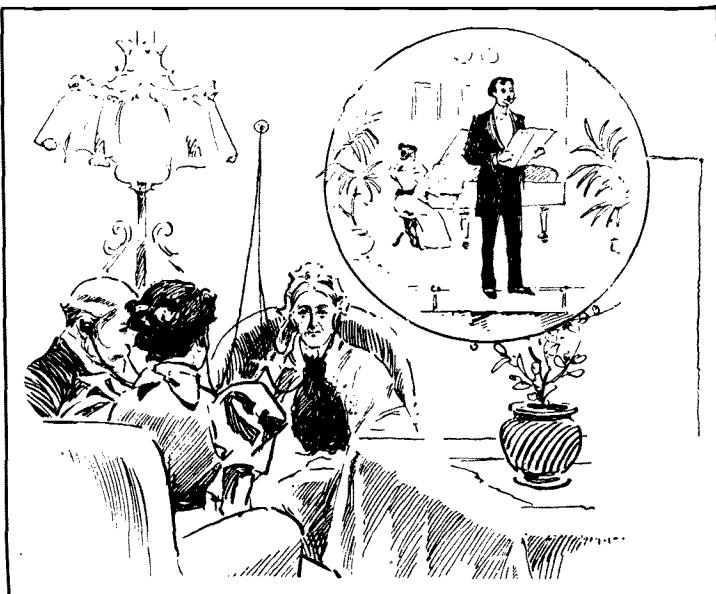
Rapid Servicing of Transistor Equipment by Gordon J. King. Intended for service technicians, students and amateurs, this book provides a guide to the servicing of domestic equipment employing transistors. Initial chapters include theoretical and practical discussions on transistors, how they are biased, operating characteristics and circuitry, signal conditions and testing. The rest of the book is devoted to practical advice on servicing and includes both electrical and mechanical information. Pp. 151. Price 30s. George Newnes Ltd., Tower House, Southampton Street, London, W.C.2.

Mathematics for Electrical Circuit Analysis by D. P. Howson. This book has been written as an introduction to the mathematics required for circuit analysis. Although not complete the material given is thought to be sufficient to cover the needs of second and third year undergraduates taking a light current electrical engineering course. Determinants, matrices and topology to assist in the evaluation of multimesh circuits and the solution of basic differential equations for linear circuits are discussed. Fourier series, Fourier integrals and Laplace transforms are also dealt with. Pp. 170. Price 17s 6d. Pergamon Press, Headington Hill Hall, Oxford.

Sound and Vision by P. E. M. Sharp. This Design Centre Publication is intended for the uninitiated who are about to purchase a radio or television receiver or a high-fidelity system and wish to know something about the subject and what is available. The book commences with a description of the technicalities of radio, television and sound and then proceeds to discuss turntables, pick-ups, pre-amplifiers, amplifiers, tuners, loudspeakers, tape recorders and accessories. Following this radio receivers, radiogramophones and television receivers are discussed. During the course of the descriptions, equipment from a large number of manufacturers is introduced. This, however, is not exhaustive. Pp. 64. Price 7s 6d. MacDonald and Co. (Publishers) Ltd., Gulf House, 2 Portman Street, London, W.1.

Semiconductors—Vol. II. Linear Circuits by E. J. Cassignol. This book, from the Philips Technical Library, is divided into two sections. The first deals with the methods of studying linear circuits and discusses the properties of the semiconductors employed in this application. The second section concerns itself in detail with the practical use of linear circuits employing semiconductors. Separate chapters discuss the l.f. amplifier, the video amplifier, the h.f. amplifier, the power amplifier and the d.c. amplifier. The feedback problem is dealt with and a section is included containing a number of practical exercises. Pp. 337. Price 104s. Macmillan & Co. Ltd., Little Essex Street, London, W.C.2.

Understanding u.h.f. Equipment by John D. Lenk. The first chapter contains answers to a series of questions that, in the author's opinion, is most often asked of instructors in the u.h.f. field. Other chapters contain information on specific items of u.h.f. equipment, circuits and components, the emphasis being placed on fundamentals and basic features. In addition comparisons between this equipment and equipment for lower frequencies is made. In the last chapter test equipment and various techniques that are unique to the u.h.f. and microwave field are described and illustrated. Pp. 144. Price 25s. W. Foulsham & Co. Ltd., Slough, Bucks.



This illustration originally appeared in an article by Arthur Mee on the future of "the pleasure telephone" in the *Strand Magazine* in 1898 and is reproduced in Leslie Baily's "B.B.C. Scrapbooks, Vol. 1, 1896-1914" published by Allen & Unwin, price 40s. In the course of his article Arthur Mee prophetically stated "Patti and Paderevski may yet entertain us in our own drawing-rooms, and the luxuries of princes may be at the command of us all. Who knows but that in time we may sit in our armchairs listening of Her Majesty's Ministers".

Towards Large-Scale Integration

Design and manufacturing techniques in the U.K.

Digital integrated circuits now commercially available include packages which are one stage higher in functional complexity than the first i.cs to appear—complete sub-systems rather than individual logic elements.

A COMPLETE arithmetic unit of a computer on a single chip of silicon a few millimetres square is one of the projects under way at Marconi's, with whom Elliott-Automation Microelectronics Ltd. are now associated*. Performing addition, subtraction, shifting and other operations on 4-bit binary numbers, the unit will consist of 226 inter-connected field-effect devices formed by the m.o.s. (metal-oxide-silicon) integrated-circuit technology on a chip of silicon measuring approximately 3mm x 2.5mm. Some of the field-effect devices will operate as transistors and the remainder as resistors. At the time of going to press the project has reached the stage where a prototype arithmetic unit (using smaller integrated circuits) has been built and proved and the masks for making the m.o.s. chip have been designed.

* See note on D.G. Smeed in "Personalities", January 1968 issue, p. 640. This new British organization has a total investment of £5.6M in microelectronics and employs about 800 people.

This example of a digital sub-system on a single chip is what might reasonably be called "m.s.i."—medium-scale integration, a step on the way to large-scale integration. As yet there is no fixed definition of l.s.i. Some authorities consider it as anything above 1,000 devices (for example m.o.s.ts) on a single chip. Others say that the actual number of devices is not as important a criterion as the functional complexity—the two are not necessarily in proportion—and that you cannot attach a numerical value to it. Yet others apply the description l.s.i. to a hybrid assembly of relatively simple integrated circuits mounted on a film circuit. It all seems to depend on what people mean by "integration".

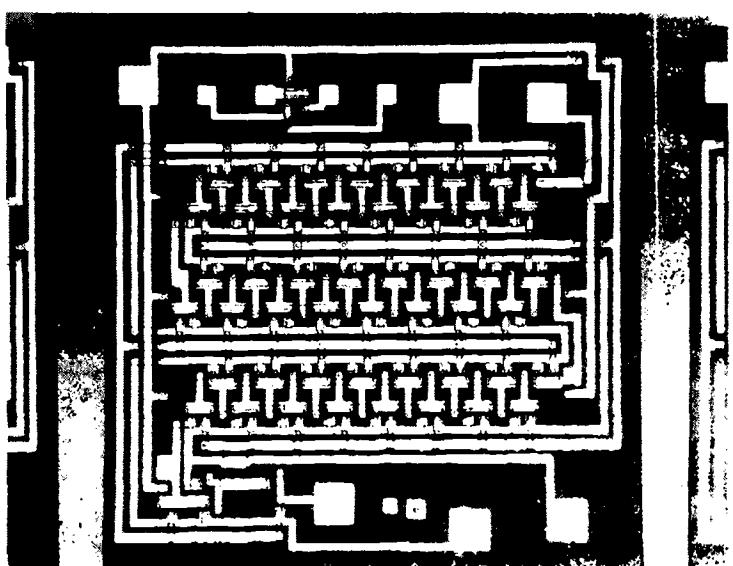
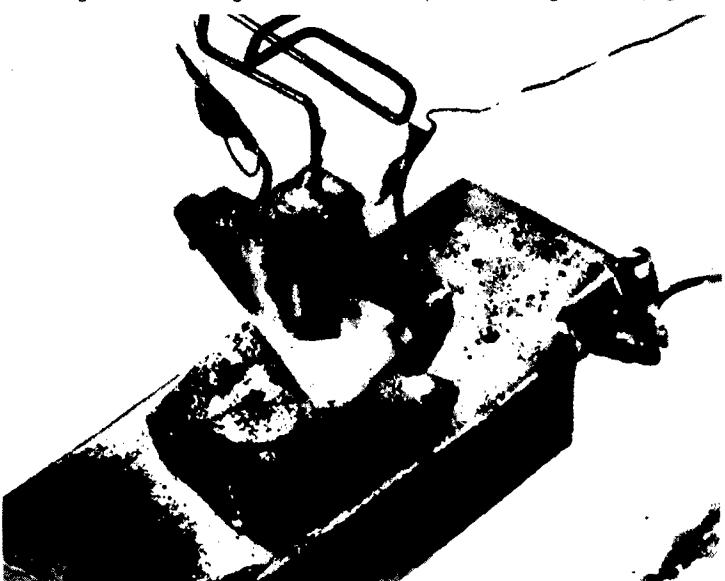
For the present it is perhaps reasonable to think of the more complex i.c. packages now commercially available—containing the equivalent of, say, fifty to several hundred discrete components—as a stage in our progress towards l.s.i. For example, there is the SGS-Fairchild Cu L9989 binary counter, comprising four cascaded flip-flops, which has 32 bipolar transistors and 23 resistors and is presented in a 14-pin dual in-line package. Slightly larger is a Marconi 8-bit static register (using one flip-flop for each bit) which is formed by 88 m.o.s. field-effect devices and is encapsulated in a 40-lead flat-pack. Considerably larger is the

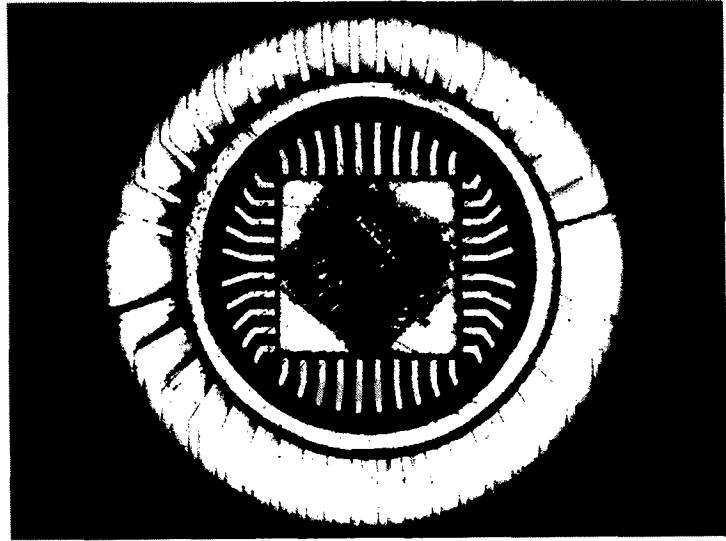
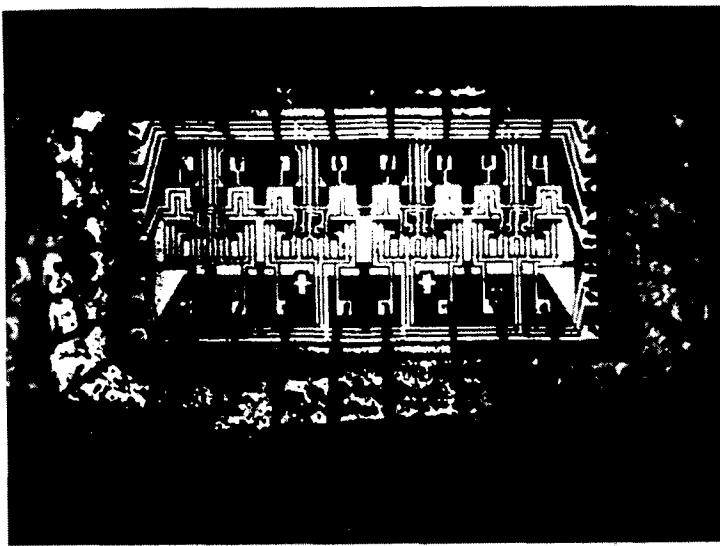
MEM5014 10-bit analogue-to-digital (and digital-to-analogue) converter supplied in a 40-lead package by General Instrument (U.K.), which contains 360 m.o.s. field-effect devices.

It can be seen that such products are really digital sub-systems—one step up in functional complexity from the gates and bistables that were the first elements to appear in integrated circuit form. As with the simpler i.cs, the main benefits to be gained from m.s.i. are greater economy and reliability in the manufacture of electronic equipment. The size reduction is generally an incidental, but may be a positive end in some applications.

While the smaller integrated circuits are being manufactured predominantly in bipolar form, with increasing complexity of circuit the m.o.s. field-effect technology becomes more and more attractive and may eventually be the natural choice for m.s.i. and l.s.i. The two main advantages of m.o.s. over bipolar are: (1) no isolation is needed between adjacent active devices (to prevent the formation of spurious transistors), so that the device packing density on a semiconductor chip can be greater; and (2) manufacturing is simpler, in that fewer masks are required (e.g. four as against eight) and there are fewer handling operations and high temperature processes. Among

How far we have come in 20 years. On the left is the first transistor, geranium point-contact, invented at Bell Telephone Laboratories, U.S.A., and patented in 1948. On the right a Marconi integrated circuit (24-bit dynamic shift register) carrying 150 field-effect devices on a chip of silicon 1.5 mm square.



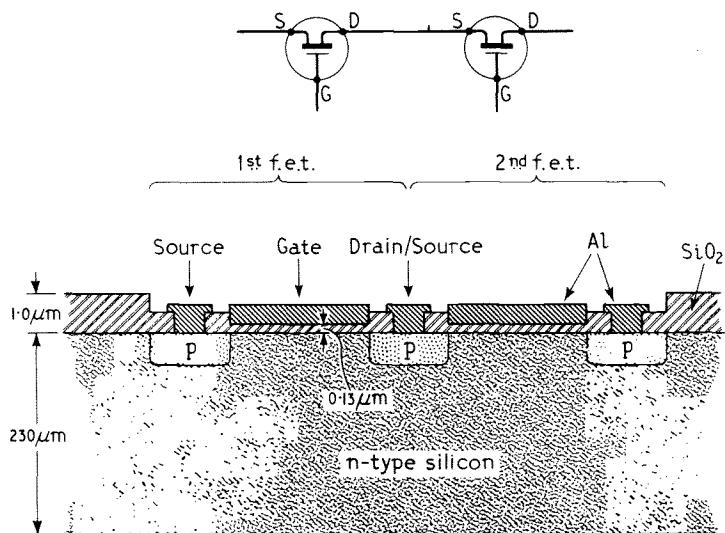


An 8-bit static register in m.o.s. integrated-circuit form, showing (left) the semiconductor chip and (right) two of the registers mounted in a flat pack.



(Left) Using a co-ordinatograph to produce a mask for an m.o.s. integrated circuit.

Fig. 1. Basic structure of a field-effect device in an m.o.s. integrated circuit (not to scale), showing how two of the devices can be easily connected in series by making one p-type region common to both.



The incidental advantages of using m.o.s. field-effect devices is the fact that the gate electrode—oxide insulation—semiconductor structure (see Fig 1) can be used as a capacitance for temporary storage of binary states. Furthermore, not only is isolation between adjacent devices unnecessary but adjacent devices can be economically connected in series (as may be required for a multiple-input gate) by making the drain of one m.o.s.t. serve also as the source of the next m.o.s.t., as shown in Fig. 1. This is possible, of course, because the f.e.t. is electrically a symmetrical device and it doesn't matter which of the two terminal regions in the semiconductor channel is used as the source and which is used as the drain.

Two major problems in making and using the m.o.s. technique are: (a) the manufacturing difficulty of achieving uniformity of threshold voltage (the V_{GS} at which I_D is at a specified low value) in the production of a given i.c.; and (b) the susceptibility of the thin layer of gate-insulation oxide to breakdown by spurious voltage pulses. Marconi say that problem (a) has now been largely overcome. Problem (b) is mitigated in some i.cs by building in special protection diodes or, in others, by forming a thick layer of oxide over the gate contact.

The accompanying photographs show some of the manufacturing processes used by the Marconi and Elliott organizations in the production of m.s.i. circuits—which are little different from those used in the production of smaller integrated circuits. With the m.o.s. technology the first stage is to grow a $1\mu\text{m}$ layer of silicon oxide (precise chemical name, silicon dioxide— SiO_2) on the slices of n-type silicon, which are approximately $230\mu\text{m}$ thick. This is done by passing oxygen over the slices while they are being heated to $1,200^\circ\text{C}$ in an electric furnace.

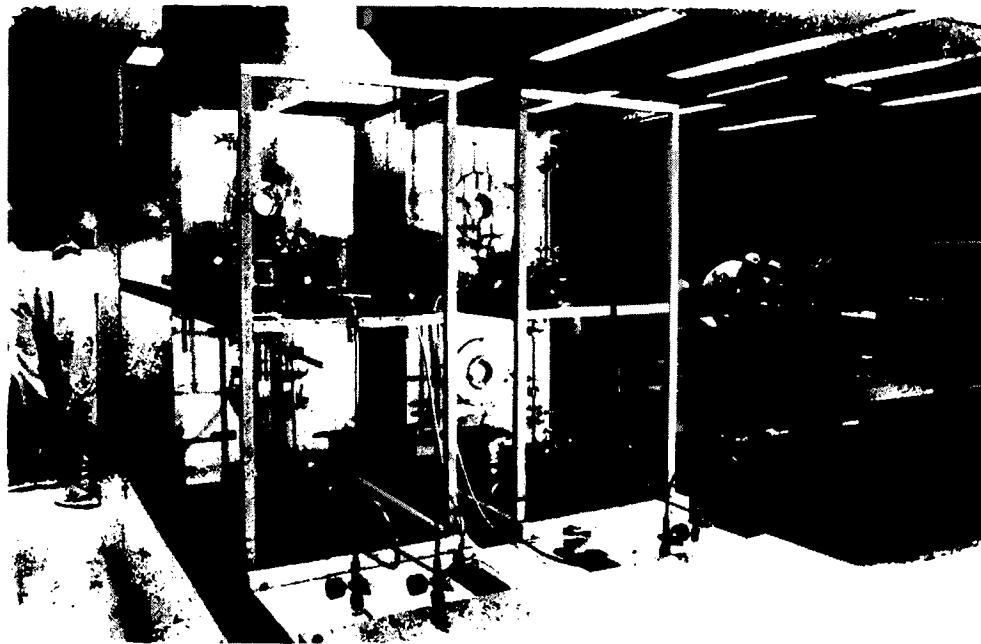
To obtain the type of structure shown in Fig. 1 it is necessary selectively to etch away areas of the oxide coating, diffuse an impurity (boron) into exposed parts of the n-type silicon to form the p-type source and drain, and, finally, evaporate areas of metal film on to the upper surface to form the source, gate and drain contacts and the interconnections between devices. The selective etching is done by a photo-lithographic process. A photo-resist lacquer is applied to the oxide surface, and when this is dry it is exposed through an optical mask to ultra-violet radiation. Where the u.v. passes through the transparent spaces in the mask the photo-resist is hardened—these are the areas *not* to

be etched. Where the u.v. is stopped by the opaque parts of the mask the photo-resist remains in its original soft state—and these are the areas that *are* to be etched. Thus, when the coated slice is immersed in a liquid developer, the soft, unexposed areas are etched and the remainder are left unaffected.

As can be seen from Fig. 1, in some places the oxide is etched away completely to form "windows" through to the silicon, whereas in other places the oxide layer is simply reduced in thickness. This is achieved partly by etching down to different levels, applying the process described above each time, and partly by forming fresh SiO_2 on the silicon exposed by etching. After the necessary "windows" have been etched through to the n-type silicon, the p-type drain and source are introduced by diffusing boron into the surface of the silicon through these "windows". For this purpose the slices are placed in a furnace and a carrier gas containing the boron is passed over them. Finally, the metal contacts, and some of the interconnections, are applied by evaporating a film of aluminium over the entire i.c. and then using the photo-lithography process to etch away the unwanted areas.

Other interconnections between the field-effect devices are provided by "cross-

London Physics Exhibition



Diffusion furnaces in laboratories at Glenrothes, Scotland.



Bonding machine used for making connections to the mounted semiconductor chips.



Testing completed integrated circuits with probes.

"unders" formed within the main body of the silicon and passing beneath the devices. These are channels of high conductivity made by diffusing an impurity into selected parts of the n-type material.

The mask patterns are, of course, designed from the required electronic circuit. Each mask starts in the form of a pattern drawn on paper about 300 times the actual i.c. size. This is then cut into a Mylar sheet, using a co-ordinatograph to transfer co-ordinates of key points from the drawing. From this the final mask is formed, by photo-reduction and photo-lithographic techniques, as a pattern of chromium metal film on a thin glass substrate. Photographic emulsion masks are also used, but the etched chromium film has been found to give better definition.

The manufacturing method outlined above is an example of what is called the "hundred per cent yield" approach. This means that for economical production every device on a chip should be functioning correctly, so that all the chips in a manufactured batch can be used. In practice this ideal is not attained. If only one device on a chip fails to work the whole chip—a complete sub-system—must be scrapped. Of course, the more complex the i.c. the greater the amount of material and processing work that has to be thrown away because of a single device failure. One attempt to combat this problem, called the "discretionary wiring" approach, recognizes at the outset that some non-functioning devices are bound to emerge from the manufacturing processes. A large number of simple circuits—many more than are needed—are produced on a semiconductor wafer, which is then tested. On the basis of the test results, patterns of interconnections are designed which will include only those simple circuits shown to be functioning correctly. Another manufacturing approach is to limit the functional complexity of individual chips but assemble a number of them together to make a hybrid l.s.i. circuit.

FOR the first time foreign concerns are being allowed to participate in the annual Physics Exhibition which opens in the Great Hall of Alexandra Palace, London, N.2, on March 11th for four days. There will be six overseas companies among the 147 exhibitors—two each from the U.S.A. and the Netherlands and one each from Germany and Denmark.

The exhibition, organized by the Institute of Physics & Physical Society, is again of instruments and apparatus mainly at the stages of research or development, rather than commercially available. It will be open each day at 10.00 and will close at 18.00 except on the 13th when it will remain open until 19.30. On the opening day admission prior to 13.00 will be limited to members of the Institute & Society and specially invited guests. Tickets are available free from exhibitors or from the Exhibitions Officer, I.P. & P.S., 47 Belgrave Sq., London, W.1. Applicants are asked to send a stamped addressed envelope ($3\frac{1}{2} \times 5$ in.).

The Exhibition Handbook (which is more than a catalogue of the exhibits; it is a valuable reference book on scientific instruments and apparatus) can be obtained from the I.P. & P.S. for 10s, including postage.

As is usual lectures have been arranged for three afternoons at 15.30. The exhibition organizing committee negotiated with the Soviet Academy of Sciences for a Russian lecturer to speak on the Soviet Space Programme and in particular the successful landing of a probe on Venus. Unfortunately, this was not able to be arranged and therefore Professor R. C. Jennison, of the Department of Physical Electronics, Kent University, will lecture on "The detection of micro-meteorites in space" on the opening day. On the 12th Professor R. L. F. Boyd, of the Department of Physics, University College, London, will lecture on astronomy in space and on the 13th G. E. Perry will talk on "A school satellite tracking station as an aid to the teaching of physics". It may be recalled that Mr. Perry described in *Wireless World* of March last year the Kettering Grammar Schools' activities in tracking Soviet satellites. The lecture will be illustrated with tape recordings made at the station.

At 11.30 each day, except on the 11th, there will be a programme of films in the Alexandra Room. On the 12th will be a $1\frac{1}{2}$ -hour educational programme including a film on positron-electron annihilation. General interest films, including one on NINA the 4GeV electron synchrotron at Daresbury, will be shown on the 13th, and on the 14th the programme comprises five new Mullard films on semiconductors.

“Doctoring” Recorded Sound

Some Techniques Employed in Recording Studios

During the past decade the equipment found in recording studios has increased in both quantity and complexity. The most obvious cause is the advent of stereophonic techniques, but there are other facets of the recording operation which may not be so familiar, and some of these are described here.

Most early stereophonic recordings were on 2-track $\frac{1}{4}$ -inch tape. This is still popular in orthodox work where there are no subsequent operations on the signal. The technique involves the use of two microphones, either laterally spaced or mounted one above the other with their major axes at 90° . It was soon found that while this approach gave excellent results on symphonic and chamber music, it was not really suited to light or popular music, where separate close “miking” of instruments or sections of the orchestra was already established for mono work. If on stereophonic recording sessions a multi-microphone arrangement was used, with some microphones disposed to the left and some to the right, the natural spread of stereo was lost. In fact, the recording was not stereo at all, but a mixture of two mono tracks having no sonic relation to each other. To overcome this “hole in the middle” defect, artificial placing of individual microphone outputs was introduced. This is accomplished by feeding varying percentages of the output of a given microphone channel to the two recording tracks: when the division is 50:50 the sound image appears central between the two loudspeakers. In order to avoid loss of separation between the two tracks, this splitting of a given channel has to be done by separate amplifiers. These became known as cross feed or “pan” amplifiers. This was the beginning of the end for the straightforward simple mixer, for if microphone No 1 was (electronically) positioned midway between left and centre, and echo was added to microphone No. 1, where should the echo go?

Of the two orthodox stereo microphone techniques, the spaced system was more popular in U.S.A., while the 90° pair was favoured in Europe. With the spaced system, difficulty was sometimes found in getting a good centre image, so the Americans decided to fix it firmly in place by putting a third microphone in the middle and giving that microphone a separate track on the tape. For reasons of signal/noise ratio, the tape was enlarged to $\frac{1}{2}$ in. to carry the three tracks. It was not long before the “pop” people saw in the 3-track machine a means of obtaining additional flexibility, as the soloist could be placed alone on the third track and fine adjustments could be made on the subsequent reduction from 3- to 2-track or mono. Nowadays, 4-track working on $\frac{1}{2}$ in. or 1in. tape is gaining popularity, while some small studios accommodate large numbers of musicians by recording successively on tracks 1-4, or even up to 8 tracks in some cases.

Such multiple work inevitably worsens the overall signal/noise ratio, while in the classical field the noise levels of microphones, amplifiers etc. have dropped below that of the tape itself. An ingenious method of overcoming this, patented and marketed by Elektromess-technik (Studer), is known as the “NoisEx” system. Briefly, the dynamic range of the signal going on to the tape is compressed so as to utilize the optimum recording level for signal/noise ratio. On playback, the output from the tape machine is fed into an expander unit whose characteristics are a mirror image of those of the compressor. It is claimed that the distortions previously inherent in such a system have been overcome so that it is impossible to detect that the units are operating.

The limiter has come in for a lot of criticism (as has also the compressor), mainly because of unpleasant effects produced by its misuse. A limiter may be used to prevent overloading of the tape or

disc, such as may occur with “pop” singers given to sudden violent shouts, or when recording a public performance or outdoor event where there may be unexpected jumps in level. Alternatively, it may be used as a “ducking” limiter. Some producers of “pop” records want everything (e.g. backing instruments, backing voices, solo voices) “up at the front”. This can be accomplished by using a limiter in the “backing” channel with means for controlling it from a separate “solo voice” sound channel. With no solo voice, the backing is set to record at full level. When the solo voice comes in, it feeds directly to the tape and also to the limiter control circuit. As a result the backing is automatically attenuated below the voice level by a predetermined amount, but the solo voice is not injected into the backing channel at this point. There may, of course, be an additional limiter in the solo voice channel, as mentioned above.

Most modern studio mixers incorporate variable bass and top controls in each channel prior to mixing. These often take the form of the well known Baxandall circuit*. Provision is made for the insertion of more complex filter and equalizer units (generally known as “cookers”) into any channel between the output of the microphone amplifier and the mixing control. Apart from “step” circuits and high- or low-pass filters, provision is often made for holes, or peaks, of varying width, depth (or height) and frequency.

When additional reverberation (or echo) was first introduced it was provided by feeding a portion of the signal into a loudspeaker placed in an empty, hard-walled, room where a microphone picked up the resultant sound and fed it back to the mixer. Cellars and other small rooms were used for this, but the method required a lot of space. A highly satisfactory artificial means is the echo plate—a sheet of tinned steel which is excited acoustically and which yields the closest approach to the random decay pattern of the ideal echo chamber. In addition, the period of reverberation may be altered by proximity dampers, motor driven and controlled from the mixing desk.

The disc record is still the eventual form of most work done in the studio. The moving-iron cutter head, apart from the B.B.C. design, has largely been displaced by the moving-coil type. A notable advance was made by Fonofilm Industri (Ortofon) when they built a moving-coil head with a second winding delivering 40 dB of feedback voltage derived directly from the motion of the cutter (as opposed to flux linkage from the drive coil). It is not at all difficult to achieve a signal/noise ratio of 60 dB on a disc, which is beyond the capability of most tape systems (but see “NoisEx” above); in fact, a saying frequently heard in disc cutting rooms is: “I can put it on: can you get it off?” Only a few very expensive pickups can reproduce the highest cuttable level without severe distortion. Trouble usually begins with the high accelerations produced by the top lift of the recording characteristic, aggravated by close microphone positions and/or cymbal clashes, etc. Some of these extremely high levels can damage a stereo cutting head, although not usually a mono head. This is because in most mono heads the coil movement is pivotal, while the coils in a stereo head are displaced en masse, thereby consuming more current.

The answer here is a form of occasional and selective top cut, preferably inaudible in action. One unit which meets these demands is the Ortofon “dynamic filter”. In this the signal is fed to a frequency weighting network, the output of which is rectified and fed to the primary of a transformer. The permeability of the transformer core is affected by the d.c. field produced by the primary, and this, in turn, varies the inductance of the secondary winding. The secondary is connected in a passive low-pass filter network, the response of which varies with the inductance. The limiter is set to operate at a predetermined point (e.g. the overload point of the cutterhead) and any excessive top levels are reduced to the safe level, the remainder of the programme being passed through “flat”. An extension of this principle is used in the Fairchild “Dynaliser” unit and the R.C.A. “Dynagroove” process, in which our old friends the Fletcher-Munson curves play a prominent part.

It is perhaps worth emphasizing that the various techniques described above do not render the engineer superfluous: on the contrary, the opportunities for mis-use are greater than ever and all the skill of the engineer is needed to prevent a diabolical mess.—D.W.S.

* “Negative Feedback Tone Control” by P. J. Baxandall *Wireless World*, October 1952, pp 402-405

Electronics in Concorde

U.K. Contribution to the Navigation, Communication, Flight Control and Other Electronic Systems

AIRCRAFT less modern than the *Concorde* can be considered to be divided into a large number of clearly defined subsystems, in which computations of drift, track, attitude, airspeed and the like are carried out many times over to differing degrees of accuracy. The penalty for this approach is felt in terms of weight and cost, although, from the servicing point of view, there is the advantage that each equipment is virtually self-contained. In *Concorde* all major computations are carried out centrally, the results being electrically signalled to the various systems, and no really clear demarcation line exists between the different equipments.

Concorde is described as a low-wing monoplane with a slender delta wing planform. The airframe is largely constructed from a high temperature aluminium alloy although localized use is made of steel and titanium alloys at isolated "hot spots". Incidentally the nose cone reaches a temperature of 153°C and the main bulk of the fuselage 117°C

during supersonic flight. Highly stressed mechanical components in the structure have been milled from solid blocks of alloy using numerically controlled machine tools. *Concorde* has a wing-span of 83ft 10in., a length of 184ft 6in. and the height to the top of the fin is 38ft. The maximum cruising speed depends on ambient temperature and has a limit of mach 2.2 at around 55,000ft. All-up weight is 326,000lb.

DESIGN APPROACH

Aircraft system designers of today are, in the main, presented with four possible approaches—simplex, duplex, duplicate monitored and triplex. Each method has its advantages and disadvantages in terms of safety (including reliability), weight and cost. The simplex approach consists of having only one set of equipment. Any failure results in either the equipment ceasing to function or in an erroneous output. It is up to the crew to

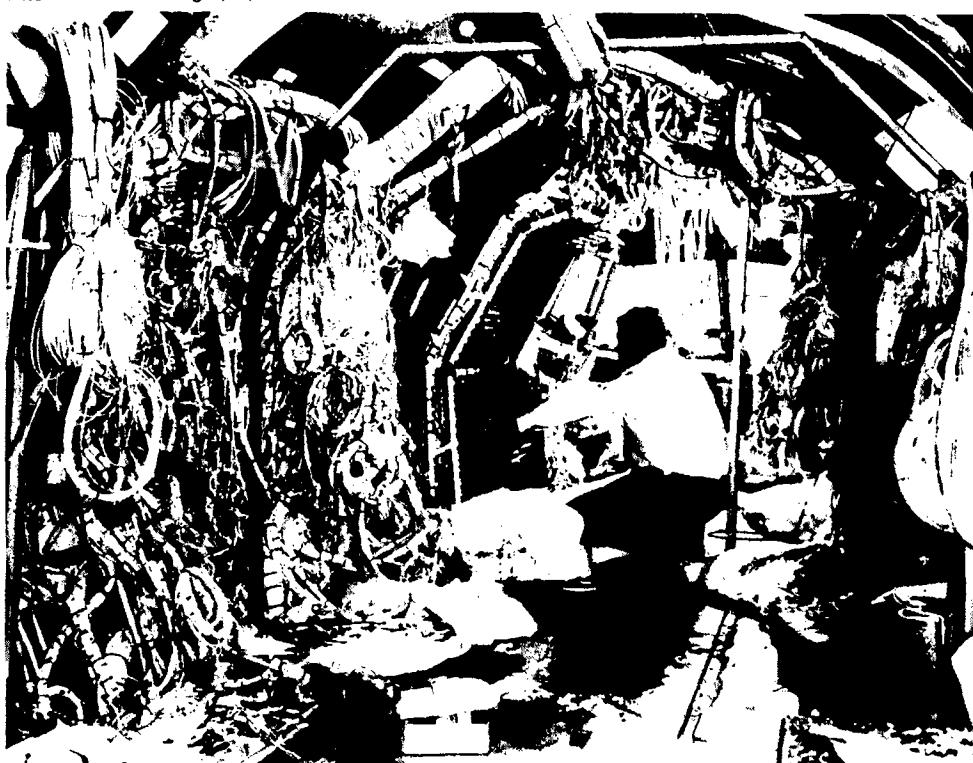
correct the effect on the aircraft of the faulty information and to take over manually from the failed equipment. Two complete sets of equipment, operating in unison, are used in a duplex system. A failure in either set will result in conflicting outputs, causing, by means of a comparator, both equipments to switch off before the incorrect output has any effect on the aircraft. It is once again left to the crew to take over the function of the failed equipment. In the duplicate monitored system two sets of equipment are again employed but a series of monitors and comparators is fitted to each set. Although both equipments are operating continuously, at any given time only one has any authority over the aircraft. Should a fault occur in a particular channel this is detected by the monitor/comparator complex and results in the serviceable equipment being given authority. In the event of the second channel failing as well it is automatically switched out before any effect is felt on the aircraft. Such a system is said to be "fail-operative" and "fail-soft". The triplex system employs three sets of equipments operating on a majority vote basis: a different answer from one equipment results in its being switched out. From then on the system operates as described for the duplex method. It must be stated that the above is a gross oversimplification, considerable differences arising in equipments from the various manufacturers.

The main contractors in the *Concorde* project, British Aircraft Corporation and the French company Sud-Aviation, decided to employ the duplicate monitored principle for the majority of *Concorde's* control systems. Using this technique results in the aircraft carrying about two-and-a-half times more equipment than a simplex equipped aircraft.

NAVIGATION

The degree of automation of the navigational equipment is such that *Concorde* does not carry a navigator, this function being performed by the pilots. Because of the long periods of acceleration and deceleration and other factors peculiar to this type of aircraft, conventional vertical gyroscopes are unsuitable as a basis for flight control and driving of instrument displays. Inertial platforms coupled to digital computers are therefore used as the central navigational element. An inertial platform can best be

Not really an electrician's nightmare but the flight deck wiring of *Concorde* prototype 002 being built at B.A.C.'s Filton Division. A large proportion of the cables have been supplied by British Insulated Callenders Cables Ltd.



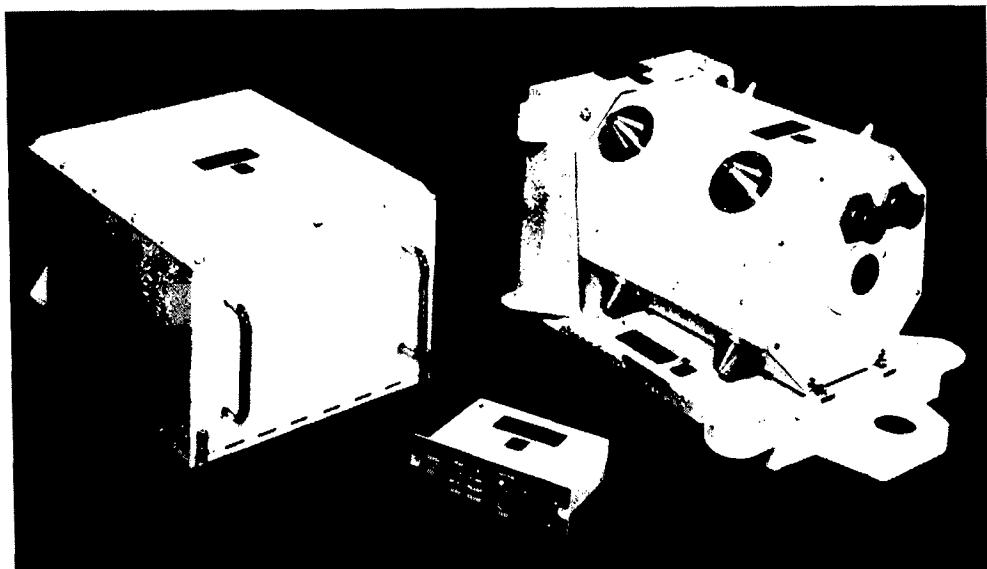
described as a platform with three degrees of spatial freedom gyroscopically stabilized relative to space but tied to the earth (as will be explained). Such a platform is said to be operating in a Schuler tuned mode. Schuler stated that a pendulum with a length equal to one earth's radius suspended with its mass at the exact centre of the earth could not be set into motion by accelerating one end. An inertial platform is stabilized relative to space using three extremely accurate, low drift, flotation gyroscopes. Digital computers calculate the corrections that have to be applied to the platform to modify the space stabilization in such a way as to keep the Z axis (vertical) pointing directly at the earth's centre and the X and Y axes pointing east /west and north/south respectively. The correction terms applied to the platform are complex and must take into account the aircraft's position over the earth's surface, the relative movements of the earth and the aircraft, the earth's curvature, centripetal force etc. The platform operating in this mode can be considered to be similar to Schuler's imaginary pendulum and is therefore unaffected by acceleration and deceleration forces.

Because the platform is stabilized in this way any movement of the aircraft is relative to the platform; this is detected by sensors and the resulting electrical signals are a measure of the aircraft's attitude relative to the earth's surface.

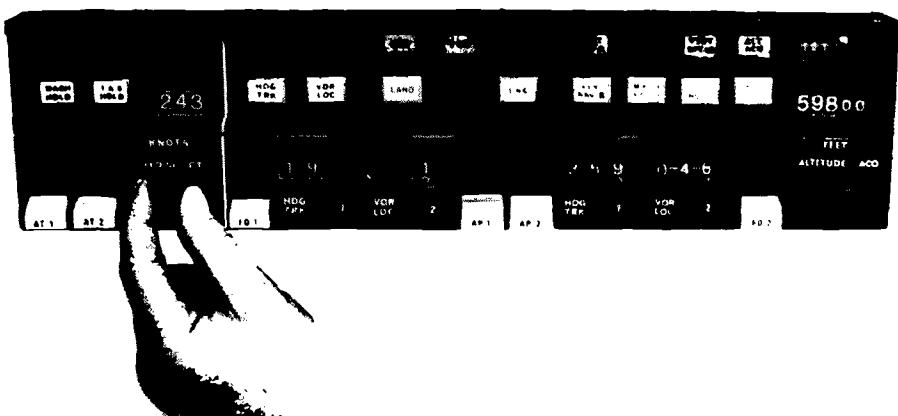
Newton's laws of motion are exploited in an inertial platform by fitting three accelerometers with electrical sensors to it. These accelerometers are orthogonally mounted (one in each axis) and their outputs can be integrated to give velocity and integrated again to provide distance flown in a given direction. From the foregoing it can be seen that an inertial platform provides a great deal of the information that is vital to navigation.

The prototype *Concorde*s will carry two inertial platforms, although it is thought that three may be fitted to the first production aircraft. The navigation system to be described here is as used in the prototypes and has been developed by a consortium formed by Ferranti (U.K.) and SAGEM of France. The navigation system provides the pilot with the following information: the position of the aircraft in terms of latitude and longitude; the position of the aircraft relative to the desired route (this route is decided upon before take-off and can be modified at any time by the crew); and the estimated time of arrival at a number of reference points along this route.

The major components in the navigation system are the two previously discussed inertial platforms with associated digital computing facilities, an automatic chart display and control panel. The automatic chart display has been entirely developed by Ferranti and provides an interface allowing two-way man/machine communication. It contains a 35 mm colour film 30 feet long that can store charts covering an area 8,000 × 2,000 nautical miles at a scale of 1:2,000,000, plus two areas of 1,000 × 2,000 nautical miles at a scale of 1:500,000 for airport terminal areas. The charts are back projected on to a screen eight inches in diameter. If required, up to 100 data sheets (approach charts, tables of frequencies,



Inertial platform, control panel and associated equipment supplied by Ferranti for the prototype.



The automatic flight system control panel fitted to pre-production aircraft. The prototype aircraft are being equipped with a more conventional selector switch type of control panel.

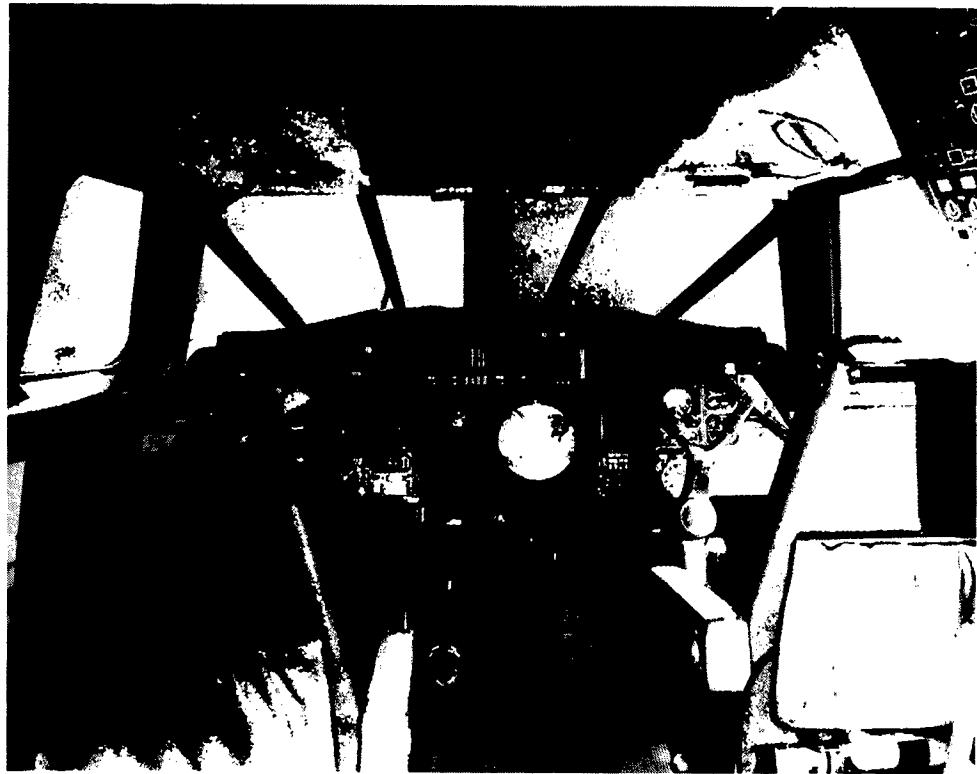
procedures, check lists, etc.) can be displayed on this screen. The present aircraft position is superimposed on the projected chart and can be in the centre of the screen or near the bottom to give a greater view ahead. The pilot can select either track or north orientation; with track orientation selected the aircraft's track always points to the top of the screen and as the aircraft turns the chart rotates. When north orientation is selected north always appears uppermost; in this case, as the aircraft turns the display's track pointer rotates.

Typically, in terminal areas, the chart will be north orientated, with the present position indicated centrally; in en route areas track orientation would be used with the present position marker offset. In the event of it being necessary to change the flight plan while airborne, because of weather conditions or some other factor, the chart is driven to bring the new destination to the centre of the screen using a joy-stick control, a button is pressed and the co-ordinates of the new destination will have been entered in the computer. The position outputs of both inertial navigators can be displayed simultaneously and in the event of a discrepancy the erring system can be corrected. V.O.R./D.M.E. (V.h.f. Omni-directional

Range/Distance Measuring Equipment) outputs also may be superimposed on the display face, among other things enabling the internal navigation equipments to be checked against them. The navigation computers also provide outputs for the automatic pilot to enable the aircraft to automatically fly along the predetermined flight path or along the flight path as modified by the pilot's manipulation of the automatic chart display. The inertial platforms, via servo-repeater systems, provide outputs of heading, attitude, velocity and vertical acceleration for use by other equipments in the aircraft. The charts for the display are being produced by International Aeradio Ltd. and some are sixteen feet long and twenty inches wide. A big problem is going to be keeping them up to date with changing air traffic control requirements.

RADIO AND RADAR AIDS

In the Marconi doppler radar system used in *Concorde* four beams are employed with a time sharing technique. The doppler shift of each beam is measured by comparing it with a sample of the transmitted signal and the aerial is servo driven in both vertical and



The prototype flight deck mockup. The Ferranti automatic chart display can be seen in the lower left of the centre instrument panel next to the weather radar. Just below these, on the control console, is the automatic flight control panel, and just above the windscreen is the combined automatic stabilizer/artificial feel control panel. The large instrument containing a white semicircle in the centre of the side panels is the flight director.

horizontal planes until all four beams are experiencing the same amount of doppler shift. In this way the aerial is aligned with the velocity vector of the aircraft. Ground speed is obtained by measuring the amount of doppler shift, and the drift angle is obtained by comparing the fore and aft axis of the aerial with that of the aircraft. A major difficulty with a pure c.w. doppler system is caused by cross-coupling between the transmitting and receiving sections of the aerial array. Mechanical vibration also causes spurious modulation of the transmitted signal, making discrimination between this unwanted modulation and the doppler signal a difficult task. Frequency modulation is used in the *Concorde*, enabling the receiver to be made insensitive to cross-coupling and near echoes from the radome and airframe. Because the signal path from the transmitter aerial to the receiver aerial is very short the phase of the modulation on the cross-coupled signal will be practically identical to that of the transmitted signal. By mixing a sample of the transmitter signal with the received signal the receiver output can be made zero. Returns from the ground will reach the receiver after some delay, with a consequent phase difference relative to the transmitted signal. The product of mixing these signals will result in a spectrum centred on zero and sidebands on either side with a spacing equal to the modulation frequency, all sidebands being subjected to doppler shift.

The sideband power falls to zero whenever the delay between transmitting and receiving the signal is equal to one cycle of the modulation frequency, these delays corresponding to critical altitudes. If a fan-shaped aerial beam is used, returns from the ground will be subjected to a wide range of different delays and the signal strength will

seldom fall below a working level. However, signals received at near critical altitudes will have their spectra distorted, giving a false centre frequency and inaccurate speed information. To overcome this effect the modulation frequency is swept at 8 Hz between 340 and 460 kHz, causing the positions of the critical altitudes to vary and the error to average out.

In use the control unit indicates the mileage flown along the required track and an associated counter indicates the miles flown across this track, away from the required course. This information is obtained from a computer that receives aircraft heading from the navigation system, adds it to the "doppler" drift to obtain aircraft track and compares this with the required track to arrive at a track error signal. This signal together with "doppler" ground speed is fed into a mechanical ball resolver which provides outputs in terms of distance flown along and across the desired track. A signal proportional to the position of the across-track counter is available for feeding to the automatic flight control system or the navigation system if required.

The d.m.e. interrogator continuously measures the slant range distance between the aircraft and a selected ground beacon within a range of 197 nautical miles. This information is combined with aircraft heading to accurately fix the aircraft's position. The interrogator operates in conjunction with VORTAC (V.h.f. Omni-directional Range TACTical) and TACAN (TACTical Air Navigation) ground stations. Once the desired frequency has been set up on the v.h.f./navigation controller, pairs of interrogating pulses are automatically transmitted to the assigned radio beacon. The ground station, on receiving the pulse pair, replies

with a return pulse pair which is in turn received by the aircraft. By measuring the time elapsing between transmitting and receiving a reply, the aircraft equipment can compute the distance of the beacon. Should the signal be lost the equipment will continue to function in a memory mode for ten seconds, after which the interrogator initiates a "search" procedure. The transmitter provides a pulse of 1.24 kW and operates in 1 MHz steps between 1025 and 1150 MHz, and the receiver has 252 channels between 962 to 1213 MHz; the 6 dB bandwidth is 340 kHz. This equipment is being manufactured under licence from the Radio Corporation of America by Marconi's.

The weather radar for *Concorde*, manufactured by Ekco Electronics Ltd., will be used to detect stormy weather conditions in the aircraft's flight path. When such conditions are detected a new course is decided upon, the details of which are read into the navigation system via the automatic chart display. If the aircraft is being flown by automatic pilot, the navigation system will supply the automatic pilot with this information and the storm will be safely bypassed. This radar operates in the X-band at 9345 MHz; the transmitted pulse length is 6 μ s (65 kW peak) and the repetition frequency is 200 Hz; the range is 360 nautical miles (pre-production aircraft only). Each channel of the dual system carries its own transmitter-receiver, indicator and aerial stabilization system although there is a common waveguide run from the waveguide switch to the aerial.

The weather radar is one of the large number of instruments in the cockpit that can command only a small portion of the pilots' attention. When negotiating a storm this presents no problem as it becomes a prime instrument and is continuously monitored. In flight phases where the crew work load is high and weather problems are not expected, the weather radar would tend to become neglected. To overcome this problem the weather radar is arranged to continuously scan a 20 degree sector 200 miles in front of the aircraft irrespective of the setting of the indicator range scale. In the event of a target being spotted the pilot's attention is drawn to the weather radar by an "alert" indicator.

AUTOMATIC FLYING CONTROLS

After take-off *Concorde* will climb subsonically to some 40,000ft under the control of a flight director that computes the optimum climb-out path for existing conditions and air traffic control requirements. Preparation would then be made to accelerate to supersonic speed, continuing the climb until cruising altitude is reached. At supersonic speeds the aerodynamic centre of pressure moves back along the airframe, causing the aircraft to adopt a nose down attitude. To help compensate for this a computed amount of fuel is transferred from the main tanks to a rear trim tank. However, the amount of nose down tendency is a function of mach number, which is not a constant, so, clearly, a further correction is required. This could be left to the automatic pilot but

this is inadvisable for two reasons; first, the autopilot would be called upon to make a "useless" constant correction, and secondly, in the event of the automatic pilot failing the amount of correction applied would suddenly be removed, resulting in a violent change in pitch attitude. To overcome this difficulty a system has been developed known as electric trim that has three functions: it allows the pilots to electrically signal pitch trim changes; it alters trim as a function of mach number; and it relieves any pressure on the automatic pilot by sensing any constant trim being applied in pitch and correcting for it.

Aircraft tend to oscillate in all three axes by an amount determined by the aerodynamic design, air speed, altitude, etc., and it would be very tiring for the pilot, or unnecessary work for the automatic pilot, if these oscillations were allowed to go undamped. The automatic flight stabilization system employed to make these corrections uses a total of six rate gyroscopes actuating the flying controls via servo systems. A rate gyroscope is either electrically or mechanically spring restrained and has an output proportional to the rate, as opposed to the amount, of displacement. It will be realized that such a system will try to oppose any deliberate manoeuvres. However, the system has only limited authority and acts as an efficient damping mechanism.

The lateral and longitudinal control channels of the automatic pilots are completely separated and each automatic pilot is supplied with information from independent sources. A single control panel is employed for the automatic pilots, the automatic throttle systems and the flight director system. The required function is selected and a choice is made between automatic pilot and flight director. If the last-mentioned is chosen the pilot controls the aircraft in response to visual guidance information presented by the flight director. In the former case the function is carried out automatically. This would seem to imply that the functions available using the automatic pilot or the flight director system are identical. This is the case, with one exception which occurs when the automatic pilot is switched to "manual". Under these conditions the aircraft will maintain the attitude existing at the time of engagement, the attitude references being supplied by the inertial platforms. Other functions provided by the flight system in the longitudinal axis are: altitude hold, mach and airspeed hold, vertical speed hold and altitude capture. For the first three functions, if selected, the aircraft will hold each condition as it existed at the time of engagement. Altitude, mach and airspeed references are obtained from an air data computer. The altitude capture facility allows the pilot to preselect any required altitude; when the aircraft reaches this height the flight system reverts to the altitude hold mode. Automatic vertical navigation is also possible, and in this case the automatic pilot/flight director follows information provided by a vertical navigation computer.

In the lateral axis the manual and heading functions of the flight system are self-explanatory in the light of what has already been said. Lateral navigation may be selected and in this case the flight system responds to

information received from the navigational computer. The signals used are track error and rate of change of error with respect to the programme stored in the navigational computer.

A VOR/LOC mode is available that captures and holds a VOR or localizer beam, the capture angle being selected by the pilot.

The automatic pilot is capable of carrying out landings in Category 3a conditions (visibility insufficient to land manually but good enough to steer the aircraft on the runway). The autopilot will hold the aircraft on the localizer and glide path beams and will initiate the flare and land sequence as indicated by the radio altimeter. Should it be decided to abort the landing, pushing the throttle forward will put the flight system into the "go around" mode. This disengages the automatic throttle system and causes the take-off director computer and the flight director computer to provide guidance information that ensures that a safe overshoot path is followed.

The automatic throttle system controls engine r.p.m. so that the mach number or airspeed existing on engagement is maintained, or alternatively, the desired airspeed can be pre-selected. The system obtains reference airspeed and mach number from the air data computers and a longitudinal term from the inertial platforms.

The control panel for the automatic flight control system represents a departure from standard aeronautical techniques in that push-button selector switches have been employed for mode selection; this practice has been frowned upon in the past on the grounds of reliability. Integrated circuit protection logic has been designed to work in conjunction with the push-buttons that will lock out a faulty mode even if the associated selector button is jammed in the "on" position.

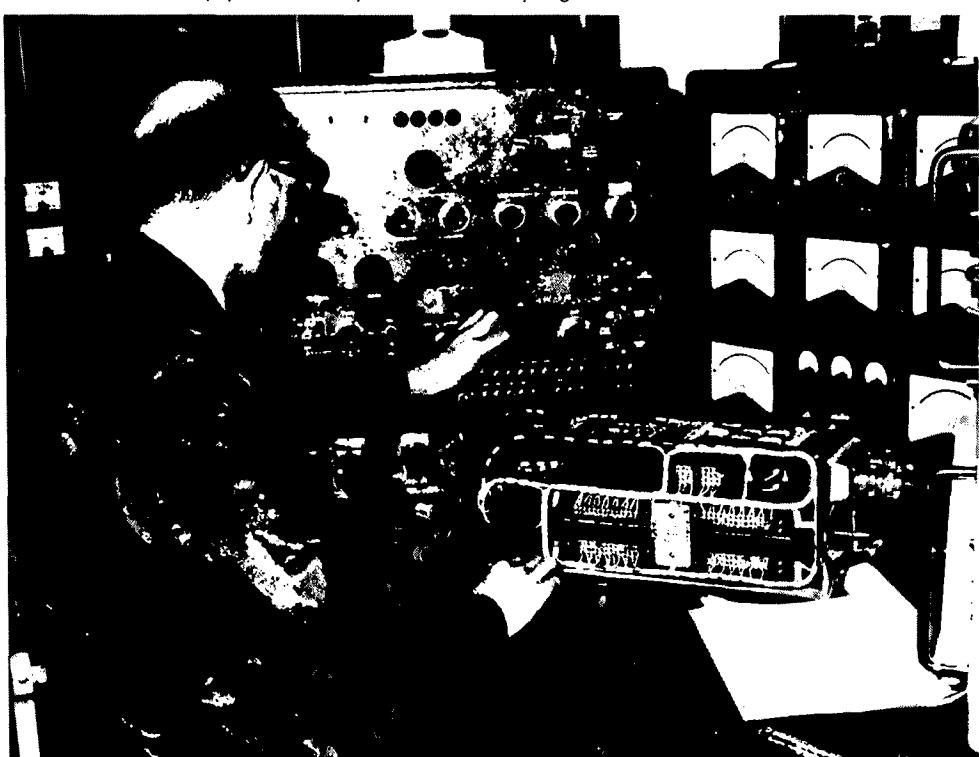
The automatic flight system described has been designed by a consortium including Société Française D'Equipment pour la Navigation Aérienne (S.F.E.N.A.) and the Navigation and Control Division of the Bendix Corporation of America headed by Elliott Brothers as prime contractors.

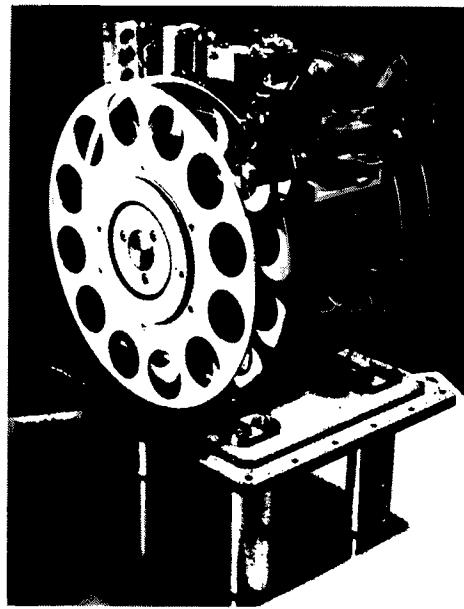
COMMUNICATIONS

Airborne selective calling units, known as Selcal, are used to relieve the crew of the continuous and tiresome task of aurally monitoring the radio communications channels. To this end each aircraft is given a four-letter code, each letter corresponding to one of twelve audio tones. This code is set in on the front of the Selcal unit using two pairs of knobs which select tuned reeds. The ground station transmits a two-pulse code signal, each pulse containing two audio frequency tones in the band 312.6 to 977.2 Hz. The aircraft receives these tones and applies them to the Selcal unit, where, after amplification they are applied to the tuned reeds. In the called aircraft all four reeds will vibrate and the appropriate warning will be given to the crew.

Collins Radio Company are supplying the h.f. transceivers. These are s.s.b. equipments for long range voice, c.w., data or compatible a.m. communications in the 2.0 to 29.999 MHz frequency range. Tuning is automatic in 1 kHz steps by means of an operator's remote control box, the operating frequency being displayed digitally. Nominal transmitter power is 400 watts p.e.p. in s.s.b. or 125 watts in compatible a.m. All injections to both the transmitter and receiver are phase locked to an internal frequency standard with a stability of 0.8 parts per million per month. Channel selection time is eight seconds. The receiver sensitivity on s.s.b. is 1

One of the prototype versions of the engine control computer undergoing final test at Ultra Electronics, Western Avenue factory, prior to delivery to Bristol Siddeley Engines.





High density precision tape recording head used in the *Concorde* prototype accident recording system being produced by Elliott Automation. The system records 300 parameters and is protected for crash loads and is automatically ejected if submerged.

μV for a 10 dB (signal + noise)/noise ratio and for a.m. it is $3 \mu\text{V}$ modulated 30 per cent at 1 kHz for a 6 dB (signal + noise)/noise ratio.

OTHER ELECTRONIC SYSTEMS

The engine control system has been designed as an electrical link between the crew and the engines. Normal control actions such as throttle opening and fuel flow are under direct crew control, but many other parameters are altered automatically by computers designed by Ultra Electronics Ltd. These include controlling fuel flow during start-up and in-flight re-lighting, control of high pressure spool speed, adjustment of idling fuel flow to prevent flame out, maintaining acceleration and deceleration throttle inputs to safe levels, limiting jet pipe temperature, correcting nozzle area, air intake control and controlling many other parameters. The variable geometry air intakes controlled by the system decelerate the supersonic free air stream to a fairly low subsonic value before allowing it to enter the engine.

The *Concorde* prototype 001 will have two E.M.I. television cameras fitted, one of which will be mounted on the nose wheel to give an improved forward view whilst taxiing. This camera has a 90° wide angle lens. The second will face the rear, enabling the landing gear and the underside of the aircraft to be viewed. In addition, for the prototype 002, E.M.I. are supplying three half-inch cameras for mounting in the engine nacelles and two one-inch cameras for viewing the wings and tailplane. During periods of high sunspot activity, solar radiation could become a problem at the altitudes at which *Concorde* will be flying. A radiation detector is being built by A.W.R.E. to enable the amount of radiation to be measured. Should this ever exceed a safe level, *Concorde* will be forced to fly subsonically at a

lower altitude. It is understood that the fuel penalty resulting from this is not high.

Aircraft instruments of the past that required inputs of height, rate of climb, air speed and mach number had to rely on a jungle of pipes relaying pitot and static air pressures to them to derive the necessary information. These pipes were very vulnerable and a good deal of servicing effort had to be spent in tracing microscopic leaks, often in inaccessible parts of the aircraft. In *Concorde* a simple pipe system carries the air pressures to two central air data computers that are being manufactured in France by Crouzet. These computers then provide electrical outputs for other equipments proportional to: altitude, airspeed, mach number, vertical speed, total temperature, static temperature, true airspeed, angle of attack and side slip angle.

An Elliott flight recording system is incorporated which collects speech, analogue and digital information from more than 300 points during a flight of up to twelve hours. This information is "conditioned" in integrated circuit computers before being recorded on magnetic tape. The crash-proof capsule containing the recording mechanism is ejected if submerged, whereupon it floats to the surface and a radio beacon emits a homing signal.

A good deal of the engine instrumentation is also being manufactured by Elliott's. These take the form of miniature indicators with, in many cases, a certain amount of the computing circuitry built into them. These instruments are mounted on the flight engineer's control panel with "essential service" indications duplicated on the pilot's panel.

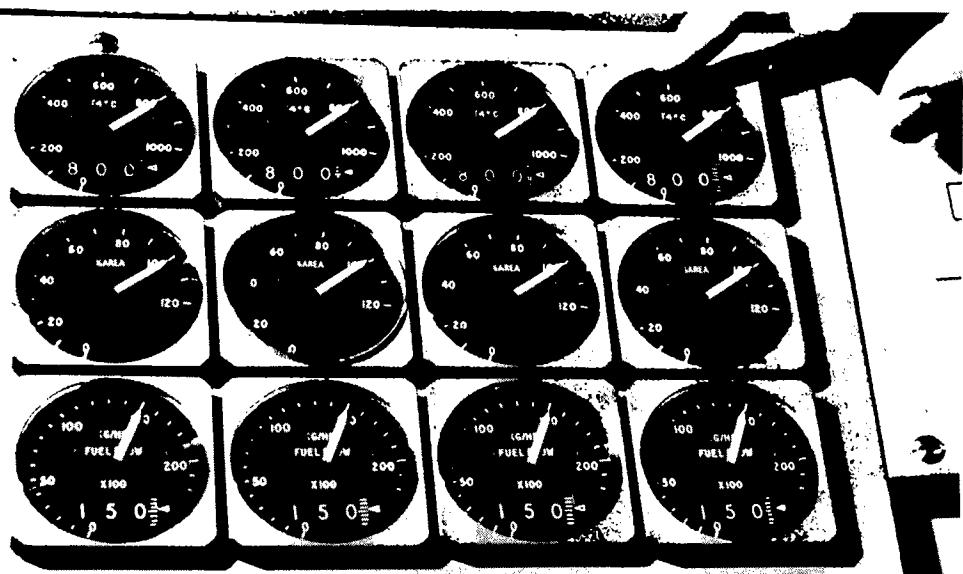
The fuel flow system comprises a transmitter and complementary indication for measuring the quantity of fuel consumed, rate of fuel flow, and the amount of fuel remaining. The flow sensor measures the mass flow rate of fuel passing in the line, determining the heat content and thus the propulsive content. The transmitter has an accuracy better than 1% over a 9:1 flow rate range at $20^\circ\text{C} \pm 5^\circ\text{C}$ whilst the flow rate indicator has an accuracy of $\pm 0.5\%$.

The electrical installation serves all other

systems and has to supply a load of up to 61 kVA. As has already been stated, all aircraft essential systems are at least duplicated, and to preserve this safety margin each equipment of a duplicated system is fed from an independent power source. The four 8,000 r.p.m. brushless alternators each have a nominal continuous rating of 40 kVA at 400 Hz 200/115 V. They automatically self excite and synchronize to deliver their outputs in parallel pairs. The d.c. busbars are supplied via transformer-rectifier units and charge two standby nickel-cadmium batteries. A 1.8 kHz supply for the flying control signalling circuits is derived from two 26-V single phase static inverters supplied from the essential services battery busbar. Loss of one generation channel leaves all services fully operational by employing transfer techniques. Loss of two channels leaves general services unimpaired but the electrical de-icing equipment becomes inoperable. In the unlikely event of a complete four engine flame out the battery capacity permits a gas turbine driving a generator to be started which will maintain essential services.

To speed up communications between Britain and France on matters dealing with *Concorde* a private wire circuit between London and Paris has been installed. The new link has been set up in co-operation with both the British and French Post Office authorities. It will carry a wide variety of communications traffic including teleprinter messages, telephone conservations, high-speed transmission of punched and magnetic tape data, and facsimile transmission of drawings or messages. The circuit was primarily installed to facilitate radio contact with *Concorde* flight test crews when prototype testing begins in the spring. It will enable ground engineers in Toulouse to operate a remote control radio-relay station at Filton, providing a three-way link between Filton, Toulouse and the aircraft. This is necessary since the range of the v.h.f. radio equipment in *Concorde* is limited to about 600 miles and contact with the aircraft may be lost on the proposed test flights over Northern Europe.

An example of the engine instruments used on *Concorde*. The photograph shows a section of the flight engineer's panel. Some of the more important instruments are duplicated on the pilot's instrument panel.



News of the Month

Employing Intelsat III

NEXT year a number of synchronous communications satellites are to be launched as part of the Intelsat III programme. Preparations are currently in hand in many parts of the world to make use of this new facility and to provide a truly global round-the-clock communications system.

In Britain a second aerial is being built at Goonhilly at a cost of £1.5m to work the Atlantic Ocean satellite. When this aerial is operational and can take over the duties of the existing aerial, the first one will be modified to enable it to communicate with the Indian Ocean satellite in 1969. Goonhilly will then be able to communicate directly with other earth stations situated over two-thirds of the earth's surface.

Post Office engineers report encouraging progress on the construction of the second aerial. The larger part of the civil engineering works has been completed and the 75.5-ft radius azimuth track has been laid and levelled; this runs from 066° to 326°. Some 200 tons of steel have so far been used in the construction of the aerial base structure which is mounted on a large central pivot and a pair of bogies which run around the azimuth track.

The dish profile is quasi-paraboloidal and is Cassegrain fed by a one-piece aluminium sub-reflector 7 ft in diameter; the main dish is 90 ft in diameter. The width of the radio beam between 3-dB points will be approximately 10.5 minutes of arc at 4GHz and 7.5

minutes of arc at 6GHz. The new installation, with exception of the modulating and demodulating equipment, which is being supplied by G.E.C., is being built by the Marconi Company.

Preliminary tests of the wideband transmitters indicate that their performance will meet all the requirements for multi-carrier operation. A first production model of the parametric amplifier, to be used in the first stage of the receiver, has been demonstrated and has met the essential parameters specified, but a fully-engineered version has not yet been completed. The parametric amplifier will be cooled by a closed-cycle cryogenic system, using helium, to a temperature of -257°C. The amplifier will consist of three identical GaAs varactor diode stages connected in cascade. Each of the three stages will be fed from a klystron pump source through a three-way passive splitter. Incidentally, the klystrons are the only part of the receiver that is not solid-state. The amplifiers are mounted behind the aerial vertex and will provide 30mW of pump power at 34 GHz.

A low-noise tunnel diode amplifier forms the second main amplifying stage in the receiver and will also be mounted on the aerial backing structure. The signal from this is converted to an i.f. of 70 MHz in a balanced diode mixer with a crystal local oscillator. The output of this system will be passed into a waveguide branching network which will separate the received channels and

The control room of the experimental station at Carnarvon.



pass them to separate frequency down-converters and on to further i.f. stages.

The transmitter will use wideband travelling-wave tubes to provide a final peak saturation power of 10 kW. A t.w.t. has been chosen in preference to klystrons since each individual carrier would require a complete klystron transmitter whereas the complete 500-MHz band can be covered by a simple t.w.t. amplifier. A single varactor diode up-converter will be used to change each of the 70-MHz carriers to the output frequency. The transmitting facilities available will be adequate for over 500 telephone channels and one television channel simultaneously, using a multi-access satellite of the Intelsat III type.

In the middle and far east two earth stations are being built at an estimated total cost of £3.5m for Cable and Wireless, one on Stanley Peninsula on Hong Kong Island and the other at Abu Jarjur, Bahrain. The Hong Kong station will be capable of operating in gales of up to 70 m.p.h., above which the dish is pointed vertically and will then withstand winds of up to 210 m.p.h. The Marconi Company are undertaking the construction of the two stations which will consist of steerable 90-ft diameter aerials mounted on 60-ft towers.

The Bahrain station situated at a longitude of about 62.5° east will be in continuous contact with the Indian Ocean satellite and through it communicate with four other stations. The station will be connected via a radio link with Sitra where traffic will be distributed. Bahrain will not initially have the capability of processing television signals, however, this facility can be added at a later date.

The Hong Kong station will use the Pacific Ocean satellite and will be in continuous contact with eight other stations. Information will be transmitted to Victoria for distribution.

Each station will have facilities for the transmission of up to four carriers and the reception of 32. Each of these carriers may have a capacity of 24, 60 or 132 separate communications channels. Initially Hong Kong will be equipped for the reception of eight carriers, each with a standby and Bahrain for four, also with standbys. The electronic equipment is of similar design to that used in the Goonhilly No. 2 aerial project but the aerials differ considerably in mechanical design.

In Australia the site for the Australian Overseas Telecommunications Commission's (O.T.C.) west coast satellite ground station is expected to be announced shortly. O.T.C. is currently using an experimental quasi-operational station at Carnarvon, 600 miles north of Perth. This station has provided live TV links with Britain, but it is primarily engaged in meeting communication needs of N.A.S.A. which operates a tracking station in the immediate vicinity. The west coast station will provide voice, video and data links with Africa, Asia and Europe via the Indian Ocean Intelsat III satellite.

In Sweden the four Scandinavian telecommunications administrations agreed that a proposed ground station for satellite communication with North and South America be built near Strömstad on the Swedish West coast. The station, which would increase the

number of transatlantic channels from 38 to 100, would be equipped with an aerial with a diameter of about 90 ft for reception and transmission via the Atlantic Ocean satellite. The Swedish West coast area was chosen as the site as it was considered comparatively free from interference from existing radio transmissions. Goonhilly has so far handled the satellite communications of the Scandinavian countries, who have ten channels at their disposal at this station. The Scandinavian ground station project is subject to approval by the four governments involved. It is hoped however that the new station will be ready for operation in 1970-71.

Telephone System for the Deaf

INDIVIDUALS suffering from total deafness will be able to communicate by telephone if development work at present being carried out by Bell Telephone Laboratories, U.S.A. reaches fruition. The system, known as touch-tone dialling, enables the letters and numbers printed on the buttons of a push-button dial telephone to be represented visually at the receiving end. In touch-tone dialling areas push-buttons generate pairs of tones to control dialling and switching functions. When two telephones are connected over the telephone network, the buttons still generate tones but do not interfere with normal switching functions. In the proposed system the code utilizes the arrangement of letters and numbers as they appear on the push-button dial e.g. A, B and C are sent using the "2" button. Pushing this button once transmits A, twice B and three times C. A readout circuit stores the signals until the required letter is fully encoded as indicated by pushing the zero button, thus to transmit A the code is 20, B is 220 and C is 2220. Letters of the alphabet not used in dialling, namely Q and Z, are encoded using the "1" button, Q being expressed as 10 and Z as 110. In addition the "1" button is used as a word separator, 111 signals end of word and 111,111 end of sentence.

Tests with a prototype have indicated that with a little training a user may attain a coding rate of 8 words per minute and with practice this rate can be doubled. At the receiving end the characters are displayed one at a time for approximately 400 ms and it has been found, at the higher sending rates, that the display is very tiring on the eyes. Three off-the-shelf indicators are used

to display the 36 digits required and two small windows show that coding is in process and the end of word and end of sentence periods.

Instrumentation Project

THE Ministry of Technology has announced the setting up of an Advanced Instrumentation Project which will foster the development and use of industrial instruments. It is hoped that this will assist process industries to improve productivity and help instrument manufacturers to transform promising new ideas into working equipment with the minimum of delay. To this end the Ministry of Technology will be providing up to £250,000 per year for three years to be spent in sharing the cost of projects with industry. There will be an arrangement for the recovery of the investment from sales. In deciding which projects to back, the Ministry will satisfy itself as to the competence of prospective firms to carry out the necessary work and to exploit its results both technically and commercially.

Australia's First Satellite

WRESAT-1, Australia's first satellite, stopped sending signals from space after five days in orbit. The Minister for Supply, Senator D Henty, said this was the planned programme for the satellite which re-entered the earth's atmosphere after a few weeks. WRESAT-1 was launched from Woomera on November 29th from a United States Redstone rocket. The 100 lb satellite was developed jointly by the Weapons Research Establishment and the University of Adelaide. The purpose of its mission was to investigate the effects of the upper atmosphere on the weather. Senator Henty said "It appears that most of the experiments were successful and will yield valuable scientific data related to the sun's effect on the earth's atmosphere".

A 19 ft two-stage high-altitude density probe was launched from Woomera as WRESAT-1 was on its 29th orbit, approaching the low point of 106 miles in its elliptical polar orbit. The experiment was to gather data on the interaction of solar radiation and the ionosphere at an altitude lower than that being investigated by WRESAT.

S.T.C. enter C.C.T.V.

Market

"TOTAL system service" is the claim of Standard Telephone and Cables Ltd as they enter the closed circuit television systems market. The Test Apparatus and Special Systems Division which is marketing the equipment will be able to draw, from other divisions, information on video and audio transmission, cabling technology and microwave and line transmission to build up C.C.T.V. systems of any required complexity. The display monitors follow conventional techniques and are available with 11- or 19-inch tubes.

The camera is of modular design that can be supplied in up to seven different configurations or if desired the basic camera can be extended to provide additional facilities by using plug-in modules. Power unit, remote focus, power-operated zoom and a 4½-inch



monitor viewfinder can be added in this way. The camera employs 625 lines scanning at 50 fields per second and incorporates an E.M.I. 9677C one-inch vidicon tube as standard; infra-red, high resolution and extra robust tubes are available as options. In most applications the camera will be fully automatic; a wide sensitivity range providing a constant video output over all normal variations in ambient illumination level. However, a remote, or on the camera, sensitivity control can be fitted if required. The camera may be powered from a 16 V d.c. supply or alternatively direct from the mains via an add-on power unit.

Polar Region Study

A "MASS ASSAULT" on the little understood Northern Lights aurorae and polar cap airglow is to be carried out by the American National Aeronautics and Space Administration. The investigation will entail the simultaneous use of aircraft, sounding rockets and satellites in a co-ordinated effort to study some of these phenomena. Scientists will have the opportunity to observe from four different levels ranging from the ground to an altitude of 250 miles. They hope to find causes, possible physical and chemical changes, which may fit into the theories and other observations made previously. It has been noted that electrons and protons from space follow the earth's magnetic field lines into the polar regions. It is believed that these are important in precipitating aurorae and the polar cap airglow. Another factor is probably cosmic radiation from the sun which is known to enter the atmosphere at the poles.

Victoria Line Television System

ONE of the largest supervisory closed-circuit television systems to be built in the U.K. is to be installed on London Transport's new Victoria Line by Peto-Scott Ltd, of Weybridge. The system consists of 74 television cameras, 42 monitors and a comprehensive switching network. The installation will perform three major functions: a monitor mounted at the end of each platform working in conjunction with a camera will allow the train driver to see along the whole length of the train; outputs of the platform cameras and other strategically placed cameras viewing escalators, subways and the like will be fed to a station supervisor's office—the switching network allowing any camera on the station to be selected; and



finally, the outputs of all the cameras at all the stations will be fed into a line supervisor's office who again can select any camera he chooses. The transmission from the stations to the line supervisor's office is carried out at r.f.,

Shipboard Satellite Terminal

A MILITARY shipboard satellite communications system is to be installed on H.M.S. *Intrepid* by the Plessey Electronics Group. This will operate in conjunction with the British military synchronous satellite Skynet due to be launched this year. The aerial will have three axes of spatial freedom with the ability to remain locked-on to the satellite when the ship is rolling at angles of up to 30°. This is achieved by sensing monopulse misalignment signals in conjunction with signals derived from a gyro stabilized platform. Error signals obtained in this way are used to control the aerial's three drive motors. Signals received by the 6-ft diameter Cassegrain aerial are amplified in an uncooled amplifier before being down-converted, amplified and fed to subsequent demodulation and demultiplexing equipment.

2LO Again

TO celebrate the 1968 City of London Festival (July 8th–20th), the Radio Society of Great Britain is to operate an amateur radio station with the call sign GB2LO from somewhere in the City. The location has not been decided upon but when operating the station will be open to visitors. GB2LO will work on the 10, 15, 20, 40 and 80 metre bands on s.s.b. only.

The British Calibration Service was set up about a year ago by the Ministry of Technology to provide authenticated calibration facilities for all kinds of measuring instruments. To date four laboratories have received B.C.S. approval and these may now provide their customers with a B.C.S. Certificate of Calibration for each instrument calibration carried out under their approval. This approval relates only to specified types of measurement to given levels of accuracy as stated in the laboratory's approval certificate. Laboratories seeking to operate within the service must satisfy the B.C.S. that they are capable of meeting its criteria. So far the B.C.S. have invited applications from laboratories in four fields of measurements: d.c. and l.f., h.f., mechanical and fluid. Preparations are being made to extend the service to optical and thermal measurements. The laboratories to receive approval are: Coventry Gauge and Tool Co. Ltd. P.O. Box 39, Fletchamstead Highway, Coventry; Pitter Gauge and Tool Co. Ltd., Market Street, Woolwich, London S.E.18; The English Electric Co. Ltd., Stafford Works (Electrical Products Group), Lichfield Road, Stafford; Ferranti Ltd (Wythenshawe Calibration Laboratories), Simonsway, Wythenshawe, Manchester 22. The first three laboratories listed have received approval for a range of mechanical measurements, while the fourth has received approval for a range of d.c. and l.f. measurements including resistance, inductance, capacitance a.c. and d.c. — voltage current and power — and frequency.

Production of their computer 'Modular One' is to commence at the Hemel Hempstead factory of Computer Technology Ltd in May and will result

in the building of 30 systems by the end of the year. Computer Technology hope to be able to supply 20 per cent of the British market and export in quantity by the end of 1969. Computer Technology was set up at the end of 1965 by an independent group of computer engineers after a critical analysis of the computer industry in Britain and America. The capability to build small high performance computers at low cost is creating new markets and Computer Technology believe that it is in this field that the major growth in the computer market will take place during the course of the next five years. The design of Modular One is based on the need for a general purpose digital computer that can be integrated into any information complex. It provides a range of modules that can be used by the scientist or engineer to build up a computer system to match his requirements exactly. Modular One can perform a million instructions a second and a simple system costs in the region of £10,000.

As a result of a cost sharing project on **computer aided design** carried out by the Ministry of Technology and Racal Research Ltd. a new service known as Racal Electronic Design and Analysis by Computer (REDAc) is available to industry. The computer programmes (REDAPs) are backed by a team of 25 engineers with development, production and computer aided design experience. Examples of REDAPs currently available are, a general circuit analysis programme, calculation of stray inductance, mutual inductance and capacitance (e.g. for printed circuit board), small signal modelling of a device such as a transistor, design of a video amplifier, manipulation of four-pole matrices, harmonic analyses of a complex waveform, filter analysis and the solution of a set of simultaneous linear equations with complex coefficients. Data for the REDAC service may be sent by telephone, telex or post and the service is completely confidential. A free brochure describing the service can be obtained from REDAC, Racal Group Publicity Dept., 26 Broad Street, Wokingham, Berks. A Users Manual is available from Racal Research Ltd., Newtown, Tewkesbury, Gloucestershire at a cost of £2.

One of the tasks of the American space craft **Surveyor VII**, recently soft-landed on the moon, will be to evaluate techniques for directing laser beams at objects in space. These tests are a prelude to a projected Apollo experiment in which an optical retro-reflector array will be landed on the moon to enable the distance from various points on the earth surface to the reflector to be measured. The television camera aboard Surveyor will be used in an attempt to photograph laser beams which can be directed from any one of six earth stations through various types of telescopes.

The photograph shows the surface sampler on Surveyor VII digging a twelve inch trench on the moon's surface. Surveyor VII was launched on January 7th by N.A.S.A. from Cape Kennedy. The camera that took the picture had a 6° field of view.



The green argon ion laser beams will be several miles wide by the time they have travelled the quarter of a million or so miles to the moon. Factors beyond the control of scientists which may make the detection of the beam difficult are glare from the sun entering the camera and twinkling caused by atmospheric turbulence on earth.

In order to **co-ordinate traffic movement in West London** the Plessey Automation Group have supplied a computer complex under a £200,000 Ministry of Transport contract. Inductive loop traffic counters spread over an area of 6.5 square miles feed information into two Plessey XL9 computers. These in turn control traffic lights in accordance with the current traffic situation and a programme prepared by Ministry of Transport and Plessey engineers. Traffic density is displayed and stored for future analysis which could result in programme modifications in the future. If desired engineers can take over manual control of given sets of traffic lights should the situation demand it.

The problem facing many users of electronic components is who makes what and where can one obtain, for instance, a capacitor of x value with a y working voltage. To assist in this, **Technical Indexes Ltd**, Index House, Ascot, Berks have produced an Electronic Engineering Index that lists about 1,000 suppliers and gives detailed information on about 20,000 products. The Index consists of 60 cross referenced volumes contained in a five-shelf rack 6 x 3 x 1 ft. The information contained in the index is brought up to date and added to once a month by a team of girls. Also included in the service which costs 50 gn a year, is a product data book that is reprinted three times a year.

A merger within the **Philips-Pye Group** has been announced. Pye T.V.T. Ltd and Peto Scott Ltd are to join forces; the new organization will be known as Pye T.V.T. and will be active in the professional market for broadcast transmitter equipment, studio cameras and monitors, industrial c.c.t.v. and audio systems, and large screen Eidophor projection.

What is thought to be the largest order for **U.K. produced integrated circuits** has been received by Mullard Ltd. The order is for 100,000 t.t.l. FJ series integrated circuits to be used on the new I.C.T. 1906A computer (described in "News from Industry" December 1967). Significant features from the performance of the range are a noise immunity of 1 V, power consumption of about 10 mW per gate and a typical propagation delay time of 13 ns.

The first British company to exhibit at the world's largest scientific exhibition, the American Physics Show, to be held in Chicago, will be Scientifica and Cook Electronics Ltd. Products to be shown by the company include electromagnets, a range of lasers, spectrometers and a number of high-field permanent magnets.

The setting up of a **Device Development Laboratory** to operate in parallel with the existing applications Laboratory has resulted in the reorganization of the research facilities at SGS-Fairchild Ltd, Aylesbury, Bucks. The new department will be responsible for developing discrete devices and integrated circuits for special applications where suitable standard components are not available. Diffusion of sample batches of new devices, built to meet customer specifications.

Since the advertisement pages went to press an error has been noticed in the announcement of W. Greenwood (London) Ltd. on p. 31. The temperature range of the 070 wirewound potentiometer is -55°C to 150°C .

Personalities

This year's I.E.E. Faraday Medalist is **L. H. Bedford**, C.B.E., M.A., B.Sc.(Eng.), F.I.E.E., F.I.E.R.E., who receives it "for his outstanding contributions to the advancement of electronics engineering, and for his inspiring leadership, both in war and peace, of the industrial design and development teams by which these and other advances have been consolidated and effectively applied." After obtaining a B.Sc. degree in



L. H. Bedford

both engineering and physics in London and a B.A. degree at King's College, Cambridge, Mr. Bedford joined the Western Electric Company (now Standard Telephones and Cables Ltd.). In 1931 he took up an appointment with A. C. Cossor Ltd. to initiate the development and manufacture of cathode-ray tubes and in 1937 a new department was formed under his control when R. A. Watson-Watt brought the radar receiver proposition to Cossor's. Mr. Bedford's own activities were then transferred full-time to radar projects including the development and manufacture of the first radar receivers for the "C.H." stations. He was appointed director of research at Cossor's and his name is associated with the elevation attachment which he produced for the early gun-laying radar equipment. In 1947 he joined the English Electric Company, being posted to the Marconi Company as chief television engineer. A year later he took charge of a guided weapons study

project and this led to the formation of a new division which eventually became the British Aircraft Corporation (G.W.) Ltd., of which Mr. Bedford is director of engineering.

Lord Jackson of Burnley, D.Sc., D.Phil., F.R.S., has been elected an honorary fellow of the I.E.E. "for his outstanding contributions to science and technology in the fields of research and education and in recognition of his services to the nation as an adviser to Government on these matters and on the related aspects of manpower and its deployment". After graduating at Manchester University in 1925 and lecturing at Bradford Technical College (now Bradford University) he joined Metro-Vick as a college apprentice in 1929. In 1936 Sir Willis (as he is still affectionately known) received his D.Sc from Manchester and his D.Phil. from Oxford University. Two years later he was appointed professor of electrotechnics at Manchester University. During the war Lord Jackson served on a number of Government scientific and technical committees and worked at the Signals and Radar Research Establishments of the Ministry of Supply, but he continued his teaching work at Manchester University and was responsible for a Ministry of Supply research team engaged there on v.h.f. and dielectric investigations. In 1946 he became professor and head

Lord Jackson



of the Department of Electrical Engineering at the Imperial College of Science & Technology, London, where he remained until 1953 when he accepted an appointment as director of research and education of the Metropolitan-Vickers Electrical Company—now part of A.E.I. In 1961 he returned to his previous position at Imperial College where, in 1967, he was appointed Pro-Rector. Lord Jackson, who is 63, was knighted in 1958 and was made a life peer last year.

Reg H. Hammans, director of engineering, Granada Television, Manchester, since April 1955, has retired from active participation in day-to-day work at the Granada Television Centre but will continue as consultant on technical and engineering matters, and as the company's representative on the technical committees of the Independent Television Authority and Indepen-



R. H. Hammans

dent Television Companies Association. Mr. Hammans was with the B.B.C. for 20 years before joining Granada previously spending four years with the International Marine Radio Company. Mr. Hammans, who operates an amateur radio station with the call G2IG, was president of the Radio Society of Great Britain in 1956/57 and also presided over the conference of the International Amateur Radio Union in Stresa, Italy, in 1956.

Wing Commander Dennis Abraham, B.Sc., M.I.E.E., head of the Electrical Engineering Department of the R.A.F. College, Cranwell, was to have taken up the post of head of the Department of Electrical and Electronic Engineering at the Borough Polytechnic last September (see April issue, p. 172) but the Ministry of Defence would not release him. He has now been appointed to a similar post at the Sheffield College of Technology from next September. Wing Commander Abraham, who graduated at the University of Wales (Swansea), served as a radar officer in the R.A.F. during World War II. He then spent some time in industry and later joined the staff of the University of Aberdeen.

The Medal of Honour—the principal award of the Institute of Electrical and Electronics Engineers Inc.—is being given to **Gordon K. Teal**, M.Sc., Ph.D., assistant vice-president in charge of technical development in the equipment group of Texas Instruments Inc., Dallas, "for his contributions to single crystal germanium and silicon technology and the single crystal growth junction transistor". Dr. Teal, who is 61, was for 23 years with Bell Telephone Laboratories where he worked with Dr. Shockley on the development of the junction transistor. He has been with Texas since 1953. Dr. Teal, who originated the grown junction single crystal technique, recently served for two years as director of the Institute for Materials Research of the American National Bureau of Standards.

The Council of the Royal Society has appointed **Professor J. M. Ziman**, F.R.S., (professor of theoretical physics in the University of Bristol), to be Rutherford Memorial Lecturer for 1968 in India and Pakistan, and to deliver lectures in these two countries during a visit of about three weeks in November/December this year. He was elected a Fellow of the Royal Society last year "for his theoretical contributions to solid state physics, especially the study of transport phenomena, and for his work on the electronic properties of metals".

D. L. Grundy, A.M.I.E.E., recently appointed head of application engineering, integrated circuits, in the Electronics Dept. of Ferranti Ltd., at Oldham, Lancs, joined the company's Application Laboratory in 1955 and worked on the applications of industrial valves. In 1957 he commenced work on the applications of silicon rectifiers with particular emphasis on the transient behaviour of high-voltage assemblies,



D. L. Grundy

and the design of units for high-power pulse duty in such devices as magnetron modulators. When Ferranti commenced the manufacture of transistors Mr. Grundy's activities turned to their application. He was co-author of the article describing a silicon transistor tape recorder in our July and August, 1965, issues.



J. A. Walker

sion Ltd. Mr. Deuchrass was appointed a director of Bush in 1952 and has been a director of the joint Rank Bush Murphy board.

W. H. O. Sweeny, chief engineer to Independent Television News Ltd., retired at the end of January. After five years with the B.B.C. as assistant maintenance engineer, he entered the film industry in 1929, where, with the exception of the war period (during which he was in the civilian service on the East Coast Radar Chain and later commissioned with the R.A.F. Film Production Unit), he remained until 1949. He subsequently served as chief engineer of the Near East Arab Broadcasting Station and on returning to this country in 1955 joined I.T.N. as senior sound engineer.

J. A. Walker, has become head of application engineering, discrete components, in Ferranti's Electronics Dept. at Oldham. He joined the Radio and Television Dept. of Ferranti Ltd. in 1949. In 1959, after a short period on missile circuit design with the Guided Weapons Division, he joined the semiconductor applications laboratory and became concerned with the applications of solid state devices, with particular emphasis on the investigation of four-layer diodes, reference diodes, silicon rectifiers and r.f. transistors. Mr. Walker's current activities cover the applications of a large range of semiconductors including high- and low-frequency transistors, small signal and power diodes and rectifiers, photocells, and hybrid networks using solid state devices and thin film circuits.

Ferranti's also announce the appointment of **Brian Taylor** as chief inspector, and **Graham Latham** as project and product assurance manager, in the Oldham Electronics Dept. Mr. Taylor has been with the company eight years during which time he has specialized on quality control, and Mr. Latham was formerly the chief inspector of the Semiconductor Division.

Dr. J. A. Saxton, director of the Radio and Space Research Station of the Science Research Council at Slough for the past two years, has accepted a visiting professorship in physics at University College London. Dr. Saxton was on the staff of Imperial College, London, for a short time after graduating and he then joined the Radio Division of the National Physical Laboratory (in 1938). Immediately, prior to assuming the directorship at Slough, he was director of the U.K. Scientific Mission in Washington, D.C., and a scientific counsellor at the British Embassy there.

W. T. Deuchrass has retired after 35 years' service with the Bush organization, in fact he was a founder member of Bush Radio in 1932. He was personally responsible for the production of the first batch of 30-line mirror-drum television receivers designed by Baird Televi-

G. D. Gokarn, B.Sc.(Hons.), was recently appointed by the Government of India as its representative on the Commonwealth Telecommunications Board, London. Mr. Gokarn relinquished the post of director of the Overseas Communications



G. D. Gokarn

Service in New Delhi to take up the new assignment. He is also communications adviser to the India High Commission in London. He was in the U.S.A. in 1951-52 under the visitor exchange programme and studied the international communication system in the States.

Each year the Institute of Electrical and Electronics Engineers elects a few of its 160,000 members to the grade of Fellow. Among the 125 recently elected for their "outstanding professional contributions" are the following engineers in the U.K.: **E. A. Ash**, B.Sc.(Eng.), Ph.D., M.I.E.E., Professor of Electrical Engineering, University College, London, "for significant contributions to microwave tubes, solid state microwave devices and electron optics"; **P. J. B. Clarricoats**, B.Sc.(Eng.), Ph.D., F.I.E.E., Professor of Electronic Engineering, University of Leeds, "for contributions in the field of guided electromagnetic wave propagation"; **J. F. Coales**, O.B.E., M.A. F.I.E.E., Professor of Engineering (Control), University of Cambridge, "for his outstanding contributions in the field of elec-

tronics and control engineering, and particularly for major contributions to the development of automation and computer interests in the United Kingdom"; **G. W. A. Dummer**, M.B.E., F.I.E.E., until recently superintendent of the Applied Physics and Technical Services Division, Royal Radar Establishment, "for contributions to microelectronics and component reliability"; **J. Greig**, M.Sc., Ph.D., F.I.E.E., William Siemens Professor of Electrical Engineering, King's College, London, "for his contributions in the educational field, and research on the behaviour of magnetic materials, computers and automatic control processes"; **E. M. Lee**, B.Sc., F.I.E.E. chairman, Bellings and Lee Ltd., "for contributions to design, specification and safety of electronic equipment and components and co-ordination of industry and government in electronic development, production and inspection"; **C. W. Oatley**, O.B.E., M.A., M.Sc., F.I.E.E., Professor of Electrical Engineering, University of Cambridge, "for contributions to research in radar and electron optics, especially for development of the scanning electron microscope"; **N. H. Searby**, C.B.E., B.Sc., F.I.E.E., a director of Ferranti Ltd., "for his contributions to research and development in the application of electronics to guided missile projects"; and **P. H. Spagnetti**, O.B.E., B.A., F.I.E.E., director of business development, Standard Telephones and Cables Ltd., "for contributions to the design of short-wave broadcasting equipment and single sideband telecommunications".

A. J. Martin, B.Sc., A.R.C.S., and **J. C. Mitchell**, B.Sc., have been appointed divisional directors of Advance Controls, Cheltenham, the industrial control division of Advance Electronics Ltd. Before joining Advance early in 1967 as applications managers, Mr. Martin was a lecturer in control engineering at the College of Aeronautics, Cranfield, and Mr. Mitchell was a senior engineer with S.T.C. The manufacture and marketing of the company's range of integrated circuit logic cards and operational amplifiers has also been transferred to the

A. J. Martin



J. C. Mitchell

Cheltenham division where Mr. Martin and Mr. Mitchell will be responsible for the application of these devices in industry.

Professor Sidney W. Wilcox, who is a specialist in technical communication in the School of Engineering at the Arizona State University, Phoenix, is on a six-months' visiting lectureship at the University of Wales Institute of Science & Technology, Cardiff. Before taking up a university appointment 12 years ago he was with the Boeing Corporation.

T. G. Clark, F.I.E.R.E., until recently technical director of Astaron-Bird Ltd., has joined the Plessey Electronics Group. While with Astaron he was also concerned with the technical direction of Coastal Radio Ltd. Before joining Astaron Mr. Clark was for some years with the Decca organization where he was concerned with the design and development of various marine and meteorological equipments.

J. H. Court, who joined Marconi's in 1950 as a graduate apprentice in the Aeronautical Division, has been appointed marketing manager of the division. Following his appointment there has been a major reorganization of the division. Four sales managers have been appointed:

Air Commodore J. A. Holmes takes charge of military sales and **G. N. Thornton** civil sales in Europe (which includes the U.K.); **K. H. Watkins** becomes sales manager overseas region dealing with both civil and military sales in Asia, Australasia, Africa and the Middle and Far East; and **J. D. McColl** will cover administration and planning.

J. W. M. Child, B.Sc.(Eng.), has been appointed sales director of Teknis Ltd., Slough, responsible for the marketing of semiconductor and integrated circuit piezoelectric and production equipment.

R. M. Mitchell has joined Plessey as marketing manager of the Semiconductor Division. Mr. Mitchell, who is 35, has for the past seven years been with Texas Instruments Ltd., latterly as field sales manager.

Announcements

A vacation school on **microwave solid state devices** will be held at Bodington Hall, University of Leeds, from 8th to 19th July. Registration forms may be obtained from the I.E.E., Savoy Place, London, W.C.2. (Fee £65.)

The University of Aston in Birmingham are holding a research exhibition—“**Aston Research 68**”—between 3rd and 5th April. Detailed programmes are available from The Research Exhibition Secretary, The University of Aston, Gosta Green, Birmingham 4.

The next conference to be organized by Varian Associates Ltd, on **electron spin resonance and nuclear magnetic resonance**, will take place from 1st to 3rd April. The first two days will be spent at the Royal Holloway College, Egham, Surrey, and the third at Varian's laboratory at Walton-on-Thames. Applications to the Workshop Secretary, Varian Associates Ltd, Russell House, Molesey Road, Walton-on-Thames, Surrey.

East African External Telecommunications Company Ltd are inviting tenders for the construction of an **earth satellite station** to be situated at Mount Margaret, in the Rift Valley, Kenya. The estimated total cost of this project is £1.75M. Operational in early 1970, the earth station will cater for the expanding requirements of international telecommunications and will increase the capacity and range of existing services.

Pye **TVT Ltd** of Cambridge have been awarded a contract, worth approximately £80,000, by the Swedish Telecommunications Administration for a number of transposers for use in the expansion of the television network. **Racal Communications Ltd** have won a £500,000 contract for the supply of radio-communication equipment for a new meteorological telecommunication network to be built in Saudi Arabia.

Electric & Musical Industries have made an offer to acquire the assets of **Precision Electronic Terminations Ltd** and **Nickols Automatics Ltd** both wholly owned subsidiaries of Royston Industries Ltd, which is in the hands of a receiver. Nickols Automatics are active in the machine tool control field and Precision Terminations manufacture high-power, low-loss, r.f. connectors and a range of e.h.t. connectors.

A new company has been formed from within the structure of Debenhams Electrical & Radio Distribution Co. Ltd which is known as **Technomark Ltd**. It will market equipment produced by Sony; Bang & Olufsen; and Radford Ltd (of Bristol).

A new holding company, **Planned Precision Ltd**, has been formed to integrate the electrical and engineering activities of the News of the World Organization. The companies concerned are Vactric Control Equipment, Vactric Precision Tools, A. P. Besson & Partner, and Renown Engineering. **Plessey Components Group** has made five licensing agreements with Industrialimport, for the production of resistors and capacitors in a Romanian factory, to be equipped with British machinery. It is hoped this will increase Plessey's trade with Eastern Europe by over £0.5M.

Spectra-Physics have announced a **trade-in offer for gas lasers** valid until 31st March. Through their U.K. distributors, Claude Lyons, they offer £80 for an old laser as a trade-in against the new Model 130C costing £356. Further information is obtainable from Claude Lyons Ltd, Instruments Division, Hoddesdon, Herts. (Hoddesdon 67161.)

A link-up has been announced between **B.M.B. (Sales) Ltd**, of Crawley, and **Cosmocord Ltd**, of Waltham Cross, for the manufacture and marketing of stylus, pick-up cartridges, microphones, etc.

The internal Plessey **microelectronics custom design service** is to be extended and will now be available for the design of integrated circuits to the whole of industry.

Full British **military approval** has been granted by the Ministry of Technology to the Elliott D930 range of integrated circuits.

Litton Precision Products, of Hayes, Middlesex, have been appointed sales and service representatives in the U.K. to the following American electronics companies: Cohu Electronics; Curry, McLaughlin & Len; Digital Devices; and Astrosystems Inc.

B & T Designs (Richmond) Ltd, High Street, Tring, Herts, have changed the name of the company to Circuitape Limited.

Cossor Instruments Ltd and Cossor Communications Co. Ltd will in future operate under the title of **Cossor Electronics Ltd**. The object is to have one main company for the Harlow activities.

Derritron Electronic Vibrators, of Sedlescombe Road North, Hastings, have changed the name of the company to Derritron Electronics Ltd.

March Conferences

Further details can be obtained from the addresses in parentheses

LONDON

Mar. 11-14

Physics Exhibition

(I.P.P.S., 47 Belgrave Sq., London, S.W.1)

Alexandra Palace

BIRMINGHAM

Mar. 28 & 29

Technology, Industry, Education

(C. Fleetwood-Walker, Birmingham & Midland Inst., Margaret St., Birmingham 3)

Aston University

CRANFIELD

Mar. 25-28

Aerospace Instrumentation Symposium

(N. O. Matthews, Dept. of Flight, College of Aeronautics, Cranfield, Beds.)

College of Aeronautics

GLASGOW

Mar. 8-16

NORBEX—North British Engineering Exhibition

(Lintex Ltd., 226 Grand Bldgs, Trafalgar Sq., London, W.C.2)

Kelvin Hall

HARROW

Mar. 12-14

Public Address Show

(Assoc. of Public Address Engrs, 394 Northolt Rd., South Harrow, Middx.)

King's Head Hotel

OVERSEAS

Mar. 5-8

Nuclear Electronics and Radioprotection Symposium

(Faculte des Sciences, Universite, 118 route de Narbonne, Toulouse)

Toulouse

Mar. 7-12

Festival du Son

(Fédération Nationale des Industries Electroniques, 16 rue de Presles, Paris 15e)

Paris

Mar. 21-23

Microwave Power

(International Microwave Power Inst., Box 342, Weston, Mass. 02193)

Boston

Mar. 25-29

Colour Television Conference

(Colloque sur la Télévision en Couleur, 16 rue de Presles, Paris 15e)

Paris

Mar. 27-Apr. 7

Electronics, Television & Radio Show & Convention

(Rassegna Internazionale Elettronica, via Crescenzo 9, Rome)

Rome

An Evening of Sonic Effects

Concert of Electronic Music in the Elizabeth Hall Attracts Big Audience

ON 15th January in the Queen Elizabeth Hall, London, a thousand people sat down to face an empty platform, except for a computer and two loudspeakers, and listen to two and a half hours of electronic music by British composers. Considering that London has become the most musical capital in the world, it is surprising that this was in fact the first London concert of its kind. So far we have had only one or two isolated electronic works in concerts of conventional music, and have heard a few B.B.C. broadcasts of pieces by the better known Continental composers. However, to judge from the full house at the Elizabeth Hall (a small queue of disappointed people was left outside) and the rapt attention given to the performances, the dearth of electronic music does not seem to have been due to any indifference or excessive musical conservatism on the part of the British public.

The eleven works in the programme, which was organized by Redcliffe Concerts, illustrated the great variety of techniques by which electronic music can be made. The basic sounds are produced by natural sources of any kind, musical or unmusical, living or mechanical, and by synthetic sources such as electronic oscillators and noise generators. They are then electronically processed—mixed, inter-modulated, filtered etc.—and recorded. Magnetic tape is used extensively, not only for final recording but for processing operations such as changing pitch and producing choral effects from single sources. Computers are being brought in, partly to automate some of the more tedious procedures in composition and partly to introduce an aleatory element into the music. Some pieces are written as concerti, for live participation by singers or instrumentalists, while others are really compositions for conventional orchestras including live electronic effects.

In Ernest Berk's *Diversed Mind*, a five-section piece abstractly related to states of mind, the natural sound sources were metal strip, a bamboo stick and a tambour, while the electronic sources included sine, square and sawtooth wave generators. Processing was mainly by amplitude and frequency modulation, filtering and artificial reverberation. Some of the sonic effects, though probably intended to be abstract, were evocative (the booming of huge bells) and for this reason were exciting to listen to; others (whistling noises) seemed somehow comic—a characteristic of many synthesized sounds.

Tristram Cary's *345* was the result of a deliberate restriction of material—on the principle, perhaps, that limited means provide a stimulus for real artistry. The basic sources were electronic oscillations of 3 Hz, 4 Hz and 5 Hz and multiples of these by 10, 10^2 , 10^3 and 10^4 . This resulted in three subsonic tones (heard either as clicks or modulants), nine sonic tones and three supersonic tones (which produced audible sounds by intermodulation with others). The duration elements, and hence the rhythmic possibilities, were also limited—to 3, 4 or 5 inches of tape at 15 in/sec speed, plus the first few numbers resulting from adding and/or multiplying these figures. More emotive was the same composer's *Birth is life is power is death is God is*. The basis of this piece, which used a large variety of sources, was the sound track for a multi-screen film shown in the British pavilion at EXPO '67, and, in so far as it was illustrative, might not have been considered a good example of the genre by the purists. Also highly allusive was *Silent Spring* by George Newson (inspired by Rachel Carson's book of the same name about the despoilation of nature). Here the basic sound sources were recordings of wild-life and machinery.

A live piano part was used in *Contrasts Essconic* by Daphne Oram and Ivor Walsworth, introducing a touch of aural fami-

liarity and drawing attention to the difference between pitched (notes in a scale) and unpitched sounds. A frankly direct appeal was made by Delia Derbyshire's *Potpourri*, realized in the B.B.C. Radiophonic Workshop, which served as a short opener for the concert. Traditional rhythms and time-signatures were utilized in *Syntheses 8, 9 and 12* by Jacob Meyerowitz and in *Partita for Unattended Computer* by Peter Zinovieff. Also composed by Zinovieff were *December Quartet*, *Agnus Dei* and *March Probabilistic*. In the last-mentioned the overall form of the piece had been specified by a programme written for an ICT 1900 computer, which had punched a paper tape giving the timing, pitch, loudness, attack or delay, and basic waveform of each note. This tape was read by a PDP-8/S computer on stage at the concert (see picture) which, using random numbers, selected during the performance the exact values to be used to control the electronic sound generators. Thus individual performances could vary slightly.

The two Lockwood monitoring loudspeakers, one on each side of the platform, performed extremely well on the demanding material, and the acoustics of the hall seemed very sympathetic to it.

For people whose musical appreciation is conditioned by the melodic and rhythmic conventions of the 19th century—and that means most of us—electronic music does not have a very direct appeal. It provides technical interest for the professional musician—the Royal College of Music is starting a pilot course in the subject—and probably has real impact for people who have progressed to modern composers such as Webern and Boulez. The writer found some parts of the concert boring, but this was probably due to his own limitations or those of the composers rather than to any inherent characteristic of electronic music. As with abstract painting, it becomes more and more difficult to distinguish the work of the genuine artist from that of the clever technician, but only a philistine would condemn the whole art-form on this count.

T.E.I.

Performance of *Partita for Unattended Computer* by Peter Zinovieff. After a programme on punched tape had been read into its store, a PDP-8/S digital computer (near the middle of the rack) calculated the exact details of the sounds to be produced and, through an interface, operated electronic generating and processing equipment—oscillators, filters, envelope shapers, reverberation units and mixing and timing units. (Courtesy Computer Weekly.)



Power Supply Stabilization Module

Outputs of 6-50 V at 50 mA; provision for currents up to 5 A

By P. R. Adby, B.Sc.

AFTER designing numerous simple power supply circuits for transistor equipment, it became obvious that the same basic stabilizing circuit is employed each time with only slight modification. A survey of past power supply requirements in the University laboratory revealed that in general, most supplies were covered by the following specification; an output voltage of 6 to 50 V and an output current of up to 5 A. Adequate stabilization was normally obtained by a simple long-tailed pair error amplifier with a Zener diode reference

but, since the supplies were internal in equipment, overload protection was not usually incorporated.

With these requirements in mind, a small plug-in module was designed for stabilization of output voltages in the above range. Cost was considered an important factor since, in most cases, at least two supplies are required for each unit. For economy, it is essential that we use (a) only one transformer winding, (b) the smallest number of subsidiary supply rails, and (c) low cost transistors, silicon for preference.

The required output voltage range being from 6 to 50 V it is assumed that the reservoir capacitor voltage lies in the range +9 V to +60 V. This range is wide, and a subsidiary h.t. rail derived from it, for the stabilizer circuit, would be limited to about +6 V maximum. Also, as the comparator is to be a long-tailed pair, an additional negative rail of at least 6 V is required. If a centre tapped transformer winding is used, the negative supply can be derived from the main output winding using two low-current rectifiers and a small smoothing capacitor. The positive and negative 6-V rails for the stabilizer are obtained from the reservoir capacitors via series resistors and Zener diode regulators. The output voltage from the long-tailed pair is limited to the range 0 to +6 V. An output amplifier and emitter follower operating from the unregulated positive supply gives the required output (+6 to +50 V) from the available drive. Output currents of up to 50 mA may be obtained either for use directly as the stabilized supply or for driving one or two emitter followers, giving 1 A or 5 A maximum respectively. A circuit of a typical power supply for use with the module is given in Fig. 1.

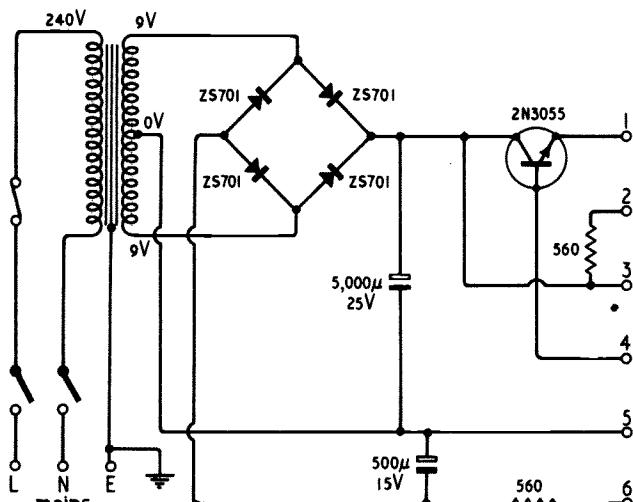


Fig. 1. A typical power supply for use with the stabilization module.

Paul R. Adby is an experimental officer at the University of Sussex, Falmer, Brighton, where he is responsible for the electronics laboratory which designs equipment for research in experimental physics. After graduating at Leicester University in 1960 he spent four years in industry before joining the University staff.

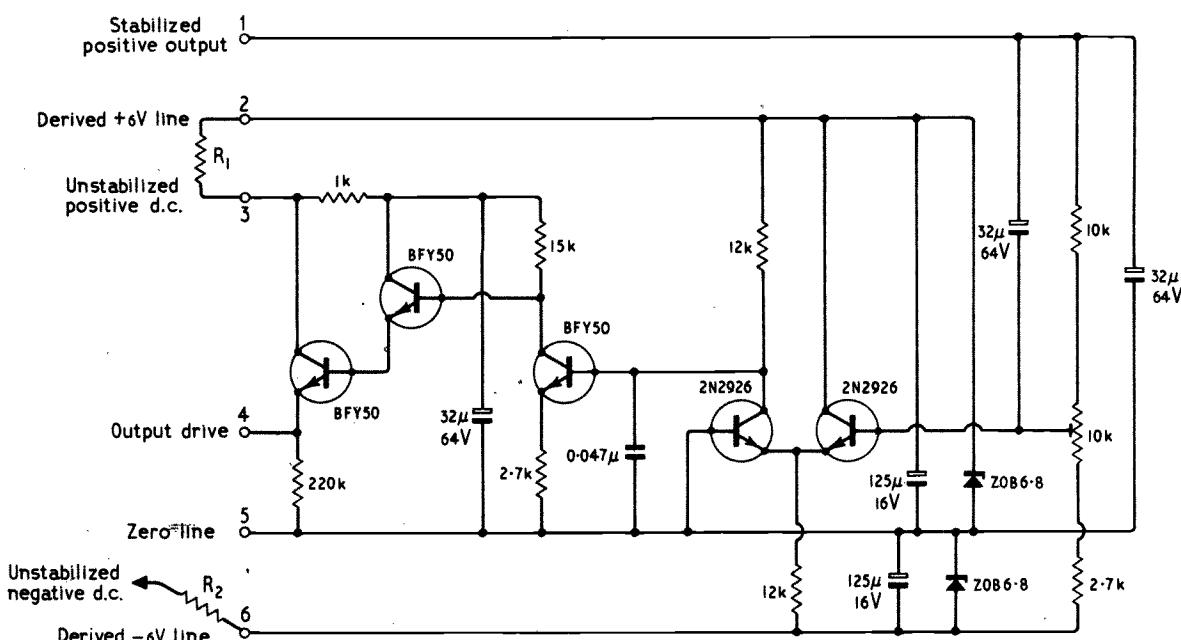


Fig. 2. Details of the stabilization module circuit including the two external resistors. All resistors are Erie EMI 5%; electrolytic capacitors, Mullard C426 series; potentiometer, Painton Miniflatpot; and the 0.047 μF capacitor, Mullard C280Ae. The output from the module is taken from terminal No. 1 (positive) and terminal No. 5 (negative).

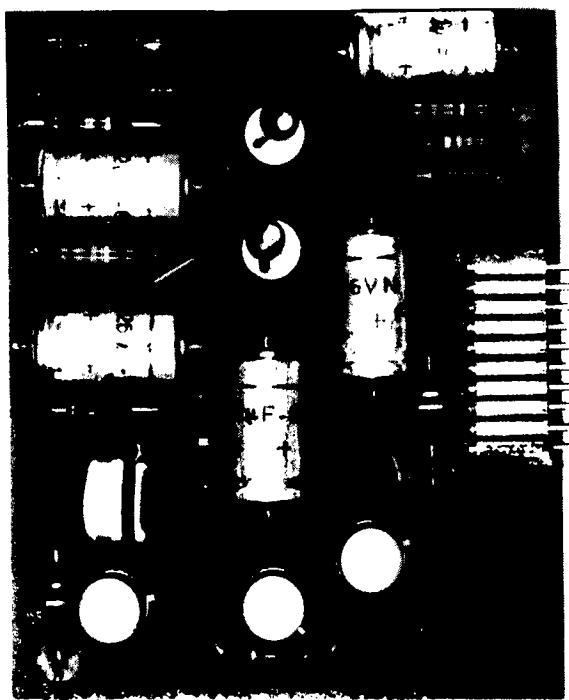


Fig. 3 The prototype module.

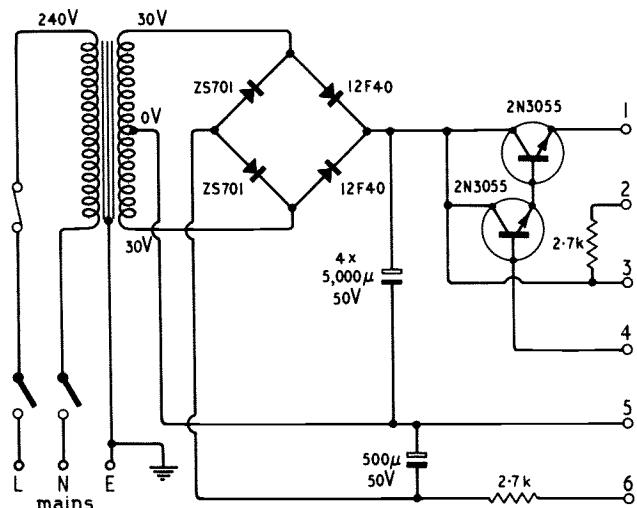
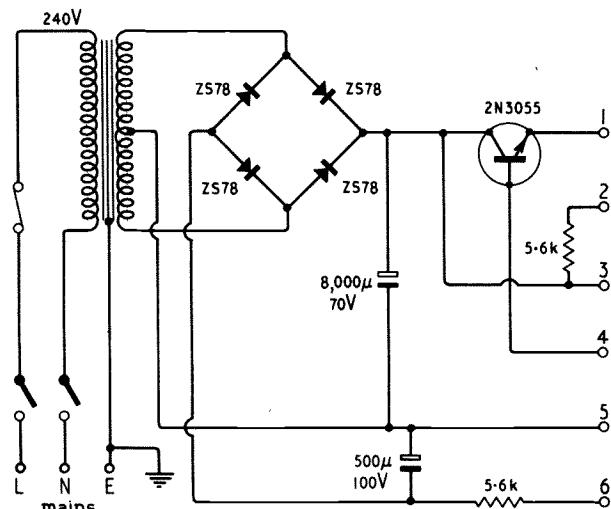


Fig. 4. Power supply giving an output of 24 V at 5 A. Output is taken from pins 1 and 5.

Fig. 5. Power supply giving an output from terminals 1 and 5 of 40 V at 1 A.



The circuit diagram of the module given in Fig. 2 shows a number of different supply rails which may be related to Fig. 1 as detailed below:

Unstabilized positive d.c.	:	main supply from the reservoir capacitor
Stabilized positive output	:	stabilized output voltage
Derived +6 V	:	supply for comparator
Derived -6 V	:	supply for comparator
Output drive	:	drive to series stabilizer
Unstabilized negative d.c.	:	from which -6 V is derived

Also shown in Fig. 2 are two essential external resistors which are adjusted in value, dependent on the unstabilized positive and negative voltages available.

$$R_1 = \frac{\text{unstabilized positive voltage} - 7}{10} \text{ k}\Omega$$

$$R_2 = \frac{\text{unstabilized negative voltage} - 7}{10} \text{ k}\Omega$$

A current of 10 mA is therefore set up through R_1 and R_2 . The stabilized output voltage is preset by a 16-turn trimming potentiometer giving fine adjustment over the complete range of output voltage. Limits for the module are:

maximum output drive current	50 mA
maximum unstabilized positive d.c.	64 V
maximum difference between unstabilized positive d.c. and stabilized output	15 V

Fig. 2 shows a typical circuit for a 1 A output. For outputs between 50 mA and 1 A, one transistor emitter follower external to the module is required. For currents up to 5 A two emitter followers are necessary. Since these are power transistors mounted on a heatsink, they were not included within the module.

Figures 1, 4, and 5 give the circuit diagrams of three power supplies which illustrate the use of the module for various output voltages and currents. The performance obtained from each circuit is given below:

	Fig. 1	Fig. 4	Fig. 5
Output voltage	6	24	40
Output current (A)	1	5	1
D.C. output impedance (Ω)	0.2	0.06	0.12
Ripple peak to peak (mV)	4	2	2
Stability for 10% mains change (mV)	50	100	50

For currents below 50 mA an external emitter follower is not necessary and the output drive pin 4 is connected to pin 1 and becomes the stabilized output. The output current is not limited to 5 A by the control circuit. Further emitter followers could be added but the lack of short-circuit protection could make the circuit impractical.

Further methods of connection suggest themselves but these have not yet been tried in test circuits:

(a) Elimination of the negative supply for higher output voltages by setting the -6 V line at zero. R_2 and the existing zero line would not be used.

(b) Stabilization of higher output voltages by setting the -6 V line at, for example, +50 V. This would be achieved by connecting the 2.7 k Ω resistor in the potential divider to a spare output on the plug. In normal operation an external link to the -6 V line would be necessary. For high-voltage operation a resistor would be connected from the 2.7 k Ω resistor to the supply zero in order to adjust the divider. A Zener diode working at a current of 10 mA would be inserted between the -6 V line and supply zero. The existing zero line and resistor R_2 would not be used. This method may be limited by variations of the unstabilized positive d.c. and by possible breakdown of the module output transistor due to switching surges.

(c) Pre-stabilization circuits inserted between the unregulated d.c. and the series transistor would improve the performance.

No specific performance advantages are claimed for this stabilization module since it is intended for general purpose work covered by other similar simple stabilizing circuits. The advantages of using a plug-in module do however include interchangeability for ease of servicing, standardization of components and construction, and well-defined performance characteristics.

Kelvin Cables

RC Transmission Line Applications

by G. W. Short*

An artificial RC transmission line can be made in a few seconds by wrapping metal foil round a resistor. These lines can be used in filters and phase shift oscillators at audio and radio frequencies.

THE distributed-constant RC transmission line (Fig. 1) has a long history. In the early days of telegraph cables, communication engineers discovered that it takes a finite time for an impulse to pass along a cable, and that the initial sharp edge becomes transformed into a sloping edge in the process. When trans-Atlantic submarine cables were proposed, this transmission distortion was seen to be a serious difficulty. The cable companies asked William Thomson (later Lord Kelvin) to advise them how to overcome the defect. Kelvin assumed that the distortion and delay were caused by the cable behaving like a distributed series R , shunt C network, and proposed a solution accordingly. (It was, first, to reduce R by using high-conductivity copper, and secondly to use sensitive instruments to detect the rising edges of incoming pulses.) Because of Kelvin's cable-model, distributed RC transmission lines are sometimes called Kelvin cables. Incidentally, Kelvin's associate, Varley, used a lumped-constant RC model to predict the signalling speed which would be possible with trans-Atlantic cables. This must have been one of the earliest examples of electrical analogue computation.

The RC transmission lines which are the subject of this article are millimetres rather than miles long. They are made from the type of high-stability resistor in which the resistive track consists of a layer of carbon, deposited on the surface of a glass or ceramic rod, and protected only by a thin film of paint or lacquer. The resistive track provides the series R , and the dielectric properties of the paint or lacquer provide the shunt C . The lines are unbalanced, the earthy leg consisting of a piece of aluminium foil wrapped closely round the body of the resistor. This does several jobs at once: it provides one

*Amatronic Ltd.

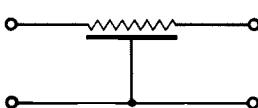


Fig. 1. Distributed RC transmission line.

Fig. 2. Low-pass filter responses. The insertion loss at low frequencies depends on the total series resistance and the terminating resistance.

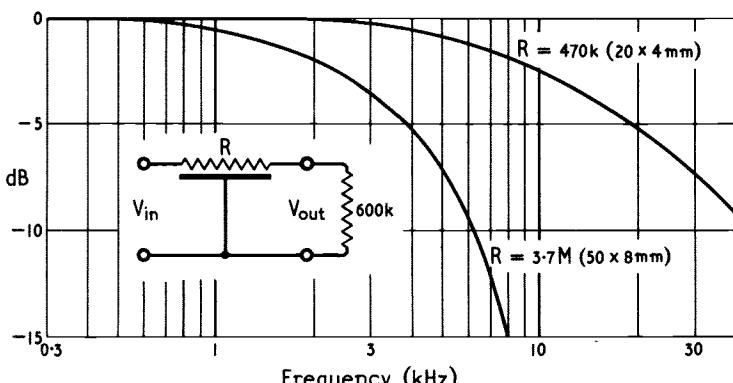


plate of the shunt C , an earth connection, and in some applications an electrostatic screen as well. (Since aluminium is not readily soldered, a piece of tinned copper wire is wrapped round and the earth connection made to it.)

Obviously, a line made like this is likely to be very different from the ideal uniform RC line. The capacitance per unit length is likely to vary both from one resistor to another and even along one resistor, as the paint thickness varies. The dielectric is likely to be lossy. These imperfections may cause the characteristics of a practical RC line to be quantitatively different from those of a perfectly uniform line, but the general behaviour of a practical RC line is what would be expected. Signals passing along it are retarded, and the amount of phase delay increases with frequency. Attenuation also increases with frequency. Input impedance decreases with frequency, and at frequencies at which the line behaves as a line and not just as a resistance it is much lower than the total series resistance.

FREQUENCY RANGE

The RC line is a low-pass filter, but the useful pass-band can be moved upwards indefinitely by reducing the ratio of R to C . In practice, this means using a lower resistance to begin with, so as to reduce R . In theory it is possible to reduce C by putting an extra dielectric layer between the body and the foil, but this makes the device less like a transmission line and more like an ordinary resistor, so can only be exploited to a limited extent.

The highest frequency in my experiments was the 5 MHz generated by an RC-line phase-shift oscillator, but no attempt was made to establish an upper limit. For some purposes, such as decoupling, where the low-pass character of the RC line can be used to keep h.f. signals out of h.t. lines, etc., much higher useful frequency ranges are obviously possible.

FREQUENCY RESPONSE

The RC line can be connected between a signal source and a load in several ways, each of which provides a different frequency response.

The simple low-pass filter connection, of interest in audio work and decoupling, has a response which is shown in Fig. 2.

As would be expected of an RC filter with an infinite number of sections, the droop in the h.f. response becomes ever more steep as the frequency is increased. There is no "ultimate slope" of so many decibels per octave as there is with lumped-constant filters. It is this characteristic which makes the RC line attractive for h.f. decoupling.

Changing the termination has a marked effect on the attenuation and pass-band—the lower the termination resistance the higher the attenuation and cut-off frequency—but obviously it can have little effect at relatively high frequencies, since these vanish before they get anywhere near the end of the line. By the same token, changing the termination has little effect on the input impedance if the line attenuation is high. One result is that a quarter-wave RC line shows none of the transformer-like properties of a lumped LC line with the same phase shift.

INPUT IMPEDANCE AND INSERTION LOSS

The input impedance falls as the frequency rises. The phase angle of impedance has the curious property of being the same at all frequencies, namely -45° , or midway between a resistance and a capacitance. For an infinite ideal uniform line, the input impedance is $\sqrt{(-jR/wC)}$, where R and C are the resistance and capacitance per unit length. The impedance is therefore a function of $\sqrt{(1/f)}$, that is, it falls relatively slowly as the frequency rises.

The 45° phase angle seems potentially useful for single-sideband generation but unfortunately the fall of impedance as the frequency rises makes application difficult, since any attempt to correct the frequency response produces an additional phase shift.

At frequencies far below cut-off, the line behaves as a resistor, and the insertion loss is exactly the same as is obtained without an earth connection.

Inserting resistance into the earth lead produces a dip in the frequency response. One critical combination of frequency and resistance produces a complete null (Fig. 3). Beyond the "null" the

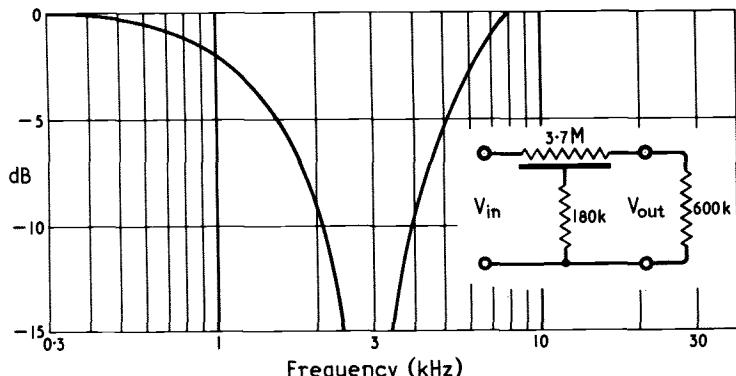


Fig. 3. Notch filter. A complete null is obtained only for one combination of frequency and earth-lead resistance.

response rises again and eventually exceeds the l.f. response. By cascading a normal network and a null network, low-pass filters with sharper cut-off are obtainable, but unless buffer stages are used there is a marked interaction between the two "sections".

If the "earth plane" is left disconnected (equivalent to a "null" configuration with infinite resistance in the earth lead), the attenuation is reduced at high frequencies (Fig. 4). Thus, by changing the earth-lead arrangements by means of a 3-position switch (Fig. 5), three different responses are made available: low-pass, null, and top lift.

OSCILLATORS

At one frequency the phase shift through the line is 180° . It is therefore possible to use the line as the feedback element in a phase-shift oscillator (Fig. 6). A transistor with a high gain is required, especially at low frequencies, where the low terminating impedance at the base end of the line introduces an additional loss. (Measurements in a working low-frequency circuit showed $V_{in}/V_{out} \approx 100$).

The graph (Fig. 7), which plots frequency of oscillation for a given style of resistor ($50 \times 8\text{mm}$ high stability carbon) against (frequency \times resistance) suggests that the frequency of oscillation may be predictable by "rule of thumb" except for high-resistance lines (over 2 megohms).

The frequency stability of these oscillators is not good, but they possess some virtues. The first, which is obvious from Fig. 6(a), is extreme economy of components. At low frequencies (high line resistance) the power drain is very low. At high frequencies, the oscillator is very tolerant of stray capacitance across the line terminations. Tests on a 1.3MHz oscillator made from a $4.7\text{k}\Omega$ ($50 \times 8\text{mm}$) resistor showed that in order to stop oscillation it was necessary to load the line with 450pF at the collector end or 1000pF at the base end. As the loading capacitance was increased from zero the frequency first increased then decreased, which indicates that there is one capacitance for which the frequency stability is highest.

ACCIDENTAL KELVIN CABLES?

The optimum conditions for oscillation seem to favour the resistance range of roughly a kilohm to a megohm. This embraces commonly used base-bias resistances. In micro-circuits, resistances made by thin-film or surface-modification techniques seem likely to act as Kelvin cables, since there is usually an earthed screen near at hand. One wonders if designers of integrated circuits have had trouble with amplifiers which turn out to be oscillators.

By the same token, the RC line, which is obviously easy to make in integrated-circuit form, seems a possible solution to the problem of making tuned circuits without inductors. A "null network" connected in a negative feedback path would produce a peaked frequency response, and so would a "low-pass" network in a positive feedback loop. If the dielectric layer were in the form of a voltage-variable capacitance, external tuning would be possible.

"Kelvin cables" are easy to make, and the associated circuits can be very simple. There are many more ways of using them than are described here. Treatment in "the literature" tends to be rich in highbrow mathematics and poor in practical circuits. They are therefore an attractive subject for amateur experimentation.

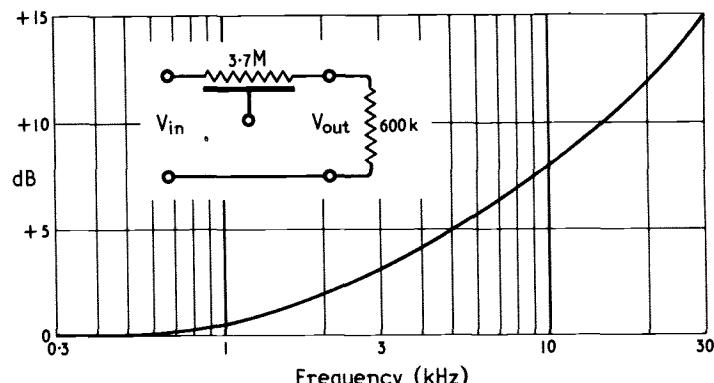


Fig. 4. Top-lift connection. When the "earth" is left off the response rises with frequency. The l.f. insertion loss depends on the resistance values.

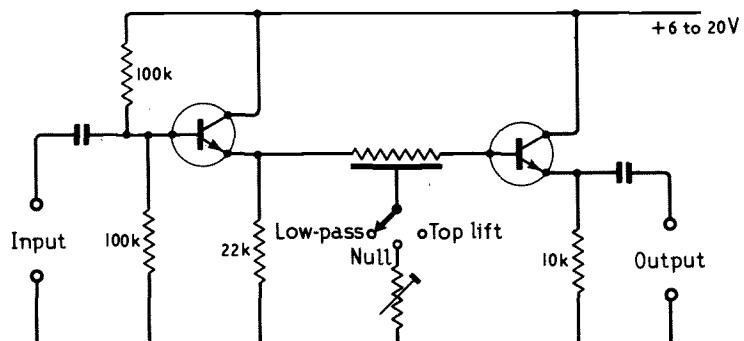


Fig. 5. Practical circuit giving low-pass, notch, and top-lift responses. Any good high-gain low level planar transistors (2N3707, BC109, BC168B, etc.) may be used.

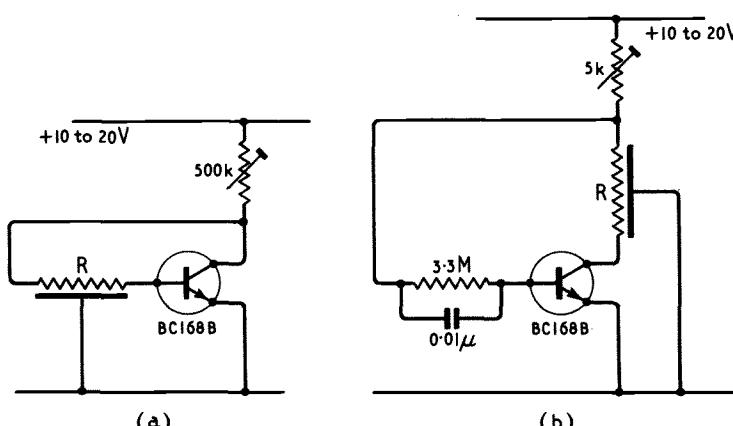
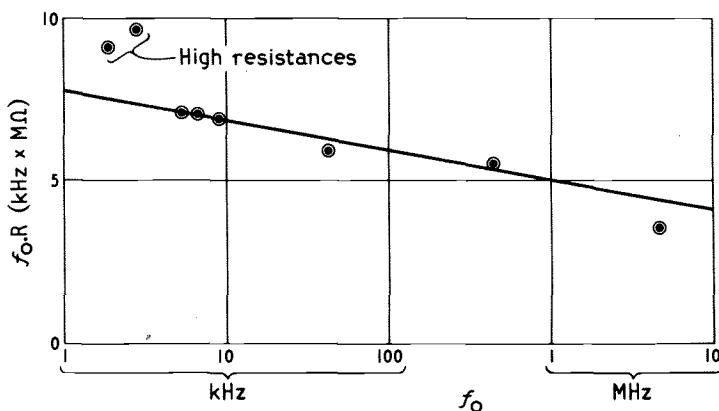


Fig. 6 Phase shift oscillators: (a) low-frequency, for R up to $5\text{ M}\Omega$; (b) high-frequency, for R down to $1\text{ k}\Omega$.

Fig. 7. Resistance-frequency product for oscillators plotted against frequency of oscillation for one size of resistor ($50 \times 8\text{ mm}$).



Letters to the Editor

The Editor does not necessarily endorse opinions expressed by his correspondents

Stereophonic Transmissions

STEREOPHONIC transmissions to the extent of about 25 hours weekly are now put out by the B.B.C. and the whole of this new service is devoted to minority interests of serious music listeners. Already no minority interest is so generously catered for as that of the serious music listener.

I believe the B.B.C. to be confusing the serious music listener with the high-fidelity enthusiast. High-fidelity enthusiasts are found from all musical interests but the greatest potential audience is without doubt the lighter music listener.

I cannot protest strongly enough at his flagrant misuse of licence money to satisfy such minority interests at the expense of all other high-fidelity enthusiasts.

Stereophonic time should now be divided proportionately between the various musical interests and a due proportion of time at weekends and in the evenings should be given to the more popular light music tastes and to the whole audience who are interested in stereo transmissions.

DAVID BAILEY

Longfield, Kent.

Future of European l.w. and m.w. Broadcasting

WITH the spread of v.h.f. broadcasting in many European countries and its obvious advantages of excellent audio quality and relative freedom from inter-station interference, it is to be hoped that eventually, the long- and medium-wave bands may become less chaotically congested than at present. The B.B.C.'s services in this country are merely one example of deterioration to an almost unacceptable level after nightfall and the l.w. band is now dominated by high power French-speaking "pop" stations that have "helped themselves" to these valuable channels.

Many of the unique characteristics of these bands, and especially the l.w. band, not possessed by v.h.f. are at present impossible to realize. Among the most valuable of these are:

1. Generally reliable propagation over paths of 800-1,000 miles or more especially after darkness, providing an often excellent service for listeners outside the country of origin.

2. Relatively small effect of unfavourable geographical features on propagation.

3. Suitability for reception in moving vehicles.

4. Relative simplicity of circuitry and aerial required for reception.

In addition to these features, it is perhaps not generally recognized that very much better audio quality is available even with the present 9kHz channel spacing than at present available in a situation where most transmitters use very high levels of modulation and automatic compression in efforts to blast their way through the background.

The following factors might be considered in the reorganization of the l.f. and m.f. bands:

1. In highly populated countries with v.h.f. services, only a small number of high-power stations, situated near the centres of the populations they serve, would be necessary in the l.f. and m.f. bands. The services of these stations could be improved in isolated areas of high population if desired by synchronized medium-power stations at the h.f. end of the m.f. band.

2. These l.f. and m.f. services offer overwhelming advantages in: (a) large areas of low population where stable but low signal strength is adequate; (b) mountainous areas; and (c) less developed countries where v.h.f. has not yet spread widely.

Consideration of the numbers of transmitters required to provide two and often three separate networks for each country show that there are adequate channels in the bands concerned given an acceptable amount of sharing by geographically distant stations.

Even without v.h.f., which of course would continue to develop alongside the new services in most areas, reorganization such as outlined would certainly provide a better service for most countries and with a smaller number of stations because of decreased interference problems.

J. G. SILCOCK
Totnes,
S. Devon.

British-American Business Methods

MAY an American, who is as reluctant to admit an imperfection of the United States, as Mr. Ness, in his letter printed in the February issue, is loath "to be able to paint

the U.S.A. in a better light", remark that it was not the practice at least until late 1965 for the American mail-order houses to pay postage on parts ordered. In light of the ever rising mailing fees in the United States, it is most doubtful that this since has been changed.

Perhaps Mr. Ness was the recipient of the generosity of an American firm that wished to be particularly kind to an Englishman! If this indeed be the case, might not Mr. Ness paint with a less grudging brush?

RONALD KLETT

Loerrach,
W. Germany.

"Semiconductor Type Numbering"

IN the January edition of *Wireless World*, the article "Semiconductor Type Numbering" by Mr. T. D. Towers contained references to sources of information on semiconductor outlines.

I would like to point out that there is a British Standard on the outlines and dimensions of semiconductor devices (BS.3934) published in 1965, which Mr. Towers did not unfortunately mention. This standard includes outlines agreed by all the principal interested trade associations, the Post Office, and the Services, as well as those agreed by VASCA and mentioned in the article.

The scope of this Standard has been further increased by the recent publication of an addendum (No. 1: 1967).

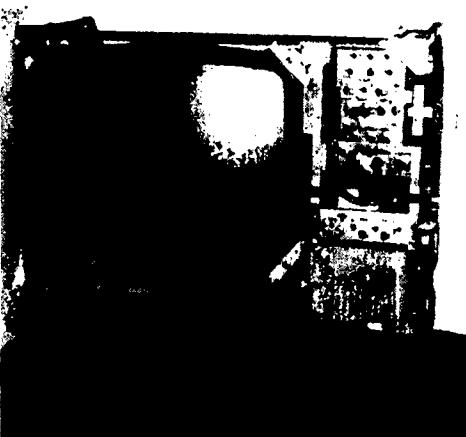
PAUL SPINK

British Standards Institution,
London, W.1.

Home-constructed Colour Receiver

YOU may be interested in the accompanying photograph of my home-constructed colour television receiver based on a Mullard delay-line PAL circuit. It employs 15 valves, 26 transistors, 45 diodes and an R.C.A. 25-in. tube. The only sections not home-made are the u.h.f. tuner and the sound and vision i.f. strip from a monochrome set. Plessey scanning and convergence units, line output transformer and voltage multiplier unit are

Mr. Berney's colour television set



used. With a 21-element Belling & Lee aerial, mast-head amplifier and two other transistor boosters the receiver is giving good results 54 miles from the Wenvoe transmitter which radiates on Channel 51.

P. BERNEY

Malmesbury, Wilts.

"Demonstrating Rectifier Action"

IN my article "Demonstrating rectifier action in slow motion" (February 1968) two words were omitted from the fourth paragraph, which may cause some confusion. The third sentence should read:—"Eventually the circuit will reach a state of equilibrium where in each cycle the charge flowing into C_1 through D_1 is equal to that flowing out of C_1 through R_1 ".

Readers may be interested in another application of the circuit. In stage three, after the steady-state has been reached, switch off the oscillator and observe that it takes some considerable time for the 2000 μF capacitor to discharge through R_1 . Now switch on the oscillator and set the output control of the oscillator to give, say, a peak value of 0.5 V. Wait for the steady-state to be reached. Now adjust the output control of the oscillator, above and below the 0.5 V setting, making the adjustment very slowly: the mean value of current through R_1 should be seen to vary in sympathy with the peak value shown on the voltmeter V_1 . If the rate of adjustment is too high, it can be seen that the capacitor cannot discharge rapidly enough to enable the mean current through R_1 to follow the variation of the peak voltage shown on V_1 , when the peak value is decreasing. This illustrates "negative peak clipping" in detector circuits when a modulated wave is being rectified.

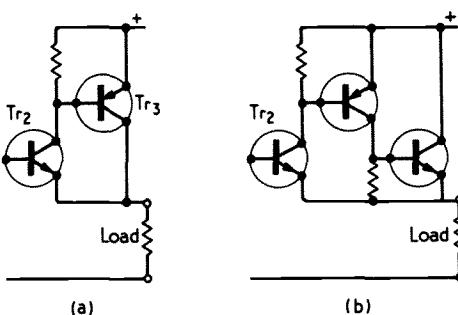
THOMAS PALMER

Kew, Surrey.

Semi-stabilized D.C. Supply

MR. G. W. SHORT goes astray in his philosophy as expressed in his letter in the February issue. The Darlington compound pair, Tr_2 and Tr_3 , will compare quite effectively the output voltage at the emitter of Tr_3 with the secondary reference voltage at the base of Tr_2 and apply correction for a fall (say) in output voltage by increasing the current supplied to load. The "dead reckoning" part of the circuit compensates for the imperfections left by this very simple and rather low-gain closed-loop stabilizer.

The performance of the closed-loop part of the stabilizer will be improved if the effective internal gain is increased. This can be done at little or no expense by using instead of a Darlington pair the "enhanced" emitter-follower arrangement, Fig. (a). Briefly the advantage is that the error voltage is now only the ΔV_{BE} required by Tr_2 instead of the sum of the voltages required by Tr_2 and Tr_3 . Further improvement could be had by using a triple, Fig. (b). This gives increased internal



Mr. Good's suggested improvements

gain because a smaller fractional change in I_c is needed in Tr_2 for a given change in load current.

The advantage of improving the closed-loop part of the stabilizer should be that the dead-reckoning part will have less work to do, and so will need less accurate adjustment.

In Mr. Short's revised circuit the current-sensing resistors for overload protection are placed between the secondary reference voltage (across C_1) and the load voltage (across C_2). It seems likely, therefore, that the dead-reckoning action effected by R_4 will have to do more work in compensating for voltage drop across R_{10} and R_{11} than in compensating for non-infinite gain in Tr_2 , Tr_3 . It would probably be better, therefore, to put R_{10} and R_{11} in the position of the lamp in Mr. Short's original circuit (*W.W.* October 1967, p.482) and arrange the associated transistor to shut down the voltage across D_1 and R_4 when overload occurs.

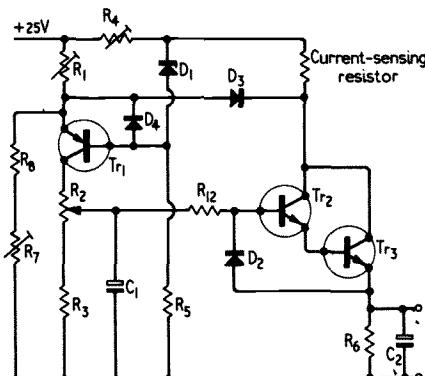
E. F. GOOD

Malvern,
Worcs.

I SHOULD like to suggest an alternative current-limiting circuit for Mr. Short's "semi-stabilized" d.c. supply (October 1967, p.482 and February 1968, p.691).

The current-sensing resistor is placed in series with the collector supply of Tr_2 and Tr_3 , and a small junction diode, D_3 , is connected from the lower end of this resistor to the emitter of Tr_1 . The diode is normally reverse-biased, but conducts when the p.d. across R_4 and the sensing resistor exceeds that across R_1 . When this happens, the voltage on Tr_1 emitter reduces, causing a reduction in collector current and hence a fall in output voltage. The load current is therefore limited

Mr. Smith's current-limiting circuit



to that value which will produce this p.d. across R_4 and the sensing resistor.

The value of the sensing resistor is given approximately by the Zener voltage divided by the required current limit. Values obtained empirically were 25 ohms for a useful limit of 300 mA and 12.5 ohms for a useful limit of 600 mA.

A worthwhile precaution when using this method of current-limiting is the inclusion of another diode, D_4 , connected as shown. In the event of a short circuit suddenly applied to the output terminals, there will be a slight delay in the operation of the limiting circuit, due to the charge on C_1 , which has to leak away before the output can fall to zero. The extra diode prevents reverse-biasing of Tr_1 base-emitter junction. Alternatively, reverse-biasing may be allowed to occur, and any consequent Zener current may be limited by a resistor in the base lead of Tr_1 .

Mr. Short's circuit has the advantage of a slightly faster limiting action at higher output voltage settings (when the slider of R_2 is at the top end) due to the additional discharge path for C_1 provided by the transistor.

K. R. SMITH

Kingston College of
Further Education,
Kingston,
Surrey.

IT is gratifying to see so many ideas for improving the performance of my simple stabilizer, and without over-complicating the circuitry.

Mr. Good is, of course, quite right; I should have made it clear, when referring to "dead reckoning", that the part of the circuit involved here is the load-current compensating system, not the compound emitter-follower, which does indeed compare the secondary reference voltage with the output voltage.

In an emitter-follower circuit, the output voltage is the input voltage (the secondary reference voltage in the present case) less the base-emitter voltage drop. (In a Darlington pair, the sum of the two base-emitter drops.) These V_{BE} drops vary with load current, spoiling the regulation. In a high-current stabilizer, with an output of an ampere or more, the V_{BE} variation from no load to full load can easily be as much as 1 V. Hence the need for load-current compensation. My simple method is essentially an attempt to compensate a non-linear effect by a linear one and so cannot do more than achieve a good compromise. It is conceivable that by involving a diode in the determination of the compensation a more accurate form of dead reckoning may be obtained. However, now that Mr. Good has shown how one of the V_{BE} variations may be removed from the scene of action and the loop gain increased the simple resistance method should be good enough for most purposes.

Mr. Smith's neat and economical current-limiting arrangement takes care of Mr. Good's other point by putting the current-sensing resistance in the positive line out of harm's way.

G. W. SHORT
Croydon.

Microvolt-Nanoammeter

A RECENT letter from a reader has brought to light an error in the components list of my microvolt-nanoammeter article, which appeared in the May 1967 issue of *Wireless World*. The mistake is mine, and I apologize for any inconvenience it may have caused. In the list, R_{20} should be given as 4.7 kilohms, not 10 kilohms.

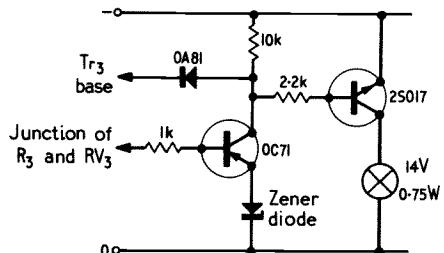
D. BOLLEN

Devon.

Model Motor Speed Control

IN his article entitled "Speed Control for D.C. Model Motors" (September issue) Mr. Butterworth uses a fuse for short-circuit protection. As this fuse is expected to rupture at each overload, and as the controller might be used by a child, it is foreseeable that replacing fuses could become expensive, if not just inconvenient.

For these reasons I devised a circuit to provide automatic overload protection and, with a little elaboration, visible indication of the overload. In the circuit shown here, when



Mr. Hubbard's overload protection circuit

the maximum current is reached the potential developed across R_3 (in Mr. Butterworth's circuit) causes the OC71 and the Zener diode to conduct. In turn, the OA81 conducts and via Tr_3 and Tr_4 the drive to the bridge circuit is reduced. The factor which decides the maximum current is the Zener voltage of the diode. It would seem that a silicon transistor would be better for the lamp driver as it is more easily turned off and has low leakage. The transistor types are otherwise uncritical. The operation of the indicator drive circuit is too simple for words.

R. P. HUBBARD

Guildford,
Surrey.

"Pin-board Construction"

IN case readers were puzzled by an unheralded reference to "terminal blocks" in the first paragraph of my article (February, p.699), it should perhaps be explained that the original text contained an earlier passage which described how, as a first attempt at making a breadboard type of construction for beginners, bits of "chocolate block" screw-down terminal strip were screwed to a wooden baseboard. This avoids the need for soldering, but it was soon abandoned because of its inflexibility: the straight lines of terminals on

the blocks force one to rearrange the circuit layout, which then moves further and further from any correspondence with the circuit diagram. This psychological difficulty, in addition to the physical limitations mentioned in the article, make it unsuitable for a beginner.

I do not yet know what is the ideal base material. Softwood has the advantage that pins can be inserted with the help of pliers, without hammering. (Special tools for pushing small carpentry pins or nails into wood can now be bought at do-it-yourself shops.) The main disadvantage of wood is its finite resistance, which can lead to mains hum in some types of circuit. Hardboard is cheaper, but unless the pins are inserted firmly they tend to work loose. (Particle board is even worse; soldering the pins melts the resin which binds the particles together.) What is needed is some uniform non-hygrosopic board soft enough to enable pins to be inserted without hammering but still able to hold them firmly. It should also be cheap! Perhaps some reader knows the answer.

There is an error in Fig. 5. The 22k resistor should not be connected to the negative rail. In constructing the receiver, the ME101 transistors should be placed upside down on the breadboard; this makes their leads conform to the theoretical diagram (Fig. 1). Incidentally, this transistor has now been renamed HK101.

G. W. SHORT

Croydon

knowledge that might be useful for better communications equipment. One promising field was research into semi-conductor materials. In 1940, a modest research effort was begun, but it was interrupted by the second world war. After the war, Bardeen, Brattain, and Shockley were among many scientists who turned to full-time work on semiconductor research.

Investigations were centred on the two simplest semiconductors, germanium and silicon. Experiments led to new theories. For example, Shockley proposed an idea for a semiconductor amplifier that would critically test a particular theory. The actual device proved to have far less amplification than had been predicted. Bardeen then suggested a revision of the theory that would explain why the device would not work and why previous experiments had not been accurately foretold by the older theory. In fresh experiments designed to test the new theory, Bardeen and Brattain discovered an entirely new physical phenomenon—the transistor effect.

The initial patent on the transistor was held by Brattain and Bardeen. The device described was a point-contact type, the transistor effect being produced by two pointed metal contacts on the surface of the germanium semiconductor material. When a small positive potential was applied to one of the contacts, holes flowed into the germanium surface, greatly increasing the flow of current from the germanium to the other point, which was negatively biased. Shockley patented the junction transistor in 1948.

Through the years, there were developed new types of junction transistors that performed better and were easier to construct. In the early 1950s work in the U.S.A. led to a commercial process for making germanium transistors by alloying techniques. Further impetus to the growing transistor industry was given in 1954 by the development of diffusion and oxide masking techniques for making p-n junctions. The immediate product of this and the zone refining technique mentioned above was the diffused-base, high frequency transistor—a device that could be mass produced at low cost. In the same year, 1954, Texas was the first company to devise a method of making silicon transistors on a commercial scale.

Another important innovation, made by the Fairchild Semiconductor Company in 1960, was the planar geometry for the junction transistor, which was based on the earlier oxide masking and diffusion techniques. During the same year the epitaxial transistor was developed at Bell, further improving performance and lowering costs. Many other devices have been derived from the transistor, each having its special capabilities. Among them are devices for handling high power, generating microwaves, and detecting extremely weak signals at optical and microwave frequencies.

It was the basic transistor technology, of course, that led eventually to the development of integrated circuits and to their latest manifestation, large-scale integration. On page 6 of this issue there is a picture comparing the first transistor with a recent integrated circuit, and this shows just how far the technology has come in 20 years.

Transistor is Twenty Years Old

TWENTY years ago the transistor was invented at Bell Telephone Laboratories, U.S.A. *Wireless World* reported the event in the October 1948 issue ("Amplifying Crystal"), stating that John Bardeen, Walter Brattain and William Shockley had demonstrated that a small piece of germanium could be utilized to obtain power amplification of about 20 dB. In 1956, these three scientists were awarded a Nobel Prize for the discovery of the effect.

Not only is the transistor one of the great inventions of the twentieth century, but it has led to a host of advances in other scientific fields. For instance, zone refining, invented to purify transistor materials, has made available ultra-pure materials for all kinds of technical and scientific purposes. The increased interest in the properties of solids has led to other quantum electronic devices, such as lasers, light amplifiers and light modulators. The study of surface properties of materials, extremely important to transistor technology, has progressed to a point where active atoms can be detected in single layers in 1 p.p.m. concentrations.

At Bell Labs basic research on materials and on fundamental physical phenomena had been encouraged in the hope of obtaining new

Letter from America

ONE of the most influential magazines catering for the American teenager is *Seventeen* and this magazine recently took a poll of the home entertainment habits of its readers. The results show that more than 12 million girls between the ages of 13 and 19 spend a quarter of their time listening to radio, TV, discs or tape. Not surprising perhaps—but here is a startling fact; *no less than 22% own their own tape recorders*—three times the national average! One reason is that tape recorders (and video systems too for that matter) are commonly used in the schools so children get used to them. As the editor of a trade journal put it, "Mother may be uninterested in the tape recorder—or even slightly afraid of it—but daughter has no such fear." These days tape recorders of one kind or another are used for all sorts of things but I must confess I would not have thought of sending in my tax returns on tape! But 450 business taxpayers *did* send their returns to Washington this way and it is perfectly legal! Let's hope there are no print-through problems!

ACCORDING to another poll—a national one—more than 35% of American homes have at least two television sets. Of course, one of the reasons is that the old faithful black-and-white set is relegated to the kitchen or children's room when the new colour set is installed. Incidentally, the last available figures indicate that 23% of all TV homes had colour sets. By the time this "Letter" appears in print the figure will be in the region of 30%, or a total of 16,000,000. One of the problems of colour television is the possibility of X-ray radiation and this has caused a lot of controversy during the past year or so. The maximum safe figure generally accepted is 0.5 millirontgen per hour (mR/h). According to a recent report by a consumers' organization two of 12 different makes tested exceeded this figure when the a.c. mains input voltage was increased to 125 volts—which could be encountered in some circumstances. One set had twice the limit from the top and the other four times the limit from the back. Measurements were taken at a distance of 2 inches and it was pointed out that the radiation would decrease rapidly with distance and even at four times the stipulated maximum the radiation at 6 feet would be negligible. However, the offending sets ended up in the "not acceptable" class at the bottom of the page! The truth is, not enough is really known about the effects of radiation and the official position is a little obscure at the present time. The Federal Government has a committee examining the current standards and at the same time another agency, the U.S. Public Health Service in conjunction with the Electronic Industries Association is also conducting an investigation. As a matter of interest, one Public Health test found that a shunt regulator valve in a GE television set could produce downward radiations. This was promptly corrected by GE, but similar valves are

used by other manufacturers. If the above mentioned authorities come up with new official standards they will have to be applied to microwave ovens, klystrons, linear accelerators and laser equipment—all potentially more harmful than TV receivers. In my opinion, the programmes themselves—or, at least, some of them—are infinitely more harmful than possible X-ray radiation! But that is another story.... To be honest, American television can be extremely good in terms of programme content, presentation and sheer technical brilliance. But the bad programmes are almost unbelievable; they are banal, trivial, rubbishy to the *nth* degree. As one TV executive said "the purpose of TV is to sell", so I suppose the moronic offerings must do just that!

ONE of the most notable advances in magnetic tape recording is the invention of chromium oxide coated tapes by Du Pont of Wilmington, Delaware. These tapes, named Crolyn, use conventional Mylar polyester base with specially de-

veloped binders. Chromium dioxide is the only known ferromagnetic oxide and it has a much higher magnetic moment per unit than iron oxide so the signal output is higher for the same degree of resolution. Alternatively, the resolution is better for a given level of output. So in practice, slower operating speeds can be used without loss of signal quality and a greater bandwidth can be achieved at normal recording speeds. Spectacular increases in signal-to-noise ratios (up to 20dB) are claimed. In video recorders the picture quality is really determined by the tape itself and the improvement with Crolyn is dramatic. A picture (Fig. 1) from an iron oxide tape played through a video recorder at half speed ($3\frac{3}{4}$ i.p.s.) shows the effects of inadequate h.f. response and poor signal to noise. Fig. 2 shows a picture played through the same recorder at half speed using Crolyn. In the computer and instrumentation fields Crolyn can also offer worthwhile advantages such as better efficiency, improved linearity and so on. How about audio applications? Well, Du Pont say that the standard tape is not suitable for ordinary recorders and they have no immediate plans to market a modified type. On the other hand, there are firm reports of an agreement with Sony which could involve audio tape; moreover a small firm, Gauss Electrophysics, demonstrated a tape recorder using Crolyn at the Audio Engineering Society's show last October. Another significant advance comes from a Professor Meyers of Madison College who has invented a process for using both sides of the tape. This involves placing a ferrite material between the two sides to act as a barrier.

THE latest figures indicate that production of i.cs is going up by leaps and bounds. As an example, sales of digital i.cs have increased by 123% over last year's and prices have come tumbling down. Some months ago, Texas Instruments introduced a line of hybrid i.cs including a complete television f.m. sound system module equivalent to 30 components all packed in a unit smaller than a sixpence. Similar systems are now marketed by RCA, Motorola and others using different techniques and various kinds of package. Motorola have just introduced a range of miniature plastic transistors so small that 144 could fit on a $2\frac{1}{2}$ inch printed circuit board. They are actually one-tenth the size of ordinary transistors and naturally they are ideal for hearing aids or possibly for pre-amplifiers that could be mounted in pickup arms or cartridges.

A NEW development by Intelectron called "neural hearing" may bring new hope to the deaf. What is neural hearing? As its name implies, it is a method of activating the nerves directly; in other words bypassing the ears. It works like this: a modulated r.f. generator is coupled to the head via electrodes so that the head becomes in effect the dielectric of a capacitor. Signals are picked up by the cochlea which converts electrical signals into mechanical ones. It is not certain just how it does this because it is a reversal of its normal function. However, the fact remains the signals are demodulated and the efficiency is quite high. The frequencies used are in the 30 to 100 kHz band. The device is the outcome of government pressure to evolve communication systems that will function under conditions of extreme ambient noise; i.e., in helicopters and tanks. Very little is known about the long-term effects on the nerves and much work has to be done before neural hearing moves out of the lab.

ANOTHER audio magazine, called *dB*, has just made its appearance here. The editor is Larry Zide, who was formerly associated with *Audio*, and he tells me that any British engineer who is professionally engaged in the audio field can have a free copy. The address is *dB*, Sagamore Publishing Co., Inc., 980 Old Country Road, Plainview, L.I., New York 11803, America.

G. W. TILLETT



Fig. 1. Picture recorded on an iron oxide tape.



Fig. 2. Improved picture from a chromium oxide tape.

Time-Controlled Combination Lock

By J. F. C. Johnson, A.M.I.E.R.E., A.M.I.R.E.E.(Aust.)

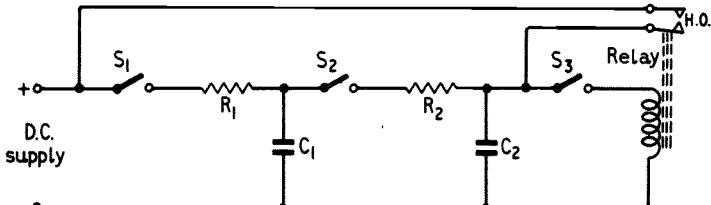
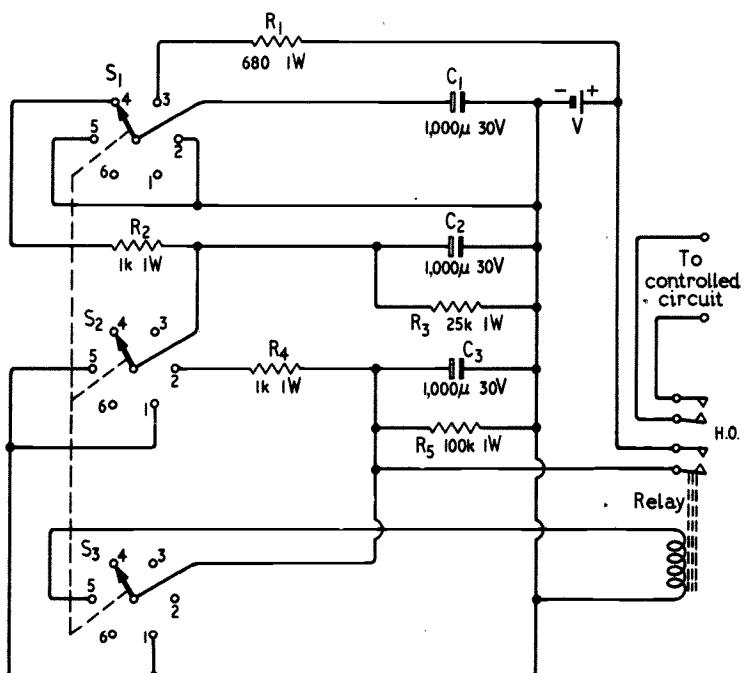


Fig 1. A simplified circuit diagram illustrating the principle involved.

Fig 2. Complete circuit diagram. The relay would normally be employed to actuate a solenoid operated bolt.



J. F. C. Johnson attended an officers' electronic engineering course at the R.E.M.E. Training Centre, Arborfield, Berks, in 1956 after completing his studies in New Zealand. On his return in 1959 he served in various New Zealand Army technical appointments with the rank of captain. In 1965 he joined the staff of the Central Institute of Technology in Petone, North Island, where he is a tutor in radio technology. Mr. Johnson operates an amateur station with the call sign ZL2AMJ.



SEVERAL designs for electrically operated locks have already been published, all have used more than one switch and in some cases more than one relay. The design presented here requires one switch (triple-bank) resulting in only one knob being visible and accessible. The original model employed an eleven-position switch with the end stops removed allowing 360 degrees of rotation and a total of 12 possible positions. Only four of these are used for the actual switching, some being used more than once. The knob must be moved a total of eleven times before the relay controlling the lock will operate. To release the relay the knob is simply moved off this eleventh position and the complete operating sequence must then be repeated again if the relay is to be re-energized.

Not only must the switch be set to eleven different settings in the correct sequence but the timing of the switching is important. The switch must rest in each position for about four seconds before moving to the next. Any longer delay in switching and the relay will not operate. Faster switching and the relay will not operate. As there are 12 switch positions available, the number of combinations possible must reach astronomical figures. The possibility of its operation by those who do not know the combination seems remote indeed. The number of settings, the sequence, and the timing can all be adjusted to suit individual requirements, the model described here is only one of many possible variations.

A simplified diagram to explain the principle of operation is shown in Fig 1. If S_1 is closed, C_1 will charge to a voltage equal to the supply voltage in a time determined by the value of R_1 and C_1 . If S_1 is released, C_1 will retain its charge. Closing S_2 will cause the charge on C_1 to distribute between C_1 and C_2 . C_2 will charge to some voltage determined by the relative capacities of C_1 and C_2 , and the time taken to reach this voltage will be determined by the value of R_2 . If S_2 is now released, C_2 will retain its charge. If S_3 is now closed, C_2 will discharge through the relay causing it to operate. Once the relay contacts close, the relay will hold in the operated position, the d.c. supply now being fed to the relay via the relay contact and S_3 . The relay can be released by opening S_3 . The practical lock is produced by making S_1 , S_2 and S_3 separate banks on a wafer switch and by carefully choosing the supply voltage so that repeated operations of S_1 and S_2 are necessary to build up sufficient charge on C_2 to operate the relay.

Fig 2. shows the complete practical circuit, only six of the twelve switch positions are shown in the interest of clarity. S_1 , S_2 and S_3 are ganged together and form the only control. V is the supply voltage which is chosen to be about 1.5 times the minimum operating voltage of the relay. C_1 is the first capacitor in the chain and it charges to full supply voltage when S_1 is in position 3. The time taken to reach full charge is approximately $5C_1R_1$ or 3.5 seconds. Part of the charge on C_1 is transferred to C_2 (about half the supply voltage in a few seconds) when S_1 is placed in position 4. By repeating this complete operation immediately, the charge on C_2 can be increased to three-quarters of the supply voltage. Neglect R_3 for the moment.

If S_2 is now put in position 2, part of the charge on C_2 is transferred to C_3 , which charges to approximately three-eighths of the supply voltage. As this is insufficient to operate the relay, the entire sequence so far must be repeated, the charge on C_3 being finally raised to about three-quarters of the supply voltage. Neglect R_5 for the moment.

The final step is to switch S_3 to position 5. C_3 now discharges through the relay which closes and is held closed by the hold-on contact.

To release the relay move S_3 off position 5. C_3 has been charged to full supply voltage via the hold-on contacts and it now discharges via R_5 . Without R_5 , C_3 would retain its charge and could operate the relay if S_3 was moved back to position 5 without the switching sequence having to be followed.

R_3 is added to discharge C_2 to ensure that the switching sequence must be made allowing only four seconds on each switch position. Any longer delay and the charge on C_2 cannot be built up to a high enough value to ensure eventual relay operation.

TABLE 1

Sequence No.	Switch Position No.	Circuit action	Approx. waiting time
1	3	C_1 charges	4 Secs.
2	4	C_1 discharges, C_2 charges	4 ..
3	3	C_1 charges	2 ..
4	4	C_1 discharges, C_2 charges	2 ..
5	2	C_1 discharges, C_2 discharges, C_3 charges	4 ..
6	3	A repeat of sequences 1 to 5 inclusive.	4 ..
7	4		4 ..
8	3		2 ..
9	4		2 ..
10	2	C_1 & C_2 shorted, C_3 discharges through relay. Relay operates.	4 ..
11	5		—
Total time required			32 Secs.

The complete sequence of events is shown in Table 1. Slight changes in sequence are possible (e.g. positions 3,4,2,3,4,2, etc. instead of 3,4,3,4,2, etc.) but from measurements taken it was found that these do not give such a fast charge build-up on C_3 as the sequence quoted.

Moving the switch from position 2 to position 5 must be done in an anticlockwise direction otherwise C_3 discharges via S_3 position 1. Similar safeguards exist on other banks to prevent possible "round and round" switch operation from operating the relay. Note too that in position 2, C_1 is completely discharged, ensuring that the full four-second charging time is required on position 3.

When the lock is not in use, the only drain on the supply that can occur is when the switch is in position 3. The current flow is the leakage current of C_1 which should be negligible. The supply voltage can be obtained from a battery or from mains supply via a transformer and a single diode rectifier. The supply voltage terminals should be connected to two inconspicuous "screws" or other accessible devices so that if the internal battery or the mains supply should fail, the lock can still be operated from an external source.

REFERENCES

1. A Combination Lock, V. J. Phillips. *Wireless World*, September 1962, P. 441.
2. Letters to the Editor, K. G. Harland. *Wireless World*, November 1962, P. 544.
3. The Electrolock, Murray E. Coultes. *Popular Electronics*, January 1966, P. 60.
4. A Sequence-operated Lock, Gordon L. Anderson. *Popular Electronics*, January 1967, P. 73.

Literature Received

A 14-page handbook on **time codes** has been made available by the Marketing Dept., Timing and Special Products Group, Systron-Donner Corporation, 888 Galindo Street, Concord, California, 94520. Called "Handbook on Precision Time Code Generation, Synchronisation and Tape Search Systems", it describes the four principal areas of a time code system: the time code generation, time code synchronization, tape search and editing, and code formats. It illustrates various systems with block diagrams and gives complete pictorial description of eight different IRIG and NASA time codes.

W.W. 330 for further details

The Gastometer is an instrument for medical applications and is described in a leaflet received from Beaumaris Electronics Ltd., Beaumaris, Anglesey. The instrument is of value in the differential diagnosis of the origin of facial palsies. It can be used to recognize damage of the chorda tympani following operations on the internal auditory canal. Several other applications are also possible.

W.W. 331 for further details

The biasing of field effect transistors for zero temperature coefficient is discussed in Ferranti application note No. 33 from Ferranti Ltd., Gem Mill, Chadderton, Oldham.

W.W. 332 for further details

A leaflet describing a range of **loose-wound precision resistors** is available from Alma Components Ltd., Park Road, Diss, Norfolk. The loose-winding technique allows the wire to expand and contract freely during heating and cooling, providing better long-term stability.

W.W. 333 for further details

Improved versions of the **series BTR voltage stabilizers** from Claude Lyons with lower distortion and higher stabilization accuracy without a price increase are described in a brochure which is now available. Claude Lyons Ltd., Valley Works, Hoddesdon, Herts.

W.W. 334 for further details

Received from Wallis Hursant Electrotech Ltd., Central Way, Feltham, Middlesex, a brochure describing their range of **high voltage power supplies** and e.h.t. voltmeters. Power supplies are available with outputs variable between 0 and 150 kV and meters with f.s.ds of up to 100 kV.

W.W. 335 for further details

Application note No. 32 from Ferranti describes a **d.c. amplifier** capable of providing 1 kW into a 10- Ω load. The amplifier operates on the class D principle and has a power gain of approximately 54 dB. Ferranti, Gem Mill, Chadderton, Oldham.

W.W. 336 for further details

A solid state **variable a.c. power controller** is the subject of the Claude Lyons leaflet QA-15M. A brief technical description includes applications, construction, and specification. Claude Lyons Ltd., Valley Works, Hoddesdon, Herts.

W.W. 337 for further details

Simple Optical Experiments with Ferranti GP Series Laser includes a demonstration of Doppler shift using a Michelson interferometer, a demonstration of Fresnel diffraction patterns, and determination of wavelength using an engineer's rule. This 22-page handbook is, in fact, intended as a guide to simple experiments using a laser for the demonstration and explanation of optical principles and phenomena. The experiments will be of interest to teachers instructing classes in A level physics. Ferranti Ltd., Kings Cross Road, Dundee.

W.W. 338 for further details

The **Electronic Services Division of S.T.C.**, Edinburgh Way, Harlow, Essex, have produced a 230-page "new stock lines supplement" to their 1966/67 catalogue.

W.W. 339 for further details

A two-page leaflet on **sound control** and associated systems has been published by Rank Audio Visual Ltd. It explains in detail the use of Rank sound control systems in schools, public halls, clubs, lecture theatres and hotels. Leaflet No. is Sfb (64), Rank Audio Visual Ltd., Woodger Road, Shepherd's Bush, London, W.12.

W.W. 340 for further details

Micronotes for Sept./Oct. 1967, No. 3, Vol. 5, discusses the design of high-power microwave windows. Described colloquially as "poker chip" or "pill box" windows, they usually consist of a single thin disc of alumina, sapphire, beryllium oxide or quartz mounted in a short section of circular waveguide. Microwave Associates Inc., Burlington, Massachusetts.

W.W. 341 for further details

A data sheet on the **Spectra-Physics (U.S.A.) 130C gas laser** has been received from Claude Lyons Ltd., Valley Works, Hoddesdon, Herts. It gives a full technical specification on this self-contained continuous-wave, helium-neon laser, which is intended for applications requiring a moderate amount of power (optical test and alignment polarity, demonstrations of coherent light properties).

W.W. 342 for further details

The **R.C.A. Select-A-Lesson teaching machine** is described in a brochure from R.C.A. Instructional Electronics. The publication entitled R.C.A. Select-A-Lesson is available from R.C.A. International Marketing, S.A., 118 Rue du Rhone, Geneva, Switzerland.

W.W. 343 for further details

Duplexer devices from the English Electric Valve Co. Ltd., Chelmsford, Essex, are described in a new booklet issued by them. S & X band TR cells, protector cells, waveguide switches, TR limiters, TB cells and pre-TR cells are covered. Unusually the products are photographed against a scale grid background. A list of U.K. stockists and overseas agents is also given.

W.W. 344 for further details

Technical Notebook

Holographic Memory Process

THE idea that memory in humans and animals might function in a manner analogous to the storage of optical information on holograms was one of the subjects discussed at a Royal Society meeting on the logical analysis of cerebral functions held in London in February. In conventional photography there is a one-to-one correspondence between points on the object and grains on the plate. As a result, the object can be recalled by illuminating the plate in an arbitrary fashion, but loss of part of the plate results in complete loss of information about part of the object. In holography, on the other hand, the correspondence is many-to-many, so that each piece of the plate contains information about the appearance of the whole object, but this information can only be recovered by illuminating the plate in a very special way. It has already been suggested that certain types of composite stimulus may be memorized in a holographic rather than a photographic manner. Professor H. C. Longuet-Higgins pointed out that not only spatial but temporal patterns could be stored and retrieved in a many-to-many fashion—frequency analysis being a simple special case. If the memorization of temporal sequences did involve "holophonic" as opposed to "gramophonic" principles, then not only would some familiar perceptual phenomena be naturally explained, but those parts of the brain which held the memories in question should exhibit periodic behavioural properties, and these might be directly accessible to study by neurophysiologists.

Transducer for Cardiac Research

ORIGINALLY developed for measuring pressures on flight model wind tunnel tests by N.A.S.A., Washington, U.S.A., a diaphragm type capacitive transducer has been produced that shows promise of being extremely useful in cardiac research. The smallest of the transducer probes is less than 1.27mm (0.05 inch) in diameter, can easily be introduced into an artery using a standard 17 gauge thin-wall hypodermic needle and then manoeuvred into the heart on the end of a thin flexible tube. Measurements can then be made inside the heart without disturbing

the blood flow. It is thought that it may be particularly useful in treating babies because of its small size. The transducers cells are made in several sizes; for instance, a cell 1.4 mm in diameter consists of a cell diaphragm 1.4 mm across and 0.0026 mm thick separated by an air gap of 0.005 mm from a film of platinum deposited on to a glass core. A central metal tube in the cell provides an electrical connection to the platinum film and allows the passage of reference air to the capacitor air space. This air reaches the device via a small diameter plastic tube contained in the centre of the interconnecting cable. The cell is linear within 1 per cent from 0 to 26.7 kN/m² (200 mmHg). The electronic system connected to the transducer via the catheter consists of a capacitance bridge excited by a 100 kHz oscillator, a low noise amplifier and appropriate demodulator producing an analogue signal for a recorder or an oscilloscope. It is hoped to connect the transducer directly to a miniature radio transmitter so that the patient under observation can have complete freedom of movement.

Integrated Microwave Circuits

FOR operation at microwave frequencies, active semiconductor devices must have extremely small junctions, and a typical junction area would be of the order of 10-100 μm^2 . Until recently junctions of this size could only be made by chemical etching or whisker contacting techniques (as in point-

contact diodes). Such methods, although providing suitable electrical characteristics, cannot, of course, be used in the manufacture of monolithic or hybrid integrated circuits. At an I.E.E. colloquium on microwave integrated circuits, C.A.P. Foxell of Associated Semiconductor Manufacturers, said that progress in planar technology had now advanced sufficiently to allow small enough active areas to be produced directly in the semiconductor. It was now possible to produce a large range of microwave devices in monolithic form or in chip form for hybrid circuits.

An example of A.S.M.'s experimental work on planar integrated microwave circuits, due to be shown at the forthcoming Physics Exhibition (Alexandra Palace, London, 11-14 March), is an X-band microwave receiver. The box shown in the photograph contains an r.f. front end using a Schottky diode balanced mixer driven by a Gunn-effect oscillator. It also contains a head amplifier for the 50-MHz i.f. The waveguide circuit is constructed in microstrip lines, formed by 0.5-mm wide gold film conductors on an insulating substrate 0.5 mm thick. The mixer and the oscillator, both gallium arsenide, are separate devices, and are bonded to the microstrip conductors in the manner of semiconductor chips in hybrid i.c.s. The mixer is encapsulated in ceramic in l.i.d. (leadless inverted device) form, while the oscillator is in a standard diode package. (A.S.M. say that the two devices could be integrated on a single substrate measuring 27 mm \times 15 mm.) The noise figure for the front end is approximately 9 dB.

Error Computation in Colour TV

THE addition of colour to television increases the number of signal parameters* that can go wrong and the number of subsystems in the television chain where they can go wrong. There are overall tolerances which must not be exceeded too often if colour picture quality is not to fall below a given subjective criterion.

Dr. R. D. A. Maurice (B.B.C. Research Department) has pointed out the advantages of using the mathematical process of convolution to obtain a meaningful and unambiguous value for the overall error that can occur in a parameter throughout the television chain. This is a matter of combining statistically the error probability distributions of the individual parts of the chain (and Maurice suggests the temporary use of rectangular, rather than Gaussian, distributions until television engineers are able to produce statistically valid performance figures for their equipments). The result can be used to produce a curve showing the cumulative probability of occurrence of overall errors from the whole television chain. From this it should be possible for a receiver manufacturer to decide, for example, whether a particular design of television set was a commercial proposition or not.

*For example, chrominance signal differential phase and differential gain; chrominance-to-luminance amplitude ratio; chrominance-to-luminance timing errors.



World of Amateur Radio

Australis OSCARS

A TAPE recording of the telemetry information to be transmitted by the Australian amateur radio satellite AO-A has been received from Melbourne University by Mr. W. Browning, G2AOX, who is looking after the European interests of the project organizers. In view of the complexity of the transmissions and the fact that the parameter is specified by the audio frequency of the signal, it is considered to be desirable that project collaborators should receive practice in resolving the information before the satellite is launched. To that end copies of the tape have been made available by the R.S.G.B. to national amateur radio societies in I.A.R.U. Region I who, in turn, are arranging for the tape to be copied locally and distributed to members.

Plans are being made to produce, later this year, a second Australian OSCAR, to be known as AO-B. This will carry a linear translator with an input in the 144 MHz band. Powered by solar cells the new satellite will operate for at least one year in either a low orbit (about 500 miles) or a near-stationary orbit (about 20,000 miles) depending on the type of launch-vehicle available at the time.

I.A.R.U. Region I Conference.—Proposals have been put forward by the Belgian national amateur radio society (U.B.A.) to hold the next triennial conference of the societies which, together, form I.A.R.U. Region I Division, at the Hotel Metropole, Brussels, during the period May 4th-10th, 1969.

Reciprocal Licensing Agreements have recently been signed by the United Kingdom with the Danish and Swedish administrations. Similar agreements have recently been signed between Canada and Luxembourg and between the United States of America and Austria.

Moonbounce Activities.—The January 1968 issue of the V.E.R.O.N. (Netherlands) v.h.f. Bulletin (English edition) features the activities of and equipment used by most of the world's leading moonbounce experimenters. After a series of near-misses the Australian amateur VK3ATN succeeded on December 20th, 1967 in once again effecting two-way contact via the moon with the Californian amateur K6MYC on 2 metres. Signals at both ends were 3 to 6dB above the noise level in a 100 Hz bandwidth but were somewhat patchy.

Malta Beacon Station 9H1MB is operational 24 hours a day on 70.1 MHz. Reception reports will be welcomed by the Scientific Studies Committee, R.S.G.B., 28 Little Russell Street, London, W.C.1.

The Canadian Amateur Radio Federation was formed recently in Winnipeg by delegates of provincial societies in Alberta, Manitoba and Ontario. The acting president is J. Rock (VE4UX) and the acting secretary/treasurer is J. Cowprie (VE4CS).

The purpose of the new organization is "to promote the welfare of the Canadian radio amateur in the national field".

I.A.R.U. Region III.—Plans are being made to inaugurate a Region III Division of the International Amateur Radio Union at a meeting to be held in Sydney, Australia, during Easter this year. Organized by the New South Wales Division of the Wireless Institute of Australia the ultimate aim of the new organization will be to establish and maintain continuous liaison between societies in I.T.U. Region III with a view to presenting a united front at future I.T.U. Conferences and to provide a programme of assistance to developing countries. The immediate short-term aims of the Conference will be to establish an administrative and organization framework. National amateur radio societies throughout the world are being invited to appoint delegates to attend the Conference, as guests of the Federal Executive of W.I.A. who will provide accommodation and hospitality for the four-day period. All correspondence in connection with the Conference should be addressed to John Battrick (VK3OR), Federal Secretary, W.I.A., P.O. Box 365, Frankston, Victoria 3199, Australia.

Welcome to Belgium.—The annual assembly of U.B.A. (the Belgium National Amateur Radio Society) will be held at Gerval, an attractive town 15 miles south of Brussels, during the weekend May 11th/12th. The programme will include a Fox Hunting competition on 2 metres and a rally for mobile stations on 80 metres and 2 metres. U.B.A. invite amateurs from other countries to participate in the programme. Visitors will be able to obtain a mobile licence free of charge for the period May 1st-31st, by applying not later than April 10th, to the Director of Radiocommunication, 42 Rue des Palais, Brussels 3, enclosing a photostat copy of the station licence. Further information, including details of hotel accommodation, can be obtained from Rene Vanmuyzen (ON4VY), 81 rue J. Baus, Wezembeek-Oppem (Brabant).

Northern Radio Societies' Convention.—The Kent Suite at Belle Vue Gardens, Manchester, will again be the venue for the Annual Convention of the Northern Radio Societies' Association on Sunday, May 19th. The Association consists of radio societies drawn from the North of England, who will be exhibiting at the Convention, together with a number of commercial concerns. Further information can be obtained from R. M. Clarke (G8AYD), "Hillside", Quickedge Road, Mossley, Ashton-under-Lyne, Lancashire.

International Meeting in Germany.—In the past the German national amateur radio society (D.A.R.C.) has held a national meeting biennially. This year, for the first time, the meeting is to be

organized on international lines and is to be held in the West German town of Wolfsburg, near Hanover, during the Whitsun tide holiday (June 1st-3rd).

QRA or GEOREF Locator System?—The location of the other man's station has, from the earliest days, been a matter of interest to amateurs although the question of the distance between stations becomes important only in certain contests where it is used as a points' "yardstick". For many years v.h.f./u.h.f. contest enthusiasts have sought a simple device which will enable them to measure distances accurately. Such a device is the well-known QRA Locator, which although popular on the Continent has failed to attract full support in the United Kingdom. Now a new system, known as GEOREF, which has a military background, looks set fair to replace the QRA Locator system. Full details of the system have been sent to the v.h.f. managers of all European national amateur radio societies who will be asked to decide on the merits and demerits of the system, for amateur radio purposes, at the I.A.R.U. Region I Conference in 1969.

BERU Contest, the most popular contest in the R.S.G.B. Calendar, will commence at 00.01 on Saturday, March 9th and end at 23.59 on Sunday, March 10th. Competitors may use any band from 3.5 to 28 MHz and operation will be restricted to telephony. The contest is confined to R.S.G.B. members resident in the United Kingdom and British Commonwealth.

Faroës Activity.—Using several transmitters and a number of operators, the headquarters station (OY6FRA) of the Faroës amateur radio society (F.R.A.) made 1435 contacts and scored 410,000 points during the recent CQ World Wide DX Contest. The Society's v.h.f. beacon station (OY7VHF), now on the air continuously on 145.26 MHz ± 50 Hz, has been heard in the Netherlands and Denmark but there have been no two-way contacts yet with the Faroës.

Equatorial Field Day.—Radio Society of East Africa held its first national field day event at Rumurati a few miles north of the Equator by courtesy of the Laikipia Country Club, but heavy rains (3.1 inches in one hour!) made travelling to the site difficult. The station operated with the special call 5Z4RS and although several hundreds of contacts were established better results would have been achieved if the weather had been more favourable.

Polish Amateur on 6 Metres.—Eng. Wieslaw Wysocki, SP2DX, has received permission from the Polish telecommunication authorities to transmit in the band 50-54 MHz, a band not normally available to amateurs in Europe. The permission is valid until the end of 1968.

"The FIRAC Bulletin".—The Federation Internationale des Radio Amateurs Cheminots has published the first issue of what promises to become a regular bulletin for the rapidly increasing number of radio amateurs who are directly or indirectly associated with the railways. An international call book is in course of preparation. British representative (Mr. R. Hooper, Station Masters' House, Tavistock North Station, Devon) will be pleased to hear from interested readers.

Zaragoza Convention.—An International Amateur Radio Convention is to be held in Zaragoza during the Spanish Spring Festival (May 22nd-26th) to which amateurs from all parts of the world are invited. An extensive programme of visits, business meetings, lectures and social functions has been arranged by the organizing committee (Delegation U.R.E., Apartment 86, Zaragoza) from whom full details can be obtained. Enrolments will be accepted up to April 15th.

Electronics in Typesetting

Photo-composing machines used for Wireless World

by R. F. Southall, B.A.(Cantab.)

As well as having a new format, *Wireless World* is now being printed by a more modern process called offset lithography. The author describes the electronic system used with this process for controlling the photo-typesetting machines that form and assemble the characters in the text you are reading.

THE increasing demand for good-quality print, and particularly for good-quality print in colour, has led to the development and to the now widespread use of the printing process known as offset lithography. This process, with its requirement that the material to be printed be presented to the maker of the printing plates as a photographic negative or positive, has led to the development of machines which photograph the letters of text directly on to film and eliminate the slow and complicated process of casting the letters in metal, proofing them and photographing the proofs. These machines are called photo-typesetters, photo-composing machines or film-setters.

The photo-typesetters on which *Wireless World* is from now on to be set come from the Photon-Lumitype family of machines, the first member of which was developed in America between 1946 and 1954 by two Frenchmen, Louis Moyroud and R. A.

Higonet. *Wireless World* will be set on two machines of the family: the Model 540, which works at eight operations a second and is electromechanical, doing its calculations with relays; and the Model 713, much faster, which photographs about 30 characters a second and whose calculation and control circuits are transistorized.

If photo-typesetting machines are to be economical in use they must be very productive (since they are expensive in first cost) and they must offer a wide choice of characters (so that jobs of different kinds may be run successively without the machines having to be stopped to change the character "matrices" which carry the characters in the manner of stencils). All the machines in productive use today (with the exception of one special-purpose machine which stores its characters in digital form in a magnetic core store) use character matrices produced by photographic processes, carrying clear images on an opaque ground. The distinguishing feature of the Photon-Lumitype machines we are discussing is that the matrices they use are in continuous motion, and the letters on them are illuminated for photography by a xenon flash tube. The duration of the flash from the tubes used is less than three microseconds, and the flash starts and stops with sufficient abruptness to give sharp character images in spite of the fairly

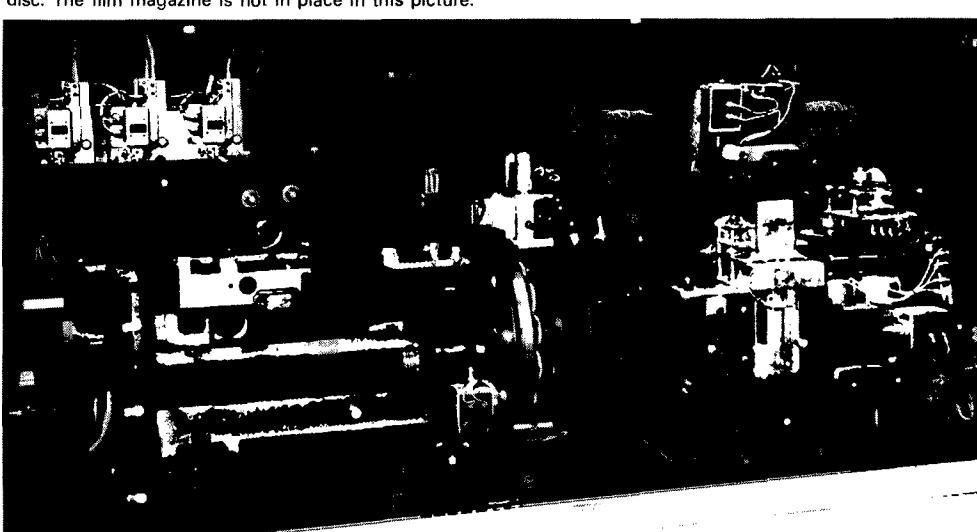
high linear speed of the matrix (the matrix in the 540 machine is a disc about nine inches in diameter rotating at 8 rev/sec; the matrix in the 713 is a drum about eight inches in diameter rotating at 30 rev/sec). The 540 disc carries eight circles of 180 characters each, and all of these can be reproduced, by means of magnifying lenses mounted in a turret, in any of twelve sizes. The drum used on the 713 carries eight rows of 96 characters each, which can be reproduced in any of eight sizes. Thus the Model 540 can produce a total of 17,280 different characters (1,440 characters \times 12 sizes) and the Model 713 a total of 6,144 (768 characters \times 8 sizes).

The 540 disc rotates in the vertical plane, with the flash tube and its condenser optics on one side of the disc and the rest of the optical system on the other; the 713 drum has two flash tubes inside it, each of which illuminates four rows of characters, and there is an arrangement of half-silvered mirrors and a vertically moving collimating lens which presents the correct row of characters to the optical system for photography.

Printers have been very well served almost since the invention of their craft by the people who designed and cast their types for them. The factors in the design of a typeface which make the difference between effortless legibility and eye-straining indecipherability are entirely unappreciated by nearly all readers: chief among them are the qualities which the typographer calls *colour* and *rhythm*.

In reading, the eye travels along the line not steadily from word to word but in jumps between "fixations", where it momentarily rests. To be easy to read, a line of type, no matter what the sequence of the letters in it, must present to the reader's eye the impression of an even line of grey; if there are dark spots or patches in the line the eye will tend to fixate on them at the expense of the rest of the line. To be easy to read also, the typeface must be designed so that the reader's eye

The photographic unit of the Lumitype 540. At the upper left are three of the eight solenoids of the variable escapement; below them and to the right is the prism carriage. To the right of this are the lens turret and the matrix disc. The film magazine is not in place in this picture.



Richard Southall graduated from Cambridge University with a B.A. in natural sciences in 1960. After four years as a book designer and a short period as a scientific information officer, he joined Crosfield Electronics Ltd. in 1965. This company, makers of electronic machinery for printers, manufactures the Lumitype 540 and sells under licence the Photon 713 photo-typesetting equipments described in the article. Mr. Southall's work is concerned with customer liaison in the typographic field.



The matrix disc of the Lumitype 540 in position in the photographic unit. The cylindrical object overlapping the left-hand edge of the disc is the housing for the photocell which generates impulses from the slits at the periphery of the disc; these impulses trigger the firing of the flash and ensure exact lateral positioning of the characters. The arrangement directly beneath the boss of the disc is a window which limits the area of the disc seen by the optical system. In the foreground is part of the lens turret.

carried from fixation to fixation forward along the line; in crude terms, it must be obvious that the type in which the line is composed is designed to be read from left to right. At least since the time of the early Venetian printers these qualities have been so much a part of the design of most text typefaces that both printers and readers have tended to take them for granted. It was not until the development of composing machines, and particularly of photo-composition (the first entirely new method of producing type-matter since Gutenberg) that it was realized by anybody other than the minute community of typeface designers and punch-cutters* what enormous technical demands the production of well-composed type makes on the producer.

The principal problem in producing lines of type of an even colour is keeping the "weight" (broadly speaking, the thickness of line) of each character the same as the designer intended; and the principal problem in retaining the designed rhythm of a typeface is maintaining the designed inter-character spacing. This is because both the colour and the rhythm of the line are strongly affected by the relation between the white spaces inside the character shapes and those outside, and this relation is affected in turn both by the thickness of the lines making up the character and by the inter-character spacing.

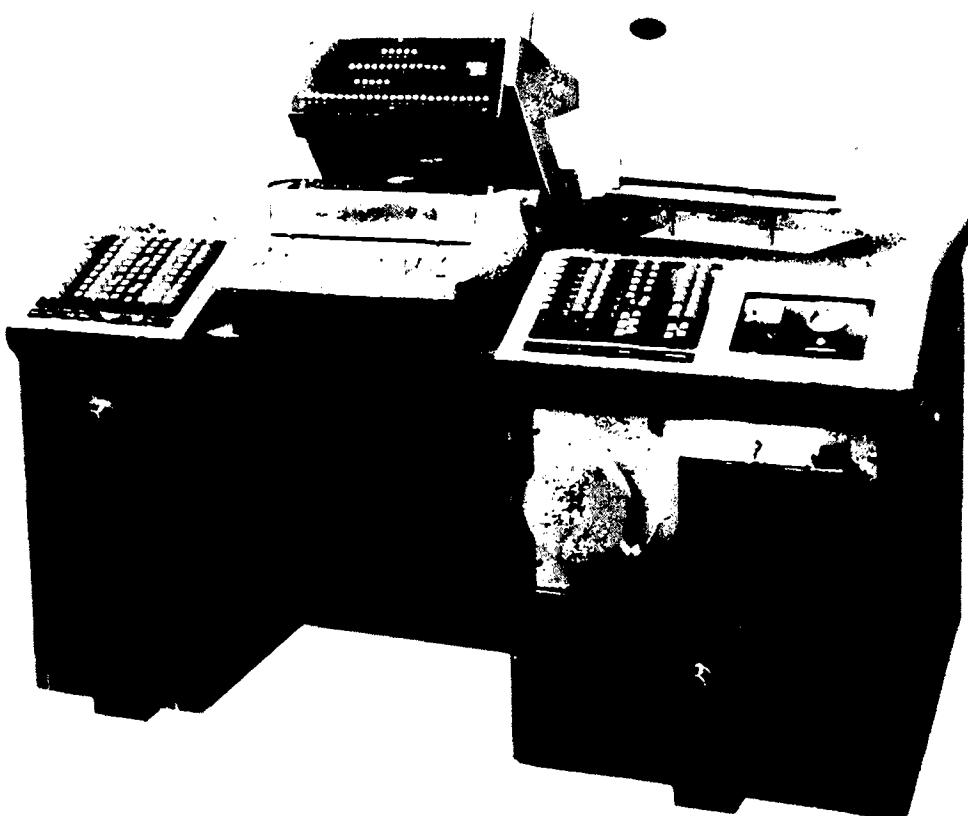
In photo-composing terms, and generally speaking, the weight of the characters in a line will be consistent if the intensity of the exposing light-source remains constant. This is not too difficult (though not entirely

simple) to achieve with electronic flash tubes, though flash variations causing density variations in the exposed parts of the film which are almost too small to measure may, with certain typefaces, have a most marked effect on the look of the end-product. It is the extraordinary high standards required in the vertical and lateral positioning of characters (standards to which, it must be said, printers have been educated by the superb performance of the best hot-metal composing machines) which are largely responsible for making the design of photo-typesetting machines both difficult and interesting. In a line of sans serif capital "I"s set close together, variations in inter-character spacing of the order of 10^{-3} in. are quite easily perceptible to the naked eye (which picks up the small alterations in the colour of the line). The clean appearance of a film of photo-typeset characters, free from the interfering effects of inking and ink squash which are present in even the best proofs from metal type, makes it necessary to achieve and maintain accuracies of positioning of this order, or better, during the whole of the time the machine is operating. Doing this with a moving matrix and other moving parts at repetition frequencies of up to 40 per second is no small achievement.

In most photo-typesetting systems the widths of characters are expressed on a "unit system" in which the body size of the type—which would be its depth from front to back if it were cast in metal—is divided into 18 "relative units" ("relative" because they change in absolute size with changes in the body size of the type). The basic unit of

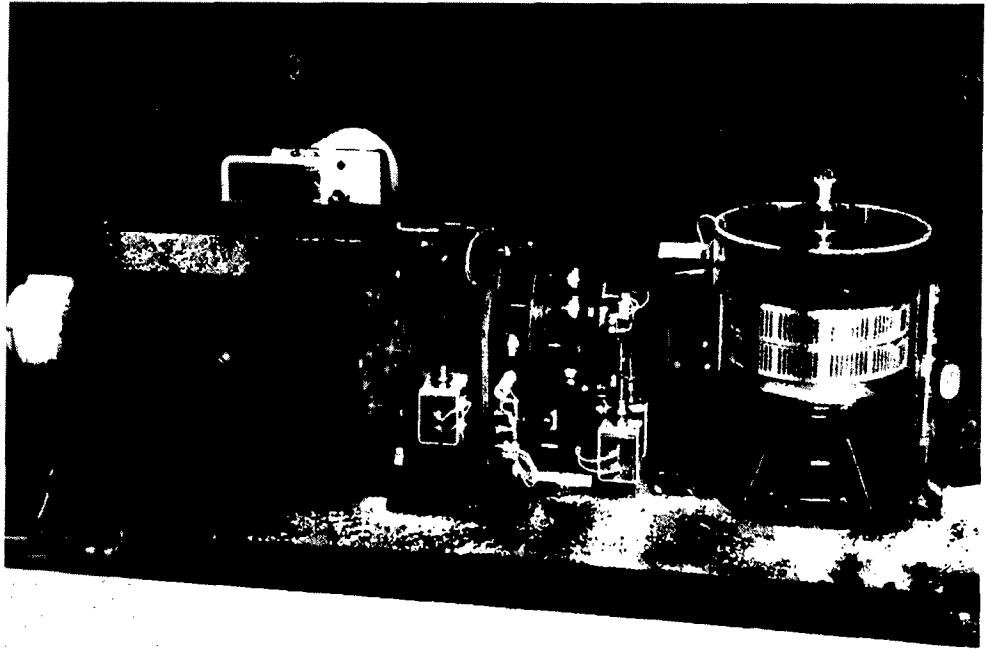
the system is one-eighteenth of one printer's point (7.685×10^{-4} in. approximately) and the actual width of a character is found by multiplying its width in relative units by the body size and by the basic unit.

The Lumitype 540 control unit does its calculations in "machine units" of two basic units, since one basic unit is too small a distance for an arrangement of friction clutches and differential gears to move reproducibly. The width of each character in machine units is calculated by the 540 keyboard and is punched into a paper tape in a "frame" following the character identity code. This punched paper tape is used to actuate the control unit of the machine. (In the 540 system each character is represented by a group of three eight-channel code "frames".) At the end of each line of text the 540 keyboard also punches into the tape the "deficit" (the difference between the totalled widths of the characters and spaces in the line and the line length set up on the keyboard) and the number of inter-word spaces in the line. The machine control unit divides the one by the other and adjusts the width of each inter-word space to bring the length of the photographed line to the length set up on the keyboard—the process known as *justification* which ensures that the column of type has an even right-hand edge. The fact that the keyboard and control unit of the 540 do all their calculations in basic units means that the operator can mix different sizes of type in the line without upsetting the justification: this is a great help in setting complicated copy.



The Lumitype 540 keyboard. In the 540 system this keyboard carries out the part of the justifying cycle which involves calculating the deficit in the line and counting the inter-word spaces. The banks of keys to right and left of the typewriter allow the operator to select typeface, size, inter-line spacing and line length.

*The artist-craftsmen who engraved the steel punches used for striking the matrices from which metal type was cast.



Photographic unit of the Photon 713 machine. On the right is the matrix drum, with leading down into it, the connections to the two flash tubes. The light-coloured oval on the extreme right is part of the magnetic pick-up for the sonic wheel on the matrix drum. Behind it is a printed circuit card carrying the character identity pulse amplifier and shaper. To the left of the matrix drum are the typeface row selection optics with their actuating solenoids, the lens turret, and the film magazine. On the extreme left is the film feed stepping motor.

The characters are imaged on the sensitive material (which may be film or paper) by a travelling lens and prism; these move along the optical axis of the machine and place the letters side by side across the film as they are flashed. The 540 reads the tape punched by its keyboard "backwards", that is, from the end to the beginning of the line, so that a character's width is read before its identity, and the first codes of a line that are read are the end-of-line group which allow the control unit to set up the value of the interword space for that line. Before each letter is photographed, the travelling prism moves by a distance equal to the width of the letter: this is achieved by the "variable escapement", an arrangement of differential gears and a rack and pinion actuated by relays set up by the codes in the tape frame containing the character's width. The variable escape-

ment is a mechanism of very high precision, but its maximum rate of operation is limited by the mass of its moving parts to 8–10 operations a second. For the much higher repetition rates achieved by the Model 713 a quite different system of character positioning is necessary.

The 713 control unit reads its tape in the same sense as it is written; that is, from the beginning of the line. The tape is punched (or, if it is magnetic tape, written) in Teletypesetter[†] or TTS[†] code; this is a simple code, long used for the remote control of hot-metal line-casting machines, in which all the characters and certain functions of the machine are indicated by single 6-channel code frames. The tape does not contain any width information, so the 713 must store for

[†]"Teletypesetter" and "TTS" are the registered trade marks of Fairchild Graphic Equipment Inc.

itself the widths of all the characters on its matrix drum. It does this in part of the magnetic core memory in its control unit. Into another part of this memory each line of data is loaded as it is read from the tape. While the line is being read, a justification process similar in principle to that performed in the 540 control unit is carried out.

Instead of moving the prism carriage for every character photographed, the 713 moves it in steps of 48 relative units (so that the actual length of the step varies with the size of the type being photographed). The problem of carriage bounce is surmounted by slowing the carriage down as it reaches the end of its step and by inhibiting the flashing of characters for about 65 ms after the end of each step to give the carriage time to settle down.

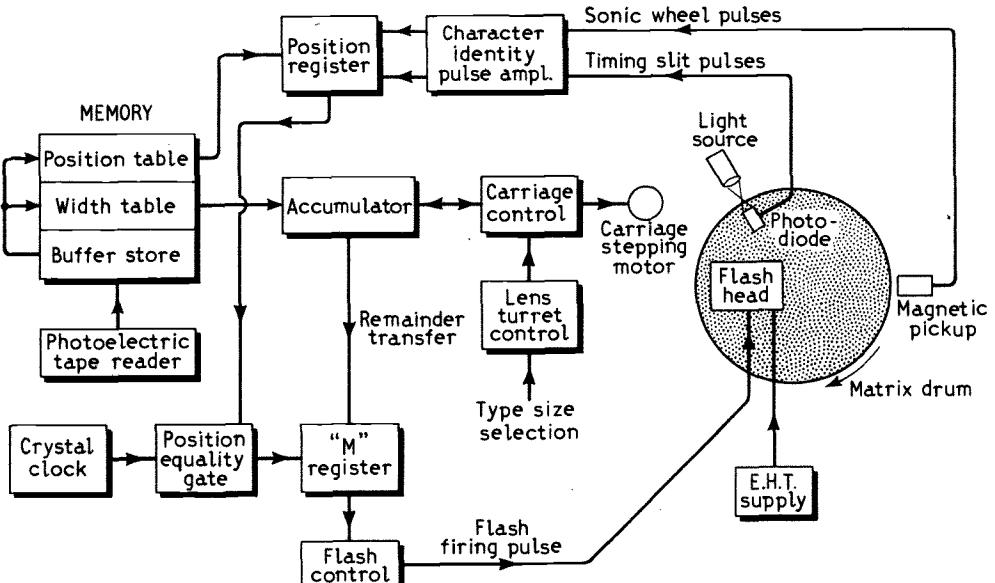
Since the average width of a character in a normal typeface is about eight relative units, six or so characters have to be flashed within each carriage step, and since the successive characters in a step are generally not of equal widths it is not sufficient simply to position them uniformly across the width of the step. However, the matrix drum rotates at a constant speed and the characters are equally spaced around it, so that if the correct instant is chosen to fire the flash tube the character can be correctly positioned within the carriage step.

Associated with each group of eight characters (one above the other) on the matrix drum of the 713 is a timing slit, and on the base of the drum is a "sonic wheel" which, in conjunction with a magnet and a pick-up coil, provides a pulse at each complete revolution of the drum (Fig. 1). When a character is read out of the buffer part of the memory during the "expose" cycle of the machine, two look-up operations take place. One, from the width tables stored in the lution of the drum (Fig. 1). When a character is read out of the buffer part of the all its calculations in half relative units). This width information is transferred into an accumulator which adds up the widths of all the characters and spaces in the line. The excess of the accumulator content over a multiple of 96 half-units is transferred to what is called the "M" register. The number of multiples of 96 half-units already in the accumulator is equal to the number of carriage steps that have already occurred in the line.

The other look-up operation gives, from the position table in the memory, the position of the character on the drum relative to the zero position defined by the pulse from the sonic wheel. This is transferred to the position register, the value in which is compared with the count of character identity pulses derived from the timing slits on the drum. When equality is reached, the drum is in the correct position to flash the character at the left-hand end (seen from the point of view of the character, which is in fact photographed inverted on the film) of the carriage step.

At this moment, pulses from a crystal-controlled clock are gated out to count down the contents of the "M" register. The frequency of these pulses is such that during each one the image of the character moves a distance of half a relative unit on the film. When the contents of the "M" register reach zero the flash tube is fired and the character

Fig. 1. Simplified schematic of the electronic flash timing system in the Photon 713 machine.



exposed on the film; its position has been determined only by its width and the widths of the characters preceding it in the line, and is thus typographically correct.

This method of character positioning, which reduces as far as possible the intervention in the process of pieces of machinery which have to start and stop abruptly, is capable of much higher repetition rates than the escape-and-flash mechanism of the 540. By restricting the character content of a 713 drum and repeating common characters on it so that they can be flashed more than once in each drum revolution, production speeds on normal text setting of greater than 10^5 characters an hour can be reached.

The Photon-Lumitype family of moving matrix machines seem to have pushed the technique of direct photography on to film from a photographically prepared matrix as far as it will go in terms of speed consistent with the large repertoire of characters which printers demand, and with the excellent typographical quality which has always been the primary objective in the machines' development. What little is published on other organizations' current research efforts suggests that a great deal of work is being done on machines which use cathode-ray tube display devices; but it must be said that none of the machines of this sort, in production or announced, have yet achieved standards of typography that even approach those of the Photon-Lumitype family. It is only with good typography that true legibility, the transmission of the author's thoughts to the reader's mind without the obtrusion of the printed word itself, can be achieved.

The South Africa-Europe Submarine cable

A NEW 3-MHz cable is to be laid linking South Africa and Europe, a distance of some 6,000 nautical miles. This cable, which is of joint G.P.O./S.T.C. design, will start at Cape Town and will "land" at Ascension, Cape Verde and the Canary Islands where it will link with a recently laid cable to Cadiz on the Spanish mainland. It will carry 360 independent two-way telephone conversations simultaneously.

In all therefore, 720 channels are required 360 for each direction. This is achieved by using separate 1-MHz wide bands of frequencies; 312-1428 kHz for one direction and 1848-2964 kHz in the other. Each band accommodates 360 channels 3 kHz wide. Groups of channels are assembled into blocks, each block being "stacked" side by side in the transmission spectra. This technique allows a particular block of channels to be selected at some intermediate point for transmission down a branch cable.

Groups of sixteen channels form the starting point for the translation. A separate carrier is applied to each of the sixteen channels in each group so that by choosing the appropriate sideband resulting from each modulation process $22\frac{1}{2}$ translated groups of 16 channels reappear each spanning the range 60-108 kHz. The $22\frac{1}{2}$ groups, so obtained, are again split up into $4\frac{1}{2}$ further groups each of these undergoing a similar translation process to place them in the band 312-552 kHz. A further carrier is applied to bring the combined signal into either the 312-1428 kHz for one direction of transmission or 1848-2964 kHz for the reverse direction.

The cable to be used is being manufactured at Southampton by Standard Telephones and Cables Ltd. The centre core consists of 41 strands of high tensile steel wire twisted together, providing the cable's strength. Keyed to this is a tube of copper which forms the inner conductor. The overall diameter is maintained within very fine dimensional tolerances. High molecular weight polythene is used for the dielectric and is extruded round the inner core. The outer conductor is next formed by folding a copper tape round the cable in a tubing mill, the cable being completed by the application of a further plastic sheath. In shallow water the cable is protected by heavy armouring to prevent damage by ships' anchors, etc.

For constructors there will be a practical design for a Wide-Range R.F. Signal Generator. It covers the range 150 kHz to 120 MHz in six bands. *Wireless World* April issue will be on sale on Monday 18th March.

for all the repeater amplifiers is fed down the same coaxial cable as the signal and in practice power will be fed from both ends of the cable simultaneously, a positive voltage from one end and a negative one from the other. This prevents the repeater from having to withstand the very high voltages that would be necessary if the cable was fed from one end only. Two amplifiers are used in parallel each one being able to take over in the event of the other one failing. If a valve heater goes open circuit a fusible element shorts out the heater chain for that amplifier maintaining the d.c. path.

It is essential in such a system that the gain/frequency curve of the amplifier must exactly match the loss/frequency characteristic of the preceding length of cable. If at some given frequency this was not so the resultant error would be amplified in each successive repeater rendering the system useless, the signal either falling into the noise or driving the amplifiers into overload. It is the task of the equalizer together with heavy frequency selective negative feedback to match these two characteristics. In addition to the individual equalizers fitted in the repeaters the cable lengths in between repeaters are carefully selected to provide optimum response. Even so with a system of this size and complexity errors are bound to creep in, so, after a certain number of repeaters, typically ten, a demountable equalizer is fitted to the cable. This is divided into two sections, a fixed section and a "variable" section. The cable section and repeaters between two demountable equalizers are known as an ocean block.

As an ocean block is being laid continuous measurements are carried out from the cable ship. These would be taken at several carefully selected spot frequencies in the pass band and include a detailed "fine grain" response measurement. These measurements, taken to very small fractions of a dB, have to be completed by the time about half the ocean block is laid. The response of the unlaid section being predicted in the light of results so far obtained. The circuit of the "variable" section of the equalizer is now designed, built and tested. It is fitted into the demountable repeater, the repeater is sealed and a cable joint made. All this is carried out under shipboard conditions to a very high order of accuracy. The repeaters and cable for this 3-MHz equipment is manufactured under clinical conditions.

A 5-MHz transistor repeater cable system is now in production and the G.P.O. is carrying out development work on a 12-MHz transistor system that will carry in excess of 1000 channels.

Our Next Issue

THE April issue of *Wireless World*, which will be current during the London Audio Fair, will contain several features of interest to people concerned with sound reproduction: **Microphone Survey:** a tabular presentation of performance data of microphones available in the U.K., enabling comparisons to be made easily between the different types and makes. There will also be a technical review of recent developments in microphone design. **Better Detection:** an article pointing out that the detector in receivers doesn't get the attention it deserves, and presenting a new type of circuit using digital techniques and integrated circuits. **High-Quality Monitoring Loudspeaker:** the second part of H. D. Harwood's article on the latest B.B.C. design is concerned with bass equalization, the cabinet, and the mid-range and high-frequency units.

For constructors there will be a practical design for a Wide-Range R.F. Signal Generator. It covers the range 150 kHz to 120 MHz in six bands. *Wireless World* April issue will be on sale on Monday 18th March.

Smaller D.C. Converters and Inverters

Operating Frequencies up to 50 MHz

by J. R. Nowicki,*M.I.E.R.E., M.I.E.E.E.

With silicon planar transistors, it is possible to design d.c. converters and inverters that will operate at high switching frequencies—typically 20-50 MHz—allowing small and light output transformers to be used. Supplies between 40 V and 400 V, or higher voltages for cathode-ray and other tubes, are feasible by this technique.

PORTABLE and mobile electronic equipment is usually required to operate from some readily available battery (shown on the left in Fig. 1) but the supply voltages which are needed for the equipment (on the right) may be from a few volts to several kilovolts. It is therefore necessary to use some device which will convert the available voltage to the required value. Such a device, in this case a d.c. converter or inverter, is shown in the middle.

The recent introduction of silicon planar transistors has made it possible to design d.c. inverters and converters with switching frequencies between 20 and 50 kHz. The high switching frequency greatly reduces the size and weight of the output transformer and therefore reduces the overall size and weight of the equipment. The main application is for d.c. supplies for airborne and mobile equipment where either 12 or 24 V batteries are available. The output voltages required may be anything between 40 and 400 V or even higher voltages, as, for example, in the d.c. supplies for cathode-ray tubes, geiger counters, and image converters.

TRANSISTOR RATING

Because of the inductive nature of the collector load, the collector voltage of the transistor during the switch off period may rise appreciably before the collector current has decreased much from its maximum value. Therefore, before commencing a design, it is necessary to consider the breakdown voltage of the transistor at high currents.

When the normal collector current collector voltage characteristics of the transistor shown in Fig. 2 are plotted beyond the published limits the curves shown in Fig. 3 are obtained. At higher collector voltages, around V_x , there is a rapid increase in the collector current due to avalanche multiplication in the collector depletion layer. The level at which the collector breakdown occurs depends on the base drive conditions. Under forward base bias conditions, the collector breakdown voltage becomes lower as the base current increases.

The reverse base bias very much improves the collector breakdown voltage at low collector currents. At high collector currents the breakdown voltages are very much the same. It may be seen from the curves that, although the reverse base bias very much improves the collector breakdown voltage, the collector voltage curves exhibit the negative resistance characteristics. This, combined with the very fast switching times obtained with silicon planar transistors, may lead to a secondary breakdown. Therefore power transistors which are intended for use with inductive loads require a high energy capability before secondary breakdown occurs in the transistor when operated with reverse bias.

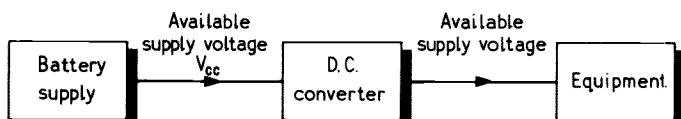


Fig. 1. Arrangement for operating equipment from batteries.

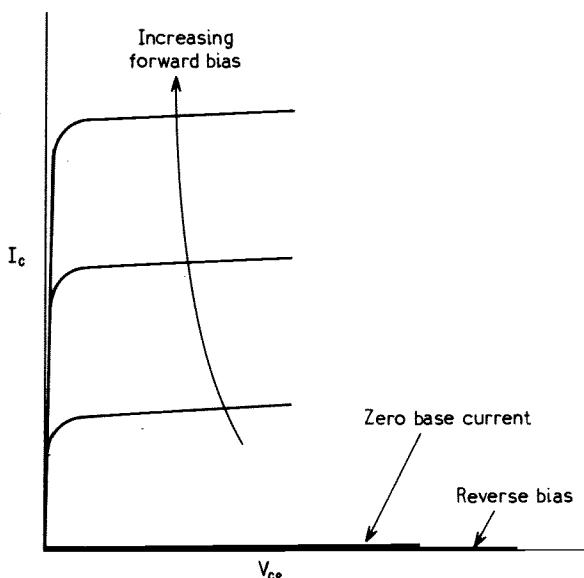


Fig. 2. Collector current vs. collector voltage characteristic of a transistor.

Fig. 3. Transistor characteristics of Fig. 2 taken beyond published limits.

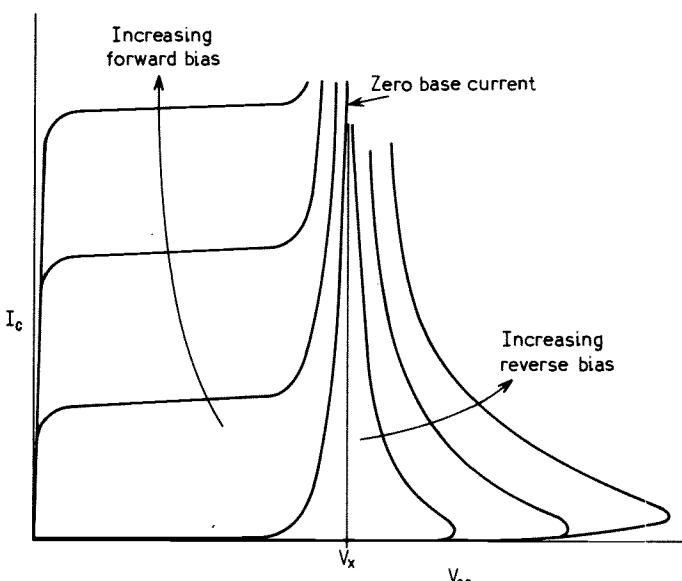


Fig. 4 shows a typical circuit of a transistor working into an inductive load. Such a condition is found in an inverter circuit. The transistor is driven by a feedback voltage derived from the collector winding, which is equivalent to a low impedance generator. If the base bias is reversed suddenly when a high collector current is flowing, permanent damage may occur in the transistor. The damage usually appears in the form of a collector-to-emitter short-circuit.

If the path taken by the operating point of the transistor is considered as shown in Fig. 5, it will be seen that, for normal loading, most of the collector current will be due to normal loading, R_L , shown as the continuous line. The resistive load current will normally decrease to zero by the time the collector voltage rises to V_{CC} , and the voltage across the load will then be zero.

For low loading conditions, however, most of the collector current will be due to magnetizing current, so that the path taken by the operating point will be that as shown by the broken line. The problem is even worse under no-load or an open-circuit load condition, as shown in Fig. 6. The current through the inductance cannot change instantaneously and remains very nearly at its maximum value while the voltage rises to twice the supply value.

If the supply voltage is too high then the operating point during switch-off may intersect the breakdown characteristic before twice the supply value is reached.

The transistor becomes a low impedance, and the switch-off time is governed mainly by the inductive time-constant. The transistor remains in a high dissipation region for a comparatively long time and may be destroyed. Therefore the choice of the supply-voltage is very important.

INVERTER AND CONVERTER TYPES

There are many possible circuits in which transistors may be used to convert voltages from one value to another. All transistor circuits, however, are either ringing choke or transformer coupled arrangements.

D.C. converters are circuits which convert a d.c. voltage of one value to a d.c. voltage of a different value. Ringing-choke circuits, being followed by a rectified output, are all classed as d.c. converters. Transformer-coupled circuits, however, are basically d.c. to a.c. inverters. An a.c. output voltage, whether it is sine-wave or square-wave, is often used. The transformer-coupled circuits become converters only if they are followed by a stage of rectification before the output is applied to a load.

Ringing Choke Converter—The simplest of the transistor d.c. converter circuits is one using a ringing choke principle¹ shown in Fig. 7. In this circuit the energy is stored in the transformer during the "on" period of the transistor and is then delivered to the output during the "off" period.

During the input stroke of the cycle the transistor is bottomed and a linearly rising current flows in the primary winding according to the expression $V_{CC} = L \frac{di}{dt}$. The collector current rises until it reaches its maximum value of $h_{FE} I_B$. The transistor then comes out of bottoming and the collector voltage rises, lowering the primary voltage, thus producing a fall in the base current and switching the transistor off. At this point, the inductance of the transformer primary contains stored energy equal to $\frac{1}{2} L_p I_{CM}^2$.

During the output stroke, when the transistor is cut off, the reverse voltage rises rapidly until the secondary voltage reaches the value V_o . This is the voltage developed across the capacitor C during the previous cycle of operation. At this point the diode D_2 starts to conduct and delivers the stored energy to the capacitor C and the load. When the secondary current has decayed to zero, the reverse voltage developed across the base emitter junction disappears and the transistor switches on again.

Push-pull Transformer-Coupled Inverters—All push-pull inverters are basically transformer-coupled circuits. For high efficiency, square wave oscillating systems are used of which there are three well known configurations: (a) common base, (b) common emitter and (c) common collector. Since the common-emitter arrangement is most efficient and most commonly used, the discussion will be limited to various forms of this type of circuit. The basic principles, nevertheless apply to all three.

The conventional single-transformer d.c. inverter is shown in

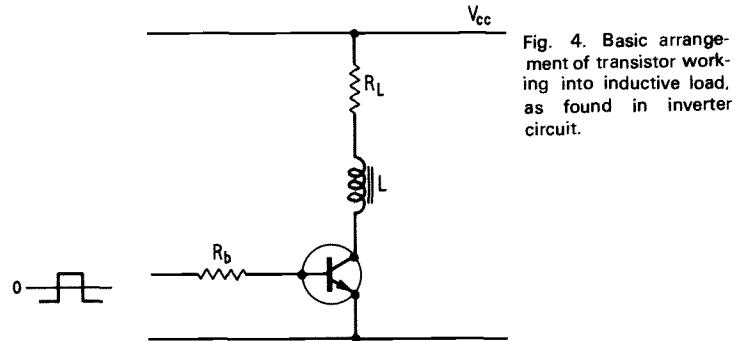


Fig. 4. Basic arrangement of transistor working into inductive load, as found in inverter circuit.

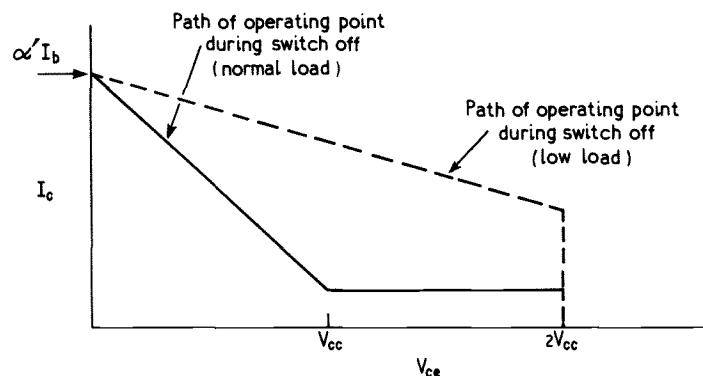


Fig. 5. Path of transistor operating point for normal and low loading.

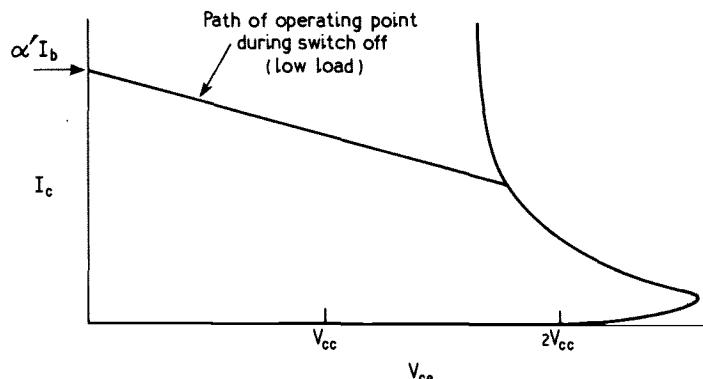


Fig. 6. For a no-load condition the path of the operating point is shown by the right-hand curve.

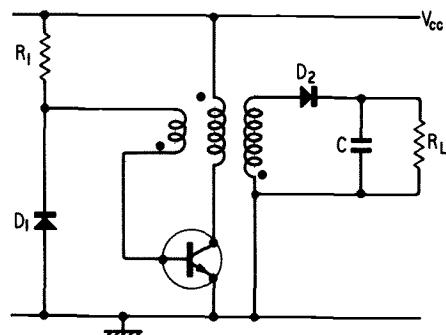


Fig. 7. Simple d.c. converter circuit using ringing choke principle.

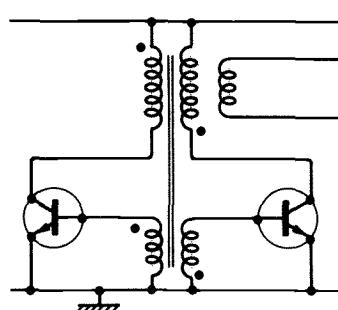


Fig. 8. Conventional single-transformer d.c. inverter circuit.

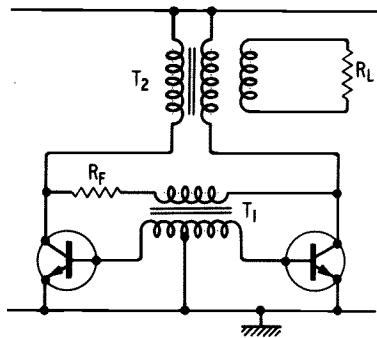


Fig. 9. Two-transformer inverter. One transformer controls switching while the other provides the correct voltage to the load.

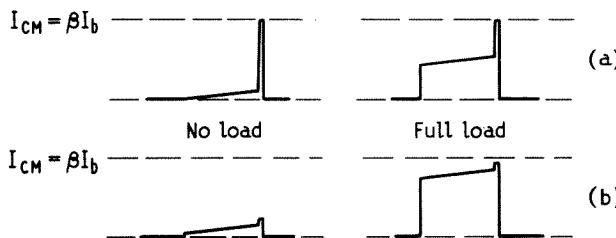


Fig. 10. Collector current for (a) single saturating transformer circuit, (b) two-transformer circuit.

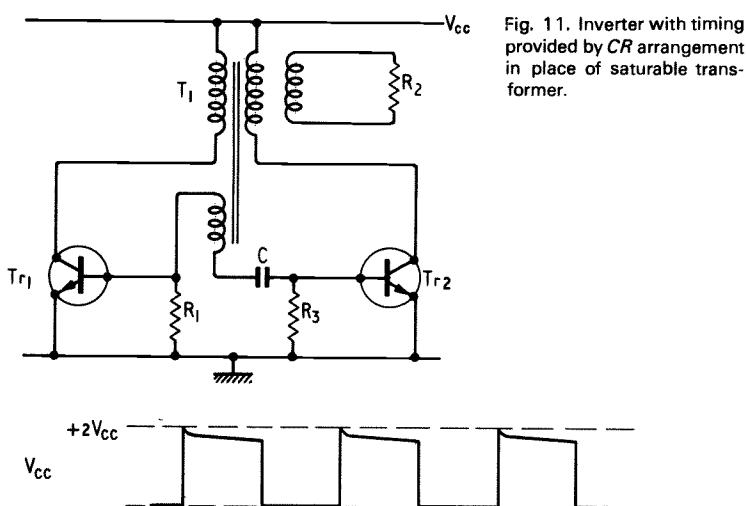


Fig. 11. Inverter with timing provided by CR arrangement in place of saturable transformer.

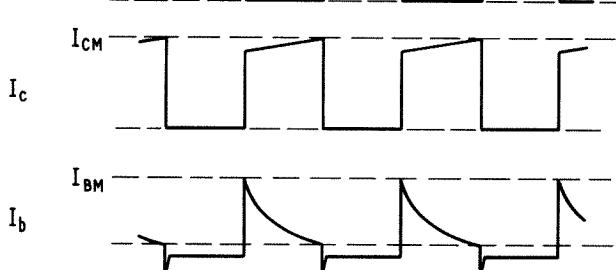


Fig. 12. Voltage and current waveforms in the inverter with CR timing.

Fig. 13. (a) Equivalent base circuit of Fig. 11, and (b) its simplified version.

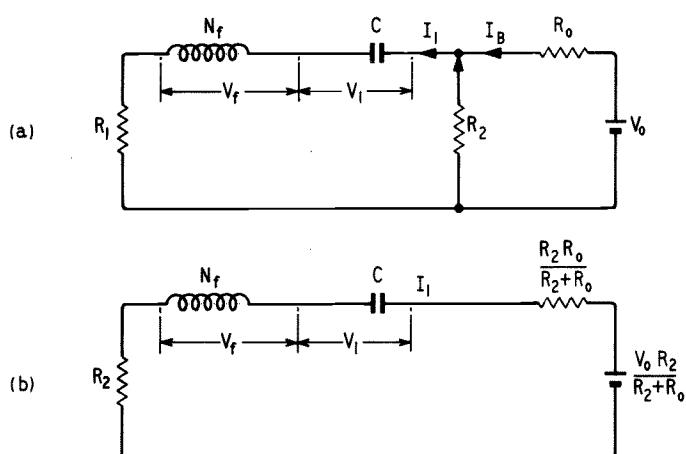


Fig. 8². The transformer can either be of a non-saturable type, or of a saturable type. In the case of the non-saturable transformer circuit, a considerable variation of frequency with load will be experienced and the transformer size required to handle the same power will be three to four times as big as one using a saturable transformer. The circuit with single non-saturable transformer is therefore regarded as not suitable for practical purposes.

The inverter with a saturable transformer, although widely used, suffers from three main disadvantages: (a) the design is affected by spreads in transistor characteristics because the peak collector current is determined by the gain and the base-emitter voltage; (b) for a given power delivered to the load, the ratio of the peak current to the load current is high; and (c) the transformer uses large amounts of an expensive core material.

If frequency is not important or a d.c. output is required, some of the disadvantages may be overcome by operating at frequencies in the range of 20 to 50kHz, for which silicon planar transistors are most suitable.

In this single-transformer circuit, the transformer performs two separate functions. First, it acts as the frequency control device and, by saturation, governs the drive to the bases of the transistors. Secondly, it acts as the output transformer and handles the power from the collector to the load.

Further improvements in operation can be obtained by using a two-transformer circuit³. The two functions then are separated and handled by separate transformers, each designed for its own purpose. This circuit is shown in Fig. 9. A small saturable transformer T_1 is used to control the switching, and a larger output type of transformer, T_2 , working linearly, is used to provide the correct voltage to the load R_L .

This circuit is very much less dependent on the transistor characteristics and therefore will provide at least twice the power obtained with single-saturable transformer circuits. Provided that the transformer T_2 is designed to reach only a small magnetizing current during the time determined by saturation of the transformer T_1 , then the total collector current will be small even under no-load conditions.

The collector currents for the two circuits, for no-load and full-load conditions, are shown in Fig. 10.

It will be seen that in the case of a single saturable transformer circuit the peak collector current I_{CM} depends on the drive conditions and is always $h_{FE} I_B$, whereas, in the case of the two-transformer circuits, the peak collector current, I_{CM} , depends on the actual load conditions.

These circuits are shown in their basic forms only. In order to make them oscillate it is necessary to provide sufficient forward bias to make the loop gain equal to or greater than one.

Although the two-transformer inverter circuit could be used at frequencies of 20 to 50kHz, it is more suited for lower frequencies, below 5kHz. To take full advantage of high frequencies a more elegant and more economical circuit is shown in Fig. 11.⁴ Here the saturable transformer of the previous circuit is replaced by a capacitor C which, in conjunction with one of the base starting resistors R_1 or R_3 , provides the required timing. The transformer T_1 again is working linearly, so that the peak collector current is independent of the drive conditions and is small for no load.

The new circuit is probably one of the best arrangements known to date which can be operated at frequencies well above 50kHz.

Silicon planar transistors with fast switching times lend themselves to high-frequency inverter applications. These transistors, when used in the inverter circuit with CR timing, provide one of the simplest and most economical arrangements.

With planar transistors, additional components are necessary to make the basic circuit of Fig. 11 work reliably. This, however, does not invalidate the above statement. The circuit will provide maximum output power using planar transistors, accepting their full production spreads when designed for operation with the same supply voltage, and at the same time be equally efficient.

The operation of the circuit is discussed next, and two practical examples are given.

Circuit Operation.—In the basic circuit shown in Fig. 11 it is assumed that transistor Tr_1 is cut off and transistor Tr_2 is on, and that the capacitor C is charged. The base current of the transistor Tr_2 , which is approximately equal to the discharging current of the capacitor C , will decrease exponentially until it will no longer support the collector load current. At this stage, the

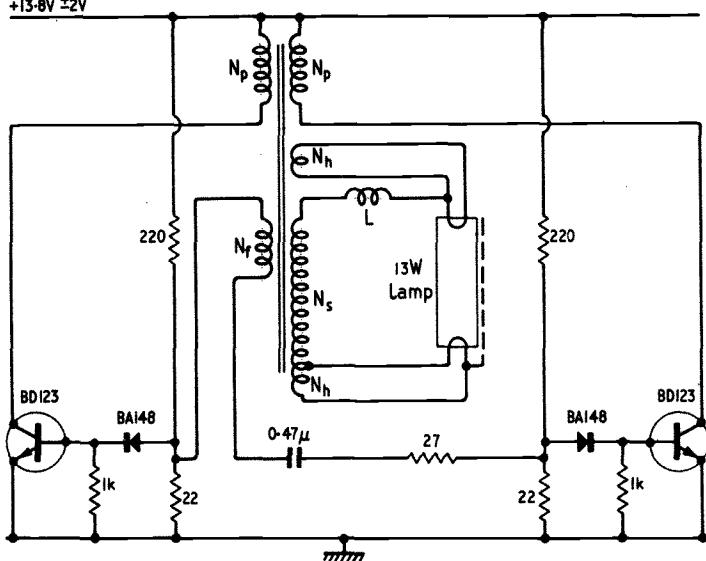


Fig. 14. Circuit of 13-watt fluorescent lamp inverter.

collector current will start to fall, causing the polarities of the voltages developed across the transformer windings to reverse. This will switch transistor Tr_1 rapidly on and the transistor Tr_2 off. The timing is thus controlled by the exponential decrease of the base current. The voltage and current waveforms are shown in Fig. 12.

Transformer Design.—The transformer is designed around the value of the inductance required for each half of the primary winding for a given magnetizing current. The value of the inductance is given by

$$L = \frac{(V_{CC} - V_{CE(SAT)})t_p}{I_M} \quad (1)$$

where V_{CC} is the supply voltage, $V_{CE(SAT)}$ is the collector-to-emitter saturation voltage, I_M is the peak magnetizing current, and t_p is the time of half a cycle.

To minimize losses, Ferroxcube cup cores are used. The cores offer higher values of inductance for a given number of turns than may be achieved with E-cores, resulting in lower copper loss and higher overall efficiency. Since the efficiency of the transformer depends on the value of the magnetizing current, the copper loss and the core loss, the transformer is designed using the thickest wire gauge possible and the lowest magnetizing current for minimum total loss.

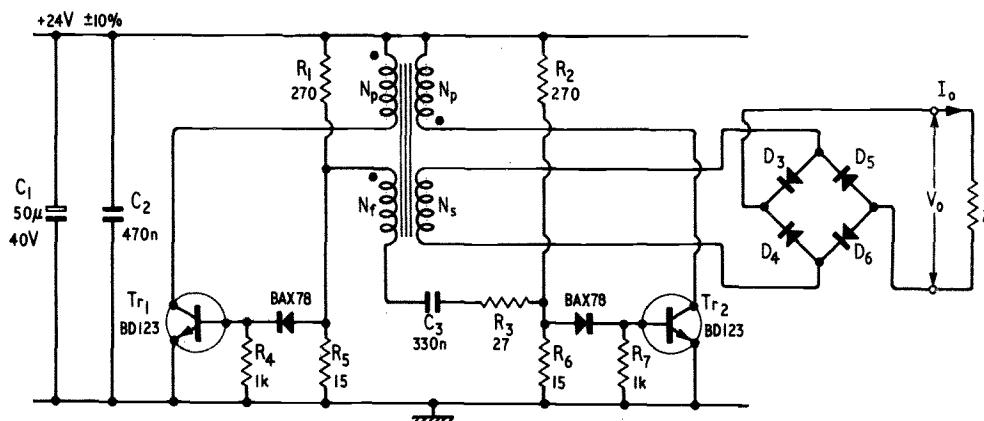
The number of turns for each half of the primary winding is found from

$$N_p = \alpha \sqrt{L} \quad (2)$$

where α is the number of turns for 1mH for a given size of core, and L is the inductance in mH.

The number of turns needed for the secondary winding will

Fig. 15. Circuit of d.c. to d.c. converter capable of delivering 60W of output power from a 24V supply.



depend on the output voltage required, and can be found from

$$N_s = N_p \frac{V_{out}}{V_{CC} - V_C} \quad (3)$$

It remains now to find the feedback voltage required for satisfactory operation and the number of turns for the feedback winding. The equations required for the design⁴ can be found with reference to the base equivalent circuit shown in Fig. 13, but first the minimum base current, I_B , required to support the peak collector current, I_{CM} , is

$$I_B = \frac{I_{CM}}{h_{FE}} \quad (4)$$

$$I_1 (\text{min}) = I_B + \frac{I_B R_0 + V_0}{R_2} \quad (5)$$

If R_1 is made equal to R_2 , which is usually the case, then

$$V_f = \frac{1}{2} I_{1(pk)} + I_{1(min)} \left[R_2 + \frac{R_2 R_0}{R_2 + R_0} \right] + \frac{V_0 R_2}{R_2 + R_0} \quad (8)$$

and the number of turns for the feedback winding

$$N_f = N_p \frac{V_f}{V_{CC} - V_{CE(SAT)}} \quad (9)$$

The value of the timing capacitor, taking into account the exponential decay, is given by

$$C = \frac{1}{3.2 f R_2 \left[1 + \frac{R_0}{R_2 + R_0} \right]} \quad (10)$$

Circuit Modifications for Silicon Planar Transistors.—There are, however, two basic limitations of silicon planar transistors. These are (i) a lower energy capability in the avalanche region and (ii) a lower base-emitter reverse voltage rating.

The energy dissipation in the avalanche will be dealt with first. It calls for the reduction of the energy available at the time of switch-off of the collector current, especially due to the leakage inductance of the transformer. This is brought about by designing a transformer with low voltage inductance achieved by (a) bifilar winding of the primaries, (b) using the highest possible frequency so that the inductance required for the primary for certain magnetizing currents is low, (c) reduction of the number of turns and the length of wire.

A compromise is necessary in choosing the value of the magnetizing current because it will affect the overall efficiency of the circuit. The minimum number of turns has already been assured by using Ferroxcube transformer cup cores.

It has been proved that the energy capability of planar transistors is higher under forward-bias than it is under reverse-bias conditions. The reverse-bias condition should therefore be avoided as the damage to a transistor in the low-resistance region is more

likely to occur when the base-emitter voltage is high. The reverse base-emitter voltage could be limited by a shunt diode placed across the base-emitter junction. The diode, however, would not eliminate the reverse base current. Series diodes are therefore used in each transistor base lead together with the shunt resistor to provide a path for leakage current.

It must be noted that diodes used for this purpose must be as fast as the transistors if they are to have any effect on the operation of the circuit. They must be fast recovery types.

Because of energy return to the supply due to inductive nature of the load, especially when the inverter is lightly loaded, it is necessary to decouple the supply by connecting a large value of electrolytic capacitor close to the transistors to avoid long lead lengths which introduce appreciable inductance at high frequencies. Because of the fast switching times, additional paper capacitors may be needed to bypass the high-frequency current.

Practical Circuits—The benefit of the planar transistors, apart from the small size and reduction of weight resulting from high frequency operation, is also realized in the elimination of audible noise.

Two circuits which illustrate these advantages are an inverter for fluorescent lamps shown in Fig. 14 and a d.c. to d.c. converter shown in Fig. 15.

The inverter circuit for 13W fluorescent lamps operates from a nominal 12V battery. The output transformer, in addition to the secondary winding, has the two heater windings required for the lamp. A choke ballast L is used to limit the lamp current. The frequency of operation is approximately 25kHz.

The d.c. to d.c. converter is capable of delivering 60W of output power from a 24V d.c. supply. The same comment applies to the rectifiers used for the bridge circuit; they must be a fast recovery type. The recovery time of the rectifiers must be approximately equal to the switching times of the transistors, otherwise the efficiency will be reduced and the operation of the circuit may be affected.

TRANSFORMER DETAILS

Fluorescent Lamp Inverter

Core	...	Ferroxcube FX2242
Bobbin	...	DT180
Primary winding, N_p	...	12 + 12 turns, 23 s.w.g. enamel copper wire
Secondary winding, N_s	...	228 turns 32 s.w.g. enamel copper wire
Feedback winding, N_f	...	10 turns 30 s.w.g. enamel copper wire
Heater windings, N_h	...	9 turns each, 30 s.w.g. enamel copper wire
Choke Core	...	Ferroxcube FX2240 with 0.09mm gap
Bobbin	...	DT2179
Winding	...	164 turns enamel copper wire

60W D.C. to D.C. Converter

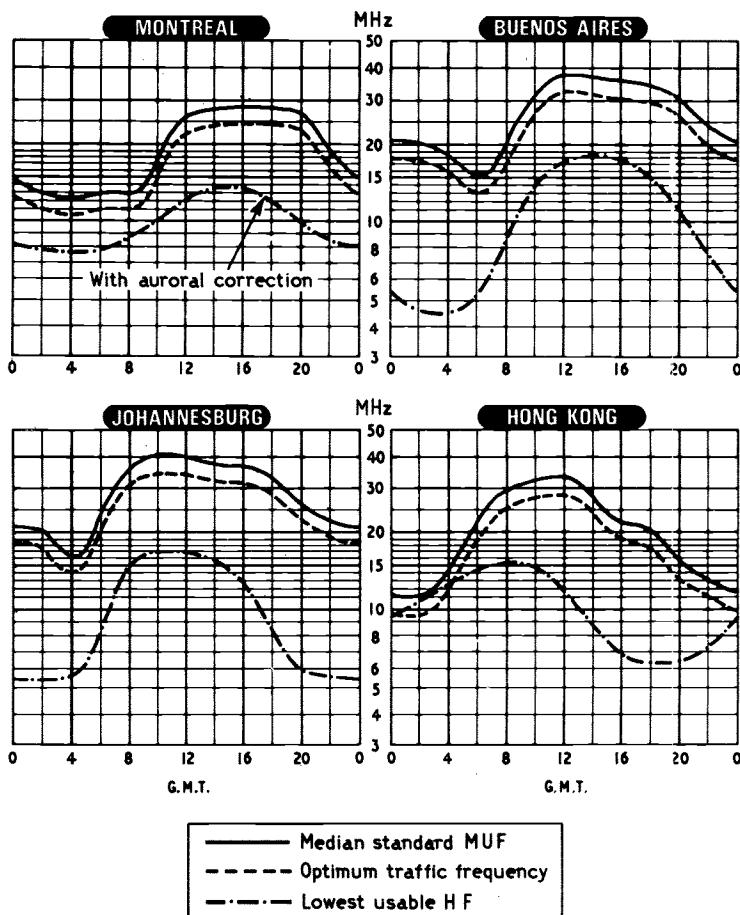
Core	...	Ferroxcube FX2243.
Bobbin	...	DT2206
Primary winding, N_p	...	12 + 12 turns, 21 s.w.g. enamel copper wire
Secondary winding, N_s	...	68 turns, 28 s.w.g. enamel copper wire
Feedback winding, N_f	...	11 turns, 26 s.w.g. enamel copper wire

H.F. Predictions—March

Maximum usable frequency curves are based on a predicted value for the Ionospheric Index (IF2) of 130. This is much lower than the corresponding period of the last cycle which reached a maximum of 208 in December 1958. Daytime peaks continue around 30 MHz but these will diminish over the next few months as summer conditions approach.

Although Sporadic-E may be evident on all routes between 10.00 and 18.00 G.M.T., it is unlikely to affect circuit operation.

The curves for the lowest usable frequencies were drawn by Cable & Wireless Ltd. for reception in the U.K. of point-to-point telegraph circuits using several kilowatts of power and rhombic aerials. Curves for domestic reception of high-power broadcasts would be similar.



REFERENCES

1. "Transistor D.C. Converter", by H. Light and P. M. Hooker. *Proc.I.E.E.*, Nov. 1955 (102B), pp.775 to 786.
2. "The Design of Transistor Push-Pull D.C. Converters", by W. L. Stephenson *et al.* *Electronic Engineering*, Vol. 31, No. 380, Oct. 1959, pp.585 to 589.
3. "Improved High Power D.C. Converters", by J. R. Nowicki. *Electronic Engineering*, Vol. 33, No. 404, Oct. 1961, pp.637 to 641.
4. "A D.C. Inverter with CR Timing", by J. R. Nowicki. *Electronic Engineering*, Vol. 34, No. 413, July 1962, pp.464 to 468.

Public Address Exhibition

THE annual exhibition of public address equipment organized by the Association of Public Address Engineers will again be held at the King's Head Hotel, Harrow, Middx., but will, this year, run for three days—March 12th to 14th. Some 40 exhibitors will be participating in the show which will be open daily from 10.00 to 18.30. The theme is outdoor p.a. and there will be a "working display" of microphones and also a display of loudspeakers for outdoor use.

Admission will be by ticket obtainable free from the headquarters of the Association, 394 Northolt Rd, South Harrow, Middx.

Forthcoming Events

Further details are obtainable from the addresses in parenthesis

LONDON

Apr. 8 & 9
Thick Film Technology
(I.E.R.E., 9 Bedford Sq., London W.C.1)

Apr. 18-21
Audio Festival & Fair
(Rex Hassan, 42 Manchester Sq., London W.1)

Apr. 22-24
Interference Problems and Microwave Communications Systems
(I.E.E., Savoy Pl., London, W.C.2)

May 13-18
Instruments, Electronics and Automation Exhibition
(Industrial Exhibitions, 9 Argyll St., London W.1)

May 14-16
Automation for Productivity
(I.E.E., Savoy Pl., London W.C.2)

May 20-25
Communication-Satellite Earth Stations
(R.E.G. Back, P.O. Engineering Dept., WS2, 207 Old St., London E.C.1)

July 29-Aug. 2
Ship's Gear International Exhibition
(Municipal and Industrial Exhibitions, 3 Clements Inn, London W.C.2)

Sept. 9-12
Elementary Particles
(I.P.P.S., 47 Belgrave Sq., London S.W.1)

Sept. 9-13
International Broadcasting Convention
(I.B.C., c/o I.E.E., Savoy Pl., London W.C.2)

Sept. 30-Oct. 2
Tropospheric Wave Propagation
(I.E.E., Savoy Pl., London W.C.2)

Oct. 2-5
R.S.G.B. Radio Communications Exhibition
(P. Thorogood, 6 Museum Hse., Museum St., London W.C.2)

BELFAST
Apr. 1-3
Heavy Particle Collisions
(I.P.P.S., 47 Belgrave Sq., London S.W.1)

BIRMINGHAM
Sept. 16-20
Machine Tool Design and Research Conference
(Dept. of Mechanical Engineer, The University, P.O. Box 363, Edgbaston, Birmingham 15)

BRIGHTON
Oct. 8-10
National Electronics Packaging Conference & Exhibition
(Gordon Savill Exhibitions, 21 Victoria Rd., Surbiton, Surrey)

CAMBRIDGE
Sept. 23-27
Electronics Design
(I.E.E., Savoy Pl., London W.C.2)

CARDIFF
Apr. 18 & 19
Audio-Visual Aids Conference and Exhibition
(National Committee for Audio & Visual Aids in Education, 33 Queen Anne St., London W.1)

DURHAM
Apr. 2 & 3
Semimetals and Narrow Gap Semiconductors
(I.P.P.S., 47 Belgrave Sq., London S.W.1)

Imperial College

Hotel Russell

I.E.E. Savoy Pl.

Olympia

I.E.E., Savoy Pl.

Royal Lancaster Hotel

Olympia

Queen Mary College, E.1

Grosvenor House Hotel

I.E.E. Savoy Pl.

R.H.S. New Hall

Queen's University

The University

Hotel Metropole

The University

Cathays Park

The University

EDINBURGH

Aug. 5-10
I.F.I.P. Data Processing Congress & Exhibition
(I.F.I.P. Congress, 23 Dorest Sq., London N.W.1)

FARNBOROUGH

Sept. 16-22
Electronics and Air Show
(S.B.A.C., 29 King St., St. James's, London S.W.1)

HARWELL

May 9 & 10
Low Energy Electron Diffraction
(I.P.P.S., 47 Belgrave Sq., London S.W.1)

LOUGHBOROUGH

Apr. 16-19
Modular Education for Industry
(I.E.E.T.E. Ltd., 26 Bloomsbury Sq., London W.C.1)

MANCHESTER

Sept. 3-6
Solid State Devices
(I.P.P.S., 47 Belgrave Sq., London S.W.1)

Sept. 24-28
Electronics, Instruments, Control and Components Exhibition
(Inst. of Electronics, 78 Shaw Rd., Rochdale, Lancs.)

Nov. 4-6
Electronic Instruments Exhibition
(Industrial Exhibitions, 9 Argyll St., London W.1)

NOTTINGHAM

Sept. 11-13
Physical Aspects of Noise in Electronic Devices
(I.P.P.S., 47 Belgrave Sq., London S.W.1)

OXFORD

Apr. 1-4
Properties and Metrology of Surfaces
(Inst. of Mechanical Engineers, 1 Birdcage Walk, London S.W.1)

SWANSEA

July 15-18
Electrical Contact Phenomena
(I.P.P.S., 47 Belgrave Sq., London S.W.1)

WARWICK

Aug. 29-31
AC Properties of Superconductors and their Applications
(I.P.P.S., 47 Belgrave Sq., London S.W.1)

OVERSEAS

Apr. 1-6
Components Exhibition & Colloquium also Electroacoustic Exhibition
(Fédération Nationale des Industries Electroniques, 16 rue de Presles, Paris 15e)

Apr. 9-11
Telemetering Conference
(R.H.D. Hardy, Serck Controls, Queensway, Leamington Spa, Warwick)

Apr. 22-24
Frequency Control Symposium
(Mr. F. Timm, Electronic Components Lab., U.S. Army Electronics Cmnd, Fort Monmouth, N.J.)

May 8-10
Electronic Components Conference
(I.E.E., 345 E. 47th St., New York, N.Y. 10017)

May 14-17
Quantum Electronics Conference
(W.W. Rigrod, Bell Telephone Labs., Murray Hill, N.J.)

May 20-22
International Microwave Symposium
(Dr. G. I. Haddad, Electrical Engineering Dept. University of Michigan, Ann Arbor, Michigan 48104)

June 10-14
British Engineering Exhibition
(S. Black, London Chamber of Commerce, 69 Cannon St., London E.C.4)

June 12-14
Conference on Communication
(I.E.E., 345 E. 47th St., New York, N.Y. 10017)

June 17-19
Microelectronics Symposium
(I.E.E., 345 E. 47th St., New York, N.Y. 10017)

June 20-22
Optimal Systems Planning
(Prof. T. J. Williams, Laboratory for Applied Industrial Control, Purdue University, Lafayette, Indiana 47907)

The University

R.A.E.

A.E.R.E.

University of Technology

Inst. of Science and Technology

Belle Vue

Hotel Piccadilly

The University

Playhouse Theatre

University College

The University

Paris

Houston

Atlantic City

Miami

Washington

Detroit

Copenhagen

Philadelphia

St. Louis

Cleveland

March Meetings

Tickets are required for some meetings: readers are advised, therefore, to communicate with the society concerned.

LONDON

4th. I.E.E.—Colloquium on "Pulsed code modulation" at 10.00 at Savoy Pl., W.C.2.

5th. I.E.E. & I.E.R.E.—Colloquium on "Large scale integration" at 10.00 at Savoy Pl., W.C.2.

6th. B.K.S.T.S.—"A new loudness analyser" by H. Blässer at 19.30 at the Royal Overseas League, Park Pl., St. James's St., S.W.1.

7th. Inst. Electronics—"Reed switches and their applications" by B. F. Pamplin at 18.45 at the London School of Hygiene & Tropical Medicine, Keppel St., W.C.1.

7th. R.T.S.—Discussion on "Cost versus quality in television receiver design" at 19.00 at the I.T.A., 70 Brompton Rd., S.W.3.

8th. I.E.E.—"British contributions to telecommunication" by R. J. Halsey at 17.30 at Savoy Pl., W.C.2.

11th. I.Mech.E. & I.E.E.—Discussion on "Roll stabilisation and auto pilots in marine engineering application" at 18.00 at 1 Birdcage Walk, S.W.1.

12th. Radar & Electronics Assoc.—"The influence of integrated circuits on equipment design" by K. H. Brinkman at 19.00 Mullard House, Torrington Pl., W.C.1.

12th. S.E.R.T.—"Colour television receiver design—current and future trends" by P. Mothersole at 19.00 at the London School of Hygiene and Tropical Medicine, Keppel St., W.C.1.

14th. I.E.E.—"Engineers must manage or be managed" by H. R. Sykes at 18.00 at 9 Bedford Sq., W.C.1.

18th. I.E.E.—Colloquium on "Threshold extension techniques" at 10.00 at Savoy Pl., W.C.2.

18th. I.E.R.E.—"Control: past, present and future" by Prof. H. H. Rosenbrock at 18.00 at the London School of Hygiene, Keppel St., W.C.1.

19th. I.E.E. & IMech.E.—Colloquium on "Engineering aspects of satellite design" at 10.30 at Savoy Pl., W.C.2.

19th. I.E.R.E.—"Integrated circuits for radio receivers" by W. D. Benson and B. Buckingham at 18.00 at the London School of Hygiene, Keppel St., W.C.1.

20th. I.E.E.—"Satellite communications" by W. J. Quill at 17.30 at Savoy Pl., W.C.2.

21st. I.E.E.—Colloquium on "The role of the computer in device, circuit and equipment design" at 14.30 at Savoy Pl., W.C.2.

22nd. R.T.S.—"Comparison of u.h.f. and v.h.f. coverage" by R. S. Sandell at 19.00 at the I.T.A., 70 Brompton Rd., S.W.3.

22nd. B.K.S.T.S.—"An electron-beam television film recorder" by John W. Overton at 19.30 at the Royal Overseas League, Park Pl., St. James's St., S.W.1.

25th. I.E.E. & IMech.E.—Discussion on "Fluidics and integrated circuits" at 17.30 at Savoy Pl., W.C.2.

27th. I.E.E.—"Waves in semiconductors—possibilities for new solid state devices" by Prof. G. Kino at 17.30 at Savoy Pl., W.C.2.

28th. I.E.E.—Discussion on "The engineer in society" at 17.30 at Savoy Pl., W.C.2.

28th. I.E.R.E.—"Cost effectiveness and systems analysis in defence" by T. H. Kerr at 18.00 at 9 Bedford Sq., W.C.1.

BANGOR

11th. I.E.E.—"Training the electrical engineer" by Prof. Emrys Williams at 18.30 at the School of Engineering Science, Dean St.

BATH

20th. I.E.R.E. & I.E.E.—"Microelectronics" by Dr. S. Forte at 19.00 at the Technical College, Avon St.

BIRMINGHAM

20th. R.T.S.—"The fully transistorised colour receiver" by S. C. Jones at 19.00 at the Medical Institute, Harborne Rd., Edgbaston.

25th. I.E.E. Grads.—"Waveguides" by Prof. E. M. Barlow at 19.00 at the University of Aston.

27th. S.E.R.T.—"Colour television" by B. J. Rogers at 19.30 at the Electrical Engineering Dept., the University, Edgbaston.

BRISTOL

6th. I.E.R.E. & B.C.S.—"Design of circuits using a digital computer" by E. Wolfendale at 19.00 at the University.

12th. R.T.S.—"Colour TV receivers—the PAL decoder" by B. J. Rogers at 19.30 at the Reception Rooms BBC, Whiteladies' Rd.

13th. S. Inst. Tech.—"Instrumentation of inertial navigation systems" by Prof. E. B. Pearson at 19.30 at the Dept. of Physics, the University, Royal Fort.

CAMBOURNE

14th. I.E.R.E. & R.T.S.—"Thyristors: modern applications in control systems" by G. Grimsdell at 19.00 at the Cornwall Technical College.

CAMBRIDGE

14th. I.E.E.—"The early history of radio" by G. M. Garratt at 20.00 the University Engineering Labs.

CARDIFF

4th. I.E.R.E. & I.E.E.—"Integrated circuits" by R. Smith at 18.00 at the University of Wales Institute of Science and Technology.

20th. R.T.S.—"Colour receiver design" by G. D. Barnes at 19.30 at the Llandaff Technical College.

CHELMSFORD

12th. I.E.R.E.—"Vision, television, colour television" by N. N. Parker-Smith at 18.30 at the Technical High School, Patching Hall Lane.

DERBY

6th. I.E.E.—"Changing patterns in communication" by J. H. H. Merriman at 18.30 at E.M.E.B. Showrooms, Irongate.

DUMFRIES

19th. I.E.E.—"Radio astronomy" by I. W. Sheffield at 19.30 at the Kings Arms Hotel.

EDINBURGH

5th. I.E.E. Grads.—"Waveguides" by Prof. H. E. M. Barlow at 18.15 at the Carlton Hotel.

13th. I.E.R.E. & I.E.E.—"Gas lasers" by G. M. Clark at 19.00 at the Dept. of Natural Philosophy, The University, Drummond St.

26th. I.E.E.—"Medical electronics" by D. W. Hill at 19.00 at Usher Hall.

GLASGOW

14th. I.E.R.E. & I.E.E.—"Gas lasers" by G. M. Clark at 19.00 at the Inst. of Engineers and Shipbuilders, 39 Elmbank Cres., C.2.

GRIMSBY

19th. I.E.E.—"Waves, waveguides and radar" by Prof. P. J. B. Clarricoats at 19.00 at the Yarborough Hotel.

HUDDERSFIELD

7th. I.E.R.E.—"Computer aided design" by J. G. Davies at 19.00 at the Dept. of Electrical Engineering, the College of Technology, Queens St.

LEICESTER

6th. I.E.R.E.—"Numerical control of machine tools" by D. Walker at 18.30 in the Physics Dept., the University.

LIVERPOOL

20th. I.E.R.E.—"Educational closed-circuit television" by E. T. Blakeman and H. Barrington at 19.00 at the Regional College of Technology, Byrom St.

27th. I.E.E. Grads.—"The design of high-quality audio amplifiers" by J. Dinsdale at 18.30 at the University.

MALVERN

25th. I.E.R.E.—"An introduction to acoustics" by F. H. Brittain at 19.00 at the Abbey Ballroom.

MANCHESTER

21st. I.E.R.E.—"Microelectronics" by I. M. Breingan at 19.15 at Renold Bldg, the University Institute of Science & Technology, Altrincham St.

MIDDLESBROUGH

26th. S.E.R.T.—"Development of electronic circuits for industry" by L. English at 19.15 at the Cleveland Scientific Inst., Corporation Rd.

NEWCASTLE-UPON-TYNE

1st. I.E.E.—"Thin film microelectronics" by R. S. Pinder at 18.30 at the University.

13th. I.E.R.E.—"Circuit design using digital computers" by E. Wolfendale at 18.00 at the Inst. of Mining and Mechanical Engineers, Neville Hall, Westgate Rd.

20th. S.E.R.T.—"Electronic remote control" by N. S. Richardson at 19.15 at the Charles Trevelyan Technical College, Maple Terrace.

28th. I.E.E.—"Medical electronics" by D. W. Hill at 19.30 at the City Hall.

NEWPORT, I.O.W.

1st. I.E.R.E.—"Optical communications using glass fibres" by Prof. W. A. Gambling at 19.00 at the Technical College.

PLYMOUTH

6th. R.T.S.—"Fleming Memorial Lecture "The strange journey from retina to brain" by Dr. R. W. G. Hunt at 19.30 at the Studios of Westward Television.

14th. I.E.R.E. & R.T.S.—"Thyristors—modern applications in control systems" by G. Grimsdell at 19.30 at Camborne Technical College.

PORTSMOUTH

13th. I.E.R.E.—"High-order idlerless multipliers" by S. V. Judd at 19.00 at the Highbury Technical College.

READING

12th. I.E.R.E.—"Transistor noise" by Dr. E. A. Faulkner at 19.00 at the J. J. Thomson Physical Labs., the University.

RUGBY

5th. I.E.E. Grads.—"Laser holography" by J. M. Burch at 18.15 at the College of Engineering Technology.

SHEFFIELD

12th. I.E.E.—"Medical electronics" by D. W. Hill at 19.30 at the City Hall.

SHRIVENHAM

12th. I.E.E.T.E.—"The laser beam and its applications" by C. S. Grace and L. G. Penhale at 19.30 at the Royal Military College of Science.

SOUTHAMPTON

5th. I.E.R.E. & Brit. Assoc.—"Modern methods of traffic control" by D. G. Hornby at 18.30 at the Lanchester Theatre, the University.

TENTERBANKS

6th. I.E.R.E.—"An approach to transistor reliability" by A. J. Melia at 19.15 at the Stafford College of Further Education.

WARRINGTON

7th. S.E.R.T.—"Electronics in nuclear power" at 20.00 at the White Hart Hotel, Sankey St.

Real and Imaginary

By "Vector"

The Parable of the P.B.X.

ONE of the more disturbing facets of the human mind is its capacity for self-deception; for maintaining its illusions in the face of contrary evidence. As an example in common experience consider the telephone, where the mental image conjured up is that of instant two-way verbal communication. This concept is often nonsense because it idealizes the circuit and takes no account of the human interfaces which can exist between the caller and his destination.

In any organization which is larger than one man and a boy, what happens? You lift the receiver and wait, meekly wait and murmur not (Moody and Sankey) until an imperious queen of your internal exchange deigns to answer; by which time your hitherto virgin blotting pad is filled with doodled fantasies and you have quite forgotten the number you wanted. This does not amuse Her Highness.

When this little *contretemps* has been sorted you settle down to another period of silence while (assuming you are not on S.T.D.) your queen seeks to attract the attention of the empress on the G.P.O. exchange. Two exchanges and three wrong numbers later your call is battering at the indicators of the destination private branch exchange. After another prescribed period (during which the leaves on the trees have been known to change from springtime hues to autumnal tints) an irritated "Yes?" signifies that you are within a stone's throw of success, awaiting only that blood-pressure moment when you are plugged in to a dead extension line and thereafter abandoned. You can agitate what is laughingly termed the recall button until smoke issues from it, and much good may it do you....

DELAYS AT THE INTERFACES

There are various theories to account for these phenomena. One strong school of thought holds that you have been inconsiderate enough to require a call at that critical phase when the girl at the P.B.X. is casting on stitches for a new cardigan; another visualizes her as immersed in a Yoga-type trance which has Mick Jagger as its focal point. Be this as it may (and lady operators will rise as one cardiganned body to deny that it is) there is no disputing that in a typical medium-distance call the ratio of time delays at the interfaces to those over the purely electrical part of the circuit can easily be of the order of 10⁷:1 or even higher. And if you are not on S.T.D. then, brother, you are in even worse trouble.

So much then for the "instantaneous" image. If only our guesstimates could work out the man-hours wasted in "trying to get through", the figures would be frightening. Hundreds of thousands of pounds, and possibly millions, wasted per annum.

But I can hear someone objecting that this is a general condition and has nothing in particular to do with electronics. Black mark, that boy! It has got everything to do with electronics; or rather it should

have—and would have, if we were on our toes. The trouble with us, I suggest, is that we immerse ourselves far too much in the business of being clever at making electrons jump through hoops, regardless of whether they perform any particularly useful service in the process. We are not engaged in pure science; we are in an industry and an industry can only prosper by providing a service to the community.

The P.B.X. interface is an admirable case in point. Whether we are doing the operators an injustice or not (and I'm sure we are) is quite beside the question. The real issue is that here we have a system of interconnection which dates back to Alexander Graham Bell; a situation which cries out for the application of electronics and automation while we continue to sit like birds in the wilderness doing nothing about it. We haven't even got the excuse that it's a new problem, because it existed even in grandad's day; even if you regard the electronics industry as dating only from World War II we've still had a quarter of a century in which to pull something out of the hat. The inescapable thought is that we're a lot cleverer at designing computers, microcircuits and the like than we are at setting them to work on something really useful.

AN INTERIM SOLUTION

One interim solution to the P.B.X. problem—offered with diffidence because it must have been doodled on hundreds of blotters by apoplectic callers—consists in essentials of the installation of a solenoid under the operator's chair in such a manner that, when energized, it causes a pin to protrude with some degree of violence through a hole in the seat. The solenoid is connected in circuit with the recall button contacts on the caller's telephone and (fair play, chaps) all users are put on their honour to refrain from using the recall device for at least 20 seconds after lifting the receiver. I should perhaps add that the apparatus described has not been protected by letters patent; it is offered without restriction for the common weal. And if this should catch the eye of those having authority over us, the C.B.E., or what have you, should be forwarded in a plain envelope, care of the Editor.

Seriously though, the P.B.X. problem is merely a symptom of the general malady that affects the industry. There are plenty of things begging for an intelligent application of electronics if only we could be bothered; road safety for one, which I mentioned a few issues ago. But no; we continue to stick to the well-trodden paths of transistor portables, television sets, record players and so forth for the consumer market while the capital goods boys confine their activities to radio communications, with radar representing their farthest flung frontier. It's not exactly high adventure, is it?

I know it's a sacrilegious thought, but couldn't

the electronics industry benefit from a pin under its chair?

TAILPIECE

If you will pardon the expression, which is not, I think, inapposite. After the above was written and (as I fondly imagined) put safely to bed, I came across a news item in the business section of *The Times* for February 2nd which seems to suggest that the sooner someone inserts a pin under the seat of British industry the better.

You probably noticed it yourself, but in case not, it was to the effect that ten chairmen of various big British companies (including at least two identifiable with electronics) were setting sail on a luxury cruise to South Africa. The outward voyage will have taken 11½ days and Old Thunderer rather let itself go in its conjectures concerning lavish junkettings in project aboard and dropped divers dark hints as to the mergers which might arise from the incarceration of ten business tycoons in one ship for nearly a fortnight. It also remarked that the basic cost of a suite on this particular excursion was a mere £2,556. I suppose it was mentioned just in case any of you other Top Readers might want to rough it for the summer hols.

Now, the readership of *The Times* is not, as Mr. Bumble, the beadle, would say, parochial. It is obligatory reading at top government levels all over the world. Let's suppose some old acquaintance of yours has bitten your ear for a fiver on the strength of a hard-luck story and that same evening you find him whooping it up with a bunch of the boys in the malamuk saloon . . . see what I mean? What must have those foreign government readers thought on reading *The Times* report? It seems to me that all those who have lent this country money or backed its devaluation policy have every right to be doing some pretty serious thinking—not to mention the few typists who set the trend for extra work without pay and all those who followed their example to "Back Britain". For here, according to report we have ten captains of industry absent from their respective helms and indulging in assorted Bacchanalia when they should be steering the ship of commerce across the green fields of Old England (as a politician once said).

There are, of course various ways of looking at a situation like this. It can be argued (and no doubt will be) that the money expended on this fiesta is fiddling and small compared with the business which may accrue. "May" is, of course, the operative word here and in any event the sums involved would pay a tidy few weeks' salaries of those who are putting in overtime for nothing. But perhaps chairmen have never heard of that new-fangled device, the heavier-than-air machine which gets one to South Africa in hours and would have taken the whole lot for approximately the price of one stateroom?

Although it is not implicitly stated in the report the reader is left with the impression that the whole enterprise is on an expense-account basis. This may not be so. We may have eleven hard-working chairmen taking their annual holidays at their private expense and, by a beautiful coincidence, electing to go to the same country on the same date and by the same ship. If that is so, then it is surely nobody's affair but their own.

Not exactly. For these are public figures and as such should pay due regard to the corporate image they project. It was surely a bad piece of public relations to have travelled in a body in such apparent ostentation with industry in such a parlous state as it is at present. It is too reminiscent of Nero fiddling while Rome was burning and, regrettably, not nearly so fictional. Or is the new slogan "I'm backing Britain—over a precipice"?

I still think we need pins, not air cushions, for the boardroom seats.

New Products

Electrolytic Capacitors

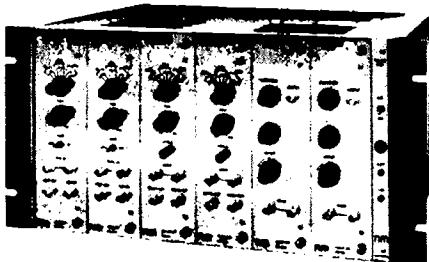
A NEW series of high value electrolytic capacitors, in which several new techniques have been used to increase capacitance, ripple current rating and working temperature without increasing can size, has been announced by Mullard. These capacitors, type 106 and 107, are suitable for use in applications where small physical size is required. Capacitance has been increased by using deeper etched foil electrodes of a new material and high permissible ripple current rating has been achieved by using a new electrolyte and a new construction method. In this method of construction, multiple connections to the anode and cathode make the capacitor immune to damage by rapid charge and discharge cycles. Heat is transferred from the capacitor windings by means of a metal spring that also holds the winding in place. A self-sealing vent acts as a safety valve and prevents pressure building up inside the can.

Compared with Mullard capacitors type C432, these in the 106/107 series have twice as much capacitance for a given can size, and at 70°C their ripple current ratings are three times as high. The capacitance range extends from 1,500 μ F to 0.15 F. Type 106 is for working voltages of 63 V and less, and type 107 for 100 V working. Mullard Ltd, Mullard House, Torrington Place, London, W.C.1.

W.W. 301 for further details

Multipulser

A COMPATIBLE series of modules forming a wide-range flexible pulse generator, known as the multipulser, is the first proprietary instrument to be developed and produced commercially by Nuclear Measurements. The modules are side-by-side rack mounted and may be interconnected by means of front panel connectors to provide a wide variety of timing and pulse width sequences with either single or multiple outputs. The three types of module currently available will provide repetition rates from 1 Hz to 50 MHz; pulse width and delay from 20 ns to 200 ms; positive or negative pulses up to 5 V in amplitude into 50 Ω with a rise and fall time of 2 ns; 100% duty cycle at all



repetition rates; and stable burst operation with a constant input to output delay. The system is d.c. coupled and all modules have true current source outputs enabling signals to be easily mixed at module inputs. Module interconnecting logic levels for a zero and a one are nominally 0 and -16 mA, respectively (0 mV and 800 mV into 50 Ω). A standard 19-inch rack or bench crate will house up to six modules, the power supply connections being made up by a rear connector. Nuclear Measurements, Dalroad Industrial Estate, Dallow Road, Luton, Bedfordshire.

W.W. 302 for further details

Helical Potentiometers

EXTENSIONS to their range of helical potentiometers have been announced by Reliance Controls Ltd, of Swindon. A five-turn version of the standard ten-turn helical potentiometer known as Type HEL 05-B05 retains all the advantages of the ten-turn unit including an end torque in excess of 100 ounce inches (7,200 gm cm). This has been achieved by incorporating the end stop mechanism as an integral part of the spindle and not relying upon the impact of the wiper upon a stop. Resistance values of up to 50 k Ω are available with a standard linearity of $\pm 1\%$ or better to $\pm 0.25\%$ if required. With a body diameter of 0.5 inches this unit is suitable for the designer who has space problems. A three-turn version of the Reliance HEL 07-05 and HEL 07-10 helical potentiometers is now available. Designated the HEL 07-03 this potentiometer has a diameter of 0.770 inches and a length of only 1.625 inches. This new version offers a resistance range of 25 Ω to 45 k Ω . The standard resistance tolerance is $\pm 5\%$ with a linearity of $\pm 1\%$ or better if required. Reliance Controls Ltd, Drakes Way, Swindon, Wiltshire.

W.W. 303 for further details

Bone Conduction Headset

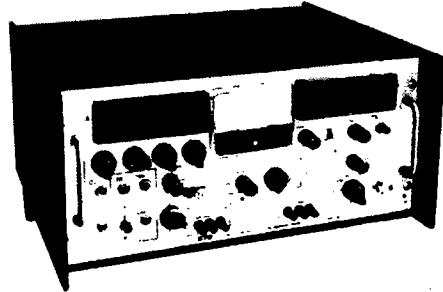
A LIGHTWEIGHT headset has been introduced that has been designed for use in applications where normal conversation is required in addition to communication with the equipment to which the headset is connected. The bone transducer microphone is of the variable reluctance type with an essentially inductive impedance of 300 Ω at 1 kHz. It has an open-circuit output of 400 μ V peak at normal conversation levels. The transducer should be terminated in a load impedance of 600 Ω for optimum performance over the telephony frequency band of 300 Hz — 3 kHz. The loudspeaker is of conventional construction and can be supplied with impedances of 30, 120, 150

or 600 Ω and requires a maximum drive power of 35 mW. The headset may be worn under a variety of protective helmets. It is comfortable and weighs only 144 grammes. Spembley Electronics, Enham Arch, Newbury Road, Andover, Hants.

W.W. 304 for further details

Group Delay Measuring Equipment

AN instrument is now available from STC for assessing the suitability of circuits for data transmission. Known as the 74257 Group Delay Measuring Equipment, the instrument may be used on audio, broadcast, and multicircuit telephone systems. The test signal may be obtained either from an internal oscillator covering the range 200 Hz—29.99 kHz, or from an external oscillator with a frequency range of 200 Hz to 120 kHz. A feature of the instrument is that both the delay time measurement and the internal oscillator frequency are displayed in digital form by cold cathode indicator tubes. The frequency of the internal oscillator is set by four switches which operate the display directly. Loop measure-



ments can be made on either a relative or an absolute basis, and end-to-end measurements may be made by using two equipments which can be many miles apart. The group delay measuring range is 0 ± 20 milliseconds in 0.01 ms steps. The instrument is portable and uses solid state circuits operating from a.c. mains. Its dimensions are $22\frac{1}{4} \times 9\frac{1}{2} \times 16$ in (565 x 241 x 406 mm) and its weight is 60lb (27.3 kg). Standard Telephones and Cables Ltd, Testing Apparatus and Special Systems Division, Corporation Road, Newport.

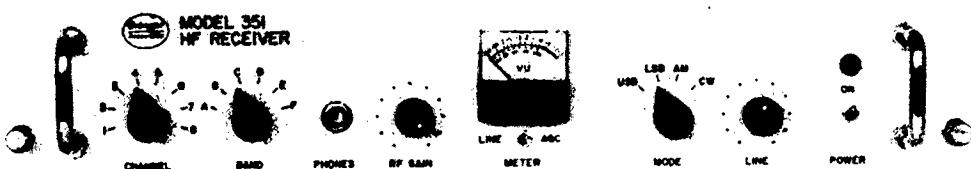
W.W. 305 for further details

H.F. Receiver

BY eliminating the r.f. stage, and the overloading and noise associated with it, Granger Associates in their Model 351 h.f. communications receiver have made possible a dynamic range as wide as 100 dB, an intermodulation distortion figure of better than 40 dB and an image rejection of better than 100 dB. The r.f. end is a single pre-selection tuned circuit followed immediately by an f.e.t. mixer which, with a v.h.f. local oscillator, provides up-conversion and places the image 130 MHz above the received frequency. The noise figure is 10 dB. Following the first mixer is a 65 MHz crystal filter and i.f. stage and a second f.e.t. mixer.

The receiver provides eight crystal-controlled channels in a frequency range of 1.65 to 40 MHz. Additional frequency coverage from 200 to 500 kHz is possible by substituting an optional set of coils for the standard ones fitted. Possible modes of reception, selected by a four-position switch are: upper sideband, lower sideband, a.m. and c.w. In addition, f.s.k. and i.s.b. reception can be provided by adaptors.

Two crystal-controlled local oscillators—the v.h.f. one already mentioned (range 66.5—



105 MHz) and an h.f. oscillator (range 4.65–43 MHz)—are used in a double frequency conversion that cancels out the drift of the v.h.f. oscillator. A fine frequency control is provided for each crystal. Frequency stability is ± 20 Hz up to 20 MHz, and 1 p.p.m. above 20 MHz.

Audio outputs provided are 10 mW into $600\ \Omega$ and 10 mW into $150\ \Omega$. A VU meter is fitted. The receiver is designed for rack mounting and has a 19-in. panel. U.K. address of Granger Associates is: Russell House, Molesey Road, Walton-on-Thames, Surrey.

W.W. 306 for further details

Thermoplastic Adhesive

A NON-STICKY adhesive that is available in thermoplastic and thermosetting forms, supplied unsupported or applied to one or both sides of a plastic film, has been introduced by G. T. Schjeldahl Co. It will bond plastic and plastic films, metals and metal foils, ferrites, natural and synthetic fabrics and rubber and wood. Visible evidence of setting is given as unsealed Schjeldahl Bond is milky-white and on setting the adhesive becomes clear. It is of high resistance and dielectric strength and is suitable for overlaying printed circuits. Rolls may be obtained in widths from 0.5 to 22 inches with thickness from 0.5 mil to 12 mil. G. T. Schjeldahl Co., Eastern Road, Bracknell, Berks.

W.W. 307 for further details

Storage Display Unit

THE Tektronix type 611 storage display unit permits stored, non-fading, displays of alphanumeric and graphic information from digital computers and other data transmission systems. The Tektronix bistable storage c.r.t. is used eliminating the need for memory devices for refreshing the display and providing high information density without flicker. A write-through feature allows the operator to visually position the writing beam at any point on the c.r.t. without disturbing the previously stored information. The erase, non-store, write-through and view operating functions are remotely programmable through contacts at the rear of the instrument. An erase interval signal connector is also provided. Manual control

of erase and view is carried out from the front panel. The initial beam position can be set at any one of nine positions by means of internal switches, each of these positions being adjustable $\pm 10\%$ of full scale both horizontally and vertically. The time taken for the beam to settle within one spot diameter of the final position is $6\ \mu s$ or $4\ \mu s/cm$ whichever is the greater. Spot positional stability is quoted as being 0.1% or less of full scale/hour with a $75\ \Omega$ source impedance at between 20 to 30°C ambient temperature. Spot drift will not exceed 0.4% of full scale at the specified source impedance throughout the temperature operating range of the instrument (0 to 50°C). Resolution in the vertical axis is 500 stored line pairs and 400 stored line pairs in the horizontal axis (screen size 21cm x 16.3cm). Tektronix U.K. Ltd., Beaverton House, Station Approach, Harpenden, Herts.

W.W. 308 for further details

A. F. Millivoltmeter

THE Si451 a.f. millivoltmeter is the first of a new range of equipment to be produced by J. E. Sugden & Co. Ltd, Bradford Rd, Cleckheaton, Yorkshire. The four position range switch (1-10-100-1000 mV) operates in conjunction with a



scale switch that multiplies the setting of the range by a factor of 1, 2, 5, 10 or 20. The calibration of the instrument can be varied so that it indicates r.m.s. through to peak-to-peak by means of a front panel mounted potentiometer. Using the three controls mentioned so far, the pointer can be positioned at any convenient point on the scale—a useful feature when making relative measurements. A dB scale is incorporated in which $0\ dB = 1\ mW$ into $600\ \Omega$. The input impedance is $1.1\ M\Omega$ and the frequency response is within 0.5 dB between 20 Hz and 20 kHz. The 3.5 inch meter movement carries four scales—1, 2, 5, and decibels and an auxiliary socket provides an output of up to 3 V at f.s.d. for feeding an oscilloscope. All internal ferrous material is cadmium plated and passivated and outer surfaces are p.v.c. clad with the exception of the front panel. The cost of the instrument is £30.

W.W. 309 for further details

Laser Range

A RANGE of argon ion and krypton ion lasers have been introduced by Nutronic Lasers, a division of Solid State Nutronics Ltd. Operating in the blue-green region of the spectrum, these lasers will supply outputs of 25 mW and 200 mW when operated in the fundamental transverse mode. When filled with Krypton the output power is less than stated above. The lasers have been designed to offer a stable 1,000 hour operational life (or 1 year) and employ a water cooled discharge tube, d.c. excitation and variable output. The output

wavelengths when filled with argon are 0.4880, 0.5145, 0.4965, 0.4579 and 0.5017 μm ; devices producing 0.4727, 0.4658 and 0.4545 μm are available using an alternative mirror system. Delivery is from stock, 60 days maximum. Nutronic Lasers, Solid State Nutronics Ltd, 5A Voltaire Road, London S.W.4.

W.W. 310 for further details

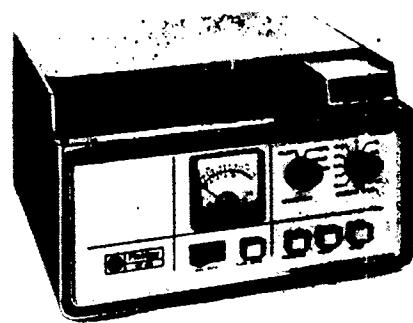
Log Plotting Unit for X-Y Recorders

LOGARITHMIC or a.c. plotting facilities can be added to any x-y recorder by means of an accessory available from Electronic Associates Ltd. The model 5.46.0001 is a self-contained unit which accepts two plug-in modules and provides power for their operation in an x-y plotter. Accurate logarithmic plots of linear a.c. or d.c. functions are provided when the 12.1384 log module is plugged in, and automatic presentations of high-frequency sine-wave signals are provided when the 12.1134 a.c. module is used. The 12.1384 generates logarithmic plots of an input a.c. or d.c. voltage function in either the arm or pen axis, and when used in the accessory unit provides d.c.-log, a.c.-log, or log-log recording. The 12.1134 a.c. module enables the user to record sine-wave signals generated by a.c. amplifiers, transducers, audio-measuring devices and analogue computers. It can also be used in either the arm or pen axis. Electronic Associates Ltd, Victoria Road, Burgess Hill, Sussex.

W.W. 311 for further details

Cartridge Tape Recorder

A CARTRIDGE tape recorder that was inspired by the EXPO '67 "talking chair" equipment developed by the Rola Division of Plessey Components (Australia) has now been placed on the market. The recorder, known as the CT80, is supplied in rack mounted, desk-top mounted, recessed, and flush mounted versions. Each version operates with either three, five or seven-inch cartridge containers and all are available as either record-and-play or playback-only models. An optional "trip cue" attachment is available that allows cue tones of different frequencies to be recorded at various intervals along the tape—either while making the recording or at a later date. On subsequent replay, these "trip cues" are used to operate associated relays performing such functions as operating a slide projector, starting a film projector or separate tape unit, or activating warning lights. The desk-top and recessed versions are intended primarily for radio stations and dimension

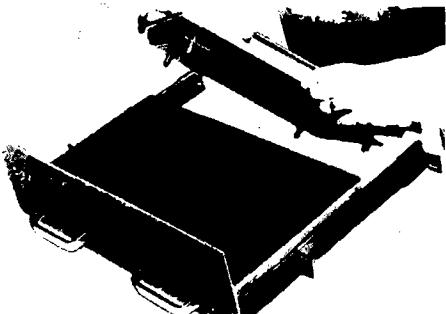


sions of the desk-top model are 7.375 inches high, 12.5 inches wide, and 11.5 inches deep. The rack-mounted CT80 unit is designed to fit into a standard 19 inch equipment rack and occupies 8.75 inches of vertical space. The Liaison Office Plessey Australia, The Plessey Company Ltd, Ilford, Essex.

W.W. 312 for further details

Plug-in Programmer

THE LATEST addition to the Sealectro range is a plug-in programme board for use with a 28 x 50 hole matrix. Programme pins are held in a single plug-in unit enabling a complete programme to be changed in one operation without the need to manipulate individual pins. With this arrangement programmes are semi-permanent although



individual pin positions in the plug-in unit can be altered if desired. The new unit is drawer mounted and requires just under 5.25 inches of vertical space in a standard 19 inch rack. Sealectro Ltd, Walton Rd, Farlington, Portsmouth, Hampshire.

W.W. 313 for further details

Rotary Stud Switch

TYPE 01 subminiature rotary stud switch with a fully adjustable stop mechanism is made by Radia-tron, 7 Sheen Park, Richmond, Surrey. There are up to 12 positions and four poles per wafer. The diameter is 0.6in. Wafer material is ceramic and it has an insulation in terms of resistance of $10^{12} \Omega$ (between wafer and earth), while contact resistance is $4 M\Omega$. Maximum static load per contact is 3 A, and the switching rating is 200 V at 0.1 A. Life expectancy is said to be up to 10^6 rotations.

W.W. 314 for further details

Pulsed Carrier Generator

THE RADA-Pulser 5071B performs three functions. It will operate as a conventional r.f. signal generator providing c.w. signal between 10 and 250 MHz in five overlapping bands with a setting accuracy of 1 per cent. It contains a video generator



that will supply pulses that can be varied from 100 ns to 100 μ s in width at a repetition rate of between 50 and 5,000 pulses per second with rise and decay times of less than 20 ns. The third mode of operation entails combining the former two functions using an internal diode switch and buffer stage, the output now taking the form of a pulsed r.f. carrier of variable frequency and repetition rate with a fast risetime (10 ns). The output attenuator allows 102.5 dB of control in 0.5 dB steps. A 2.5 V (into 50Ω) sync pulse is available, preceding the output pulse by 40 ns. Kay Electric Company, Maple Avenue, Pine Brook, New Jersey 07058. U.S.A.

W.W. 315 for further details

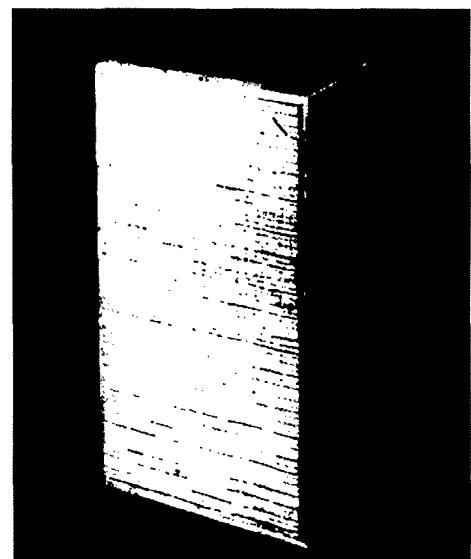
Wire-wound Resistors

RESISTORS wound to customers requirements for industrial or amateur use are available from the Planet Instrument Co., 25 Dominion Avenue, Leeds 7. Present facilities allow any value from 1 Ω to 20 k Ω to be wound. Four-lead meter shunts in the range 0.1 to 20 Ω are also available. Tolerances can be 0.5% or 1% with a maximum power handling of 1 W. Orders for individual components are handled.

W.W. 316 for further details

Transient Voltage Protected Rectifier

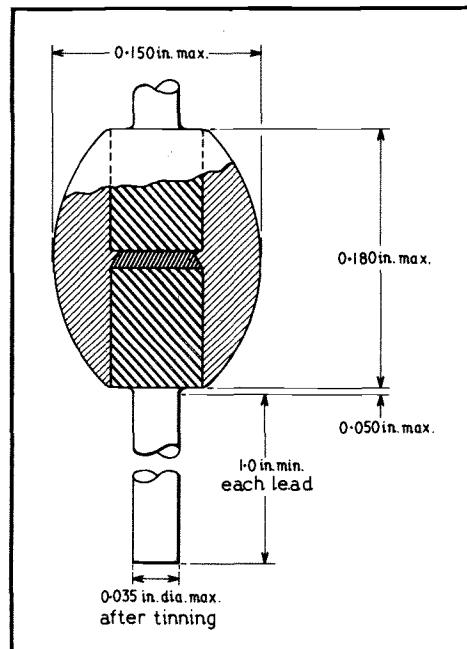
THE rectifier type A14D announced by the General Electric Company (USA) is a 1 amp device intended for general purpose, domestic and light



Speaker Enclosure

THE "Standard" loudspeaker system introduced with the Ravensbourne stereo amplifier earlier this year by Rogers Developments Ltd has been joined by a new, lower cost, enclosure called the Compact. The main drive unit is 8 inches in diameter with a 15 tesla (15,000 gauss) magnet and with a 25 Hz resonance. The tweeter is the type HF1300 by Rola Celestion. A crossover unit operating at 2.5 kHz employs air cored inductors and paper foil capacitors. The cabinet finish is in teak veneer with gold Tygan fret material. Frequency response is stated as being 50-14,000 Hz, the impedance 8-16 Ω and power handling capacity 10-15 W. Overall dimensions are 22 x 11.5 x 8.625 inches and the price is about £30. Rogers Developments Ltd, Rodevco Works, 4/14 Barneston Road, Catford, London S.E.6.

W.W. 318 for further details



Press-fit Terminal

A NEW press-fit feed-through terminal is now available from Sealectro Ltd, Farlington, Portsmouth, Hants. Designated press-fit part no. FT-SM-56-L1 the component is manufactured from Teflon and has a gold plated brass lug which extends 0.370 inches above the 0.172 inch shoulder. The terminal is 0.0625 inches in diameter and has a central hole 0.040 inches in diameter.

W.W. 319 for further details

X-Band Hot Carrier Diodes

HOT carrier diodes are silicon epitaxial surface-passivated devices that use a metal-semiconductor junction rather than a p-n semiconductor junction. With a metal-semiconductor junction (Schottky barrier) the diode has no minority carriers and hence charge storage effects are virtually eliminated. The response, therefore, to a change in bias is much faster than with p-n junctions. A series of such diodes is being produced by Hewlett-Packard Ltd. One of these devices, type HP 2511, is encapsulated in a hermetically sealed metal-ceramic package designed for use with stripline techniques and is suitable for coaxial mixer and detector applications. Package inductance and capacitance are typically 0.35 nH and 0.21 pF respectively—low values that render the diode suitable in broadband applications. The noise figure, when the device is used in a conventional s.s.b. mixer, is less than 6 dB at a carrier fre-

quency of 10 GHz. The diode is available in two voltage ratings, 100 V and 200 V, with current ratings of 100 A and 200 A respectively. The devices are available from Jermyn Industries, Vestry Estate, Sevenoaks, Kent.

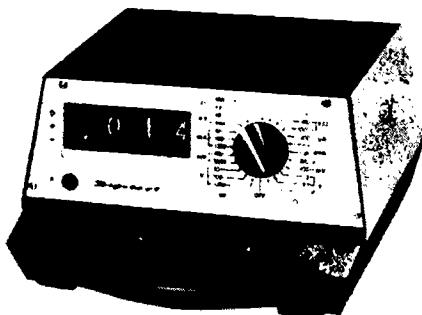
W.W. 317 for further details

quency of 3 GHz. The HP 2511 can withstand 15×10^{-7} Joules and the peak power dissipation ($1 \mu\text{s}$ pulses with a 1% duty factor) is 4 W. Power dissipation on c.w. is 200 mW. Mounted in a symmetrical microminiature ceramic package for waveguide, coaxial and stripline applications the diodes in the HP 2700 series are intended for use at frequencies both above and below and X-band. The package size is less than 0.06 inch in diameter and 0.05 inch in height, package inductance and capacitance are in the region of 0.3 nH and 0.13 pF. The symmetrical design allows the diodes to be inserted with either polarity into the circuit, meeting the need for forward or reverse pairs in balanced mixer configurations. The s.s.b. noise figure of the HP 2701 is less than 6 dB with a carrier frequency of 9.375 GHz. Allowable c.w. power dissipation is 100 mW. Hewlett Packard Ltd, 224 Bath Road, Slough, Bucks.

W.W. 320 for further details

Digital Test Meter

POWER FOR this instrument may be obtained from one of three separate sources; from the mains—100/140 V or 200/270 V, 50-60 Hz; from an internal 12 V accumulator which will give five hours of continuous operation on one charge (charging unit built in); or from ten U2 dry cell batteries giving 25 hours of intermittent operation. Weight without dry cells is 6.5 lb and the instrument measures $9 \times 8 \times 5$ inches. The display con-



sists of three cold-cathode type digital indicators and neons to show polarity of input and permissible over-ranging. The instrument is protected against incorrect use and overloads by a system of diodes, fuses and warning lamps. The Digital test will measure 100 mV to 1,000 V d.c. in 5 ranges; 300 mV to 300 V a.c. (r.m.s.) in 4 ranges; 100 μA to 1 A d.c. in 5 ranges; 300 μA to 300 mA a.c. (r.m.s.) in 4 ranges; 100 Ω to 1 M Ω in 5 ranges. Accuracy is between 0.5 per cent and 2 per cent depending on range and function selected. The price is £158. Kynmore Engineering, 19 Buckingham Street, London W.C.2.

W.W. 321 for further details

Tape Reader

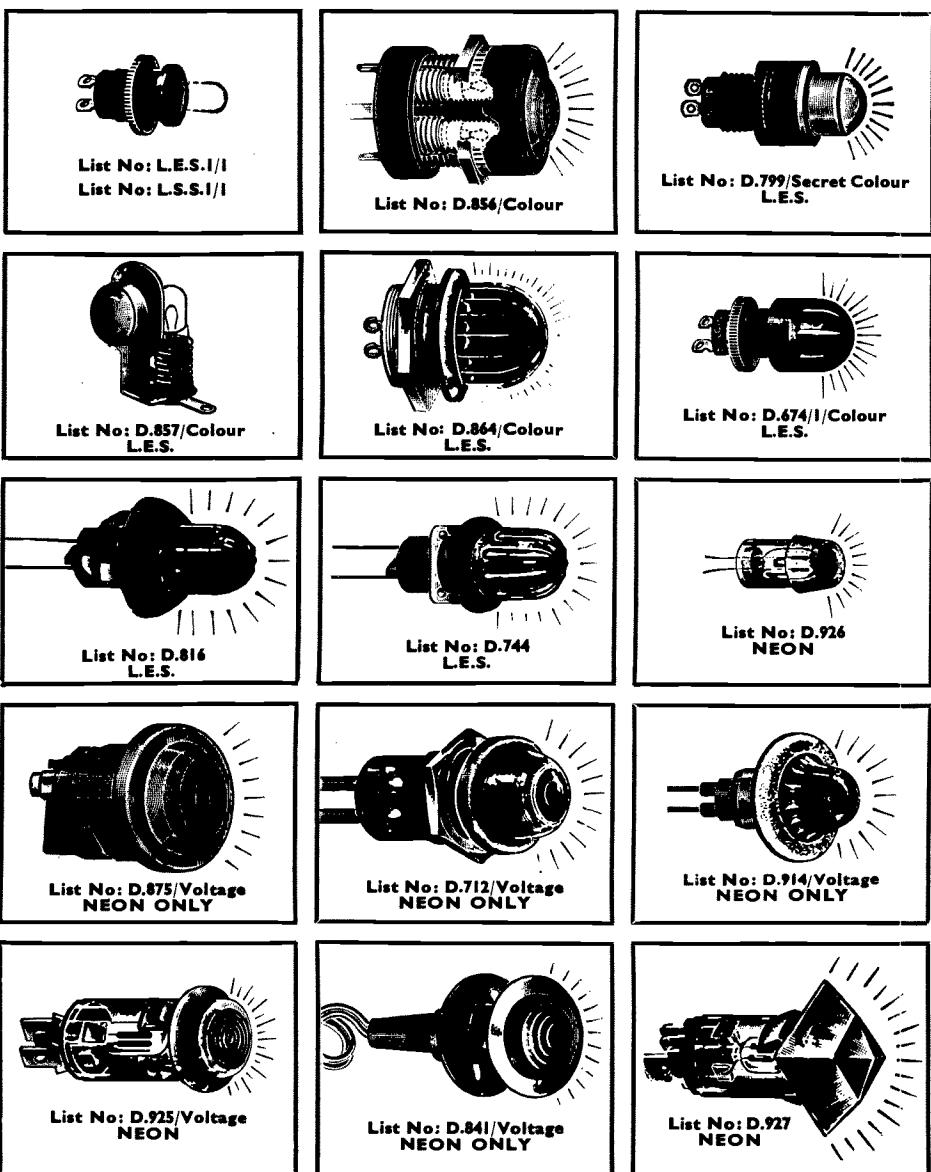
THE DDR40 tape reader has been designed by Data Dynamics to provide a low-cost unit for a wide range of applications in the business machine, data processing and industrial fields. The DDR40 is constructed on a modular basis and operates asynchronously at speeds up to 40 characters per second. Back spacing is available as a standard feature and the equipment will handle all standard grades and widths of paper tape. Reading is by means of a moulded brush system feeding into a set of gated amplifiers. Bi-directional drive is achieved by the use of a high torque stepping motor operating from a solid-state drive package. The DDR40 is fully compatible with the Data Dynamics range of Teletype page printers. Prices



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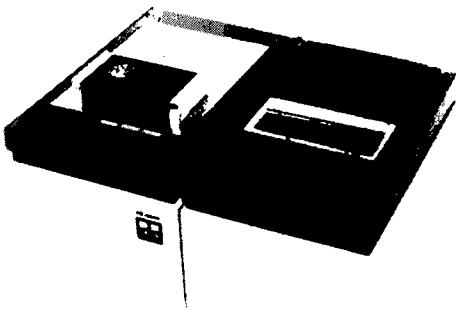
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WW-099 FOR FURTHER DETAILS

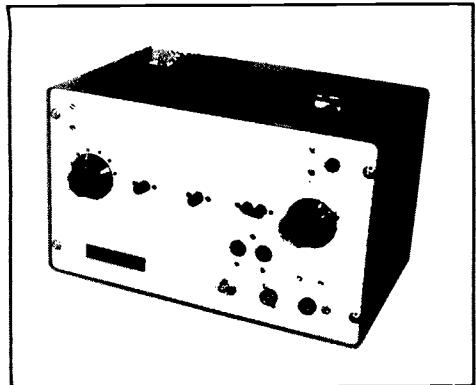


is between $\pm 3\%$ and $\pm 5\%$ depending on range. As a coulombmeter 13 ranges are included from 10^{-13} to 10^{-6} coulombs, accuracy $\pm 5\%$ of f.s.d., drift due to offset current is not greater than 5×10^{-15} coulomb/sec. The instrument can also be used as a variable input resistance unity-gain amplifier with an accuracy of 50 parts per million or $100 \mu V$ exclusive of zero offset. In addition voltage and current recorder outputs are provided. Keithley Instruments Inc., 28775 Aurora Rd., Cleveland, Ohio 44139.

W.W. 324 for further details

Transient Measuring Voltmeter

TRANSIENTS of the order of $1 \mu s$ may be detected and measured on the Peak Lok model 440A voltmeter manufactured by the La Jolla division of Control Data Corporation, situated in California, U.S.A. The voltmeter reads positive, negative or bipolar (highest of either positive or negative) peaks, holding the reading indefinitely or until reset by a push button or electrical signal. Nine input ranges from 0.1 V to 1000 V are



specified by the B.B.C. except that there are no equalizing pulses before and after the field pulse sync. group. The TPG55 measures $12 \times 7.75 \times 8.5$ inches; weight with battery is under 9lb; and the price is £88 10s. The power supply needed for mains operations is extra costing £4 5s. Rank Bush Murphy Ltd, Welwyn Garden City, Herts.

W.W. 326 for further details

for the DDR40 range from £50 for a basic reader to £120 for a free-standing unit complete with electronics and power supply unit. Data Dynamics Ltd, Data House, Arundel Road, Uxbridge, Middlesex.

W.W. 322 for further details

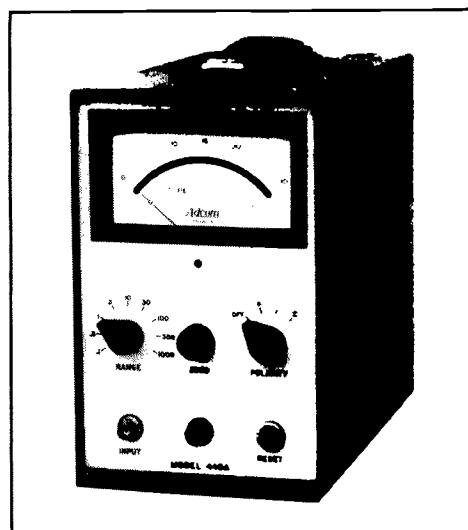
Sealed Push-Button Microswitch

A SERIES of panel-mounted sealed push-button microswitches has been introduced by the Plessey Components Group's Microswitch Unit at Titchfield, Hants. Known as the 76.2510 Series, the microswitches incorporate an "O" ring panel seal and an oil-proof diaphragm actuator seal which protects the component from pressures of up to 3.46 kg/cm^2 (15 lb/sq.in). A one- or two-pole or changeover switch is fitted as a detachable assembly. Compression of the actuator tabs enables the basic switch assembly to be removed, thereby facilitating easy installation and wiring.

W.W. 323 for further details

Low Drift Electrometer

ZERO DRIFT on the model 602 electrometer from Keithley Instruments of America is less than 1 mV per day and the input impedance is $10^{14} \Omega$. As a voltmeter the instrument has nine ranges with f.s.ds of 1 mV to 10 V at an accuracy of $\pm 1\%$ f.s.d. excluding noise and drift; zero offset is less than $300 \mu V/\text{degree F}$ after a 30 minute warm up period has elapsed. As an ammeter there are 28 ranges with f.s.ds of 10^{-14} to 0.3 A (accuracy varies between $\pm 2\%$ and $\pm 4\%$ of f.s.d. depending on range selected), offset current is less than 5×10^{-15} A. As an ohmmeter 23 ranges are available from 100— $10^{13} \Omega$, accuracy



provided and the response is d.c. to 1 MHz. There is no limitation on the input risetime and no recovery period is required. Accuracy on the taut-band meter is 1.5% of f.s.d. while an electronic output of 0 to +5 V (at up to 2 mA) is accurate to 1%. Applications of this instrument include the detection of momentary overloads; in product control, the determination of maximum weight or other parameter during a production run; in quality control reading peak strain of a sample during a vibration test. For those who require a portable instrument a battery operated option is available. The equipment is distributed in the U.K. by Claude Lyons Ltd, Instruments Division, Hoddesdon, Herts.

W.W. 325 for further details

Crosshatch and Dot Generator

THE TPG55 generator will provide (1) a dot pattern for static convergence tests; (2) a grid pattern for dynamic convergence tests; (3) a grey scale for tracking checks; and (4) a raster for purity adjustments. It provides either an r.f. output of several millivolts tunable over bands III, IV and V or a video signal of about 1 V into 75Ω (negative sync). The signal characteristics are as



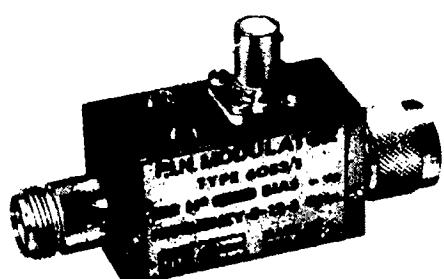
Parametric Amplifiers

TWO parametric amplifiers have been announced by Mullard for use at S- and X-band frequencies. Neither of the amplifiers requires cooling and both have a noise figure of 3 dB. Type CL9010 is for use at S-band frequencies in the range 2.7 to 3.3 GHz with a bandwidth of 15 MHz; type CL9060 is an X-band amplifier that operates in the range 7 to 12.4 GHz with a bandwidth of 50 MHz. Because of their compact size— $15 \times 9 \times 9$ inches—the amplifiers can be mounted directly behind a radar aerial. Mullard Ltd., Mullard House, Torrington Place, London W.C.1.

W.W. 327 for further details

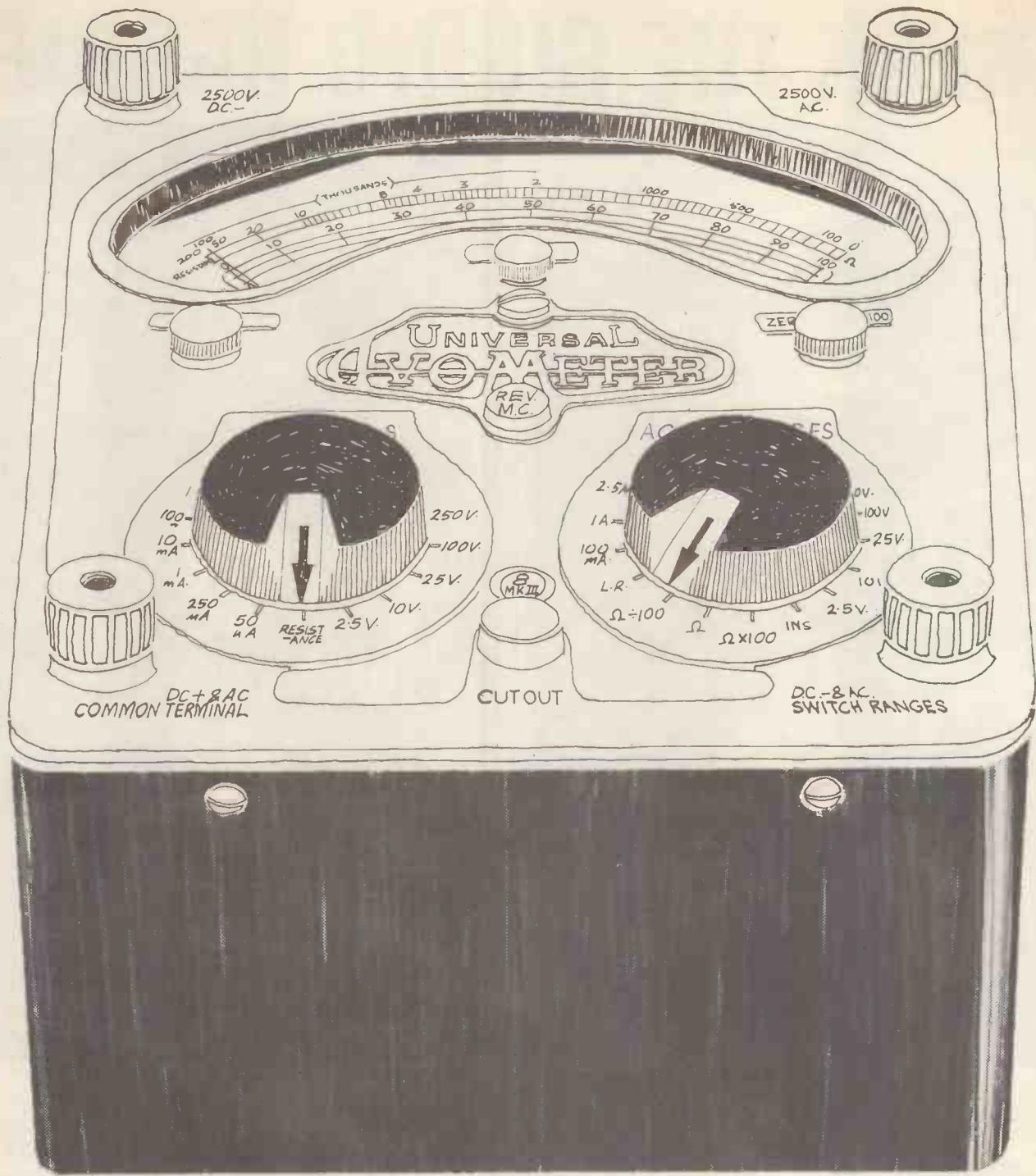
PIN Diode Modulator

THIS variable r.f. reflection type attenuator (Sanders Type 6503/1) consists of a length of co-axial line containing a shunt p-i-n diode assembly to which negative bias is applied in order to increase the attenuation of the line. In this way attenuation of up to 35 dB can be achieved with a bias of 100 mA. Insertion loss is 2 dB and the specification is guaranteed to within the frequency limits 0.5 to 12.4 GHz. However, the makers state that the device is useful down to 100 MHz. The unit is fitted with one male and one female 50Ω type N stainless steel connector and bias is applied via a silver-plated brass b.n.c. connector. Typical applications include



sweep or signal generator levelling, as a chopper for low-level signal detection, as a pulse or square-wave modulator for laboratory or system use, or as a protection device for wideband receivers. Musto & Steele Ltd, c/o Marconi Instruments—Sanders Division, Gunnels Wood Road, Stevenage.

W.W. 328 for further details



OK, so you're a knob-twiddler

After all, you're only human, and those two big knobs on the Model 8 Avometer are terribly tempting. Just by twiddling them, you can have over 30 calibrated ranges at your command—11 current, 15 voltage, 5 resistance, and a 30dB power scale. Twiddle yourself a good combination of accuracy (1%fsd/dcA, 2%fsd/dcV, 2½%fsd/ac) and sensitivity (20kΩ/Vdc, 1kΩ/Vac, except 2.5Vac scale 100Ω/V). Plus automatic cut-out, fused ohms circuit, trio of ohms zero-adjustments, reverse-polarity button and anti-parallax mirror. No wonder the Model 8 is the first choice of electronic, radio and TV engineers everywhere. Get yours from your local dealer or direct from Avo Ltd, Avocet House, Dover, Kent. Telephone Dover 2626. Telex 96283.

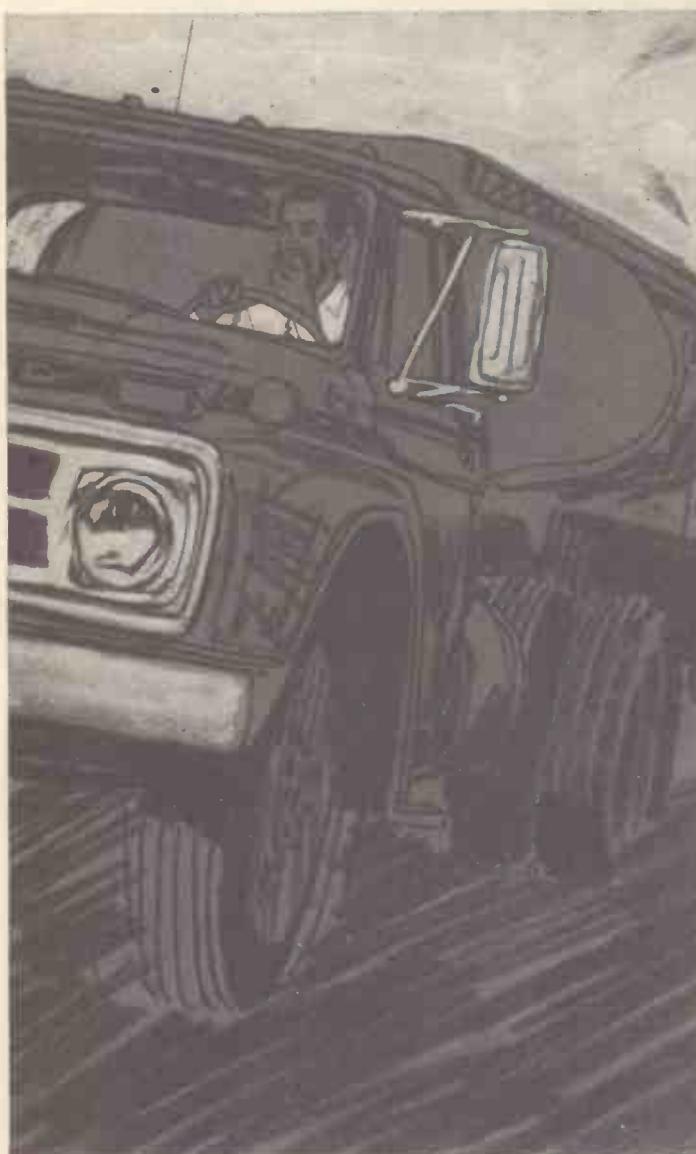


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A2

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MODEL 488 SONO-BAR



MODEL 419 RANGER II

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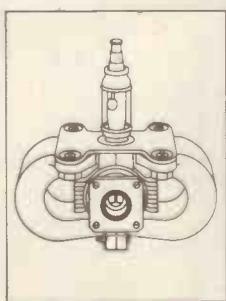
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Navigators feel all the safer for having an EEV magnetron on board. It's because they know that EEV specifically designs for a longer, more reliable life. As well as being prominent in the airborne and marine field EEV is also the only British manufacturer of magnetrons for heavy radars. The range available is wide enough for practically every requirement but if you have something special in mind EEV's long and unique experience in magnetrons shows that this is the company to make it. In the meantime details of the standard range are available on request.



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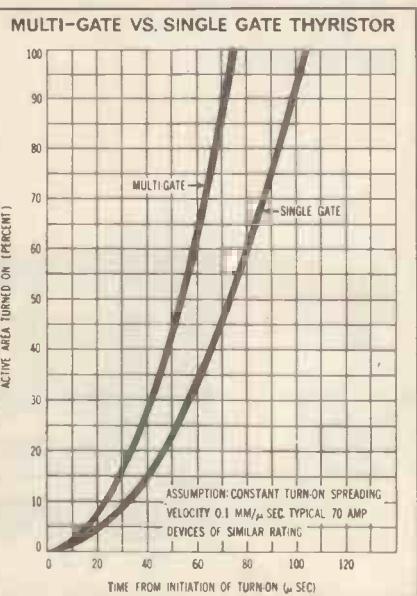
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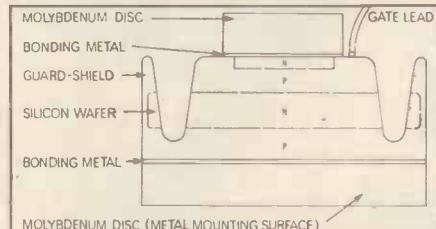
If it's worth 3 minutes of your time to learn the state-of-the-art in Thyristors,

start here: Exclusive Multi-Gate Thyristors When thyristors are to be operated with steeply rising current pulses and/or high repetition rates, great care must be exercised in establishing the operating conditions and selecting the device to be utilized. A self-saturating reactor may be introduced into the circuit to limit the rate-of-rise of current (dI/dt); this will permit a conventional high-power thyristor to carry heavy load currents which exhibit high dI/dt . Where it is not practical to use such a reactor, which is often bulky and expensive, a thyristor with enhanced turn-on action must be used. Such action can be obtained by providing the thyristor with multiple gates.

IR multi-gate thyristors exhibit reduced turn-on voltage at any given instant during the turn-on period and shorter time for equalization of current flow throughout the entire semiconductor wafer. The consequent reduction in turn-on power losses will permit increased load current to be carried and the device will exhibit faster turn-off time. It will also be able to withstand greater rates of rise of re-applied off-state voltages because of the lower junction temperature at the instant of current commutation.



MIM-Protection IR's epitaxial thyristors offer the exclusive feature of metalion migration (MIM) protection.



During manufacture, the silicon wafer for epitaxial thyristors is contoured to improve the high-voltage characteristics of the device. This illustration shows the cross-section of a typical contoured silicon wafer.

Metal-ion migration can occur because of the electrical potential that exists at the junction interfaces at the edge of the wafer. When the device is energised, metal-ions are attracted from the metal mounting surface towards the junction interfaces. Migration may occur even though the wafer has been cleaned by etching and sealed with inert sealers or varnishers. When the minute metallic particles reach the interfaces, they can cause degradation or failure of the device. IR's epitaxial devices employ an exclusive groove etching technique which provides needed contouring and, in addition, builds a guard-shield against metal-ion migration.

Bulk Avalanche Thyristors These devices exhibit true avalanche behaviour in the bulk of the crystal, thus avalanching at approximately the same voltage in both forward and reverse avalanche modes. Bulk avalanche devices are characterised by extremely low leakage current, which is mostly bulk leakage and which does not show any drift or instability under long-term, high-voltage blocking operation. In addition, IR's epitaxial thyristors can be repeatedly broken over into the conduction mode without detrimental effects as long as the power ratings and the rate-of-rise of turn-off current (dI/dt) are kept within the listed specifications.

As a result of the epitaxial construction, there is a substantial decrease in the for-

ward voltage drop during turn-on. This reduces the total power loss during the turn-on action, which in turn reduces the temperature of the device. Therefore IR epitaxial thyristors are well adapted for inclusion in inverter and switching applications.

Ultra Fast Turn-Off Thyristors Early last year IR implemented a major technological breakthrough by going into quantity production at Oxted of thyristors exhibiting turn-off times below 3 microseconds, faster than those yet produced by any other semiconductor manufacturer. To date this claim remains undisputed. The devices designated "RCU" are offered in two current ranges of 8 and 10 amperes (full-cycle-average) with voltage ratings of 50-800 volts PRV/PFV. The turn-off times of all IR "RCU" thyristors are measured at maximum base temperature. The maximum operating frequency of a thyristor circuit is obviously dependent on turn-off time, and introduction of "RCU" thyristors means that high-power inverter circuits may be operated at frequencies in excess of 30 kHz. By utilizing "RCU" thyristors, the inverter designer may subsequently reduce the size and cost of the inverter components used in commuting circuits.

The principal applications for the "RCU" thyristors also include high-frequency induction heating, ultrasonic equipment and d.c.-d.c. converters.

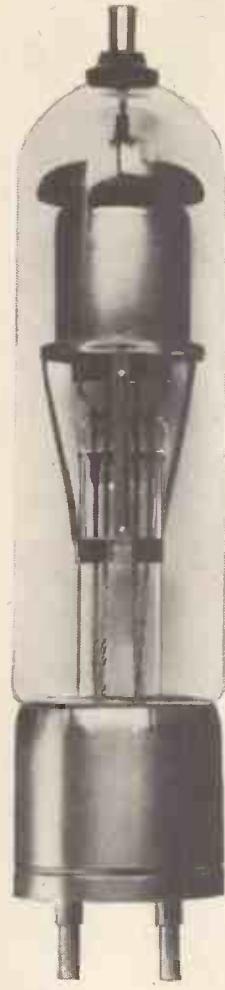
Detailed information about the world's leading range of thyristors and how they can solve your specific problems is yours on request from International Rectifier. Just ask.

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WW—008 FOR FURTHER DETAILS



Mercury Vapour Rectifiers

DATA

Type	Service type	Peak inverse voltage max. (kV)	Peak anode current max. (A)	Mean anode current max. (A)	Max. d.c. output 3-phase full wave	
					Voltage (kV)	Current (A)
869B	—	20.0	10.0	2.5	19.0	7.5
AH200	—	20.0	10.0	2.5	19.0	7.5
AH205/ 857B	CV2673	22.0	40.0	10.0	21.0	30.0
AH211A	CV532	16.0	8.0	2.0	15.2	6.0
CV5						
AH221	CV1435	20.0	5.0	1.25	19.0	3.75
AH238	CV1629	13.0	5.0	1.25	12.4	3.75
BD10	—	1.0	25.0	8.0	0.95	24.0
BD12*	—	1.0	2 x 50*	2 x 16.5	0.95	49.5

*Full wave rectifier.

This range of Mercury Vapour Rectifiers is available from your local EEV stockist. English Electric Valves production methods ensure the reliability and performance you are looking for and prices are competitive.

Coventry Factors Ltd, Coronet House, Upper Well Street	Coventry Tel: Coventry 21051
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Monobloc ; an advanced product for sophisticated applications. A tiny component that has become the most exciting prodigy this side of the Atlantic. Its capacitance is vast, its size minute – up to 1 uf in $0.3 \times 0.3 \times 0.1$ in. (nine times smaller than a postage stamp). This capacitance-to-volume ratio is achieved by the unique monolithic construction. Wafer-thin ceramic dielectrics and platinum electrodes are fused into a solid, layered structure, to give a volumetric efficiency 10 to

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We manufacture a preferred range, concentrated on the individual requirements of the British designer. There are other configurations available for more complicated designs : glass-encased, precision moulded, phenolic coated, and unencapsulated chips for hybrid integrated circuits.

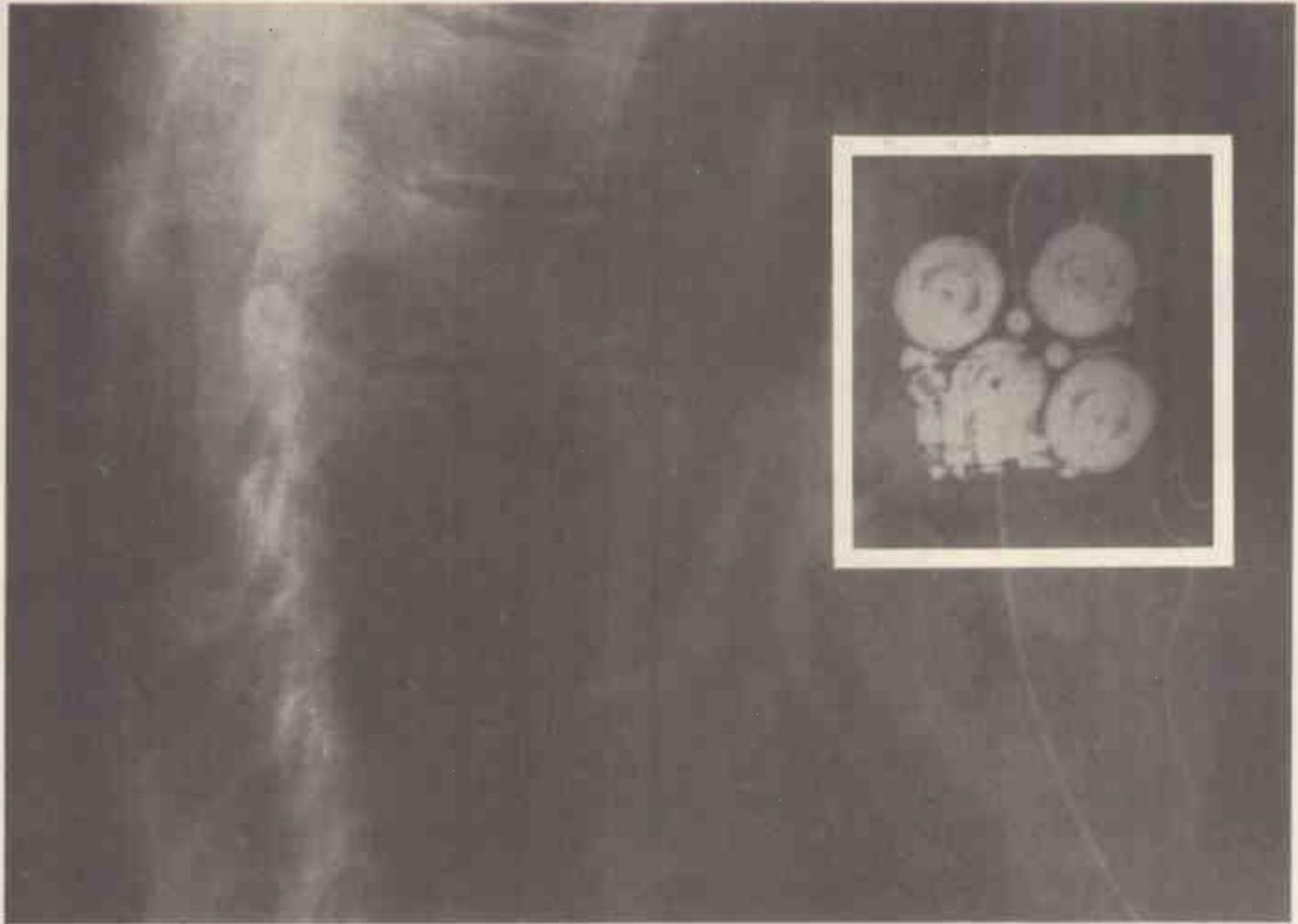
The monolithic capacitor is already a pretty important contribution to the progress of modern electronics – our Monobloc Ceramicon design caters for projects of the future.

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Monoblocs are to be featured in the 1968 edition 6 catalogue of S.T.C. Electronic Services. Monobloc and Ceramicon are registered trade marks.

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Mallory made it.

What can we do for you?

Medical science needed a battery. A battery that literally could keep your heart beating. A battery to power a heart pacemaker—the electronic device that "shocks" sluggish hearts into a normal beat. A battery that would last three years or more in the surgically-implanted device, even in the high temperature environment of the body. Mallory made it. Mallory leads the way in miniature power sources for all needs. The high-energy of the Mallory mercury battery and its extraordinary reliability have found many uses in medical-electronics. Mercury batteries can be made so small they will fit into "radio capsules" that transmit from within your stomach. The Electronic Larynx is used to transmit sound waves into the throat cavity of people whose larynx has been removed.

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5in. GENERAL-PURPOSE OSCILLOSCOPE, 10-12U

- "Y" sensitivity 10 mV. r.m.s. per cm. at 1 kc/s. • Bandwidth 3 c/s-4.5 Mc/s.
- Frequency compensated input attenuator X1, X10, X100. T/B, 10 c/s-500 kc/s. in 5 steps.
- Two extra switch selected pre-set sweep frequencies in T/B range. • T/B output approx. 10 v. peak to peak.
- Built-in IV calibrator • Facility for "Z" axis modulation • Electronically stabilised power supply • Power req. 200-250 v. A.C., 40-60 c/s., 80 watts • Fused • Front panel, silver and charcoal grey • Cabinet, charcoal grey, size 8½" x 14" x 17½" deep. Net weight 23lb. 56-page construction and operation manual.

Kit £35.17.6. Ready-to-use £45.15.0

Attenuator and demodulator probes available as optional extras.



6in. VALVE VOLTMETER, 1M-13U

- Modern styling • Extra features • The ideal VVM for the Electronic Engineer • 6in. Ernest Turner 200μA. meter with multi-coloured scales
- Unique gimbal bracket allows bench, shelf or wall mounting • Measures A.C. (r.m.s.), D.C. volts 0.1-5, 5, 15, 50, 150, 500, 1,500 • Resistance range 0.1 to 1,000MΩ with int. battery • Vernier action zero and ohms adjustment • Roller-tinned printed circuit • High input resistance (11MΩ) • Comprehensive assembly and operation manual • Size 5 x 12½" x 4½" in. Complete with test prod and leads.

Kit £18.18.0. Ready-to-use £26.18.0

4½in. Valve Voltmeter-V-7A (not illustrated). Kit £13.18.6.

Ready-to-use £19.18.6

3in. PORTABLE GENERAL-PURPOSE SERVICE OSCILLOSCOPE, OS-2

- Modern styling, lightweight and compact size, make this the ideal 'scope for service man, laboratory technician, amateur radio enthusiast or hobbyist • "Y" bandwidth 2 c/s-3 Mc/s. ±3 dB.
- Sensitivity 100 mV/cm • Push-pull vertical and horizontal amplifiers • Wide range time-base generator 20 c/s-200 kc/s in four ranges.
- Automatic lock-in synchronisation • Mu-metal c.r.t. shield • Printed circuit board construction • Power req. 200-250 v. 50-60 c/s A.C. 40 watts • Fused • Front panel silver and charcoal grey. Size 5in. w. x 7½in. h. x 12in. deep. Weight: 9½lb.

Kit £23.18.0. Ready-to-use £31.18.0



GENERAL-PURPOSE SERVICE RF SIGNAL GENERATOR, RF-1U

- Ideal for the alignment and trouble shooting of RF, IF and audio circuits • Large easy-to-read dial • Pre-aligned coil and bandswitch assembly
- RF output of at least millivolts • 100 c/s-100 Mc/s, fundamentals up to 200 Mc/s harmonics • 400 cycle audio signal with 4 v. output • Dimensions 9½in. wide x 6½in. high x 5in. deep.

Kit £13.18.0. Ready-to-use £20.8.0



AUDIO SIGNAL GENERATOR, AG-9U (not illustrated)

Kit £23.15.0. Ready-to-use £31.15.0

See these and other Heathkit models in the FREE catalogue

NEW! PORTABLE STEREO TAPE RECORDER, STR-1

- ½ track stereo or mono record and playback at 7½, 3½ and 1½ i.p.s. • 18 transistor circuit • Record level indicator • Digital counter with zero reset • Stereo mic and aux. inputs. • Speaker/headphone outputs.
- Built-in audio amplifier gives 4 watts rms output per channel. • Two high efficiency 8in. x 5in. speakers.

Versatile Recording facilities. So-easy-to-build. Outstanding performance for price.



Kit £45.18.0. Ready-to-use £59.15.0

THE CAR RADIO TO COMPLETE YOUR MOTORING PLEASURE CR-1

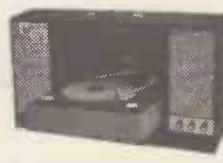
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- Complete your motoring pleasure with this small, compact, high output unit. Superb long and medium wave entertainment whenever you drive. For 12v. positive or 12v negative car earth systems.
 - 8 latest semi-conductors (6 transistors, 2 diode circuit) • Powerful output (4 watts) will drive two speakers. • Styled to harmonise with most car colour schemes • Supplied in two units, pre-assembled and aligned RF unit kit. £11.13.6 inc. P.T. IF/AF amplifier kit £11.3.6.

Total price kit (excl. LS)...£12.17.0 inc. P.T.

L/speakers and accessories available as extras.

NEW! PORTABLE STEREO RECORD PLAYER, SRP-1

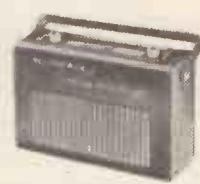
- Compact, economical stereo and mono record playing for the whole family
- Mains operated • All "solid state" circuitry. Modern compact styling
- Detachable second loudspeaker gives optimum stereo effect • Automatic playing of 16, 33, 45 and 78 rpm records
- Suitcase portability • Two 8in. x 5in. speakers • Controls: Volume, Balance and Tone. Dimensions: overall 27in. wide x 14½in. high x 7½in. deep.



Kit £27.15.0. Ready-to-use price on request.

"OXFORD" LUXURY TRANSISTOR PORTABLE, UXR-2

- This superb transistor radio is the ideal domestic or personal portable Medium and Long Wave receiver • Solid leather case and handle • Easy-to-read tuning scale • Extra large loudspeaker. Push button L, MW and tone • 10 semi-conductors (7 transistors plus 3 diodes) • Sockets for personal earphones, tape recorder, car aerial • Internal 9-volt battery (not supplied) lasts for months • Latest printed circuit techniques • Comprehensive, easy-to-follow, fully illustrated Instruction Manual.



Kit £14.18.0 inc. P.T. Ready-to-use price on request

• Prices quoted are Mail Order, and include free delivery in U.K. • Retail prices slightly higher.

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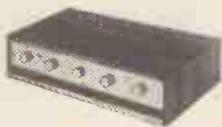
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NEW! 12+12W TRANSISTOR STEREO AMPLIFIER

Model TSA-12

Luxury performance
at lowest cost



• 17 transistors, 6 diode circuit • ± 1 dB., 16 to 50,000 c/s at 12 watts per channel into 8 ohms • Output suitable for 8 or 15 ohm loudspeakers • 3 stereo inputs for Grams, Radio and Aux. • Modern low silhouette styling • Attractive aluminium, golden anodised front panel • Handsome assembled and finished walnut veneered cabinet available • Matches Heathkit models TFM-1 and AFM-2 transistor tuners.

Kit £30.10.0 (less cabinet)

Ready to use £42.10.0

Beautiful Walnut cabinet £2.5.0 extra.

20+20W TRANSISTOR STEREO AMPLIFIER

Model AA-22U

An International Class amplifier which offers superb realism and beauty of music at a very competitive price. Professional, elegant, compact, slim-line styling. The best of American transistor techniques allow high output with low distortion. 5 stereo inputs (five each channel) for pick-up, radio tuner, tape and two other sources. 20 transistor, 10 diode circuit. Beautiful, fully finished walnut veneered cabinet (optional extra).

Kit £39.10.0 (less cabinet)

Walnut cabinet £2.5.0 extra.

Ready to use £59.15.0 (inc. cabinet)

5 W HI-FI MONO AMPLIFIER KIT Model MA-5

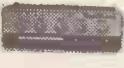


A low-priced general purpose Hi-Fidelity amplifier based on the popular S-33 for those who do not require a stereophonic system. Separate bass and treble controls. Gram and Radio inputs. Suitable for most crystal pick-ups. A printed circuit simplifies construction.

Kit £11.9.6

Ready to use £15.15.0

STEREO CONTROL UNIT KIT Model USC-1



Incorporates all worthwhile features for Hi-Fidelity stereo and mono. Push-button selection, accurately matched ganged controls to ± 1 dB. Negative feedback rumble and variable low-pass filters. Printed circuit boards. Accepts inputs from most tape-heads and any stereo or mono pick-up.

Kit £19.19.0

Ready to use £27.5.0

LW/MW TRANSISTOR PORTABLE RADIO KIT Model UXR-1



Beautiful leather case. Easy-to-read scale. 7 semi-conductors. Printed circuit board 7in. x 4in. Special loudspeaker. Pre-aligned IF transformers. 9-volt battery operated. Easy to construct, excellent in performance and value.

Kit £12.11.0 (inc. P.T.)

"MOHICAN" GENERAL COVERAGE RECEIVER KIT
Model GC-IU



This fully transistorised receiver which includes 4 piezo-electric transmitters, is in the forefront of receiver design. It is an excellent portable or fixed station receiver. The R.F. "front-end" is supplied as a pre-assembled and pre-aligned unit. Its many features include a 10-transistor circuit, printed circuit board, telescopic whip antenna tuning meter, and a large slide-rule dial giving a total length of approximately 70 inches. Housed in a steel cabinet and powered by two 6 volt dry batteries (not supplied), mounted internally, it gives frequency coverage from 580 kc/s to 30 Mc/s in five bands; thus enabling world-wide reception. Electrical bandspread covers the amateur bands from 80 to 10 metres—each band having a scale length of approximately 8 inches. BFO tuning and Zener diode stabiliser. Size 6½in. x 12in. x 10in.

Please write for specification leaflet.
Kit £37.17.6 Ready to use £45.17.6

STABILISED POWER PACK
Models MSP-IM and MSP-IW



Specially recommended for industrial and laboratory use, meeting the need for a reliable and versatile stabilised power pack capable of a very high performance. Input 200-250 v. 40-60 c/s., A.C., fully fused. Output: H.T. 200-410 v. D.C. at 0-225 mA. in 3 switched ranges. Unstabilised A.C., 6.3 v. at 4.5 A. centre-tapped. Two 3in. "easy-to-read" meters for reading voltage and current simultaneously. Separate L.T. and H.T. supply transformers. All output circuits are isolated. Size 13in. x 8½in. x 9½in.

MSP-IM (with meters)
Kit £36.12.6 Ready to use £43.12.6
MSP-IW (less meters)
Kit £29.17.6 Ready to use £36.17.6

BALUN COIL UNIT KIT

Model BI-U. Will match unbalanced co-axial lines to balanced lines of either 75 or 300Ω impedance. Frequency range 10-80 m., input up to 200 watts.

Kit £5.5.6 Ready to use £5.18.0

TAPE PRE-AMPLIFIER KITS
Models TA-IM and TA-IS



The Combined Tape Record/Replay Amplifier is available in both monophonic and stereophonic model. Model TA-IM can be modified to the stereo version with modification kit TA-IC.

TA-IM Kit £19.18.0 Ready to use £28.18.0

TA-IS Kit £25.10.0 Ready to use £35.18.0

TA-IC Kit £6.15.0

All prices are mail order and include free delivery in the U.K.

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are available on all orders above £10

AMATEUR TRANSMITTER KIT

Model DX-100U



The World's most popular

Amateur TX Kit

Completely self-contained. 150 w. D.C. input. Built-in highly stable VFO and all Power Supplies. The KT68 High-level anode and screen modulator stage gives over 100 watts of audio from less than 1.5 mV input. Keying on CW is via the VFO and buffer amplifier cathodes; the other RF valves are biased beyond cut-off. Provision has been made for remote control operation. Covers all Amateur bands up to 30 Mc/s. Phone or CW. Kit £81.10.0 Ready to use £106.15.0

AMATEUR BANDS RECEIVER KIT

Model RA-I The ideal economically



priced fixed station, portable or mobile receiver covering the Amateur bands from 160-10 m., each band separately calibrated on a large illuminated slide-rule dial. Features: Signal strength meter, tuned RF amplifier stage, half-lattice filter, adjustable noise limiter. Freq. coverage 160, 80, 40, 20, 15, 10 metre bands, I.F. 1620 kc/s. Kit £39.6.6 Ready to use £52.10.0

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SINGLE SIDE BAND EQUIPMENT

Transmitters, Receivers, Transceivers. Send for details of models. Fully illustrated American Catalogue of Heathkit range sent for only 1/- post-paid. Or see selection of models in British catalogue.

REFLECTED POWER METER KIT

Model HM-IIU Indicates reliably but inexpensively, whether the R.F. power output of your transmitter is being transferred efficiently to the radiating antenna. Kit £8.10.0 Ready to use £10.15.0

VARIABLE FREQUENCY OSCILLATOR KIT. Model VF-IU



Specially designed to meet the demand for the maximum possible flexibility from an amateur Transmitter which would otherwise be subject to certain limitations imposed by crystal control. Calibrated for all Amateur bands 160-10 metres, fundamentals on 160 and 40 m. Ideal for Heathkit DX-40U and similar transmitters. Kit £10.17.6 Ready to use £15.19.6

Q MULTIPLIER KIT.

Model QPM-I

A reasonably priced Q Amplifier for the amateur and short-wave enthusiast. This self-powered unit (200-250 v. 50/60 c/s.) may be used with communications receivers to provide both additional selectivity and signal rejection.

Models QPM-I for 470 kc/s. I.F. QPM-16 for 1.6 Mc/s. I.F. Kit, either model £8.10.0 Ready to use £12.14.0

AERIAL TOWER KITS. Model HT-1, HT-IG



Height 32ft. sq. section 3ft. x 3ft. at base (no stays required). Accessories available as extras:

HT-IG Kit (galvanised) £43.15.0

HT-1 Kit (red oxide) £37.15.0

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FM TUNER KIT, Model FM-4U

 Tuning range 88-108 Mc/s Flywheel tuning. Attractive perspex front panel in two tone grey with golden trim. Thermometer type tuning indicator, pre-aligned I.F. transformers. Own built-in power supply. Tuning heart model FMT-4U £2/15/- incl. P.T. I.F. amplifier and power supply, Model FMA-4U. Complete with case and valves £13/13/- Sold separately. Kit Total £16.8.0.

STEREO DECODER SD-1

Ideal for use with valve FM Tuners. Kit £8.10.0 Ready-to-use £12.5.0

3+3 W HI-FI STEREO AMPLIFIER Kit Model S-33H

An inexpensive stereo-mono amplifier with the high sensitivity necessary for lightweight miniature ceramic pick-ups (e.g., Decca Deram). De luxe version of the S-33 with attractive two-tone grey Perspex panel. Kit £15.17.6 Ready-to-use £21.7.6

MONO CONTROL UNIT KIT Model UMC-1

 Ideal for use with MA-12 or similar amplifier. Output 0.25 v. Send for full details. Kit £9.2.6 Ready-to-use £14.2.6

AMATEUR TRANSMITTER KIT Model DX-40U

 Covers all amateur bands from 80 to 10 metres, crystal controlled. Power input 75 watts C.W. 60 watts peak controlled carrier phone. Output 40 watts to aerial. Provision for VFO. Filters minimise T.V. interference. Modulator and power supplies are built-in. Single knob band switching is combined with a pi-network output circuit for complete operating convenience. A high-grade moving-coil meter indicates the final grid or anode current. Provision is made for the use of 3 crystals. Prices now reduced to:—

Kit £29.19.0 Ready-to-use £41.8.0

GENERAL COVERAGE RECEIVER KIT RG-1

An inexpensive communications type receiver specially designed for the short wave listener with many refinements found only in receivers costing much more. Freq. coverage 32 Mc/s.-1.7 Mc/s. in 5 ranges also M.W. band. Kit £39.16.0 Ready-to-use £53.0.0 Optional extras available.

GRIP-DIP METER KIT. Model GD-1U

 Functions as oscillator or absorption wavemeter. With plug-in coils for continuous frequency coverage from 1.8 Mc/s. to 230 Mc/s. Kit £11.9.6 Ready-to-use £14.9.6 Additional Plug-in Coils Model 341-U extend coverage down to 350 kc/s. With dial correlation curves. 17/6.

TRANSISTOR INTERCOM KITS Models XI-IU and XIR-IU

9 v. battery operated. Up to five remote stations can be operated with each Master. The Master unit can call any one, a combination, or all five Remote stations and any Remote station can call the Master.

Model XI-IU (Master) Kit £11.9.6 Ready-to-use £17.9.6

Model XIR-IU (Remote) Kit £4.9.6 Ready-to-use £5.18.0

HI-FI STEREO AMPLIFIER KIT Model S-99

18 w. output (9 per channel with 0.2 per cent. distortion at 9 w. per channel). It has ganged controls Stereo/Mono, gram, radio and tape recorder inputs and push-button selection. Ultra-linear push-pull output. P.C. boards. Attractive Perspex front panel with golden surround and grey metal cabinet.

Kit £28.9.6 Ready-to-use £38.9.6



HI-FI SPEAKER SYSTEM KIT Model SSU-1

Ducted-port bass reflex cabinet "in the white". Frequency response is 40-16,000 c/s. Power rating 10 watts Matched speaker units 8in. high flux (12,000 lines) with hyperbolic cone and 4in. wide angle dispersion type for higher frequencies.

Kit (with legs) £12.12.0 (less legs) £11.17.6 (inc. P.T.)



A.M./F.M. TUNER KIT

Tuning range 88-108 M. (FM) 16-50, 200-550, 900-2,000 m. Flywheel tuning. Attractive Perspex front panel in two-tone grey with golden trim. Thermometer type tuning indicator, pre-aligned I.F. transformers. Switched wide and narrow A.M. bandwidths.

TUNING HEART Model AFM-T1 £4/13/6 (inc. P.T.) I.F. AMPLIFIER and Power Unit Model AFM-1. Complete with metal cabinet and valves £22/11/6. Sold separately.

Kit Total £27.5.0



ELECTRONIC WORKSHOP KIT EW-1

20 exciting experiments can be made with this one kit.

Kit £7.13.6 (incl. P.T.)

SINE/SQUARE GENERATOR Model IG-82U

 Covers 20 c/s-1 Mc/s. in 5 bands. Simultaneous Sine and Square Wave outputs. Less than 0.15μs rise time on Square Wave. Less than 0.5% distortion on Sine wave. Up to 10 volts output. This attractively styled generator is designed for maximum operating convenience. Size 13in. x 8½ x 7in. deep.

Kit £25.15.0 Ready-to-use £37.15.0

OSCILLOSCOPE TRACE DOUBLER KIT Model S-3U

 This device will extend the use of your single-beam oscilloscope, and at a nominal cost, will give you the advantages of a double (or other multiple) beam 'scope.

Kit £13.10.0 Ready-to-use £19.10.0

OSCILLOSCOPE ACCESSORY KITS

Demodulation Probe kit 337-C £2.17.6

Low-cap Attenuator Probe kit Pk-1 £3.12.6

See also Oscilloscope page

● Deferred Terms available on all orders above £10.

HI-FI MONO POWER AMPLIFIER KIT Model MA-12

 A compact Hi-Fidelity power amplifier (including auxiliary power supply). 12 watts output. Wide frequency range and low distortion. A variable sensitivity control is fitted enabling it to be used with an existing amplifier in a stereophonic system. Other applications includes sound reinforcement systems, transmitter modulators, for use with tape recorders.

Kit £12.18.0 Ready-to-use £16.18.0

"COTSWOLD" SPEAKER SYSTEM KIT

This acoustically designed enclosure measures 26 x 23 x 14½ in., and houses a special 12in. base speaker with 2in. speech coil, elliptical middle speaker, together with a pressure unit to cover the full frequency range of 30-20,000 c/s. Its polar-distribution makes it ideal for really Hi-Fi Stereo. Delivered complete with speakers, cross-over unit, level control, grille cloth, etc. Left in the white for finish to personal taste.

Kit £25.12.0

Also available Ready-to-use £33.4.0



4½ in. VALVE VOLTMETER KIT Model V-7AU

The world's most popular valve voltmeter with printed circuit and 1 per cent. precision resistors to ensure consistent laboratory performance. It has 7 voltage ranges measuring respectively D.C. volts to 1,500 and A.C. to 1,500 r.m.s. and 4,000 peak to peak. Resistance measurements from 0.1 ohm to 1,000 megohms, with internal battery. D.C. input resistance is 11 megohms and dB measurement has a centre-zero scale. Complete with test prod, leads and standardising battery. Power requirements, 200-250 V. 40-60 c/s. A.C. 10 watts. H.V. and R.F. Probes available as optional extras.

Kit £13.18.6 Ready-to-use £19.18.6



DECADE RESISTANCE BOX KIT Model DR-1U

Range 1-99,999Ω in 1Ω steps. Ceramic switches throughout. Current rating from 500 mA. to 5 mA. according to decades in circuit. Polished wooden cabinet supplied complete.

Kit £10.18.0 Ready-to-use £14.18.0

● Prices include Postage U.K.

DECade CAPACITOR KIT Model DC-1U

Capacity values 100μμF to 0.11μμF in 100μμF steps. Precision silver-mica capacitors and minimum loss ceramic wafer switches ensure high accuracy.

Kit £7.15.0 Ready-to-use £10.18.0

TELEVISION ALIGNMENT GENERATOR KIT Model HFW-1

Offers the maximum in performance, flexibility and utility at the lowest possible cost. Several outstanding features have been incorporated in this model which are unusual in instruments in this price range. Frequency coverage 3.6 Mc/s. to 220 Mc/s. on fundamentals. Unique non-mechanical sweep oscillator system. High level output on all ranges. Sweep deviations up to 42 Mc/s. Built-in fixed and variable marker generator (5 Mc/s. crystal supplied).

Kit £38.18.0 Ready-to-use £49.15.0

● Prices quoted are Mail Order Prices; retail prices slightly higher.

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(Mono version TFM-IM available)

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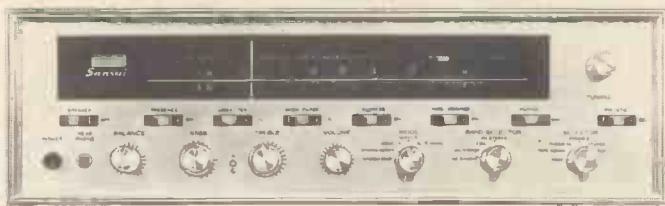
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AM sensitivity: 30 μ V (IHF).

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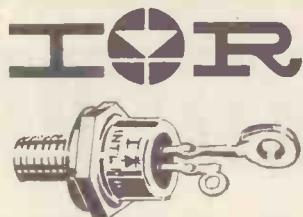
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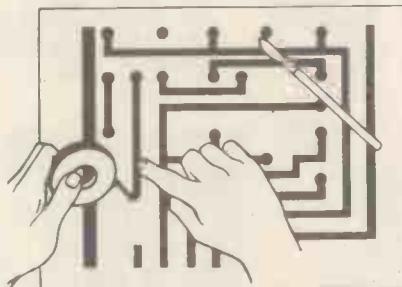
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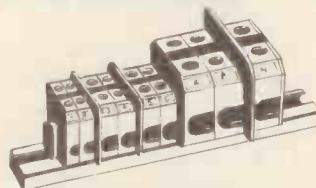


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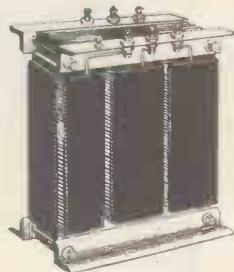
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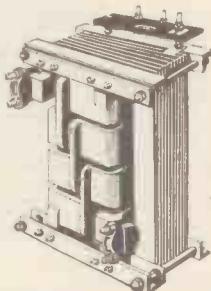
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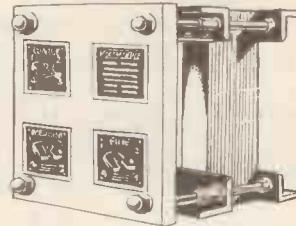
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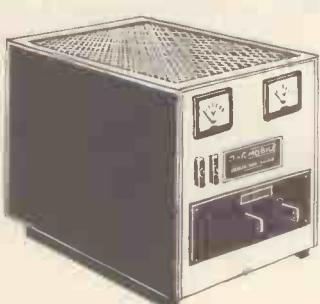
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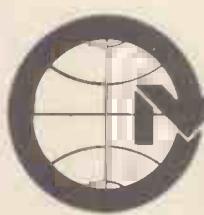
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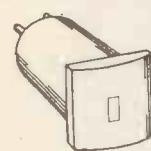
MAGNETIC RECORDING

TYPE "A"



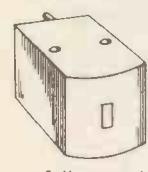
Standard 1/2 track, Record/Playback and Erase. Many special versions can be made to customers' requirements such as narrow track—raised track—or cut-away for cine use. Ideal head for dictating machines, etc. Size $\frac{3}{8}$ in. dia. by $\frac{5}{8}$ in. long. The round body makes for easy azimuth adjustment and takes up a minimum of space. Head has internal screen and fly leads for easy wiring.

TYPE "R"



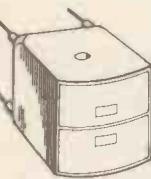
Size is $\frac{7}{16}$ in. square at the front with body $\frac{3}{8}$ in. dia. by $\frac{5}{8}$ in. long. Curved front $\frac{1}{4}$ in. radius. This head is available in a wide range of Record/Playback impedances. Also available as Erase. This novel design possesses many advantages over comparable types—higher output—lower losses—extremely good H.F. response—very low noise pick up—has internal mumetal screen. Round body aids mounting arrangements—easy azimuth alignment.

TYPE "DR"



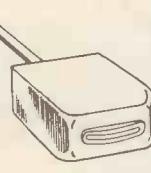
Exactly as Type R except body is $\frac{7}{16}$ in. square along its length providing simple mounting arrangements. The Erase versions of R and DR types are double field heads. These are not just double gaps but two Erase heads in one, giving better than 60dB erasure of a saturation (+6dB on full record level), 1 k/c recording at $3\frac{3}{8}$ l.p.s.

TYPE "X"



1/1 — 1/2 — 2/2 and 2/4 Heads for $\frac{1}{2}$ in. tape. Record/Playback and Erase Heads for high quality tape recorders. Size only $\frac{1}{2}$ in. cube and available in a whole range of impedances. Excellent HF performance, efficient screening and very low crosstalk are features of the R/P head. Mounting brackets are available for twin or triple head assemblies.

TYPE "T"



Built into a deep drawn mumetal case ensures complete shielding. Type T is the protruding pole type with special narrow track (as narrow as .002in.) and can be made as a Record/Playback or Erase Head, or combined Record / Playback / Erase Head, or even Record/Playback and self-oscillatory Erase Head. The Erase track can be made wider than the R/P track on the Combo Head, a fully screened lead is incorporated as part of the head.

H

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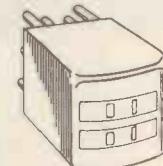
S

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SINGLE TRACK COMBO TYPE "X"

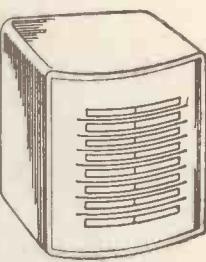
Designed as a combined Record/Playback/Erase Head for the commercial market, such as telephone answering machines. Built into $\frac{1}{2}$ in. cube deep drawn mumetal case it incorporates the R/P features of R-Type head. The Erase track is made wider than the R/P track to ensure complete erasure and to overcome machine to machine alignment tolerances.

TYPE "Z"



A brand new concept in combination head design incorporating all the best features of the X-Type Head combined with integral erase facilities. Accurate gap alignment between tracks makes this head eminently suitable for high quality stereo use. The one-piece deep drawn mumetal case (only $\frac{1}{2}$ in. cube) ensures complete screening across the front as well as the sides.

MULTITRACK



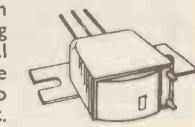
Available to special order in Two-Four-Eight or Sixteen tracks, or to specification. These tracks are located by precision machined slots and track dimensions and positions remain consistent. The track to fixing base dimensions are held to tight limits and any tolerances are non-cumulative as each track is indexed from the base. Special purpose optical equipment ensures a high order of accuracy in the alignment of the head halves. Erase heads, identically sized to the R/P head are available to special order.

TYPE "W" ERASE



Designed especially for the Cassette Type Recorder using .15in. wide tape. Built-in tape guides are a feature of this head. The Standard type now in production is $\frac{1}{2}$ -track but a compatible Stereo version will soon be available. The high Q factor of Type W Erase gives maximum economy in battery applications.

TYPE "W" R/P.



The Record/Playback Head for Cassette Recorder incorporated in a deep drawn mumetal case ensuring complete screening. As an integral part of the head the mounting plate is of tempered Beryllium copper to provide a simple azimuth adjustment. The winding is centre tapped to give the option of presenting a lower impedance to bias and signal sources during recording.

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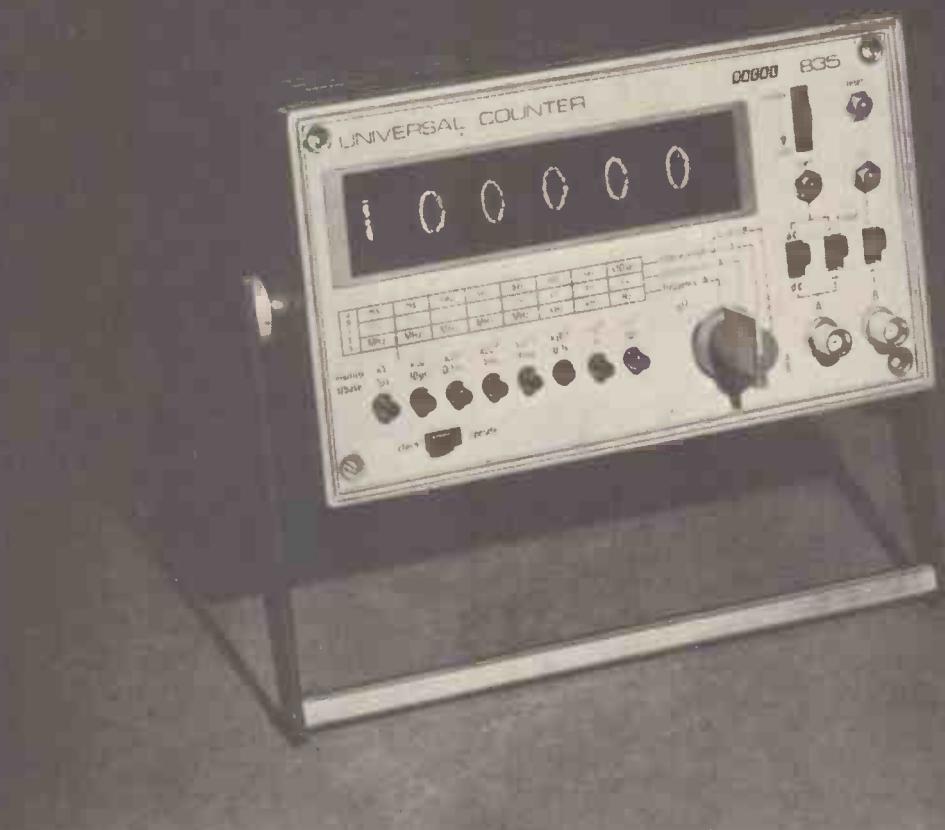
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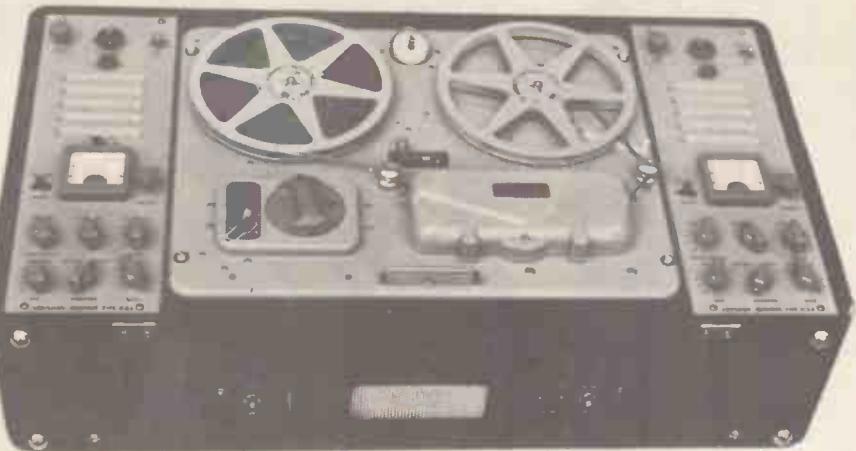
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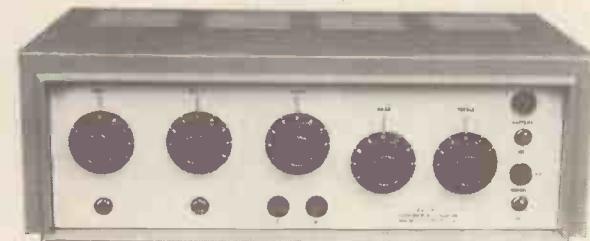
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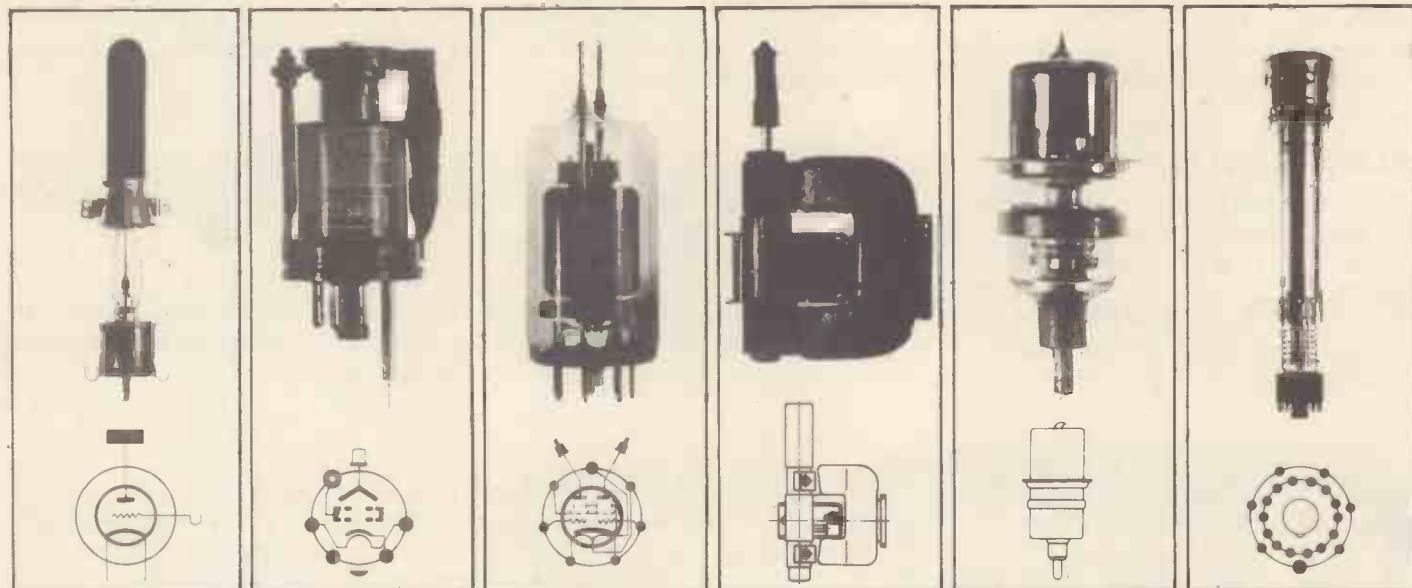
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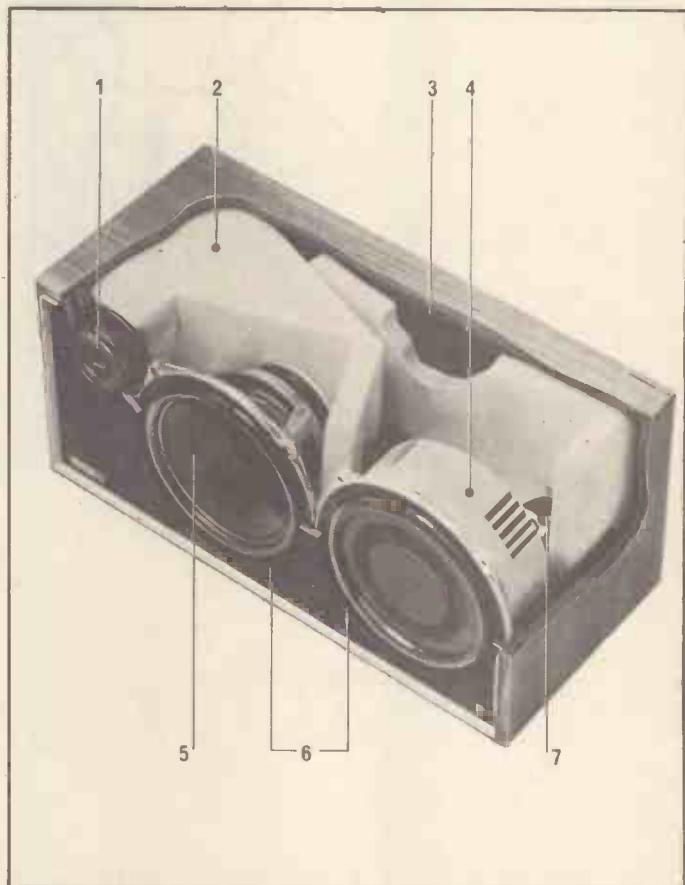
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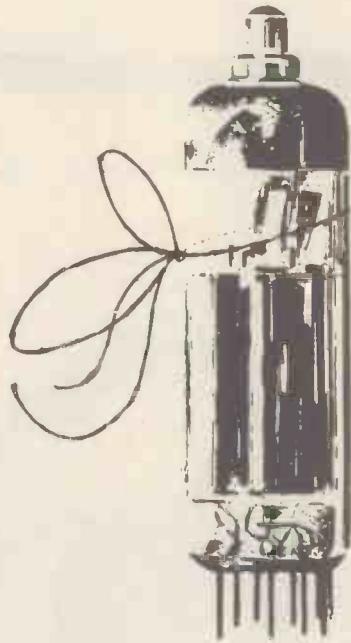
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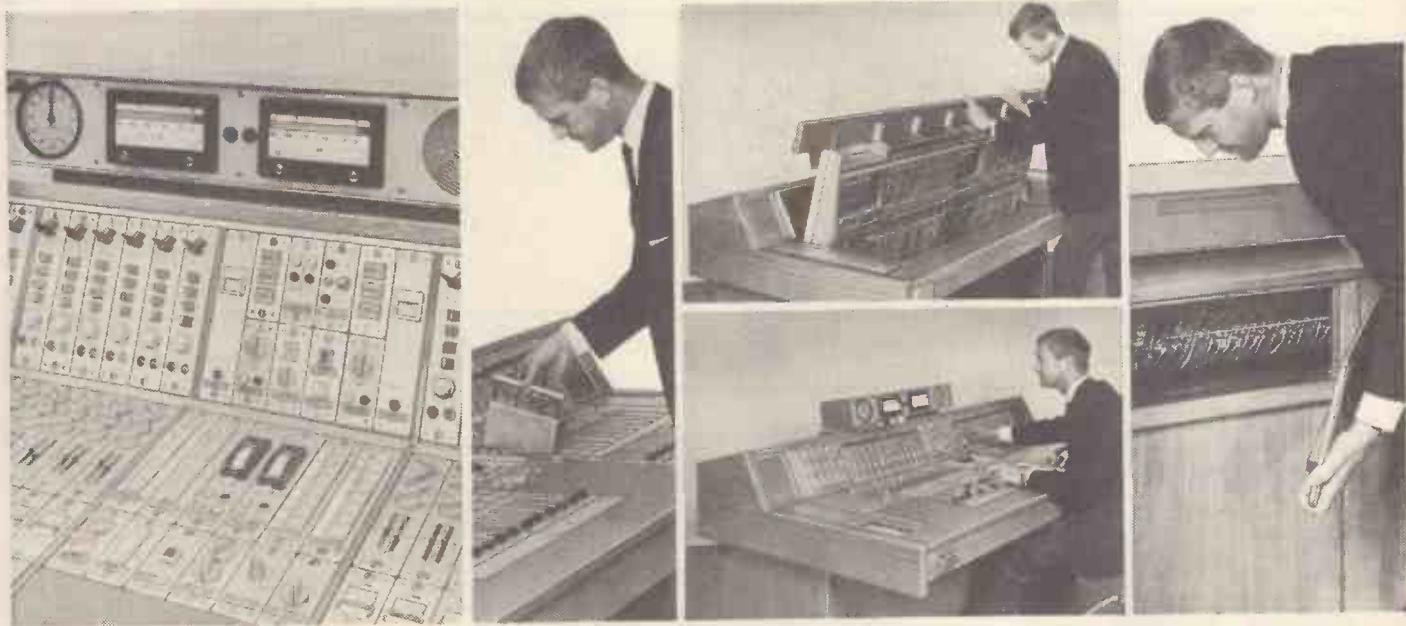
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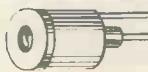
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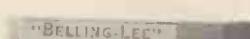
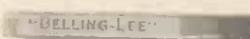
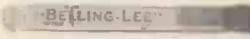
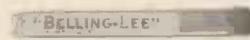
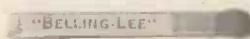
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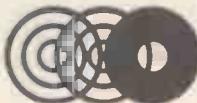
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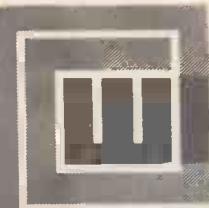
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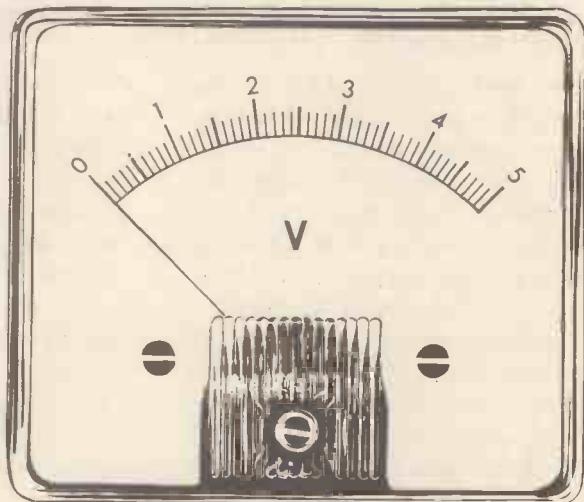
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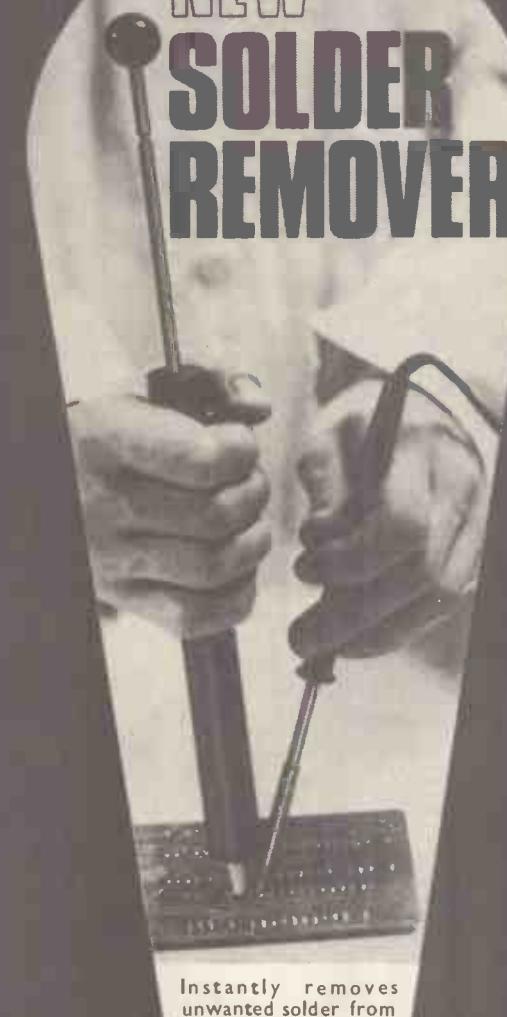
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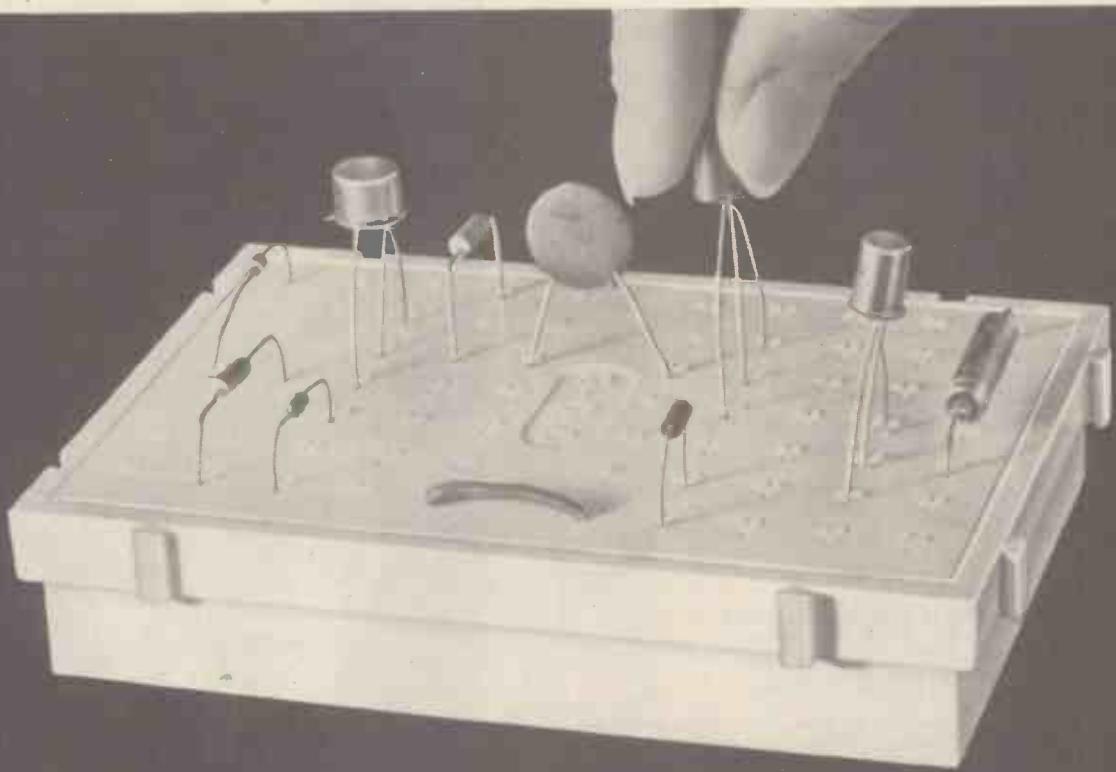
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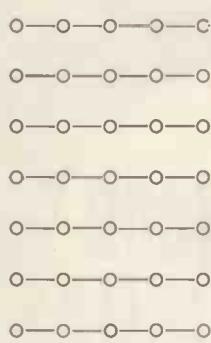
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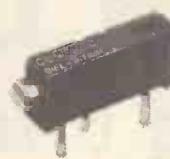
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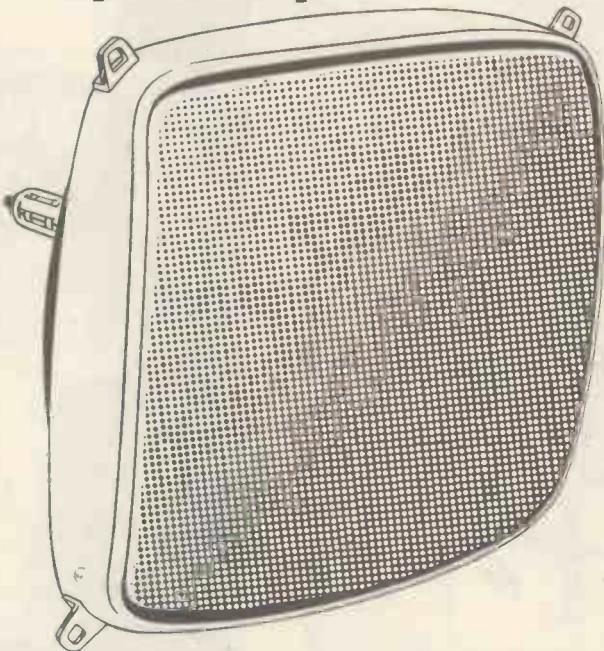
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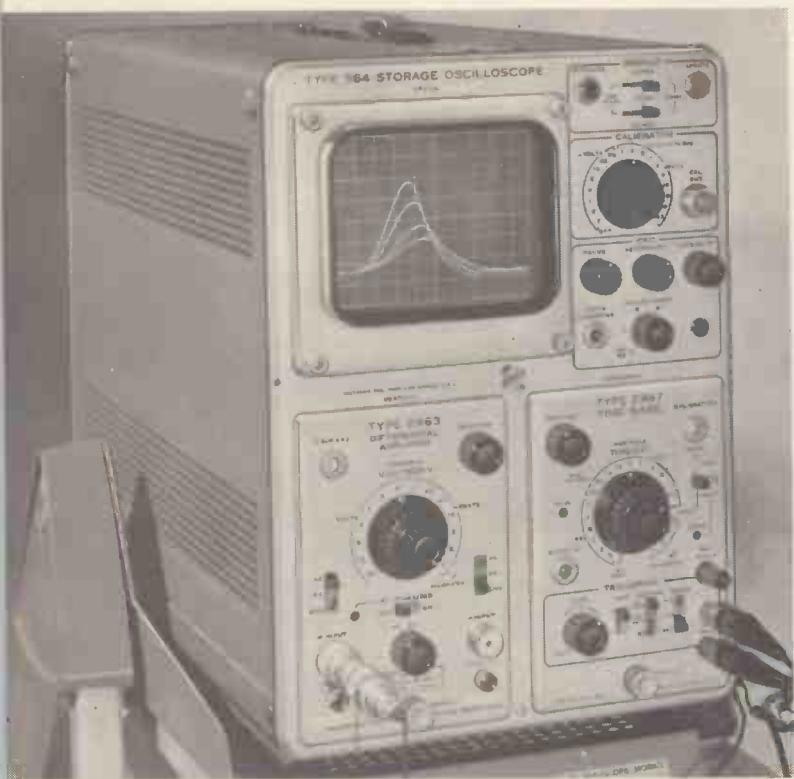
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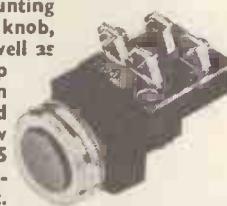


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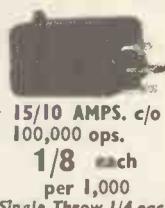
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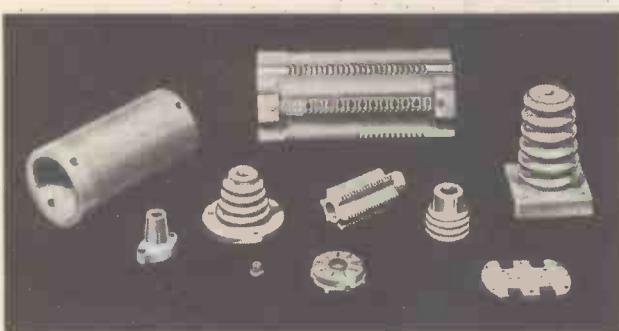
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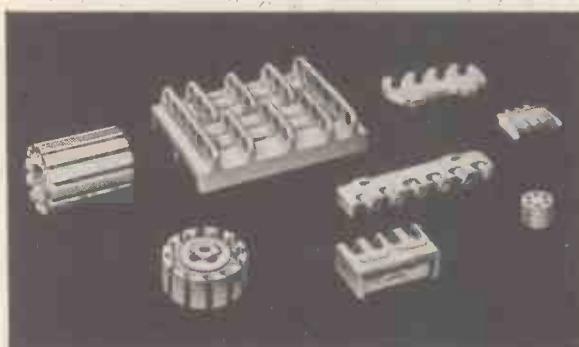
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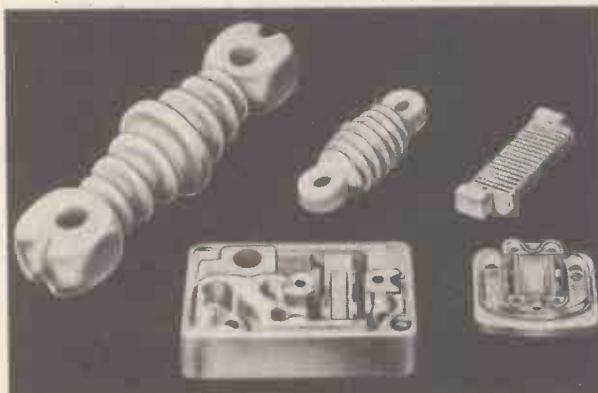
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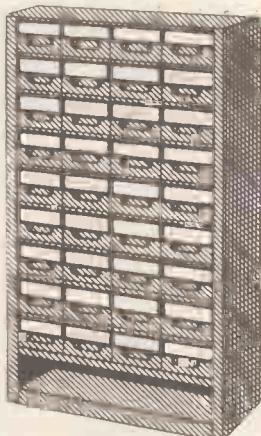
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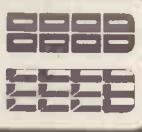


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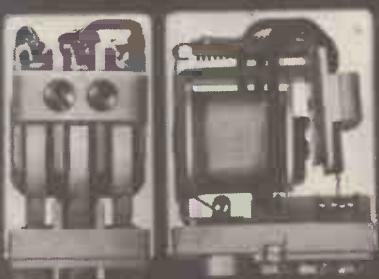
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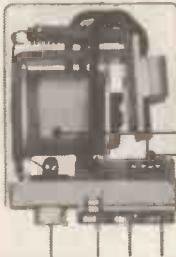
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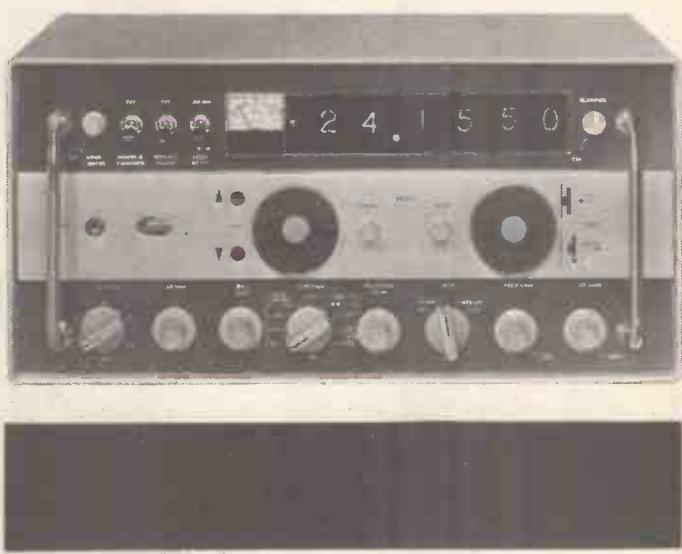
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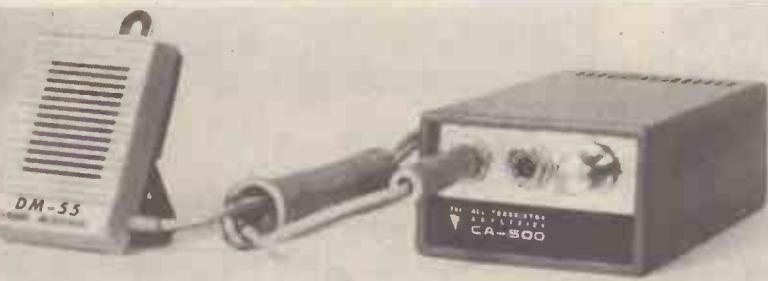
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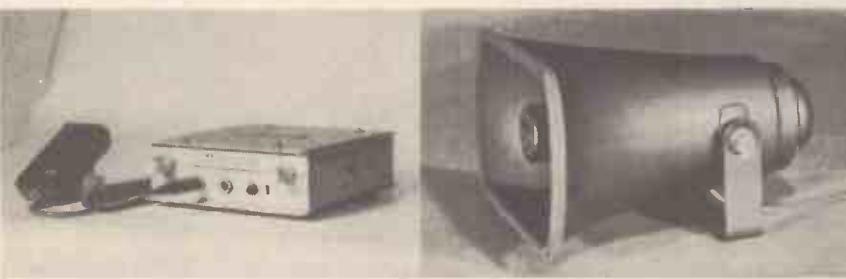


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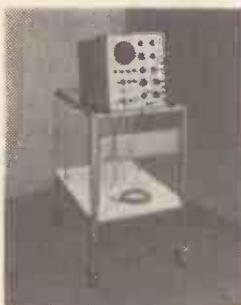
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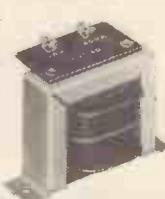
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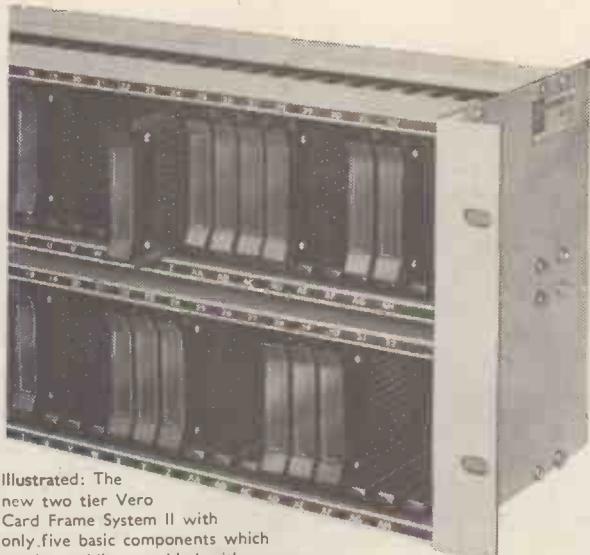
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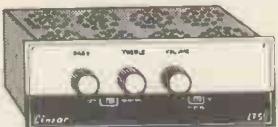
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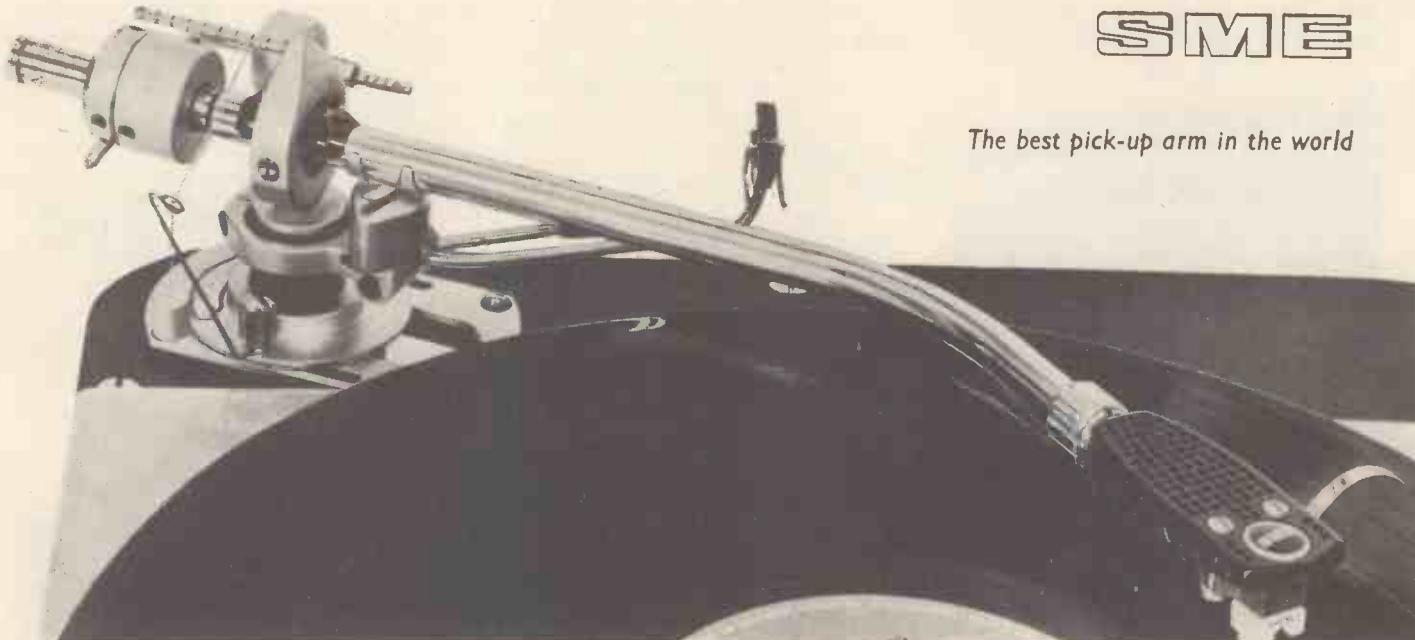
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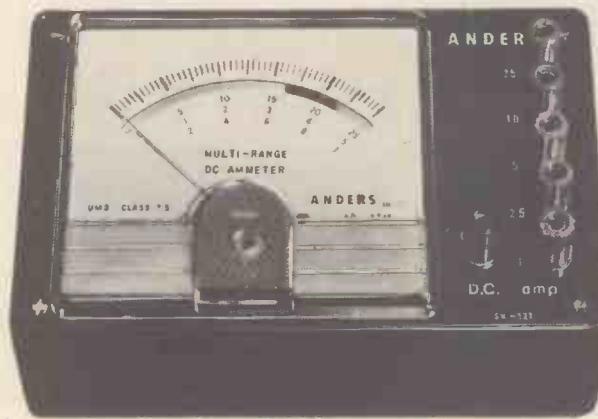
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Wireless World, March 1968



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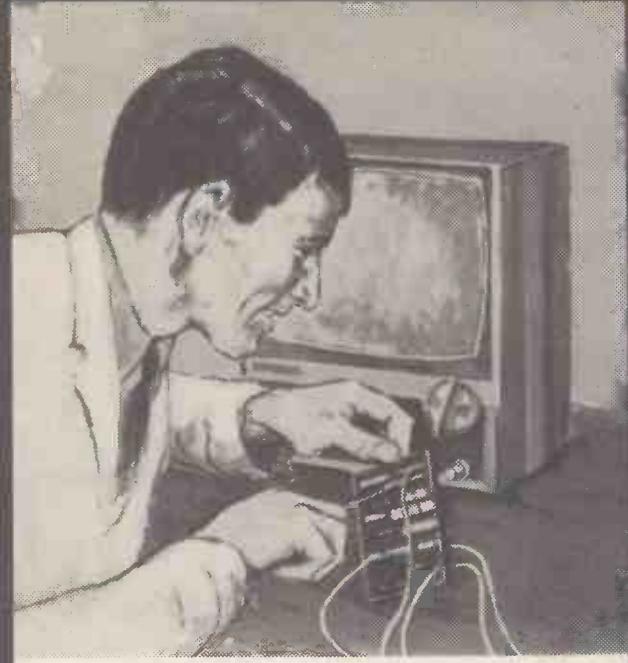
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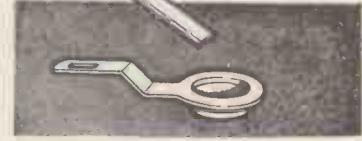
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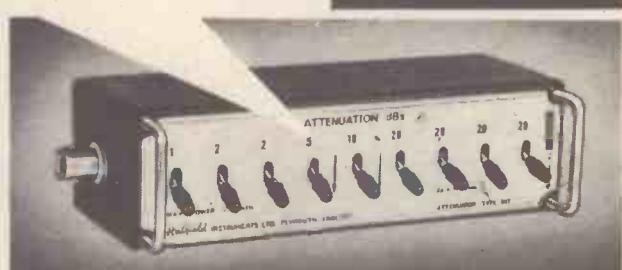


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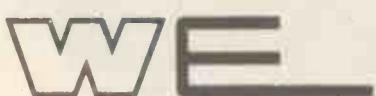
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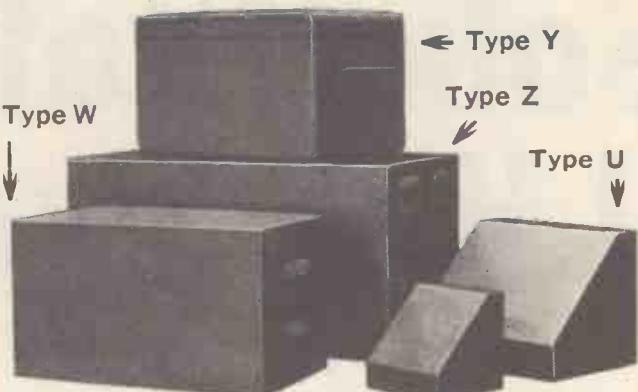
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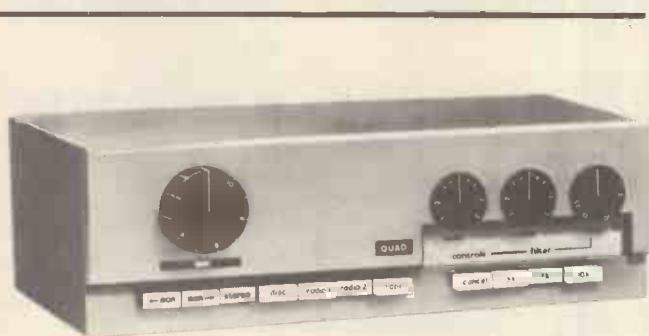
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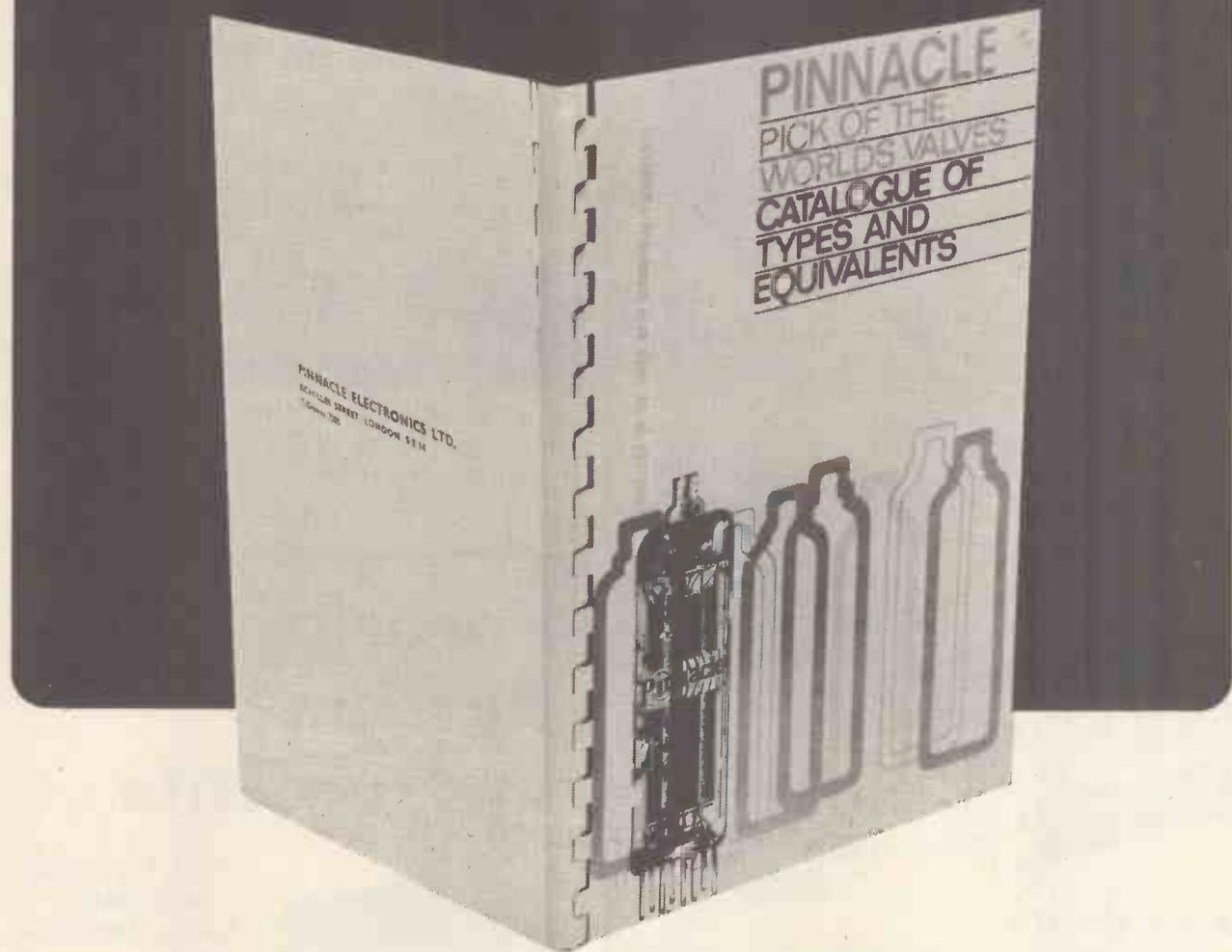
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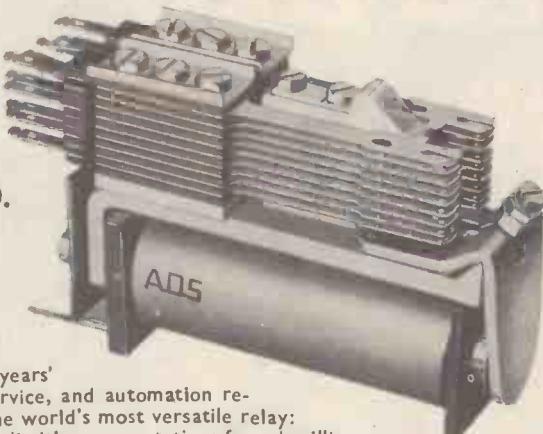
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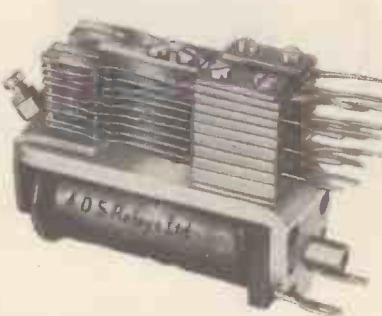
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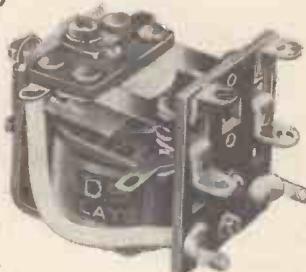


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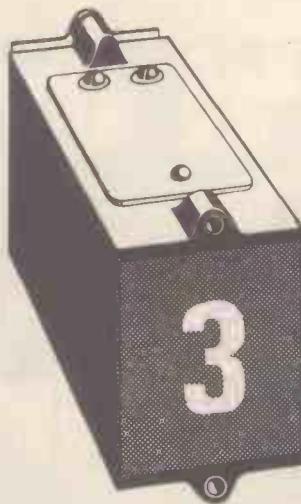
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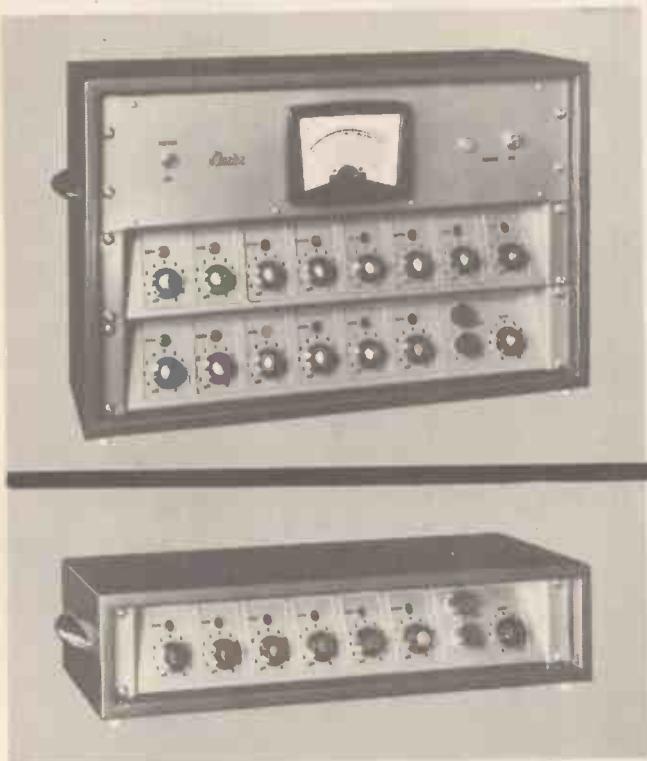
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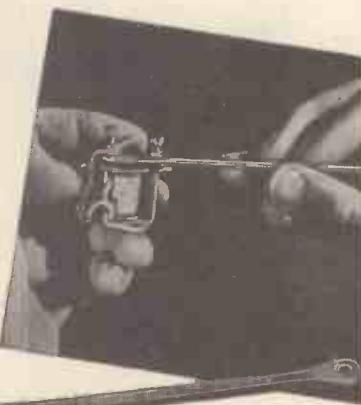
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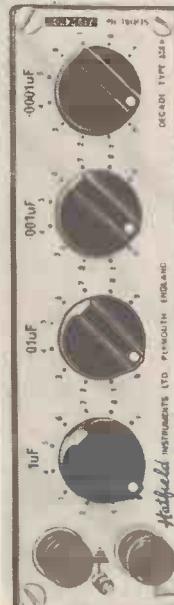
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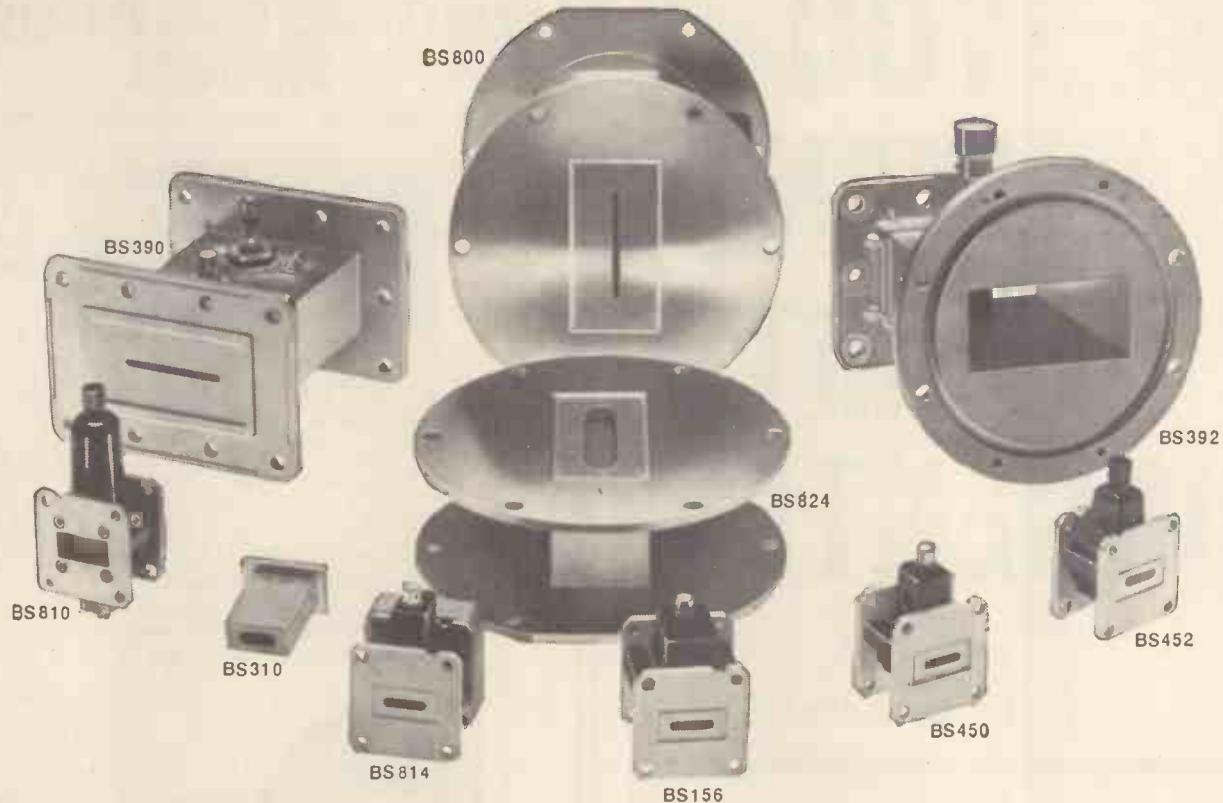
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BS800	—	S	2840-3100	1250	1.2	0.8	15
BS824*	—	S	2700-3100	250	1.25	0.4	15 to 3db
BS156	CV2306	X	9000-9600	200	1.2	0.8	4.0
BS452	—	X	9310-9510	100	1.3	0.8	4.0
BS810†	—	X	9250-9550	75	1.4	0.8	4.0
BS850	—	X	9300-9500	50	1.2	0.7	4.0

* For protection of travelling wave tube amplifiers

† Tunable

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BS392	S	2925-3075	150	0.25-25.0	0.5	0.85	30
BS460	X	8500 to 12000*	100	1.0-25.0	0.5	0.85	30

* Set to customers' requirements within this range

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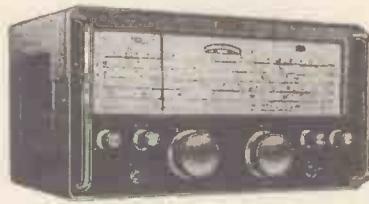
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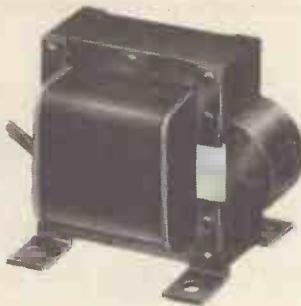
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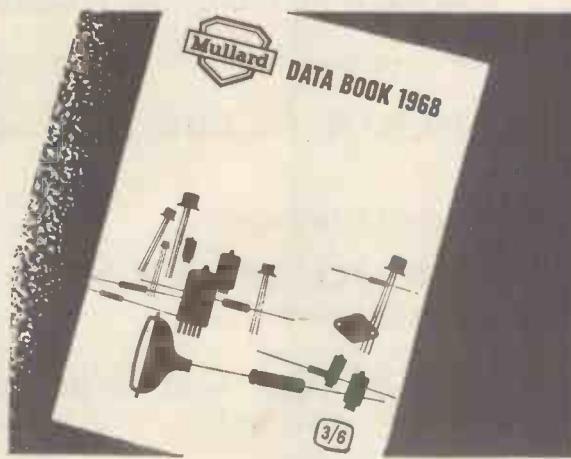
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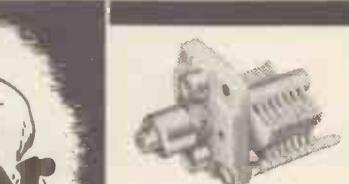
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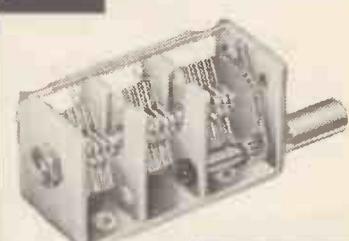
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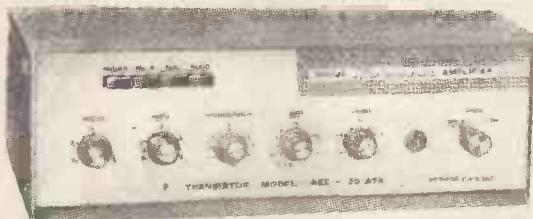
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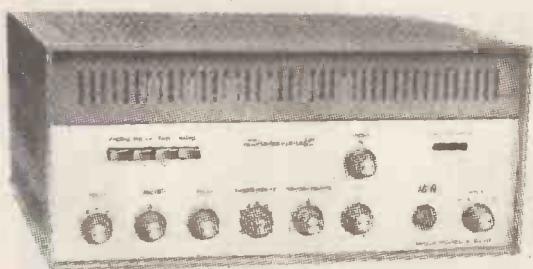
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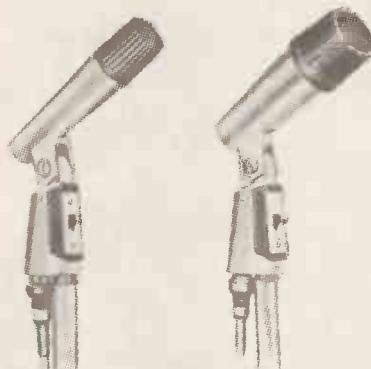
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D 43

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with plug-in amplifiers

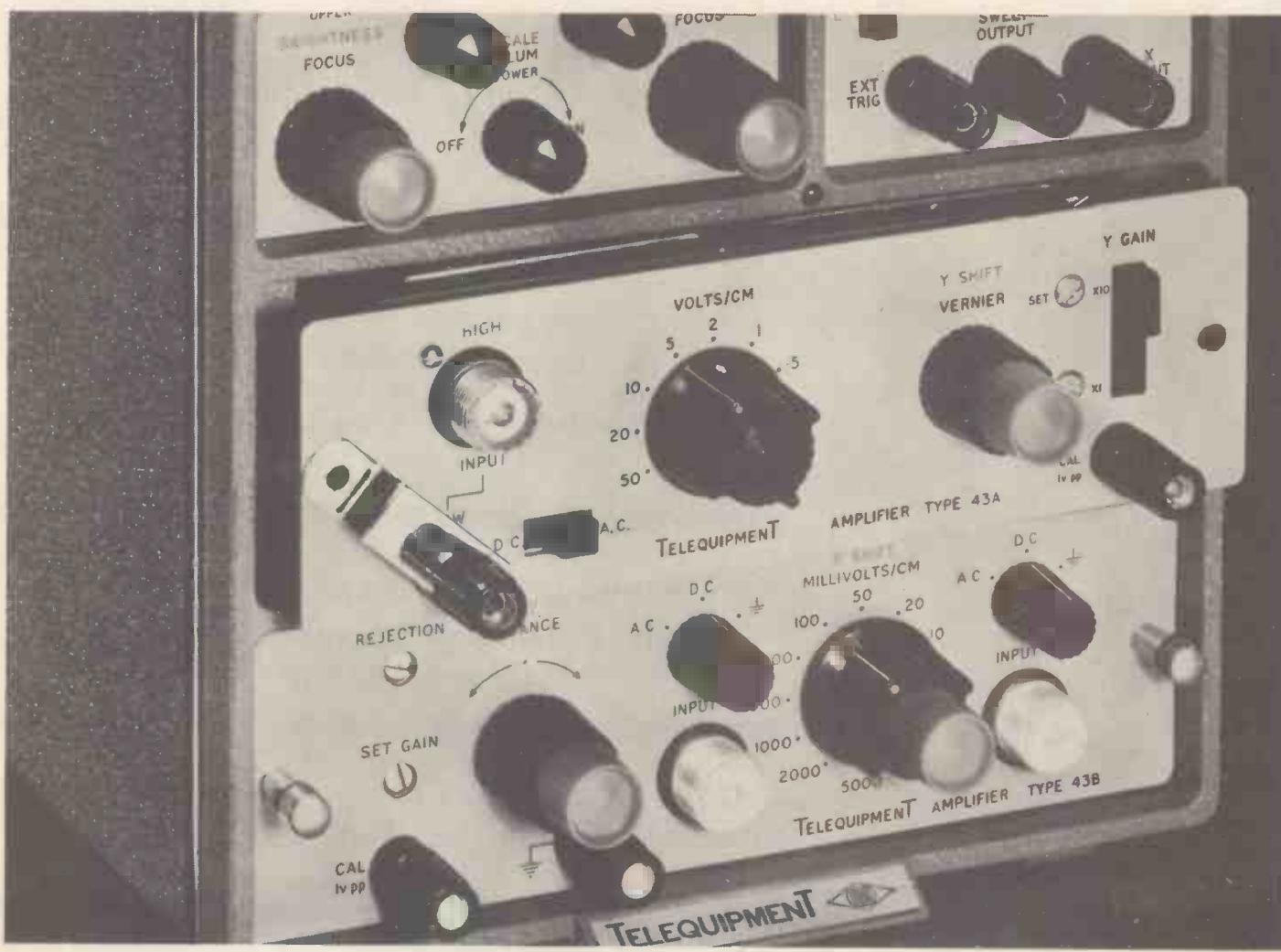
D43 is a double-beam laboratory oscilloscope with a 4in. double-gun aluminised PDA tube, operating at 4kv. Alternative time bases are available: T41, calibrated 18 speeds, and T42, calibrated 22 speeds with single-shot facility and a DC coupled X amplifier. Both have comprehensive triggering systems. Six plug-in Y amplifiers are already available—General Purpose, Differential, Ultra High Gain, Envelope Monitor, General Purpose Differential, and Wide Band. With General Purpose (type A) Y amplifiers and T41 time base, D43 weighs

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MARCH 1968

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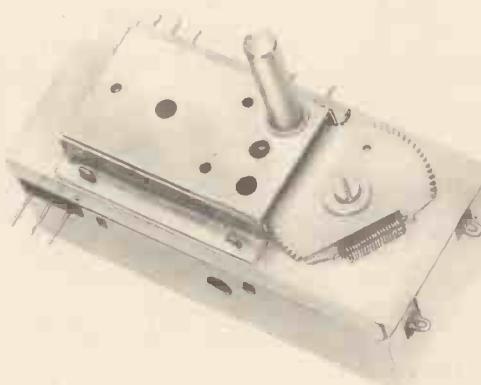
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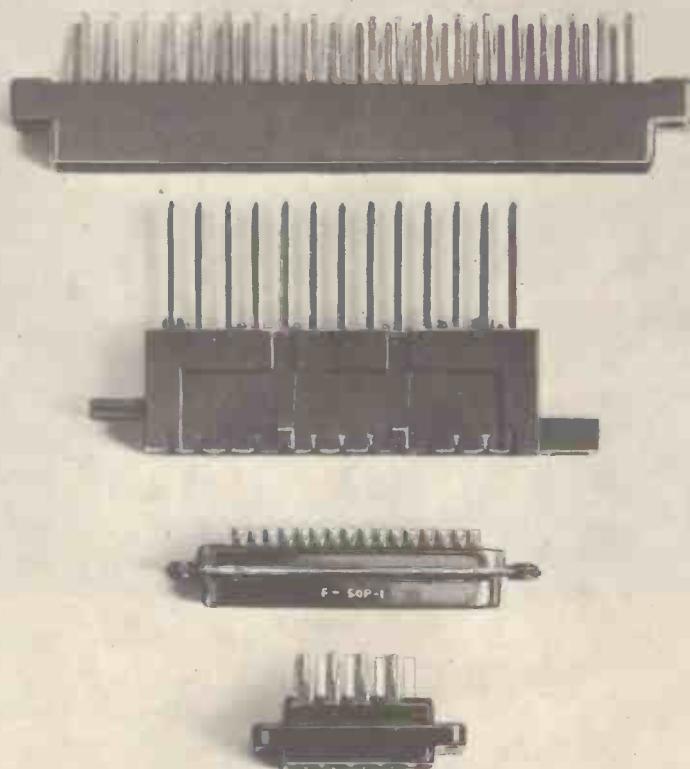
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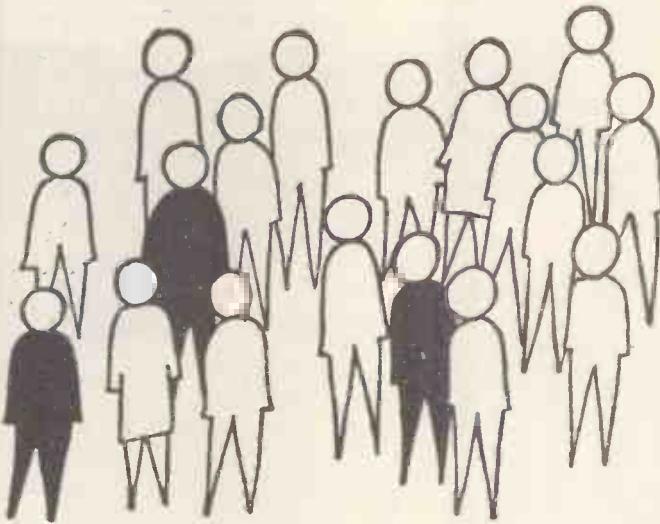
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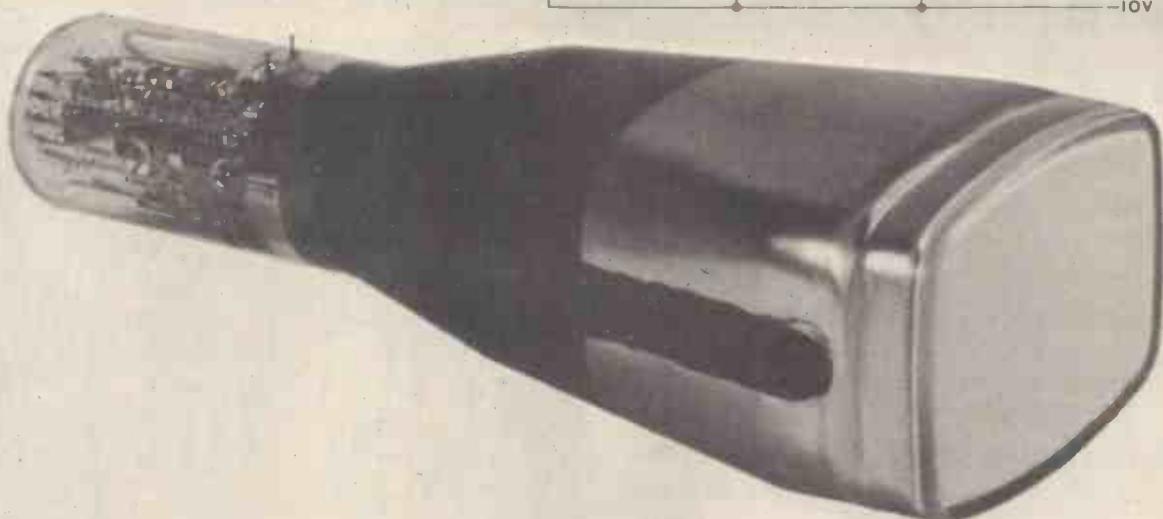
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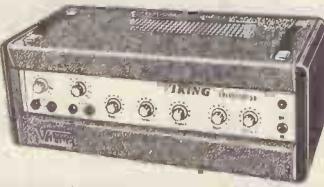
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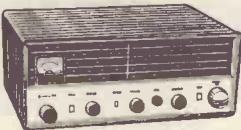


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STAR SR 150 COMMUNICATIONS RECEIVER

Frequency range 535 kc/s—30 Mc/s four wave bands, four valve plus metal rectifier superhet circuit incorporates B.F.O. band spread tuning, "S" meter external telescopic aerial—ferrite aerial, built-in 4in. speaker, easy to read dial. For 240v. A.C. operation, complete brand new with full instruction manual. £17/17/- + 10/- p. & p.



PRICE:
£5.5.0 Plus 7/6
P. & P.

Circuit and parts list 2/6, free with parts.

The comprehensive easy-to-follow drawings supplied make this the easiest-ever transistor radio set of parts, with the following features:

- ★ Simple connections to only 6 tags on the R.F./I.F. module, 3.I.F stages, osc. coil and 3 transistors which, with their associated components are completely wired.
- ★ Only 4 connections on the A.F. module to complete the 4 transistor 600 milli-watt solid state amplifier.
- ★ Pre-aligned R.F./I.F. module built and tested.
- ★ A.F. module built and tested.
- ★ Fully tunable over M.W. and L.W. bands. M.W. 540-1,640 Kc/s. (557-183 metres). L.W. 150-275 Kc/s. (2,000-1,100 metres).
- ★ Intermediate Frequency 470 Kc/s.
- ★ Sensitivity: M.W. at 1 Mc/s 10 microvolts plus or minus 3 dB. L.W. at 200 Kc/s. 40 microvolt plus or minus 4 dB.

NEW! The DORSET TRANSISTOR PORTABLE RADIO with BABY ALARM Facilities

Special offer—Power Supply Kit to purchasers of Dorset Portable Radio parts incorporating mains transformer, rectifier and smoothing condenser, AC mains 200/250v. output 9v. 100mA. 9/6 extra. 600 milli-watt solid state 7 transistor plus diode and thermistor.

Completely modulated high quality portable radio featuring complementary N.P.N. and P.N.P. output stage.

The comprehensive easy-to-follow drawings supplied make this the easiest-ever transistor radio set of parts, with the following features:

- ★ High Q internal ferrite rod aerial on both wavebands.
- ★ Class "B" modulated output stage with thermistor controlled heat stabilization. Class "B" output stage ensures long battery life. Current drain is proportional to the output level. Total current drain of the receiver under no signal conditions is 10-12 mA. At reasonable listening level 20-30 mA.
- ★ Extension sockets for car aerial input, tape recorder output (independent of volume control) and Ext. Speaker.
- ★ All components (except speaker) mounted on the printed circuit board. Easy to follow instructions. Size of cabinet 12in. long, 8in. high and 3in. deep.
- ★ Fingertip controls.

BRESGES Geared Motor

240 V. A.C. Mains 50 Hz. 0.49 amp (65 watt). Ungeared speed 2,750 R.P.M. Geared speed 80 R.P.M. Constant Gear ratio 35:1. Reversible. Spindle dia. 12 mm. (0.473in.). Spindle length 1½in. 7½in. long × 4½in. wide × 4½in. deep. Cost £20, our price £7/19/6. 7/6 P. & P.

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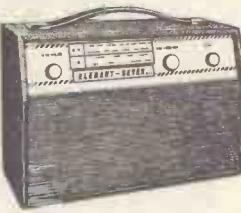
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5in. Std.	850ft.	9/6	5in. L.P.	850ft.	10/6	ON EACH
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3in. L.P.	240ft.	4/6	5in. T.P.	1,800ft.	25/6	1/6.
5in. L.P.	1,200ft.	11/6	5in. T.P.	2,400ft.	32/6	4 OR MORE
5in. D.P.	1,800ft.	18/6	7in. T.P.	3,600ft.	42/6	POST FREE.
7in. L.P.	1,800ft.	18/6	4in. T.P.	900ft.	15/-	

FOUR PLUS FOUR Stereo Amplifier

A superb High Quality, yet inexpensive stereo amplifier. Due to great demand we are now able to offer this precision made instrument at a fantastically low price. Its quality, reliability and styling has in no way been marred by its low price.

SPECIFICATIONS. Elegant styled cabinet (sizes 16in. wide, 5in. high, 8½in. deep) in black enamel and wood-grained sides. Brushed aluminium front panel with contrasting black/silver knobs.

CONTROLS. Stereo/Mono switch. Gram/Aux. switch. Volume left. Volume right. Treble (cut and lift). Bass (cut and lift). Separate on/off switch. Neon pilot Indicator.

INPUTS AND OUTPUTS (per channel). Gram, Aux., Tape out and Speaker out. A switched mains socket is also provided at the rear of unit.

Employs Mullard valves throughout. ECC83 and 2x ECL 86. With a metal bridge rectification.

TECHNICAL SPECIFICATIONS Gram sensitivity 40 mV. at 1 KHz. Aux. sensitivity 50 mV. at 1 KHz. (sensitivities are given for rated output). 4 watts R.M.S. per channel (8 watts R.M.S. in monaural position). Output matches into standard 3 ohms speaker system. Suitable 10in. x 6in. speakers are available at 29/6 each + 5/- P. & P.

Bass control at 100 Hz lift +9dB, cut -10 dB. Treble control at 10 KHz. Lift +8dB, cut -13dB. Total harmonic distortion 0.35% at 3 watts and 2% for rated output at 1 KHz. Negative feedback 13dB at 1 KHz. Mains supply 220-250 v. A.C. 50-60 Hz. PRICE 13 gns. P. & P. 15/-.

600 mW SOLID STATE

4-TRANSISTOR AMPLIFIER

Features NPN and PNP Complementary Symmetrical Output Stage. 2½ x 7 x 5in. Speaker output impedance 12 ohms.

Frequency response — 3dB points 90 c/s. and 12 kc/s. Price 15/- plus 1/- P. & P. 7x4 speaker to suit, 13/6, plus 2/- P. & P.

2½ WATT ALL TRANSISTOR AMPLIFIER

A.C. mains 240v. Size 7in. x 4½in. x 1½in.

Frequency response 100 c/s—10 Kc/s.

Semi conductors, two OC 75's, two AC 128's and two stabilizers AA129.

Tone and volume controls on flying leads. £2/10/- + P. & P. 3/6.

Suitable 8in. x 5in. 10,000 line high flux speaker. 18/6 plus 2/- P. & P.

BSR TAPE DECKS 200/250 v. A.C. mains

Type TD2. Tape speed 3½ twin track, £6/19/6.

Type TD10, 2-track, 3 speed, plus rev. counter, £7/19/6.

Type TD10, 4-track, 3 speed, plus rev. counter, £9/5/- P. & P. on each type 7/6.

3 TO 4 WATT AMPLIFIER

3-4 watt Amplifier, built and tested. Chassis size 7x3½ x 1in. Separate bass, treble and volume control. Double wound mains transformer, metal rectifier and output transformer for 3 ohms speaker. Valves ECC81 and 6V6, £2/5/- plus 5/6 P. & P.



M. I. P. PYROMETER

Temperature Range

50°F—230°F and 10°C—110°C

Built in a robust case, (5¾in. x 4in. x 1½in.)

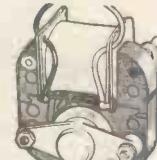
Complete with probe and batteries.

Only £5.0.0. Plus 5/- P. & P.

A very useful instrument, directly calibrated in centigrade and Fahrenheit on an easy to read moving coil meter.

Particularly suitable where heatrise plays an important part in the functions of:— Instruments, Cars, Cooling or Heating Systems, etc.

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1400 R.P.M. Price 9/6 P. & P. 230/250 V. 3/-

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ALL TRANSISTOR 6 WATTS PER CHANNEL STEREO HI-FI SYSTEM OFFERING A PERFORMANCE EQUAL TO IF NOT BETTER THAN SIMILAR SYSTEMS COSTING UP TO DOUBLE THE PRICE. Modern styling plus advanced circuitry using latest silicon transistors throughout. The famous GARRARD 3000 Record Changer fitted lightweight tubular arm with SONOTONE 9TAHC STEREO/MONO DIAMOND CARTRIDGE will play all sizes of records. (4 speeds 78, 45, 33 1/3 r.p.m.) Will play up to 9 records automatically, also provision for manual play. Amplifiers and controls are mounted below record player and incorporate Bass, Treble, Volume and Balance controls and On/Off, Gram/Radio, Mono/Stereo slide switches. TWO IDENTICAL LOUDSPEAKER SYSTEMS each incorporating separate base speakers and high frequency units with crossover network provide full frequency reproduction and are complete with 10ft. leads and plugs for connection to amplifier. Will fit easily on to bookshelves, room dividers or existing furniture. BRIER SPEC. Player/Amplifier unit. Teak finish, size 16½ x 14 x 8½in. 200/250 v. A.C. operation. Inputs for Radio/Tuner/Tape Recorder also outputs for Tape Recorder. Loudspeaker Systems. Teak finish. Size (each) 13 x 7 x 8in. Supplied complete with instruction booklet. Ready to plug in and play. SEND YOUR ORDER NOW OR CALL AND HEAR THIS MARVELLOUS HI-FI STEREO SYSTEM. Only 59 gns. plus 20/- Carriage and Insurance. (Rosewood finish 3 gns. extra.) (Perspex Cover 3 gns. extra.)

ONLY 59 GNS. CARR. 20/-

Rosewood finish 3 gns. extra.
Perspex cover 3 gns. extra.

GARRARD DECKS

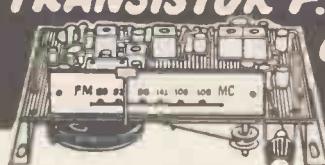


Model 3000 with Sonotone			
9TAHC Stereo Cartridge	£28	19	6
AT60 Mk. I less cartridge	£20	19	6
AT60 Mk. II less cartridge	£21	19	6
SP25 Mk. II less cartridge	£20	19	6
LAB80 Mk. II less cartridge	£24	19	6
			Mono Cartridge 17/6 extra.
			Stereo Cartridge 22/6 extra.

TEAK FINISH PLINTHS with perspex cover 6/- gns. (For LAB80 8/- gns.). P. & P. 5/- Agents for Thorens Dual, Goldring. Prices on request.

TRANSISTOR F.M. TUNER

ONLY £6-7-6 P&P 4/-



For the Stereo enthusiast Multiplex Adaptor for Stereo Radio reception, £25/19/6 extra.



LINEAR AMPLIFIERS

Latest A.C. Mains Models offering highest quality at modest cost.

LT66. All Transistor 12 watts Stereo. Inputs for Tuner, Gram., Mike. Separate Bass, Treble, Balance and Volume Controls, £15/15/- Carr. 7/6. Teak case £23/10/- extra.

PTA15 (as illus.) All Transistor. 15 watts Mono. Inputs for Tuner, Gram., Mike, Guitar Bass, Treble and Two volume controls, £21/15/- Carr. 7/6. Teak case, £23/10/- extra.

LT45. 3 VALVE 5 watt Mono. Inputs for Tuner, Gram., Bass, Treble and Volume controls, £8/19/6. Carr. 5/6. Metal cover 15/- extra. Full details sent on request.



MOTOR BARGAINS

Ideal for model makers, record players, tape decks, etc.

6.3 D.C. Motor, 10,900 r.p.m. at 230 mA. 11in. x 1in. dia. Shaft 1in. long. 3/64 dia., 9/8. P. & P. 2/6.

9 V. D.C. Gram. deck motor. Replaces old motor. 2in. x 1in. dia. Shaft 1in. long x 3/32in. 17/6. P. & P. 2/6.

24V. 10,900 r.p.m. at 230 mA. 11in. x 1in. dia. Shaft 1in. long x 3/32in. 17/6. P. & P. 2/6.

24V. 10,900 r.p.m. at 230 mA. 11in. x 1in. dia. Shaft 1in. long x 3/32in. 17/6. P. & P. 2/6.

24V. 10,900 r.p.m. at 230 mA. 11in. x 1in. dia. Shaft 1in. long x 3/32in. 17/6. P. & P. 2/6.

24V. 10,900 r.p.m. at 230 mA. 11in. x 1in. dia. Shaft 1in. long x 3/32in. 17/6. P. & P. 2/6.

24V. 10,900 r.p.m. at 230 mA. 11in. x 1in. dia. Shaft 1in. long x 3/32in. 17/6. P. & P. 2/6.

24V. 10,900 r.p.m. at 230 mA. 11in. x 1in. dia. Shaft 1in. long x 3/32in. 17/6. P. & P. 2/6.

AERIALS. TV/UHF VHF STEREO

CRESTA Room Aerial Band I/II/III. Cream or black, 25/-.

VEEMASTER Table Top VHF/UHF. Tunable Aerial. Chrome or grey, 70/-.

YAGAI. All Channel Table Top Aerial, BBC1/2/ITV/VHF, 65/-.

HLS55 LOFT AERIAL. HILO V + 5 for vertical. Band I/II/III. With mounting arm and bracket, 49/-.

NEW MAJOR. 10-element BBC2 Aerial for loft or outdoor fixing. With roller bracket for up to 2in. dia. mast, 42/6.

VANTENA Table Top V Aerial, BBC/ITV, 25/-.

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LOFT SIX. 6 element BBC2 Aerial for loft or outdoor fixing. With arm and bracket, 34/6.

J-BEAM. 4-element outdoor Band II VHF/FM Stereo Aerial. With mast, 87/-.

Please add 4/- postage.

PROFESSIONAL ELECTRIC INSTANT HEAT SOLDER GUN

Ideal for model makers, home repairs, electronics, radio, TV, etc. Unique features include interchangeable tips, extension barrels, comfortable grip with trigger control "U" shaped 3in. bit to minimise wear. Light beam is automatically directed on to end of bit when ON/OFF trigger is in use. 85 watt element with special ventilation. Complete with 2-pin, 5 amp. plug 230-250 volts. Spares available.

49/6 plus 2/6 F.P.

MULTIMETERS

TTC1001 (as illus.) 20,000 opv. £3/19/6.

C1000. 1,000 opv. £22/2/- Cabys NH 200. 20,000 opv. £28/10/- Cabys B40 4000 opv. £26/10/-

TMK800 30,000 opv. 20/19/6.

TTC Model 1030 50,000 opv. £29/19/6.

TCC Model 1031 100,000 opv. £21/19/6. Also stockists of Avo, Nombrex, Eagle etc. Test equipment. P. & P. 5/6.

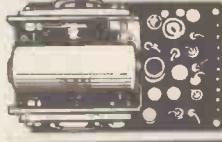


Ideal for model makers, home repairs, electronics, radio, TV, etc. Unique features include interchangeable tips, extension barrels, comfortable grip with trigger control "U" shaped 3in. bit to minimise wear. Light beam is automatically directed on to end of bit when ON/OFF trigger is in use. 85 watt element with special ventilation. Complete with 2-pin, 5 amp. plug 230-250 volts. Spares available.

49/6 plus 2/6 F.P.

We have a complete range of new and old types of Valves, Transistors and Diodes.

SINCLAIR PRODUCTS

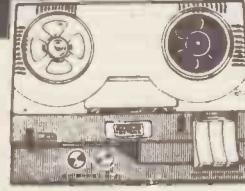


MAGNAVOX-COLLARO 363 TAPE DECKS

The very latest 3-speed model—1½, 3½, 7½ ips. available with either 2 track or 4 track head. Features include: Pause control; digital counter; fast forward and rewind; new 4 pole fully screened induction motor; interlocking unit keys. Size of top plate 13½ x 11 x 6½in. deep below unit plate. For 200/250 v. A.C. mains 50 c.p.s. operation. New unboxed and fully guaranteed.

2 track model. £10/10/0 4 track model. £13/9/6

Carriage and Packing 7/6.

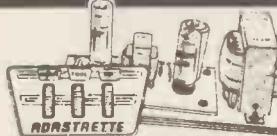


MARTIN TAPE AMPLIFIERS

FOR USE WITH ABOVE TAPE DECKS.
2 track model. £14/10/6; 4 track model. £15/19/6. Carriage and packing 7/6.

2-3 WATT AMPLIFIER

An ideal basis for building your own portable record player. Just add speaker and turntable and you will have an all-average model for a mere fraction of the cost. 2-track printed circuit, with control panel on flying lead. On, OFF, TONE CONTROL AND VOLUME, colourfull escutcheon. Brimar valves: EZ80, ECL82 and composite installation booklet. Price £3/17/6.



STEREO HEADPHONES

Selection from stock:—
TTC G1110, 19 ohms £3 18 6
AKAI AGSE8, 8 ohms 25 19 6
CORAL E102, 16 ohms 24 19 6
Eagle SEL, 16 ohms £2 9 6
TTC Stethoscope, 8 ohms 22 9 6
P. & P. 4/- each. Also stockists of Koss, Beyer, etc.

AUTO TRANSFORMERS

Input 0-200, 220, 600 w. 26 9 6
240 v. Output 110 v. 1,000 w. 25 18 0
50 w. 21 7 8 2,000 w. 25 18 0
75 w. 21 17 0 3,000 w. 234 18 0
100 w. 22 5 0 4,000 w. 25 18 0
150 w. 22 15 0 6,300 w. 30 18 0
200 w. 23 5 0 6,300 w. 17 9 0
300 w. 24 5 0 6,300 w. 37 8 0
400 w. 24 19 6 6,300 w. 42 0 0
500 w. 25 9 6 Post Extra.

MAINS TRANSFORMERS

Input 200-250 v. 50 c/s.
24 v. 3 amp. £2 12 6 24 v. 8 amp. £5 5 0

24 v. 5 amp. £3 15 0 24 v. 12 amp. £6 15 0

Post extra.

Mains and Output Transformer Lists available.

On request.

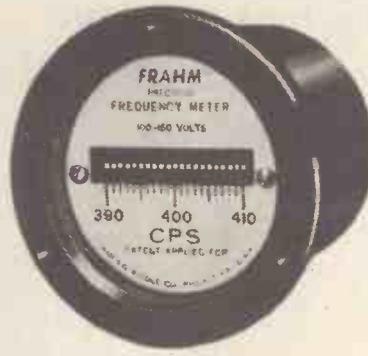
EAGLE SUBSTITUTION BOXES

On/R. 9 Capacitance ranges: 0.001, 0.010, 0.022, 0.047, 0.1, 0.22, 0.47, 1, 2.2 mfd. With leads and clips. 28/6. P. & P. 2/-
OM.G. Two Resistance ranges:
Low: 15 ohm to 10 Kohm (1 watt resistors).
High: 15 K ohm to 10 meg. ohm (# watt resistors). Selects 24 separate resistances. With leads and clips. 42/6. P. & P. 2/-



TRANSISTORS	VALVES
V60201P 8/	OAS 6/6
V6030 10/	EZ81 6/6
BFY50 8/6	PCC84 8/8
OC102 20/	PCLB8 11/8
BFY52 8/	PCLB8 10/6
OC128 12/6	KT66 27/6
BYZ12 10/	KT88 27/6
BYZ13 10/	DY88 9/6
OC222 10/	BCY34 8/6
OC225 9/8	ED33 9/6
OC226 15/	DK95 9/8
OC227 12/6	DAPF6 7/9
OC228 12/6	DL96 8/6
OC229 12/6	DF96 8/6
OC230 12/6	PY81 7/6
OC231 12/6	PLR1 9/6
OC232 12/6	PY33 10/6
OC233 12/6	PL36 15/8
OC234 5/	DIODES 6
OC235 5/	OAS 4/6
OC236 5/	AF114 7/6
OC237 5/	AF115 6/6
OC238 7/	AF116 5/6
OC239 5/	AF117 5/6
OC240 14/	AF120 3/3
OC241 5/	AF121 4/6
OC242 5/	AF122 9/6
OC243 5/	AF123 10/6
OC244 5/	AF124 10/6
OC245 5/	AF125 10/6
OC246 5/	AF126 10/6
OC247 5/	AF127 9/6
OC248 19/6	AF128 8/6
OC249 19/6	AF129 7/6
OC250 4/-	AF130 2/6
OC251 5/	AF131 3/6
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OC360 15/	AF240 3/6
OC361 15/	AF241 3/6
OC362 15/	AF242 3/6
OC363	

FRAHM vibrating reed FREQUENCY METERS



are widely used as standards in many industries because:—

- 1) They are accurate ($\pm 0.3\%$ or $\pm 0.1\%$ as specified)
- 2) They are not voltage or temperature sensitive, within wide limits
- 3) They are unaffected by waveform errors, load, power factor or phase shift
- 4) They will operate on A.C., pulsating or interrupted D.C., and superimposed circuits
- 5) They need only low input power.
- 6) They are compact and self-contained
- 7) They are rugged and dependable

FRAHM Vibrating Reed Frequency Meters are available in miniature switchboard and portable forms, in ranges from 10 to 1700 cps. Descriptive literature on these meters, and on FRAHM Resonant Reed Tachometers, freely available from the sole U.K. distributors:—

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LONDON NW1 TEL: 01-387 9092. MINISTRY OF AVIATION APPROVED

WW-101 FOR FURTHER DETAILS

TELETON COMES TO THE U.K.

Already highly successful in Belgium, Germany, Switzerland, Holland, France, and Italy, we now proudly present the finest integrated Solid-State Hi-Fidelity Equipment for your approval. Ultra-modern designs have been created according to European technical standards and popular requirements. These outstanding products are supplied exclusively to us by MITSUBISHI Shoji Kaisha of Japan.

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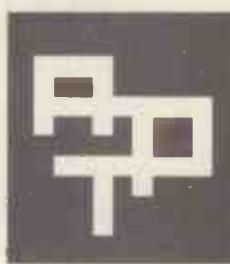
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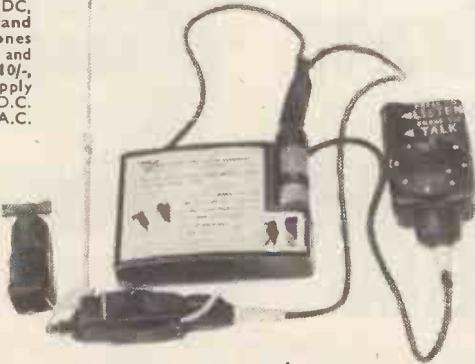


WW-103 FOR FURTHER DETAILS

TRANS/RECEIVER TWO-TWO

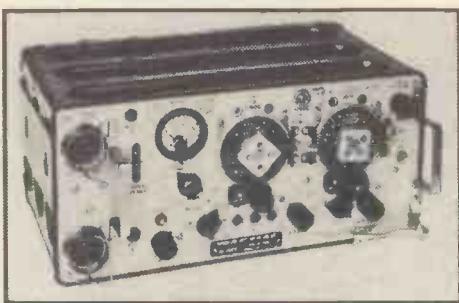


This is one of the latest releases by the Govt. of an extremely recent R/T set covering 2-8 Mc/s. in two switched bands, containing 13 valves (3 EL32s in TX Output) which can be used for Morse CW or R/T. Also has Netting Trimmer, BFO, RF & EF Controls, Switched Meter for checking all parts of set, Size 17in. x 8in. x 12in. Power required LT 12 volts D.C., HT 325 Volts D.C. Supplied Brand New and Boxed with Headphones & Mike, also Two Spare Valves and Circuit of set. Few only at £5/10/- Carr. 30/- New Plug in Power Supply made for us for either 12 volts D.C. Input £5/10/- or 200/250 Volts A.C. £3/17/6.



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M.K. III

This set is made up of 3 separate units: (1) a two valve amplifier using a 6V6 output valve; (2) (some only, not built in the very latest models) a V.H.F. transreceiver covering 220-241 Mc/s using 4 valves; (3) the main short wave transmitter/receiver covering in two switched bands, just below 2 Mc/s-4 Mc/s, and 4 Mc/s-8 Mc/s (approx. 160-37.5 metres) using 9 valves. For R.T., C.W. and M.C.W. The receiver is superheterodyne having 1 R.F. stage, frequency-changer, two I.F. (455 Kc/s) signal detector, A.V.C. and output stage. A B.F.O. included for C.W. or single side-band reception. T.X. output valve 807, other valves octal bases. Many extras, e.g. netting switch, quick flick dial settings, squelch, etc. Power requirements LT 12 volts, HT receiver 275 volts D.C., HT transmitter 500 volts D.C., size approx. 17½ x 7½ x 11in. Every set supplied in new or as new condition in carton with book including circuits, only £4/10/- or Grade 2 slightly used 50/-, or Grade 3 used but complete, 35/- Carr. ALL 15/- WE MAKE A MAINS 200/250 VOLTS TRANSFORMER UNIT In a rugged metal case so plug direct into set power socket to run (1) receiver, 70/12 volt D.C. (2) TX and RX, 22/10/-, post 7/6, (3) 12 volt D.C. P.U. (original) fair condition, 40/- Carr. 5/- A charge of 10/- to unpack and test the receiver of these sets is made only if requested. Headphones & Mike, 15/-, new and boxed.

This is a modern self contained tunable V.H.F. low powered frequency modulated transceiver for R.T. communication up to 8-10 miles. Made for the Ministry of Supply at an extremely high cost by well-known British makers, using 15 midget B.G. 7 valves, receiver incorporating R.F. amplifier. Double superhet and A.F.C. Slow motion tuning with the dial calibrated in 41 channels each 200 kc/s apart. The frequency covered is 39 mc/s-48 mc/s. Also has built-in Crystal calibrator which gives pips to coincide with marks on the tuning dial. Power required L.T. 4½ volts, H.T. 150 volts, tapped at 90 volts for receiver. Every set supplied complete with valves and crystals. New in carton, complete with adjustable whip aerial, and circuit. Price £4 10s Od, carriage 10s.

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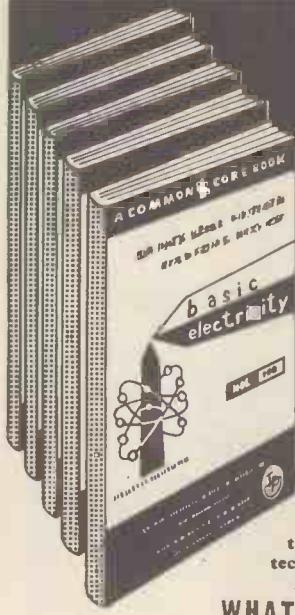
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500μF	30 volts	1/2	8+16	450 volts	1/9
800μF	15 volts	1/2	50+50	275 volts	2/-
500μF	25 volts	10d.	40+40+20	275 volts	2/-
16/16/16, 350v	2/2	100/100, 50v	3/2	250μF, 50v	10d.
50/50/50, 350v	2/7	10,000μF, 12v	4/6	12,500μF, 30v	16/-
1,000μF, 70v	3/2	1,250μF, 30v	4/-	30,000μF, 30v	25/-
3,000μF, 35v	3/9	150/350, 300v	4/-	1,700μF, 15v	1/6
1,500μF, 50v	4/-	250/250, 325v	4/-	1,000μF, 18v	1/-
		2000/2000, 25v	4/6	500μF, 15v	10d.

All at 9/- per dozen. 20 per 10/- (our selection).

PAPER CAPACITORS

0.001μF	500 volt	0.02μF	600 A.C.	0.25μF	350 volt
0.001μF	1000 volt	0.02μF	350 volt	0.5μF	350 volt
0.002μF	600 volt	0.1μF	350 volt	0.5μF	500 volt
0.005μF	750 volt	0.1μF	750 volt		

All at 15/- per 100. 3/- per dozen.

MULLARD POLYESTER CAPACITORS. ALL HALF PRICE

0.0022μF	400 volts	4d.	0.15μF	400 volts	7d.
0.0018μF	400 volts	4d.	0.22μF	180 volts	7d.
0.0015μF	400 volts	4d.	0.27μF	180 volts	8d.
0.0014μF	400 volts	4d.	0.058μF	125 volts	7d.
0.01μF	400 volts	4d.	1μF	125 volts	1/6
68pF	Tubular pulse ceramic	6d. each			
120pF	Disc pulse ceramic	6d. each			

VERY SPECIAL VALUE! Silver Mica, Ceramic, Polystyrene Condensers. Well assorted. Mixed types and values. 10/- per 100.

RESISTORS. Give-away offer! Mixed types and values. 1/- to 1 watt. 6/- per 100 or 55/- per 1,000.

Also 1/- to 3 watt close tolerance. Mixed values. 7/6 per 100. 55/- per 1,000.

WIRE-WOUND RESISTORS. 1 watt, 3 watt, 6 watt, 8d. each. 7 watt and 10 watt 9d. each.

CONNECTING WIRE THIN, P.V.C. INSULATED

10yds 1/-; 100yds 7/6; 500yds 25/- (post 4/6); 1,000yds 40/- (post 6/-).

VALVES. BRAND-NEW AND BOXED. ROCK-BOTTOM PRICES!

DY87	5/10	EY86	5/10	PCL86	7/4
EABC80	6/1	EY87	5/10	PCL200	10/2
ECC82	6/5	PABC80	6/2	PL50	8/9
ECC83	6/5	PCE80	5/10	PL81	7/4
ECL80	6/2	PFC84	6/5	PL83	7/4
ECL86	7/4	PFC80	7/4	PL84	5/-
EF80	6/2	PFC86	8/9	PL500	10/7
EF85	6/2	PCL82	7/4	PY32	7/10
EF183	8/2	PCL83	8/6	PY81	6/10
EF184	8/2	PCL84	7/4	PY82	4/1
EF51	5/10	PCL85	7/4	PY800	5/10

A further 10% discount will be given on lots of 60 of any one type.

Signal Injector Kit. 10/-. Signal Tracer Kit, 10/-.

NEEDLES FOR RECORD PLAYERS. HALF PRICE!

All types below at 3/6 each! 2 1/2in. x 5in. x 3/11; 2 1/2in. x 3in., 3/3; 3 1/2in. x 5in., 5/8; 3 1/2in. x 3 1/2in. x 3/11; Terminal Pins. 36 for 3/-; Spot Face Cutter, 7/3.

Special Offer—Cutter and 5 boards, 2 1/2in. x 1in., 9/9. Pin Insert Tool 9/6.

ORDERS BY POST—TO G. F. MILLWARD, 17 PEEL CLOSE,
DRAYTON BASSETT, STAFFS.

PLEASE INCLUDE APPROPRIATE POSTAGE COSTS
No Enquiries without stamped addressed envelope please

For customers in the Birmingham area, goods may be obtained from: Rock Exchanges, 231 Alum Rock Road, Birmingham 8 (Post Orders to Drayton).

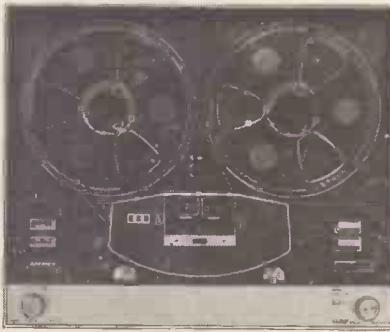
It's Ampex. It's 91 gns

The new Ampex 753 Tape Deck (complete with pre-amplifiers) gives you these important new features:

- off-tape monitoring sound-on-sound
- sound-with-sound echo control

Plus rigid block construction—tapes align with heads to one thousandth of an inch,

and the 753 finds every sound on the tape. deep-gap heads give three years' peak performance—few other makes give more than one year. stereo 4-track dual - capstan drive 3 speeds digital counter fast wind solid state throughout vertical or horizontal operation available in teak case.



For further information and list of UK dealers send coupon below, or write to Ampex Great Britain Ltd., (Dept. WW3), Acre Road, Reading, Berks.

Please send me 753 details and dealer list.

Name _____

Address _____

AMPEX

CA-9 WW3

WW-107 FOR FURTHER DETAILS

SUPERIOR QUALITY NEW RESISTORS

High Stability

Carbon Film

Low Noise

1W 5% E24 series 5.1Ω to 330kΩ 1/10 doz. mixed; 14/6 per 100 mixed.
1W 10% E12 series 1Ω to 4.7Ω only, as above but 1d. extra per resistor.
1W 10% E12 series 4.7Ω to 10MΩ 1/9 doz. mixed; 13/6 per 100 mixed.
1W 5% E24 series 4.7Ω to 10MΩ 2/2 doz. mixed; 17/- per 100 mixed.
1W 10% E12 series 10Ω to 10MΩ 4d. each; 3/3 doz. mixed.
1/6 per 100 less when ordered in 100's of one ohmic value.

PLEASE state your choice of values in mixed quantities:

Quality carbon Skeleton Pre-sets, fit 0.1in. matrix: 100, 250, 500 1k, 2k, 2.5k, 5k, 10k, 20k, 25k, 50k, 100k, 250k, 500k, 1M, 2M, 2.5M, 5M, 10MΩ. All values available in horizontal or vertical mounting, 1/- each.

Volume Controls: 100, 250, 500Ω and series to 10MΩ linear, 2/3 each. 5k, 10k, 25kΩ and series to 5MΩ log., 2/3 each.

Electrolytics: 5, 10, 25, 50μF 10V 9d. 50V Ceramics: .01, .02, .05μF, 5d. Mullard electrolytics, sub-min. C426, whole series stocked.

PICK OF THE NEW SEMICONDUCTORS

Silicon, many types including:

BC107 45V 8125-500, 4/-
BC108 20V 8125-900, 3/11
BC109 20V 8240-900 4/-
BC110 and BC169 are low noise types. BC167, -8, -9 are plastic.

Best value in High Power: 2N3055 117W 100V, 16/6.

Best value in Field Effect: MF105, gm: 2 to 6mA/V, 10/-.

Also: 2N3702, -3, -4, -5, 4/- each. 2N3707, 5/- 262926 from 2/6.

Germanium, many types including:

Low noise: 2G308, 6/9; 2G309, 7/9; NKT275, 3/8.

General purpose old-timers: 2N1304 (NPN), 2N1305 (PNP), 4/- each.

Best in High Power: NKT403, 16/3; 2N2147, 16/9.

Miniature Silicon Diodes: IS940, 30V 75mA., 1/3.

Other Diodes: OA47 (gold bonded), 1/9; OA91 (115V 50mA), 1/3.

PEAK SOUND PRODUCTS

CIR-KIT No. 3 Pack, 12/6; adhesive copper: 5ft. x 1in. or 1/2in., 2/-; 100ft., 30/- Perforated board 0.1in. matrix, 5in. x 3 1/2in., 4/-; 2 1/2in. x 3 1/2in., 2/6. Transistorised Stereo Amplifier Kit type SA8-8, £10/10/-.

Cabinet, £3; Power Supply Kit, £3. Post free and 15% discount!

ALL GOODS BRAND NEW NO SURPLUS FAST DELIVERY

DISCOUNTS: 10% over £3; 15% over £10. P. & P. 1/-; free over £1. Send 1/- for 1968 Catalogue. Contains data and equivalents.

ELECTROVALUE
6 MANSFIELD PLACE, ASCOT, BERKSHIRE.

CONVECTOR HEATER

Just screw it together. Uses 1,250 watt copper clad element which gives off black heat. Will last a lifetime. Ideal for bedroom, it's so safe. Complete in stove enamelled case. 29/6, plus 8/- worth double. Carriage & ins. 8/6.

MINIATURE WAFER SWITCHES

4 pole, 2 way—3 pole, 3 way—4 pole, 3 way—2 pole, 4 way—3 pole, 4 way—2 pole, 6 way—1 pole, 12 way. All at 3/6 each, 36/- dozen, your assortment.

WATERPROOF HEATING ELEMENT

46 yards length 70W. Self-regulating temperature control, 10/- post free.

See in the Dark INFRA-RED BINOCULARS



These infra-red binoculars when fed from a high voltage source will enable objects to be seen in the dark, provided the objects are in the rays of an infra-red beam. Each eye tube contains a compound optical lens system as well as the infra-red cell. These optical systems can be used as lenses for T.V. cameras—light cells, etc. (details supplied). The binoculars form part of the Army night driving (Tabby) equipment. They are unused and believed to be in good working order but sold without a guarantee. Price £3/17/6, plus 10/- carr. and ins. Handbook 2/6.

SPECIAL BARGAINS

50 OHM 50 WATT WIRE WOUND POT-METER. 8/6 each.

1 MEG MINIATURE Pot-meter Morganite standard, 1/8 in. spindle 1/8 in. each, 9/- per dozen.

1 MEG MINIATURE Pot-meter Morganite preset screw-driver control, 9d. each, 8/- per dozen.

PRE-SET 100K by Welwyn with internal bakelite knob, 1/8 in. each, 9/- per dozen.

100K POT-METER. Miniature type with double pot switch and standard 1/8 in. spindle, by Morganite. 2/- each, 18/- per dozen.

BLANKETSTAT GLASS. Enclosed, normally closed circuit, will open should blanket overheat. 4/6 each.

THERMAL RELAY. Can be used to delay the supply of HT while heaters warm up, or will enable 15 amp. loads to be controlled by miniature switches or relays. Regular list price over £2, price 7/6 each.

SIEMENS HIGH SPEED RELAY. Twin 1000 ohm coils. Platinum points changeover contacts—Ex equipment. 8/6 each.

TOGGLE SWITCH BARGAIN. 10 amp. 250 v. normal one hole fitting. 2/6 each, or 30/- per dozen.

ELECTRIC LOCK. 24 v. coil, but rewirable to other voltages. 4/6 each.

COMPRESSION TRIMMERS. Twin 100 pF. 1/- each, 9/- per dozen.

PRECISION WHEATSTONE BRIDGE. Opportunity to build cheaply. 100K wire wound pot. 15 w. rating, only 5/-.

SCHEET PAXON. Ideal for transistor projects. 12 panels each 8in. x 8in. 5/-.

3IN. FM LOUDSPEAKER. 3 ohm. 12/6. 80 ohm. 13/6.

TRANSISTOR FERRITE SLAB AERIAL WITH medium and long wave coils. 7/6 each.

SLIDE SWITCH. Sub miniature double pole changeover. 2/- each. 18/- per dozen.

Vacuum Cleaner Flex. Non-kinkable fibbed rubber, most pliable but very tough. 24/36 Cores. Normally 1/8 per yard, offered at £3 per 100 yard coil, post and insurance 8/6.

Sub-Miniature Silicon Diodes. General purpose type with gold-plated leads. 1/8 each or 7/6 per dozen.

MESSAGE TAPE. 225ft. Tape on 3in. spools, normally 4/6 each, we offer 4 tapes for 12/6.

WHITE CIRCULAR FLEX. Ideal for lighting drops, twin made by BICC. Usually 8d. yd. 100 yd. coil for 30/-, plus 6/- postage.

EDGEWISE CONTROL. Morganite, as fitted many transistor radios, 2K or 5K with switch. 2/6 each or 24/- per dozen.

12V INVERTER. Full transistorised for operating a 20-watt fluorescent tube, size 6in. long x 1 1/8in. 23/10/- Post and insurance 3/-.

SILICON RECTIFIER equiv. BY100 750 mA. 10 V. 10 for 20/-.

MINIATURE PICK UP for 7in. records made by Cosmocord, crystal cartridge with sapphire stylus only. 3/9 or 36/- dozen.

TELESCOPIC AERIAL for radio or transmitter, chrome plated, 6 section extends from 7 1/8in. to 47in. 7/6 each, 24/- dozen.

MIDGET NEONS for mains indicators, etc. 1/3 each or 12/- dozen.

MIDGET RELAY twin 250 ohm coils, size approx. 1 1/8in. x 1in. x 1in. 4 pairs change-over contacts. 7/6 each.

P.O. RELAY. Twin 200 ohm coils, size approx. 3in. x 2in. x 3in. 4 pairs changeover contacts. 8/6 each.

PRINTED CIRCUIT BOARD, EDGE CONNECTOR, solder terminations. 32 contacts, standard spacing for veroboard, etc. 6in. long but easily cut. 7/6 each, 80/- dozen.

1,000 W. FIRE SPIRAL, replacement for most fires. 1/3 each, 12/- dozen.

PP3 Eliminator. Play your pocket radio from the mains! Save 2d. Complete component kit comprises 4 rectifiers—mains dropper resistances, smoothing condenser and instructions. Only 6/6 plus 1/- post.

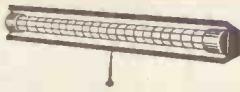
PHOTO-ELECTRIC KIT

All parts to make light operated switch/burglar alarm/counter, etc. Kit comprises printed circuit. Laminated Boards and chemicals. Latching relay. Infra-red sensitive Photocell and Hood, 2 Transistors, cond., Terminal block. Plastic case. Essential data, circuits and P.O. chassis plans of 10 photo-electric device including auto, car parking light, modulated light alarm, Simple invariable ray switch—counter-stray light alarm—warbling tone electronic alarm—projector lamp stabiliser, etc., etc. Only 39/6, plus 2/- post and insurance.

INFRA-RED HEATERS

Make up one of these latest type heaters. Ideal for bathroom, etc. They are simple to make from our easy-to-follow instructions.

uses silica enclosed elements designed for the correct infra-red wave length (3 microns). Price for 750 watts element, all parts metal casing as illustrated. 19/6, plus 4/6 post and ins. Pull switch 3/- extra.



DRILL CONTROLLER

Electrically changes speed from approximately 10 revs. to maximum. Full power at all speeds by finger-tip control. Kit includes all parts, case, every thing and full instructions. 19/6, plus 2/6 post and insurance. Or available made up 32/6, plus 2/6 P&P.



THIS MONTH'S SNIP FOOD MIXER

Famous Dutch made food mixer, 3 speed interchangeable beaters, 220-240 volt. Normally 7 gns. Our price 59/6, plus 6/6 postage.

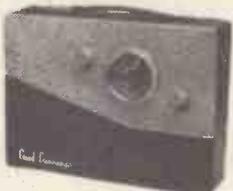


SUPERTONE D.C.V.

Saves you work—
It's partly built

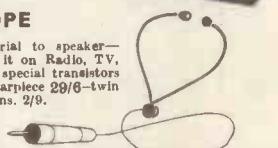
Like its predecessors this latest Companion has full performance—such as only a good wooden cabinet and biflux speaker can give, and due to its being partly built you will have it going in an evening. Note these features.

- 7 Transistors, superhet circuit.
- Two-tone Cabinet, size 11 x 8 x 3in.
- All circuit requirements—Push-pull output—A.V.C. and feed back, etc.
- Printed circuit board, all wired only connections, e.g. to Volume control W.C. Switch and Tuning Condenser.
- Pre-aligned IF stages complete with full instructions. Price only 24/9/6 plus 6/6 post and insurance.



RADIO STETHOSCOPE

Easiest way to fault find—traces signal from aerial to speaker—when signal stops you've found the fault. Use it on Radio, TV, amplifier, anything—complete kit comprises two special transistors and all parts including probe tube and crystal earpiece 29/6—twin set instead of earpiece 7/6 extra—post and ins. 2/9.



CASSETTE LOADED DICTATING MACHINE

Battery operated and with all accessories. Really fantastic offer a British made £31 outfit for only 26/19/6 brilliantly designed for speed and efficiency. Cassette taken, normal spools, drops in and out for easy loading—all normal functions—accessories include—stethoscopic earpiece—crystal microphone has on/off switch—telephone pick-up—tape reference pal—DON'T MISS THIS UNREPEATABLE OFFER—SEND TODAY 86/19/6 plus 7/6 post and insurance. Footswitch 18/6 extra. Spare Cassettes at 7/6 each, three for 21.



THE "TECHNICAL" RECORD PLAYER

4 speed, gram. motor with lightweight pick-up, motor electronically balanced and free from wow and flutter. Speed change by push button—16, 33, 45, 78 r.p.m. Price 39/6, 2 Valve amplifier 32/6. Elliptical Speaker 9/6. Cartridge extra mono 10/6, stereo 15/- plus 4/6 post and insurance. DON'T MISS THIS TERRIFIC BARGAIN.



OZONE AIR CONDITIONER

For removing smells and generally improving oppressive atmosphere. In neat hammer finish box. Use Phillips ozone lamp and mains unit. Lamp easily replaceable. Only 39/6 plus 6/6 post and ins.



TUBULAR HEATERS

New and unused made by G.E.C.—rated at 60 watts per ft.—these are ideal in airing cupboards, bedrooms, offices, stores, greenhouses, etc., curtains or papers can touch them without fear of scorching or fire. Supplied complete with fixing brackets and available in the following sizes. Prices which are about 1/2 of list price include carriage by B.R.B. 8ft. 30/-; 10ft. 36/-; 12ft. 42/-.



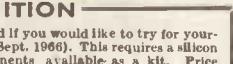
CIRCULAR FLUORESCENT

Bring sunshine into your home. 150 watts of light but uses only 40 w. Beautiful fittings with glass, non-plastic centre, fluorescent tube and choke control. Regular price 44/15/-.. Special budget price 65/- plus 10/- carr. and ins. Please state colour of glass centre, white, pink, blue, red, black, yellow or cream. Also whether plug into lamp holder or ceiling mounting model 80 watt model 99/6, 10/- carr. and ins.



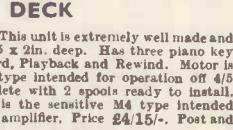
SOLID STATE IGNITION

Big things are claimed of Electronic ignition systems and if you would like to try for yourself a circuit was described in "Practical Electronics" (Sept. 1966). This requires a silicon controlled rectifier, four transistors and other components available as a kit. Price 28/15/- post free.



BATTERY OPERATED TAPE DECK

With Capstan control. This unit is extremely well made and measures approx. 6 x 5 x 2in. deep. Has three piano key type controls for Record, Playback and Rewind. Motor is a special heavy duty type intended for operation off 4/5 volts. Supplied complete with 2 spools ready to install. Record, Replay head is the sensitive Md type intended for use with transistor, amplifier. Price 24/15/- Post and Insurance 4/6.



FLUORESCENT CONTROL KITS

Each kit comprises seven items—choke, 2 tube ends, starter, starter holder and 2 tube clips, with wiring instructions. Suitable for normal fluorescent tubes or the new "Grolux" tubes for fish tanks and indoor plants. Chokes are super-silent, mostly resin filled. Kit A—15-20 w. 19/6. Kit B—30-40 w. 17/6. Kit C—80 w. 17/6. Kit D—125 w. 22/6. Kit E—65 w. 19/6. Kit MF1 is for 8in., 9in. and 12in. miniature tubes. 19/6. Postage on Kits A and B 4/6 for one or two kits then 4/6 for each two kits ordered. Kits C, D and E 4/6 on first kit then 3/6 for each kit ordered. Kit MF1 3/6 on first kit then 3/6 on each two kits ordered.

MAINS TRANSISTOR POWER PACK

Designed to operate transistor sets and amplifiers. Adjustable output 6 v., 9 v., 12 volt for up to 500 mA. (class B working). Takes the place of any of the following batteries: PPL, PP3, PP4, PP6, PP7, PP9, and others. Kit comprises: mains transformer rectifier, smoothing and load resistor, condensers and Instructions. Real snip at only 16/6, plus 3/6 postage.

DOOR INTERCOM

Know who is calling and speak to them without leaving bed or chair. Outfit comprises microphone with call push button connectors and master intercom. Simply plugs together. Originally sold at £10. Special snip price 79/6, plus 3/6 postage.



GEARED MOTOR HALF REV. PER MINUTE

Made by famous Smith Electric, mains operated and quite powerful. Size 3 1/2 x 2 1/2 x 1 1/2in. deep. Secondary use as process timer. Internal switch can be made to break circuit within a period up to 2 mins. 17/6. P. & P. 2/6 unless ordered with other goods.



MAINS MOTOR

Precision made—as used in record decks or other low current devices to control up to 30 amps—ideal also for extractor fan-blower, etc. New and perfect. Snip at 9/6. Postage 3/- for first one then 1/- for each one ordered. 12 and over post free.

RELAY SWITCHES. These enable micro switches, delicate thermistors or other low current devices to control up to 30 amps—ideal also for switch thermal storage heaters—new—stepped by the manufacturer. A.E.I. group these are listed at £25 each—you can buy if you hurry at a very keen price of 39/6 each and we will include diagrams and data. Mounted on panel size approximately 6 x 7 x 2in. deep.

ALL PRICES GREATLY REDUCED

Type No.	Type No.	Type No.	Type No.
2N1272	Q45	Q46	Q47
2N1278	Q47	Q48	Q49
2N1274	Q47	Q48	Q50
2N1747	Q47	Q49	Q51
2N1748	Q47	Q49	Q52
AC107	Q47	Q49	Q53
AC127	Q47	Q49	Q54
ACY17	Q48	Q49	Q55
ACY18	Q48	Q49	Q56
ACY19	Q48	Q49	Q57
ACY20	Q48	Q49	Q58
ACY21	Q48	Q49	Q59
ACY22	Q48	Q49	Q60
AF114	Q48	Q49	Q61
AF115	Q48	Q49	Q62
AF116	Q48	Q49	Q63
AF117	Q48	Q49	Q64
AF118	Q48	Q49	Q65
AF119	Q48	Q49	Q66
AF120	Q48	Q49	Q67
AF121	Q48	Q49	Q68
AS22Z1	Q48	Q49	Q69
BC107	Q48	Q49	Q70
BY100	Q48	Q49	Q71
BY213	Q48	Q49	Q72
MAT100	Q48	Q49	Q73
MAT101	Q48	Q49	Q74
MAT120	Q48	Q49	Q75
MAT121	Q48	Q49	Q76

SIMMERSTAT HEATER REGULATOR

Suitable to control elements, heater, soldering iron and boiling rings up to 2,500 watts. Complete adjustable, normal price 50/- each. Special Snip. Price 12/6, plus 2/- post and ins.



GANGED POTS

Standard type and size with good range of spindle—made by Morganite. List price is 10/- each but if you act quickly you can have them at 12/- doz. (or 1/6 each less than doz.). Following valves in stock all "in" 100K—100K—500K—500K all new and unused. Post 2/9 on 1st doz. then 1/- per doz. 6 doz. or more post free.

When postage is not definitely stated as an extra then orders over 25 are post free. Below 25 add 2/9. Semi-conductors add 1/- post. Over £1 post free. S.A.E. with enquiries please.

ELECTRONICS (CROYDON) LIMITED

(Dept. W.W.), 1023 TAMWORTH RD., CROYDON, SURREY
also at 266 LONDON ROAD, CROYDON, SURREY.

S.A.E. WITH ENQUIRIES PLEASE

MULLARD

AAY11	2/-	RFY60	6/-	OC82	4/6
AC107	14/6	RFY51	5/-	OC82D	4/3
AC127	6/-	BFY52	6/-	OC83	3/6
AC128	4/-	BF184	8/-	OC84	4/-
AC176	6/-	BSX79	3/-	OC123	7/-
AD149	11/-	BTY79-400R	27/6	OC139	12/-
AD161	7/6	BTY87-150R	23/-	OC140	12/-
AD163	7/6	BTY91-150R	35/-	OC169	6/-
ACY17	5/-	BSX36-100	3/-	OC170	4/-
ACY20	3/6	BTY87-500R	47/-	OC171	6/-
ACY21	4/-	BYZ10	11/-	OC200	6/-
ACY22	2/6	BYZ12	7/6	OC201	10/-
AFZ11	10/-	BYZ13	5/-	OC202	13/-
AFZ12	11/6	BYZ93 C24	12/-	OC203	8/-
AF114	4/9	BY100	5/-	OC204	11/-
AF115	4/9	BYX20-200	8/-	OC205	10/6
AF116	4/9	GET102	5/4	OCP71	19/6
AF117	4/9	GET103	4/4	OPR12	9/-
AF118	8/-	GET111	10/-	OPR80	8/-
AF184	12/-	GET573	10/-	OPR83	9/-
AF239	12/-	OC19	5/-	OPR93	18/-
ASV26	5/-	OC20	33/-	OPR90	19/6
ASY28	5/-	OC22	13/-	OA5	3/-
ASZ21	4/-	OC23	25/-	OA10	4/-
ASY29	6/6	OC24	19/-	OA47	1/6
AT210	38/6	OC25	7/-	OA70K	1/6
BA115	2/6	OC26	12/-	OA79K	1/6
BC107	5/-	OC28	12/-	OA81K	1/6
BC108	5/-	OC29	15/-	OA83K	1/6
BC109	5/-	OC35	9/6	OA90K	1/6
BCY10	20/-	OC36	13/-	OA91K	1/6
BCY12	22/-	OC41	3/6	OA95K	1/6
BCY30	7/-	OC42	4/-	OA200	2/-
BCY31	13/-	OC44	3/-	OA202	2/-
BCY32	8/-	OC45	3/-	OA210	7/6
BCY33	8/-	OC71	3/-	BX631	7/-
BCY34	8/-	OC72	4/6	BX638	10/-
BCY38	19/-	OC73	3/-	BX639	12/-
BCY39	10/-	OC75	5/-	BZ20C	13/-
BCY40	18/-	OC76	3/-	B18V	95/-
BCY71	15/-	OC81	3/-	B18C	95/-
BCZ11	10/-	OC81D	3/-	SVC1	19/6

GUARANTEE: All the above-listed semi-conductor devices are Brand New, First Grade, and guaranteed. We will replace at no charge any device found to be faulty. Further: all devices carry the Manufacturer's name or Trade Mark, type number and batch number. We do not offer for sale devices often described as "new and tested" or bearing re-marked type numbers, these often have a short and unreliable life. L.S.T. COMPONENTS.

TRANSISTOR STEREO 8 + 8



A really first-class Hi-Fi Stereo Amplifier Kit. Uses 14 transistors giving 8 watts push pull output per channel (16W. mono). Integrated pre-amp with Bass, Treble and Volume controls. Suitable for use with Ceramic or Crystal cartridges. Output stage for any speakers from 3 to 16 ohms. Compact design, all parts supplied including drilled metal work, Cir-Kit board, attractive front panel, knobs, wire, solder, nuts, bolts—no extras to buy. Simple step by step instructions enable any constructor to build an amplifier to be proud of. Brief Specification: Freq. response ± 3 dB. 20-20,000 c/s. Bass boost approx. to +12dB. Treble cut approx. to -16dB. Negative feedback 18dB. over main amp. Power requirement: at 26V. at .8 amp.

PRICES:

Amplifier Kit, £9/10/- (Built and Tested £12/10/-) P. & P. 4/6 Power Pack Kit, £2/10/- (Built and Tested £3/-) P. & P. 4/- Cabinet (as illus.), £2/10/- P. & P. 5/6

(Special Offer—£14/10/- post free if all above kits ordered at same time or built and tested for £18/- post free)

Circuit diagram, construction details and parts list (free with kit) 1/6 (S.A.E.).

HSS "FOUR" AMPLIFIER KIT

3-VALVE 4 WATT USING ECC83, EL84, EZ80 VALVES for A.C. mains 200/240 v. ★ Heavy duty double-wound mains transformer with electrostatic screen. ★ Separate base, treble and volume controls, giving fully variable boost and cut with minimum insertion loss. ★ Heavy negative feedback loop over 2 stages ensures high output efficiency, quiet operation, low distortion factor. ★ Suitable for use with guitar, microphone or record player. ★ Provision for remote mounting of controls or direct on chassis. ★ All this builds on to a chassis size only 7in. wide x 4in. deep. Overall height 4in. ★ All components and valves are brand new. ★ Very clear and concise instructions enable even the inexperienced amateur to construct with 100% success. ★ Supplied complete with valves, output transformer (3 ohms only), screened lead, wire, nuts, bolts, solder, etc. (No extras to buy). PRICE 79/6. P. & P. 6/- Comprehensible circuit diagram, practical layout and parts list 2/6 (free with kit).

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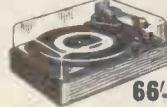
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Employing latest type Transistors. 200-250 v. A.C. mains operated. Frequency Response 30-20,000 c.p.s. -2dB Harmonic Distortion 0.3% at 1,000 c.p.s. Separate Bass and Treble "lift" and "cut" controls. 3 input sockets for Mike, Gram, Radio or Tape. Input Selector Switch. Output 3-15 ohm speakers. Max. Sensitivity 5mV. Fully enclosed enamelled case. 9 1/2 x 2 1/2 x 5 1/2in. Attractive brushed silver finish plate 10 1/2 x 3 1/2in. and matching knobs. Complete kit of parts with full wiring diagrams and instructions. Or 6 Gns. factory built with 12 mths. guarantee. Post paid 8 gns. Carr. 7/6

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EQUALISATION to Standard R.I.A.A. and C.C.I.R.

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HARMONIC DISTORTION at 10 Watt R.M.S. 1,000 c.p.s. 0.25%. Carr. 12/6.

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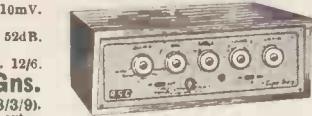
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THESE UNITS ARE EMINENTLY SUITABLE FOR USE WITH ANY MAKE OF PICK-UP OR MICROPHONE (Crystal, Ceramic, Magnetic, Dynamic or Ribbon) CURRENTLY AVAILABLE - SPECIFICATIONS COMPARABLE WITH UNITS AT ALMOST TWICE THE COST



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Inc. Garrard SP25 Mk. II 4-speed Player Unit (with heavy cast turntable mounted on plinth with leads and plugs fitted Goldring CS90 high compliance ceramic cartridge in cabinet and pair of diamond stylus. Assembled TA12 Stereo Amplifier in cabinet and pair of Dorsi Speaker Units. Total for above saving £12. Carriage 25/- Perspex cover 59/9 extra with above only. Or Dep. 876/0 and 9 mthly. payments 25/3/0 (Total £53/13/0)

SENSATIONAL VALUE IN HIGH FIDELITY STEREO SYSTEMS

Extremely attractive cabinets finished Satin Teak Veneer. Tinted Perspex "hinged" lid Special Inclusive Price

69 1/2 Gns. 35/-

Fully wired and fitted in cabinet consisting of (1) The Garrard SP25 Mk. II PLAYER UNIT 4-speed with heavy turntable, HYDRAULIC LOWERING device, etc. etc. Fitted Goldring CS90 P.U. Cartridge. Ready wired on Plinth (baseboard). Fitted plug for instant use. (2) SUPER 30 AMPLIFIER fully wired and fitted in cabinet above. (3) PAIR OF STANTON Mk. III LOUDSPEAKER UNITS. Performance comparable with equipment at twice the cost and saving over £18 on above units. H.P. Terms available. Send S.A.E. for leaflet.

HI-FI LOUDSPEAKER ENCLOSURES

All types of pleasing modern design, acoustically lined and ported and beautifully finished in light Teak or Walnut veneer.

JES. Size 20 x 11 x 8in. Gives

pleasing results with any 8in. 4 Gns.

Hi-Fi Speaker.

SES. For optimum performance with any Hi-Fi speaker. Size 22 x 15 x 9in. 5 Gns.

SEL10. For 10in. Hi-Fi Speaker. Size 24 x 15 x 10in. 6 Gns.

SE12. For outstanding performance with any 12in. Hi-Fi speaker. Cut for tweeter. Size 25 x 18 x 10 1/2in. 7 Gns.

LINEAR LP/I TAPE PRE-AMPLIFIER

Switched Equalisation. Positions for Recording at 1 1/2, 3 1/2, 7 1/2in. per sec. and Playback. EM84 Recording Level Indicator. Designed primarily as the link between a Magnavox Tape Deck and Hi-Fi amplifier suitable most Tape Decks. Terms available.

10 1/2 Gns.

INTEREST CHARGES REFUNDED

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FULLY TRANSISTORISED, SOLID STATE CONSTRUCTION, HIGH FIDELITY. OUTPUT OF 6.5 WATTS PER CHANNEL. Designed for optimum performance with any crystal or ceramic Gram P.U. cartridge, Radio, Tuner, Tape Recorder, "Mike", etc. 3 separate switched input sockets on each channel. Separate Bass and Treble controls. Slide Switch for mono use. Speaker Output 3-15 ohm. Frequency Response 20-20,000 c.p.s.

Harmonic Distortion 0.3% at 1,000 c.p.s. Hum and Noise -70dB. Sensitivities (1) 300mV (2) 100mV (3) 10mV (4) 2mV. Handsome brushed silver finish fascia and knobs. Complete kit of parts with full wiring diagrams and instructions.

11 Gns. Carr. 7/9. Factory built with 12 months guarantee. 15 Gns. Carr. 7/9. Or Deposit £4/16/- and 9 monthly payments 29/- (Total 17 Gns.). Teal finished cabinet as illustrated £23/13/6 extra.

Or larger size as used in Stereo System 86/6.

R.S.C. HIGH FIDELITY SPEAKER SYSTEMS

Consisting of matched 12in. 12,000 line, 15 ohm high quality speaker, cross-over unit and Tweeter. Smooth response and extended frequency range ensure surprising realistic reproduction. Standard 10 watts rating. Or Senior 15 watt inc. Audioline HF 126 speaker. 6 Gns. Carr. 6/6. 5 Gns. Carr. 5/9

FR 3 3 SPEAKER SYSTEM

inc. Audioline HF 126, 12in. Bass unit, with 15,000 line magnet. 5in. 10 watt 11,000 line mid-range speaker HF 510M. High Flux 4in. Tweeter. Cross-over units for mid- and high-frequencies and circuit. Housed in suitable cabinet will provide quality comparable with very expensive units. Rating 15 watts. Impedance 15 ohms. 9 Gns. Carr. 7/6

Or ready wired on baffle board 17 1/2 x 12in. 10 Gns. Carr. 10/6

AUDIOTRINE HIGH FIDELITY MODULES

Model MT 54 Consisting of HF 510M Mid-range speaker, Tweeter and Cross-over used in FR 3 3 Speaker system above mounted on baffle board 10 1/2 x 5 1/2in. wired and ready for connecting across a 12in. 15 ohms speaker.

£5.15.0 Carr. 6/6

HI-FI TAPE RECORDER KIT

Model MT 54 Consisting of Garrard 24 1/2 Gns. Carr. 17/8 speed Tape Deck, Matched

4-5 watt Tape Amplifier. Reel of high quality recording Tape, empty 7in. spool. High quality dynamic microphone, 7x4in. Loudspeaker and circuit. Full record and playback facilities. Magic eye level indicator. Equalization for each speed. Twin track. Only 4 pairs of soldered joints plus mains. Save approx. 10 Gns. on package deal. 4 track version, 27 gns.

R.S.C. STEREO/20 HIGH FIDELITY AMPLIFIER

PROVIDING 10/14 WATT ULTRA LINEAR PUSH-PULL OUTPUT ON EACH CHANNEL SUITABLE FOR "MIKE" GRAM, RADIO OR TAPE 7 Valves ECC83 (2), ECL86 (4), EZ81. Frequency Response: ±2dB 30-20,000 c.p.s. Hum Level: 65dB down. Sensitivity: 20 millivolts max. Harmonic Distortion: (each channel): 0.2%. Four-point tone compensation and Input Selector Switch. ★ Stereo/Mono switch. ★ Neon panel indicator. ★ Handsome Perspex Frontplate. ★ Separate Bass and treble controls. Output transformers High-quality sectionally wound. Outputs for 3 and 15 ohm speakers.

Or factory assembled, with our usual 12 months' guarantee 19 gns. Carr. 12/6. Or send Dep. £4/10/0 and 9 monthly payments of £2 (Total £22/10/0). Send S.A.E. for leaflet.



Complete kit with point-to-point wiring diagrams Carr. 12/6. and instructions.

High Quality 14 Gns.

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Covered in two-tone Rexine/Vynair ideal for vocalists and Public Address, 15 ohm matching.
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 (Total £28/1/-)
 Carr. 10/-
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12in. HIGH QUALITY LOUDSPEAKERS

In teak veneered cabinets.

10 Watt Model. Gauss 12,000 lines, 5 Gns.

3 or 15 ohms.



20 Watt Model. 15 ohm. Size 18 x 18 x 10in. Gauss 12,000 lines. 8 Gns.

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LOUDSPEAKERS Limited number at fraction of list price. 15 ohms impedance. Brand new, guaranteed. Terms available.

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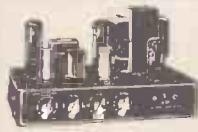
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Normally £13 approx. Carr. 10/-.

15in. 40 WATT

15in. 40 WATT Carr. 15/-.

Massive units. Usually 18 gns.



R.S.C. A10 30 WATT HIGH FIDELITY AMPLIFIER

Highly sensitive. Push-Pull high output with Pre-amp./Tone Control stages. Performance figures equal to most expensive amplifiers available. Hum level -70 dB. Frequency response ±3 dB 30-20,000 c/s. Sectionally wound ultra linear output transformer with 87 output valves. All first grade components. Valves, EF86, EF88, ECC83, 807, 807, GZ34. Separate Bass and Treble Controls. Sensitivity 12 millivolts so that any kind of Microphone or Pick-up is suitable. Designed for Clubs, Schools, Theatres, Dance Halls or Outdoor Functions, etc. For use with Electronic Organ, Guitar, String Bass, etc., Gram., Radio or Tape. Two inputs with associated volume controls. 200-250 v. 50 c/s. A.C. mains. For 3 and 15 ohms speakers. Complete kit of parts with point-to-point wiring diagrams and instructions. Carr. 12/6. Supplied factory built with EL34 output valves. 12 months' guarantee for 15 gns. Terms: Deposit £4/13/- and 9 monthly payments of 28/9 (Total £27/11/9). Twin-handled perforated cover can be supplied for 25/-. Send s.a.e. for leaflet.

R.S.C. GRAM AMPLIFIER KIT 4 watts output. Negative feedback. Controls: Vol., Bass, Treble and Mains 8 switch. For 200-250v.A.C. mains. Fully isolated chassis. Circuit etc. supplied. 59/11

POWER PACK KIT Consisting of mains transformer, Metal Rectifier, Electrolytes, smoothing choke, chassis and circuit. 200/250 v. A.C. mains. Output 250 v. 60 mA. 6.3 v. 2a. Supplied with case in lieu of chassis 28/11. Or assembled 39/11.



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Type BMI. An all dry battery eliminator. Size 5½ x 4 x 2in. approx. Completely replaces batteries supplying 1.5 v. and 90 v. where A.C. mains 200/250 v. 50 c/s is available. Complete kit with diagram 47/8 or ready for use 59/11.

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250v. 60 mA. 6.3v. 2a. 14/11

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300-0-300v. 130mA. 6.3v. 4a. c.t. 6.3v. 1a. For Mullard 510 Amplifier. 33/9

350-0-350v. 100mA. 6.3v. 2a. 0-5-6.3v. 3a. 33/9

350-0-350v. 150mA. 6.3v. 4a. 0-5-6.3v. 3a. 42/9

425-0-425v. 200mA. 6.3v. 4a. c.t. 5v. 3a. 67/9

425-0-425v. 200mA. 6.3v. 4a. 6.3v. 4a. 5v. 3a. 68/9

450-0-450v. 250mA. 6.3v. 4a. c.t. 5v. 3a. 78/9

TOP SHROUDED DROP-THROUGH TYPE

250-0-250v. 70mA. 6.3v. 2a. 0-5-6.3v. 2a. 19/9

250-0-250v. 100mA. 6.3v. 3.5a. 21/9

250-0-250v. 100mA. 6.3v. 2a. 6.3v. 1a. 22/9

350-0-350v. 80mA. 6.3v. 2a. 0-5-6.3v. 2a. 23/9

250-0-250v. 100mA. 6.3v. 4a. 0-5-6.3v. 3a. 32/9

300-0-300v. 100mA. 6.3v. 4a. 0-5-6.3v. 3a. 32/9

300-0-300v. 130mA. 6.3v. 4a. 0-5-6.3v. 1a. Suitable for

Mullard 510 amplifier. 38/9

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19/1. 12/1. 8/9. 12v. 3a. 24v. 1.5a. 19/9. 9-18v. 14a. 15/9.

0.15-25-42.5v. 2a. 27/9.

CHARGER TRANSFORMERS 0.9-15v. 1.1a. 13/11. 2.1a. 18/11.

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AUTO (Step UP/Step DOWN) TRANSFORMERS 0.110/120v.-200-230v-260v. 50-80 watts. 14/9

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Push-Pull 10 watts 6V ECL86 to 5, 8 or 15Ω. 21/9

Push-Pull EL84 to 3 or 15Ω 10-12 watts. 19/9

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Push-Pull 20 watt high quality sectionally wound, EL34, 6L6, KT66, etc., to 3 or 15Ω fully shrouded. 55/9

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B5.	7-Matched set, OC44, 45/81D/81+diode	10/-
B6.	15-Red spot AF. trans. or white spot RF	10/-
B8.	2-Power trans. OC26/35 type	10/-
B9.	1-Light sensitive cell, ORP12 type	9/-
B10.	1-50V trans. german. PNP latest type	10/-
B44.	1-Tunnel diode, AY11, 1050 Mc/s.	10/-
B21.	2-Sil. recs. 10 amp., 50-100 PIV	10/-
B42.	5-Switching trans. TK28C STC	10/-
C2.	1-Uni junction, 2N2160 or 2N2640	15/-
C4.	2-RF power trans., OC22 and BUY11	15/-
C31.	4-Sil. recs. 800 PIV 5 amp. top hat	15/-
C32.	2-Power trans. TK 400A/NKT404 VCB64 IC 8 amp.	15/-
D18.	1-ORP60 type light sensitive cell	5/-

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TRANSISTORS	PRICE	BSY26	10/-	OC171	4/-	POWER TRANSISTORS
AC107	6/-	BSY26	5/-	OC200	5/-	OC20
AC126	2/6	BSY27	5/-	OC201	8/-	OC23
AC127	2/6	BSY28	5/-	OC14	1/11	OC25
AC128	3/-	BSY29	5/-	OC15	1/9	OC26
AC178	5/-	BSY35A	5/-	2N711	10/-	OC28
AF117	2/-	OC41	2/6	2N1302	4/-	OC35
AF118	2/-	OC71	2/6	2N1303	4/-	DIODES
AF118	3/-	OC72	2/6	2N1304	5/-	AAV42
AF117	4/-	OC73	5/-	2N1305	5/-	OA10
AF118	3/6	OC81	2/6	2N1306	6/-	OA70
AF119	3/8	OC81D	2/6	2N1307	6/-	OA79
AF178	10/-	OC83	4/-	2N1308	8/-	OA81
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4	6, 12 v. at 20 amps.	£5/17/6	6/6
5	17, 18, 20 v. at 20 amps.	£6/12/6	6/6
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3 figure, 24 v. D.C. operation (illustrated).

Similar to above, but may be pre-set to any number up to 999 reducing to zero. Either type 32/6, P. & P. 2/6.

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4 figure, 10 impulses per second. Type 100A, 500 ohm coil. Type 100B, 2,300 ohm coil. Either 15/- each, plus 1/6 P. & P.

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Type D15G 5 r.p.m. 1.7lb. inch, £2/9/6, P. & P. 3/- Type B16G 80 r.p.m. 26lb. inch, £2/2/-, P. & P. 3/- Type D16G 13 r.p.m. 1.45lb. inch, £2/17/6, P. & P. 3/-

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Manufactured by M.E.C. 50 k., 45 turn. Fly leads, all metal sealed construction. 10/6. Plus 1/6 P. & P.



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Sintered Cadmium Type 1.2 v. 7AH. Size: height 3½in., width 2½in. x 1½in. Weight: approx. 13 ozs. EX-R.A.F. Tested 12/6. P. & P. 2/6.

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(NEW) Ceramic construction, winding embedded in Vitreous Enamel, heavy duty brush assembly designed for continuous duty.

AVAILABLE FROM STOCK IN THE FOLLOWING 11 VALUES:

1 ohm 10a., 5 ohm 4.7a., 10 ohm 3a., 50 ohm 1.4a., 100 ohm 1a., 250 ohm .7a., 500 ohm .45a., 1,000 ohm 280mA., 1,500 ohm 230mA., 2,500 ohm 2a. Diameter 3½in. Shaft length ½in. dia. 2½in. 27/6. P. & P. 1/6.

50 WATT 1/5/10/25/50/100/250/500/1,000/1,500/2,500 ohm, 21/-. P. & P. 1/6.

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New special offer of Dry Reed Switches, 1 amp. contact, 1/8 x 1½in., 4 for 10/-, post paid.

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This precision instrument, built to highest Ministry specification, is based on a 24 v. D.C. LOW INERTIA (Integrating) Motor. The Motor, fitted with gold brushes and drawing only 800 microamp at 24 v. D.C. drives two precision pots with platinum wipers through close tolerance gear-trains, including miniature slipping clutch, combined with two sub-miniature pots for calibrating the electrical bridge circuit. The 3in. calibrated dial, with a number aperture indicating one rev. per revolution of pointer with maximum of 5 revs., gives an effective scale length of approx. 30in. Offered at fraction of Manufacturer's price: 32/6, plus 6/- P. & P.



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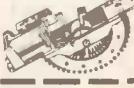
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25 ohm coil, 24 v. D.C. operation. £4/17/6, plus 2/6 P. & P.



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3 banks of 11 positions, plus homing bank. 40 ohm coil. 24-36 v. D.C. operation. Carefully removed from equipment and tested. 22/6, plus 2/6 P. & P.

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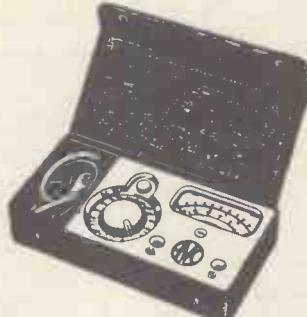
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VM77C: A.C. Millivoltmeter

1 mV-300 V full scale in 12 ranges. Freq. range 15 c/s-4.5 Mc/s. Input impedance 10 Megohms 20 pf. Calibrated in r.m.s. volts for sine wave input and dB. 100-250 V a.c. input.

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VM78: A.C. Millivoltmeter

Transistorised. 1 mV-300 V in 12 ranges. Freq. 1 c/s-1 Mc/s. Input impedance 2 Megohms 60 pf. Calibrated in r.m.s. for sine wave and input dB.

Manufacturer's price £70: Our price £55

TT1S: Transistor Tester (CT472)

Suitable for measuring medium and low powered transistors. Current gain (B) can be measured in range 10 to 500 for p.n.p. and n.p.n. types, either in circuit using the clip-on probes provided. Small, compact instrument.

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J2B: Audio Signal Generator

Same specification as for the J1B except that this model has an additional 2 in. meter calibrated 0-40 V a.c.

Manufacturer's price £50: Our price £35

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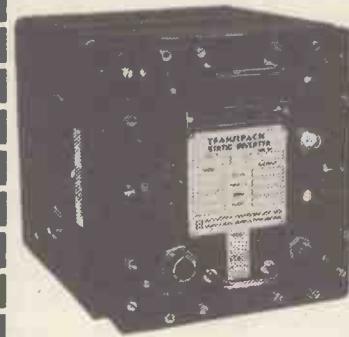
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MARCONI CT218: price £65 each, carr. 30/-.
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30/-

HRO RECEIVER. Model 5T. This is a famous American High Frequency superhet, suitable for CW, and MCW, reception crystal filter, with phasing control. AVC and signal strength meter. Freq. range 50 kc/s. to 30 mc/s., with set of nine coils. Receiver only in working order, £18/10/-, carr. 15/-. Each. Set of nine coils, £12/10/-, available only with set. Power unit for HRO 100/240 v. A.C., £2/15/-, carr. 10/-.

SPECIAL OFFER: Complete HRO SET (Receiver, Coils and Power Unit) for £30, plus 30/- carr.

HRO-M-SETS available with UX type valves; secondhand cond., with 5 coil and power unit, £20 each, carr. 30/-.

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RECEIVER TYPE S.27: UHF: freq. 35-143 tunable Mc/s., AM/FM 100/250 A.C. £25 secondhand cond., £50 as new, 30/- carr.

AIRCRAFT RECEIVER TYPE 1392: freq. 100-150 Mc/s. tunable, with power unit for 200/250 v. A.C. mains. In serviceable cond., £10 each, carr. 25/-.

ROTARY TRANSFORMERS: 24 v. input, 175 v. at 40mA output, 25/-, plus 2/- post. 12 v. input, 225 v. at 100 mA output, 25/-, plus 3/- post (All the above are D.C. only).

ROTARY CONVERTERS: Type 8a, 24 v. D.C., 115 v. A.C. @ 1.8 amps. 400 c/s 3-phase, £6/10/- each, 8/- post. Converter 12 v. D.C. input, 110 v. A.C. 60 c/s output, £15 each, £1 carr.

AVOMETERS: Model 47A, £9/19/6 each, 10/- post. Model 7x, £13/10/- each, 10/- post. Excellent secondhand cond. (Meters only). (Batteries and Leads extra—at cost).

OSCILLOSCOPE Type 13A, 100/250 v. A.C. Time base 2 c/s.-750 Kc/s. Bandwidth up to 5 Mc/s. Calibration markers 100 Kc/s. and 1 Mc/s. Double Beam tube. Reliable general purpose scope, £22/10/- each, 30/- carr.

COSSAR 1035 OSCILLOSCOPE, £30 each, 30/- carr.
COSSAR 339 OSCILLOSCOPE, double beam, £10 each, 30/- carr.

RELAYS: Relay Unit (with 9 American relays) 24 v. D.C., 250 ohm coils, heavy duty, M. & B. 30/- each, 4/- post. GPO Type 600, 10 relays @ 300 ohms with 2M and 10 relays @ 50 ohms with 1M., £2 each, 6/- post.

CALIBRATION TACHOMETER Mk. II: Maxwell Bridge Type 6C/869, £25 each, £2 carr.

ROTAZ VARIAC & METER UNIT: Type 5G.3281. Reading 0-40 v., 0-40 mA and 0.5 amps., all on 275 deg. scales, £30 each, £2 carr.

MARCONI IMPEDANCE BRIDGE, TF-373: inductance 5μH-100H in 5 ranges capacity 5pF-100μF in 5 ranges, resistance .05 meg.-1 meg., power supply 250 v. A.C., £37/10/- each, carr. 15/-.

HEWLETT PACKARD TYPE 400C: 115 v./230 v. input 50/60 c/s. Freq. range 20 c/s-2 Mc/s. Voltage range: 1mV-300 v. in 12 ranges. Input impedance 10 megohms. Designed for rack mounting, £30 each, carr. 15/-.

TCS MODULATION TRANSFORMERS, 20 watts, pr. 6,000 C.T., sec. 6,000 ohms. Price 25/-, post 5/-.

AR88 SPARES. Antenna Coils L5 and 6 and L7 and 8. Oscillator coil L55. Price 10/- each, post 2/6. By-pass Capacitor K.98034-1,3 x 0.05 mfd. and M.98034-4, 3 x 0.01 mfd., 3 for 10/-, post 2/6. Trimmers, 95534-502, 2-20 p.f. Box of 3, 10/-, post 2/6. Block Condenser, 3 x 4 mfd., 600 v., £2 each, 4/- post. Filter Choke, L45 and 50, K901433-501, 25/- each, 4/- post.

CONDENSERS. 10 mfd. 1,000 v., 12/6, post 2/6. 8 mfd., 1,200 volts, 12/6, post 3/-. 8 mfd. 600 volts, 8/6 post 2/6. 0.25 mfd., 2 kv., 4/- post 1/6.

AUTOMATIC PILOT UNIT Mk. 2. This complex unit of diodes and valves, relays, magnetic clutches, motors and plug-in amplifiers, with many other items, price £7/10/-, £1 carriage.

S.A.E. for all enquiries. List available 6d.
If wishing to call at Stores, please telephone for appointment.

TELEPHONE EQUIPMENT:

DESK TELEPHONES with dial, in excellent secondhand cond. £2/10/- a pair, 10/- post.

TELEPHONE WIRE: 220 yds., £1 a roll, post 6/-.

GPO TERMINAL BLOCKS, 7/6 each, **FUSE AND PROTECTOR**, 7/6 each. Post on both 2/6.

TELEPHONES (PORTABLE) TYPE "F". Suitable for all outdoor activities up to a range of 5 miles. Price £7/10/- each, as new, complete with carrying case. Price £5/10/- each, secondhand. Carr. 10/-.

TELEPHONE EXTENSION CORD. Brown, 3-way; come in lengths of 6ft. and 14ft., 7/6 and 15/- respectively. Post 2/6.

NIFE BATTERIES: 6 v. 75 amps., new, in cases, £15 each, £1 carr.; 6 v. 160 amps., new in cases, £25 each, £1/10/- carr.; 4 v. 160 amps, new, in cases, £20 each, £1/10/- carr.

L.R.7 CELLS, only 1.5 v. 75 amps., new, £3 each, 12/- carr. The above batteries are low resistance designed to give a heavy surge for starting and can be stored for long periods without any effect to their performance.

WAVE GUIDES FLEXIBLE CG-182/APM40. Length 18 inches. Price £2 each, post 4/-.

MACHMETERS: Range 0 : 1 and 0 : 1.2, 6A/3384 and 5325 respectively, price 30/- each, postage 5/-.

FUEL INDICATOR Type 113R: 24 v. complete with 2 magnetic counters 0-9999, with locking and reset controls mounted in a 3in. diameter case. Price 30/- each, postage 5/-.

DRY BATTERIES, No. 1. HT 90 v. and 7½ v. size 2½in. x 3½in. x 5in., 5/- each, or 5 for £1, post 4/- and 7/6 respectively.

BATTERY NO. 4 (suitable for bells, etc.). 4½V, size 4½in. x 6in. x 2½in., 5/- each, post 3/-.

UNISELECTORS (ex equipment): 10 Bank 50 Way, alternate wipe, £2/5/- ea. 6 Bank, 25 Way, alternate wipe, £2/2/6 ea. 8 Bank, 25 Way, £2/5/- ea. 6 Bank, 25 Way, £2 ea. 4 Bank, 25 Way, 35/- ea. All the above are 75 ohm coil. Postage 4/- per uniselector.

FREQUENCY METERS: 1M 13 or BC-221; 125-20,000 Kc/s., £25 each, carr. 15/-. TS.175/U, £75 each, carr. £1. TS323/UR; 20-450 Mc/s., £75 each, carr. 15/-. FR-67/U: This instrument is direct reading and the results are presented directly in digital form. Counting rate: 20-100,000 events per sec. Time Base Crystal Freq.: 100 Kc/s. per sec. Power supply: 115 v., 50/60 c/s., £100 each, carr. £1.

CT.49 ABSORPTION AUDIO FREQUENCY METER: freq. range 450 c/s-22 Kc/s., directly calibrated. Power supply 1.5 v.-22 v. D.C. £12/10/- each, carr. 15/-.

AMERICAN EQUIPMENT: Power supply, PP893/GRC 32A; Filter D.C. Power Supply F-170/GRC 32A; Cabinet Electrical CY 1288/GRC 32A; Antenna Box Base and Cables CY 728/GRC; Mast Erection Kits, 1186/GRC; Receiver type 27 8B; Directional Antenna CRD.6: Comparator Unit, CM.23; Directional Control CRD.6, 567/CRD and 568/CRD; Azimuth Control Units, 260/CRD. Test Set URM.44, complete with Signal Generator TS.622/U, £100 each, £2 carr.

CATHODE RAY TUBE UNIT: With 3in. tube, colour green, medium persistence complete with nu-metal screen, £3/10/- each, post 7/6.

TRANSMITTER/RECEIVER TCS-12: Freq. 1.5 Mc/s-12 Mc/s., output 25 W, complete stations available with antenna equipment, mast, and petrol generator. Trans-receiver, complete with 12 v. D.C. Power Unit and A.T.U., £25 each, carr. £2/10/-. Petrol Generator Unit for the above £20 each, carr. £3. Complete aerial systems, £10 each, carr. £2.

TACAN. Trans./Receiver, same as ARN21, British made, STC, TR9171 complete with five 2C39As with associated valve-holders. As new price, £25. Used condition, £15, carriage £1.

APNI ALTIMETER TRANS./REC., suitable for conversion 420 Mc/s., complete with all valves 28 v. D.C. Dynamotor and 3 relays, 11 valves, price £3 each, carr. 10/-.

GEARED MOTORS: 24 v. D.C., current 150 mA, output 1 r.p.m., 30/- each 4/- post. Assembly unit with Letherbar Tuning Mechanism and potentiometer, 3 r.p.m., £2 each, 5/- post.

MOTORISED ACTUATOR: 115 v. A.C. 400 c/s. single phase, reversible, thrust approx. 3 inches complete with limit switches, etc. Price £2/10/- each, postage 5/- (ex equipment).

Actuator Type SR-43: 28 v. D.C. 2,000 r.p.m., output 26 watts, 5 inch screw thrust, reversible, torque approx. 25 lbs., rating intermittent, price £3 each, post 5/-.
28 v. D.C. 200 r.p.m. current consumption approximately 6 amps. Price £3/10/-, post 7/6.

FRACTIONAL MOTORS & FANS: Low inertia Motor 5UD/5361, Type 903, 24 v. input D.C., £2/10/- each, 5/- post.

Model PM84: 28 v. D.C. @ 2 amps., 4,500 r.p.m., output 40 watts continuous duty complete with magnetic brake. Price £2 each, postage 4/-.

Model SR-2: 28 v. D.C. 7,000 r.p.m., duty intermittent, output 75 watts, price 25/- each, postage 4/-.
A.C. Motor 115 v. 50 c/s. 1/300 H.P., 3,000 r.p.m. Capacitor 1mfd., 25/- post 3/-. Dalmotor SC5, 28 v. D.C. at 45 amps; 12,000 r.p.m. output 750 W. (approx. 1 h.p.), brand new, £2/10/- each, post 7/6.

W. MILLS

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OB2	6/- 6BW6	7/- 6X5GT	5/3 20L1	13/- 807	11/9 DW4/350	ECL80	6/-	EZ35	5/3 PCFB62	6/- SP61	2/- U251	1E/6 AC168	7/- BFY52	5/- GET897	4/- OC43	12/6																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																
OZ4	4/3 6BW7	5/8 6YTG	12/6 20P1	17/6 956	2/-	8/8 ECL82	6/-	EZ40	6/- PCFB64	8/- TDD2A/12/8	1/8 U281	9/8 AC169	6/8 BF115	2/- GET898	4/- OC44	2/-																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																
IA3	2/8 6C6	3/9 7B6	10/0 20P3	17/- 1821	10/8 DW4/500	ECL83	9/-	EZ41	6/- PCFB66	8/- TD14	7/- U282	12/8 AC176	11/- BF115	5/- GE1X3	3/8 OC44PM	5/3																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																
IA5	5/- 8C9	10/9 7B7	7/- 20P4	17/6 8763	10/-	8/8 ECL84	12/-	EZ43	6/- PCFB68	9/- PC102	9/0 TH233	8/9 U283	12/8 AC177	5/- BF116	5/- GE1X3	4/- OC44M	1/9																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
IA7GT	7/6 6CD6G	19/0 7C7	40/- 20P5	17/- 7475	2/-	6/8 EY86	5/9 ECL85	11/-	EZ44	6/- PCFB70	7/- PC105	9/0 TH230	7/- U284	12/8 AC178	5/- BF117	5/- GE1X3	10/- OC44M	8/3																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
IC5	4/9 6CH6	6/- 7C8	8/- 25A6	7/6 1834	20/-	6/8 ECL86	7/-	EZ45	7/- PCFB72	8/- PCL83	10/3 UB41	10/6 VP25	9/6 AC179	5/- BF118	5/- GE1X3	11/- OC44M	8/3																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
ID5	6/- 6CW4	12/- 7H7	5/- 26LG6	4/9 ECO44	14/-	6/8 ECF	24/- ECL800	ID5	EZ46	14/- PCFB74	8/- PCL84	10/3 UB41	10/6 VP25	9/6 AC179	5/- BF119	5/- GE1X3	11/- OC44M	8/3																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
ID6	9/- 6DS3	7/6 TR7	12/6 25V5	6/-	AC2PEN	EFS3	19/-	EFD1	6/- 6D6	3/- 7V7	5/- 25Y5G	8/8 EF22	6/6 HABCO 9/8	11/- PCFB76	8/- PCL86	10/3 UB41	10/6 VP25	9/6 AC179	5/- BF119	5/- GE1X3	11/- OC44M	8/3																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
ID9	3/3 6FL1	9/6 TY4	6/8 25ZG4	6/3 AC2PEN	EFS3	19/-	EFD9	18/- 6D6	18/0 EAS0	1/8 EFS7A	7/- HN308	26/-	9/6 PEN453D	7/- ECL87	11/- PCFB78	8/- PCL88	10/3 UB41	10/6 VP25	9/6 AC179	5/- BF119	5/- GE1X3	11/- OC44M	8/3																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
IG6	6/- 6FGG	4/- 9BWB6	9/8 25Z5	7/-	DD	18/0 EAS0	1/8 EFS7A	EH5GT	7/- 6F12	3/3 9D7	7/6 25ZG6	8/8 EFS7B	5/- HN308	19/6 U190	7/- PCFB79	8/- PCL89	10/3 UB41	10/6 VP25	9/6 AC179	5/- BF119	5/- GE1X3	11/- OC44M	8/3																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
IL4	2/6 6F13	3/6 10C1	9/- 30C1	7/-	AC/PEN (5)	EFS40	9/- EBC80	6/-	IL5	6/- 6F14	10/0 10C1	9/- 30C1	7/-	AC/PEN (5)	EFS40	9/- ECL89	10/3 UB41	10/6 VP25	9/6 AC179	5/- BF119	5/- GE1X3	11/- OC44M	8/3																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
ILD5	5/- 6F15	15/- 10C2	12/- 30C15	12/-	AC/PEN (7)	EFS42	7/- EBC81	6/-	ILN5	4/8 6F15	10/9 10D1	7/- 30C17	13/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILD5	5/- 6F15	15/- 10C2	12/- 30C15	12/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILN5	4/8 6F15	10/9 10D1	7/- 30C17	13/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILD5	5/- 6F15	15/- 10C2	12/- 30C15	12/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILN5	4/8 6F15	10/9 10D1	7/- 30C17	13/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILD5	5/- 6F15	15/- 10C2	12/- 30C15	12/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILN5	4/8 6F15	10/9 10D1	7/- 30C17	13/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILD5	5/- 6F15	15/- 10C2	12/- 30C15	12/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILN5	4/8 6F15	10/9 10D1	7/- 30C17	13/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILD5	5/- 6F15	15/- 10C2	12/- 30C15	12/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILN5	4/8 6F15	10/9 10D1	7/- 30C17	13/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILD5	5/- 6F15	15/- 10C2	12/- 30C15	12/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILN5	4/8 6F15	10/9 10D1	7/- 30C17	13/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILD5	5/- 6F15	15/- 10C2	12/- 30C15	12/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILN5	4/8 6F15	10/9 10D1	7/- 30C17	13/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILD5	5/- 6F15	15/- 10C2	12/- 30C15	12/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILN5	4/8 6F15	10/9 10D1	7/- 30C17	13/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILD5	5/- 6F15	15/- 10C2	12/- 30C15	12/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILN5	4/8 6F15	10/9 10D1	7/- 30C17	13/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILD5	5/- 6F15	15/- 10C2	12/- 30C15	12/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILN5	4/8 6F15	10/9 10D1	7/- 30C17	13/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILD5	5/- 6F15	15/- 10C2	12/- 30C15	12/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILN5	4/8 6F15	10/9 10D1	7/- 30C17	13/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILD5	5/- 6F15	15/- 10C2	12/- 30C15	12/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILN5	4/8 6F15	10/9 10D1	7/- 30C17	13/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILD5	5/- 6F15	15/- 10C2	12/- 30C15	12/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILN5	4/8 6F15	10/9 10D1	7/- 30C17	13/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILD5	5/- 6F15	15/- 10C2	12/- 30C15	12/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILN5	4/8 6F15	10/9 10D1	7/- 30C17	13/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILD5	5/- 6F15	15/- 10C2	12/- 30C15	12/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILN5	4/8 6F15	10/9 10D1	7/- 30C17	13/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILD5	5/- 6F15	15/- 10C2	12/- 30C15	12/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILN5	4/8 6F15	10/9 10D1	7/- 30C17	13/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILD5	5/- 6F15	15/- 10C2	12/- 30C15	12/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILN5	4/8 6F15	10/9 10D1	7/- 30C17	13/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILD5	5/- 6F15	15/- 10C2	12/- 30C15	12/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILN5	4/8 6F15	10/9 10D1	7/- 30C17	13/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILD5	5/- 6F15	15/- 10C2	12/- 30C15	12/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILN5	4/8 6F15	10/9 10D1	7/- 30C17	13/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILD5	5/- 6F15	15/- 10C2	12/- 30C15	12/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILN5	4/8 6F15	10/9 10D1	7/- 30C17	13/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILD5	5/- 6F15	15/- 10C2	12/- 30C15	12/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILN5	4/8 6F15	10/9 10D1	7/- 30C17	13/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILD5	5/- 6F15	15/- 10C2	12/- 30C15	12/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILN5	4/8 6F15	10/9 10D1	7/- 30C17	13/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILD5	5/- 6F15	15/- 10C2	12/- 30C15	12/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILN5	4/8 6F15	10/9 10D1	7/- 30C17	13/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILD5	5/- 6F15	15/- 10C2	12/- 30C15	12/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILN5	4/8 6F15	10/9 10D1	7/- 30C17	13/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILD5	5/- 6F15	15/- 10C2	12/- 30C15	12/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILN5	4/8 6F15	10/9 10D1	7/- 30C17	13/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILD5	5/- 6F15	15/- 10C2	12/- 30C15	12/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILN5	4/8 6F15	10/9 10D1	7/- 30C17	13/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILD5	5/- 6F15	15/- 10C2	12/- 30C15	12/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILN5	4/8 6F15	10/9 10D1	7/- 30C17	13/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILD5	5/- 6F15	15/- 10C2	12/- 30C15	12/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILN5	4/8 6F15	10/9 10D1	7/- 30C17	13/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILD5	5/- 6F15	15/- 10C2	12/- 30C15	12/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILN5	4/8 6F15	10/9 10D1	7/- 30C17	13/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILD5	5/- 6F15	15/- 10C2	12/- 30C15	12/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILN5	4/8 6F15	10/9 10D1	7/- 30C17	13/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILD5	5/- 6F15	15/- 10C2	12/- 30C15	12/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILN5	4/8 6F15	10/9 10D1	7/- 30C17	13/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILD5	5/- 6F15	15/- 10C2	12/- 30C15	12/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILN5	4/8 6F15	10/9 10D1	7/- 30C17	13/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILD5	5/- 6F15	15/- 10C2	12/- 30C15	12/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILN5	4/8 6F15	10/9 10D1	7/- 30C17	13/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILD5	5/- 6F15	15/- 10C2	12/- 30C15	12/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILN5	4/8 6F15	10/9 10D1	7/- 30C17	13/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILD5	5/- 6F15	15/- 10C2	12/- 30C15	12/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILN5	4/8 6F15	10/9 10D1	7/- 30C17	13/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILD5	5/- 6F15	15/- 10C2	12/- 30C15	12/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILN5	4/8 6F15	10/9 10D1	7/- 30C17	13/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILD5	5/- 6F15	15/- 10C2	12/- 30C15	12/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILN5	4/8 6F15	10/9 10D1	7/- 30C17	13/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILD5	5/- 6F15	15/- 10C2	12/- 30C15	12/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILN5	4/8 6F15	10/9 10D1	7/- 30C17	13/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILD5	5/- 6F15	15/- 10C2	12/- 30C15	12/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILN5	4/8 6F15	10/9 10D1	7/- 30C17	13/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILD5	5/- 6F15	15/- 10C2	12/- 30C15	12/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILN5	4/8 6F15	10/9 10D1	7/- 30C17	13/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILD5	5/- 6F15	15/- 10C2	12/- 30C15	12/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILN5	4/8 6F15	10/9 10D1	7/- 30C17	13/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILD5	5/- 6F15	15/- 10C2	12/- 30C15	12/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILN5	4/8 6F15	10/9 10D1	7/- 30C17	13/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILD5	5/- 6F15	15/- 10C2	12/- 30C15	12/-	AC/PEN (7)	EFS42	7/- EBC81	12/-	ILN5	4/8

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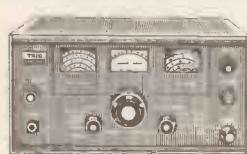
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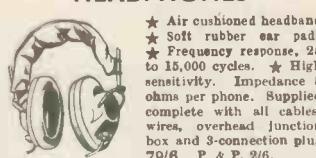
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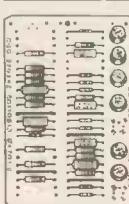
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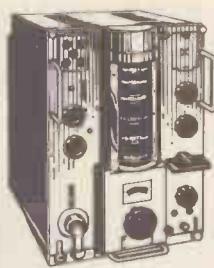
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Five assorted printed circuit boards with transistors, diodes, resistors, condensers, etc. Guaranteed minimum 20 transistors. Ideal for experimenters. 5 Boards for 10/- P. & P. 2/-.

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An extremely high quality oscilloscope originally costing £400. Switched beam. Identical Y1, Y2 Amplifiers D.C. to 9 Mc/s. Sensitivity 3mV/cm. Time base 10μsec. to 2.5 Mc/s. Z Modulation. X amplifier D.C. to 2.5 Mc/s. Also checks impedance turns ratio. Insulation, 200/250 v. A.C. Brand New. £25. Carr. 7/6. Extra.

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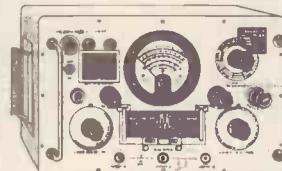
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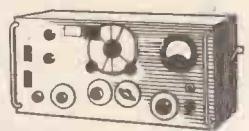
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It has the fullest capacity for checking on A, B and I_{co}. Equally adaptable for checking diodes, etc. Spec.: A: 0.7-0.9987. B: 5-200. I_{co}: 0/50 micro-amps. 0.5 mA. Resistance for diode 200Ω+1 MEG. Supplied complete with instructions, battery and leads. £5/19/6. P. & P. 2/6.



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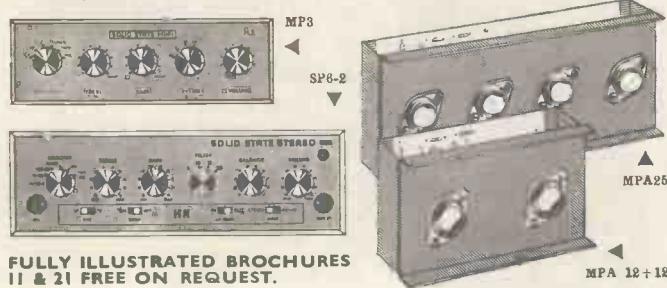
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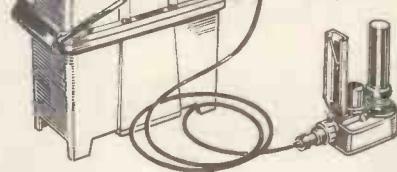
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3N140	N dualgate	20	20	8.0(8)	—	5-30	1	150	6,000-18,000	300	—	£1 2 2
Thyristors		PIV Volts	If cont A	If peak A	Ig peak A	Pc-G W	Igt mA	Vgt Volts	Iho mA		Price	
C106-Y1		30	2	25	0.2	0.1	0.5	0.5-0.8	8	16 10		
TIC31		400	4	125	2	5	25	0.25-3.5	25	£2 0 0		
2N4441		50	8	80	2	5	30	0.7-1.5	40	19 4		
2N4442		200	8	80	2	5	30	0.7-1.5	40	£1 6 9		
2N4443		400	8	80	2	5	30	0.7-1.5	40	£1 17 0		
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MCR2304-6		400	8	100	2	5	20	0.2-1.5	25	£2 5 3		
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Triac's												
40527 no diode		400	2.5	25	0.5	0.15	10	2.2	5	£1 17 0		
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Silicon Diodes

	PIV Volts	If cont A	If peak A	Ir mA	Vf Volts	
ESK1/10	800	I(0.8)	50	0.1	1.2	3 2
ESK1/02	125	I(0.8)	50	0.1	1.2	3 0
ESK1/06	400	I(0.8)	50	0.1	1.2	3 1
ESK1/12	900	I(0.8)	50	0.1	1.2	3 3
IN4001	50	I(0.7)	30	0.05	1.1	4 8

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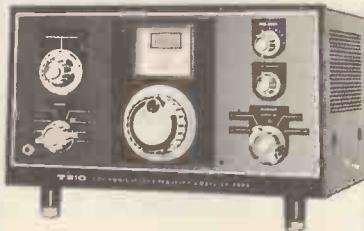
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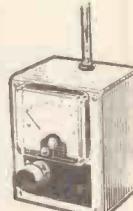


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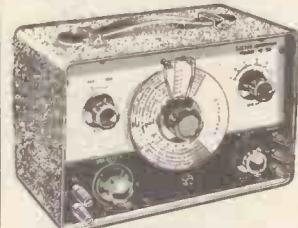
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RF SIGNAL GENERATOR

Model TE-20



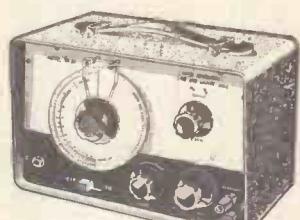
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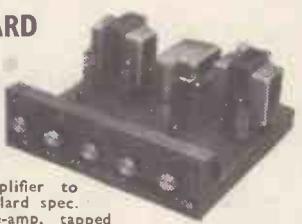
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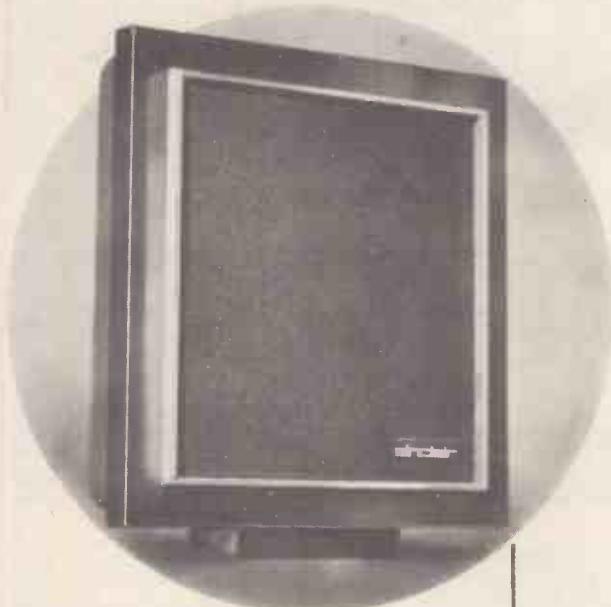
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Elliot portable recording milliammeters.
As D.C. recorder: 1 mA. FSD. Movement resistance 1200 Ω .
As A.C. current or voltage recorder: Movement resistance at 50 c/s. 1800 Ω . Sensitivity 1 mA. A.C. FSD.
As decibel meter: source impedance 600 Ω . Range +5 to -10 dB. Frequency response 50 c/s. to 15 kHz.
Chart drive: 230 v. A.C. at 1in. and 6in. per hour. Movement is fitted with "high" and "low" alarm contacts which can be set for any value of the current.
Strip chart 3½ in. wide. Curvilinear trace
PRICE £40

Packing and carriage 15/-

RECORD PORTABLE RECORDING MILLIAMMETERS

These are similar to the above but are somewhat smaller and lighter, and D.C. resistance of the movement is 400 Ω . Other details as above. PRICE £42 10

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These are also available as decibel meters. Type 19A/C.T.A. Range +3dB/-3dB 6+ with current of 500 μ A at 0dB. Movement resistance 1800 Ω £45

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Cartridge Type
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1N23WE, 100/-; CS10, 70/-;
10,000 mc/s.: CS3A (CV253), 20/-;
12,000 mc/s.: CS3A, 17/6; CS4B, 37/6; CS9B, 30/-; CS10BR, 70/-;
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Type RA8508AF, 960 p.i.v. at 6 amps. max., stud mounted 10/8

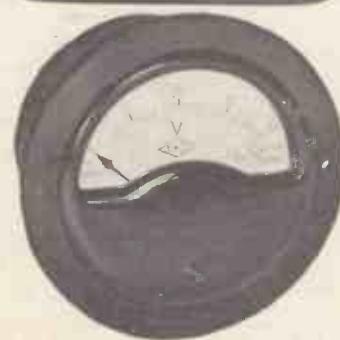
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Moving Coil Headphones with moving coil Hand Microphone fitted with press-to-talk switch. Rubber earpads. Cord terminated with army type 5-point moulded connector. Low Impedance. Brand new. 20/- ea. P. & P. 3/8 per set.

WE ARE INTRODUCING FIRST CLASS (1.5% ACCURACY) MOVING COIL METERS OF CURRENT MANUFACTURE. THESE STURDILY BUILT INSTRUMENTS HAVE HIGH TORQUE MOVEMENTS AND ARE CAREFULLY ADJUSTED FOR CORRECT AMOUNT OF DAMPING

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100 μ A	62/-	49/-	74/-
150 μ A	—	44/-	—
250 μ A	54/-	42/-	65/-
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600 μ A	48/-	36/-	60/-
1A	46/-	—	—
2.5mA	—	—	58/-
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40mA	46/-	34/-	58/-
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100mA	—	34/-	—
150mA	46/-	—	—
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600mA	46/-	34/-	—
1A	46/-	—	58/-
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Type 85DA and 85DV, 85mm. dia. flange. Flush mounted. 87mm. dia. body. 48mm. depth from the panel.

Type 120DA and 120DV, 120mm. square flange. Flush mounted. 88mm. dia. body. 40mm. depth from the panel.

RANGE	70DV	85DV	120DA
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10V	—	40/-	—
15V	—	—	62/-
25V	—	40/-	—
40V	82/-	—	—
60V	82/-	—	—
100V	—	—	—
150V	82/-	48/-	—
250V	53/-	48/-	65/-
400V	—	47/6	69/-
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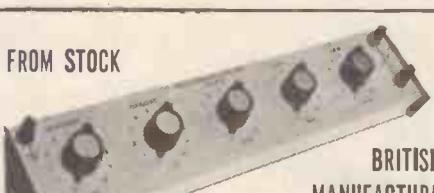
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G UATEMALA: Small radio station requires volunteer radio technician to assist in establishing relay stations and radio schools. Interesting post concerned with development of remote areas. Volunteer terms: board and lodgings, pocket-money, fares, allowances.—Write CIIR/OV, 38, King St., London, W.C.2. [1981]

I MPERIAL COLLEGE—Senior Experimental Officer or Experimental Officer (Electronics) for instrumentation of experimental high pressure equipment used in metal working, to supervise manufacture and use, and to ensure maintenance. Qualifications: H.N.C. or Corporate Membership. Salary range £1,335—£2,040. Superannuation Scheme. Application to Mr. R. W. Wells, Mechanical Engineering Department, Imperial College, London, S.W.7. [1970]

P AN American require Radio Technician for project and maintenance duties involving ground-based U.H.F. and V.H.F. systems. Based at London Airport but some travel in European area. C. & G. Certificates in radio or equivalent, plus minimum of two years related experience required. Commencing salary approx. £1,300 p.a. Reduced rate holiday travel privileges, superannuation scheme, etc.—Write to Pan American, Personnel Supervisor, London Airport, Hounslow, Middlesex. [1992]

E XPERIMENTAL OFFICER required to assist in electronic techniques associated with development of on-line digital data recording and computer control of mechanical engineering equipment. Experience of high speed pulse and logical circuitry techniques desirable; good working conditions, superannuation scheme, 4 weeks' holiday; salary in the range £1,335—£1,745 per annum. Applications to: Assistant Director, Department of Mechanical Engineering, Imperial College, London, S.W.7. [1968]

A PPLICATIONS are invited for 2 technicians posts in the Dialysis Unit. The successful applicant will be responsible for the maintenance of electronic apparatus used in the treatment of kidney failure. They will also take part in a development programme in association with the Department of Medical Electronics, St. Bartholomew's Hospital, where the initial training will be carried out. Experience in the maintenance of electronic equipment is desirable. Salary and qualifications in accordance with P.T.B. Circular 21/1—£711—£1,004—£75 London Weighting. Applications to Dr. B. W. Watson, Department of Medical Electronics, St. Bartholomew's Hospital, London, E.1. [1967]

V ACANCY for an electronic technician to participate in a number of brain research projects, involving both animal and human subjects. Duties will include the maintenance of E.E.G. and polygraph recorders, a frequency analyser, assisting with the taking of E.E.G. recordings in an animal laboratory and the setting up and maintenance of A/D conversion equipment to be used in a project concerning the computer analysis of the human electroencephalogram. Salary scale: £400—£847 or £900—£1,130 according to experience or qualifications.—Apply, with full details (and quoting Ref. GWF) to The Secretary, Institute of Psychiatry, De Crespigny Park, Denmark Hill, London, S.E.5. [1966]

**FOR SALE AND WANTED
ADVERTISEMENT FORM
TURN TO PAGE No. 119**

ELECTRONIC DESIGN & DEVELOPMENT ENGINEERS (ALL GRADES) SALARIES UP TO £2,800 P.A.
ELECTRONIC TEST & SERVICE ENGINEERS (ALL GRADES) SALARIES UP TO £1,600 p.a.
TECHNICAL SALES ENGINEERS (EXPERIENCED) SALARIES UP TO £2,500 p.a.
TECHNICAL AUTHORS (ALL GRADES) SALARIES UP TO £1,800 p.a.
ALSO

DRAUGHTSMEN, PRODUCTION ENGINEERS

We have over 500 registered vacancies for above types of engineers in the Home Counties and South England areas. If you have had at least 2 years' experience in British Industry and require a job which offers first class prospects, top salaries and interesting work.

Phone (any time day or night) or write to:—

ELECTRONICS APPOINTMENTS LTD.,

**Norman House,
105-109, Strand, W.C.2
TEMple Bar 5557-8.**



R ADIO ENGINEERS required by the National Guard of Saudi Arabia. Initial contracts for one year, including six weeks' paid leave in United Kingdom. Unmarried men preferred. Salary and allowances approximately £3,300 per annum net. Candidates should have good knowledge of modern HF SSB communications equipment and VHF techniques. Previous experience of petrol engines and teleprinters an advantage. Duties involve repair and maintenance of static, mobile and portable radio equipment throughout Saudi Arabia, and training of local personnel as radio mechanics and operators. Frequent air and road travel is involved. Initial applications, giving brief details of qualifications, experience and past employment, should be made to Brigadier H. E. R. Watson, C/o H.Q., National Guard, P.O. Box 182, Riyadh, Saudi Arabia, by civil air mail at full postage rates. [1961]

T ECHNICAL OFFICER. Home Office Police Research and Planning Branch. Unestablished vacancy for a Technical Officer, Grade III, with knowledge and experience of workshop practice and electronic equipment; the successful candidate will work in the equipment group, which is concerned with assessment, trials and development of a wide range of equipment for police use, and will carry out construction, modification and test work in co-operation with police officers. Qualifications: Ordinary National Certificate or evidence of an equivalent standard of technical education, together with a five-year apprenticeship and at least three years' practical experience. Salary: £895—£1,149 (age 28 or over) £1,283, plus £125 London Weighting. Applications should be made to the Principal Establishment Officer, Room 326, Home Office, Whitehall, London, S.W.1, by 29th March, 1968. [1969]



The Civil Service
(Professional and other appointments)

**RADIO AND ELECTRONIC ENGINEERS
BOARD OF TRADE (CIVIL AVIATION)**

Qualified engineers required as Assistant Signals Officers in the field of Civil Aviation for the provision and installation of advanced electronic equipment—including the latest type of radar, telecommunications, navigational aids, etc.

QUALIFICATIONS: Degree with 1st or 2nd class honours in Electrical Engineering or Physics, or have passed all examinations for M.I.E.E., A.M.I.E.R.E. or A.F.R.E.A.S.

AGE: 23 and normally under 35 on 31st December 1968 (extension for Forces and Overseas Civil Service).

SALARY (Inner London): On the scale £1,160—£2,092 depending on age and qualifications. Pensionable appointments. Good prospects of promotion. (Reference: S/85/ASO)

**EXECUTIVE ENGINEERS
AND ASSISTANT EXECUTIVE ENGINEERS
POST OFFICE**

EXECUTIVE ENGINEERS are required for research, development and design work for electronic telephone exchanges, satellite communications, submarine telephony, novel line and radio transmission systems, electric acoustics, mechanical aids and postal mechanisation. Most of these posts are in London.

There are also posts in engineering management to direct and control the provision and maintenance of communications installations and plant. These posts are available in London and in a number of provincial centres.

ASSISTANT EXECUTIVE ENGINEERS are required in London and provinces for work on the development and design of communications systems and postal service equipment.

QUALIFICATIONS: Executive Engineer: Degree or Dip. Tech. in Mechanical or Electrical Engineering, or Physics or Applied Physics, or have achieved Corporate Membership of the I.E.E., I.Mech.E., or I.E.R.E. Final year students may apply. Assistant Executive Engineer: G.C.E. (or equivalent) pass in English language, and one of the following: H.N.D., in Electrical or Mechanical Engineering or Applied Physics; a pass in (or exemption from) Parts 1, 2 and 3 of the examinations of I.E.E., or I.Mech.E.; a pass in (or exemption from) Sections A and B of the I.E.R.E. examinations; a pass in (or exemption from) Parts 1 and 2 of the examination of the Council of Engineering Institutions, in subjects acceptable to one of the Institutions named above.

SALARIES (national): Executive Engineer: £906 (at 21)—£1,677 (at 34 or over)—£1,884. Assistant Executive Engineer: £734 (at 18 or under)—£1,097 (at 25 or over)—£1,631.

Salaries increased for officers serving in London: £125 Inner London, £75 Outer London. Non-contributory pension. Promotion prospects to higher grades with maxima of £2,484 and £3,105.

AGE: Executive Engineer: At least 21 and under 35 on 31st December 1968. (Some extensions for service in H.M. Forces or Overseas Civil Service.)

Assistant Executive Engineer: At least 17½ and under 27 on 31st December 1968. Applications for both posts from well qualified older candidates will be considered. (Reference: S/353)

APPLICATION FORMS are obtainable from the Secretary, Civil Service Commission, Savile Row, London, W.1. Please quote appropriate reference.

RADAR SIMULATION

Resulting from continued expansion, the following vacancies now exist at Crawley.

PROJECT MANAGER

Applicants should have a minimum of five years' experience in control of projects involving digitalised equipment. They must understand applications of network theory to project control.

DESIGN ENGINEERS

Preferably with experience of radar systems or simulators and analogue computers. Experience of digital techniques and design of computer interface systems would be an advantage.

DIGITAL PROGRAMMER

Applicants must have a sound background in engineering and/or physics, and have a logical mind. Some experience of digital computers and software would be an advantage. Training on the solution of real time problems will be given.

Our products have an assured future in an expanding market. We offer good conditions of service, including contributory pension scheme, coupled with free life assurance.

Apply to: General Manager,
REDIFON LIMITED

RADAR SIMULATOR DIVISION

Kelvin Way, Crawley, Sussex.

Tel: Crawley 23422

A Member Company of the REDIFFUSION Group.



A CAREER IN THE SUNSHINE



RADIO
TECHNICIAN
TRAINING
IN THE



RAAF

Vacancies exist in the Royal Australian Air Force for men who are interested in being trained in the Technical Radio fields. Applicants should be United Kingdom citizens residing in the U.K. and aged between 18 and 33 years. Qualified personnel up to the age of 43 years are also invited to apply.

Free passage to Australia is provided for families and pay commences from date of enlistment in London.

Further information can be provided by writing or phoning:

RAAF CAREERS OFFICER Dept. (ww1) AUSTRALIA HOUSE STRAND, LONDON W.C.2. Telephone No: 01-836 2435



VICKERS
ENGINEERING GROUP

TECHNICIANS

required by the Radiation and Nuclear Engineering Division at South Marston Works, Swindon, Wiltshire, for the installation, commissioning maintenance and service of Electron Accelerators. The work is mainly connected with Electron Linear Accelerators for medical research and industrial applications, and with Cobalt Radiation Units and Nuclear Reactor equipment. Applicants must have a minimum of O.N.C. and preferably H.N.C. or be trained to Technical Sergeant standard in H.M. Forces. Experience with this type of equipment or in radar is desirable but not essential. Applicants must be prepared to travel anywhere in the world. These positions provide for Life Assurance, Pension and sickness benefit with excellent career prospects. The Works are pleasantly sited on the outskirts of Swindon with first-class sports and social amenities. Please reply giving a résumé of career and experience to:

Mr. J. Barber (Ref. 4054), Vickers Limited Engineering Group, South Marston Works, SWINDON, Wiltshire.

CAMBRIDGE

PYE T V T LIMITED

Can offer the following opportunities:—

INSTALLATION ENGINEERS

Senior and Assistant Engineers to install and commission Colour T.V. Transmitting equipment at home and abroad. The posts offer opportunities for travel.

Applicants for the SENIOR ENGINEER posts should have an H.N.C. or equivalent, but candidates without such qualifications who have considerable experience of installation of T.V. broadcasting or other transmitting equipment will be considered.

Applicants for the ASSISTANT ENGINEER posts should have an O.N.C. or equivalent trade or services qualification in electronic engineering. Some experience of installation work on electronic equipment would be an advantage.

Attractive salaries will be paid, according to experience and qualifications. Travelling expenses are paid in addition.

ELECTRONIC DEVELOPMENT ENGINEERS

Engineers for development of Colour Television Transmitters and associated equipment. The vacancies fall into two categories:—

Applicants for the first category are expected to be aged between 24 and 34, with H.N.C. or equivalent qualifications and design experience in at least one of the following activities:—

1. Video and radiofrequency amplifiers up to 1 GHz using solid state and microwave tube techniques.
2. Amplitude and phase equalising networks.
3. High power coaxial networks and feeders.
4. Other work connected with television transmitters.

Applicants for the second category will be aged between 20 and 26, with O.N.C. or equivalent, with some experience in the electronics industry.

Attractive salaries will be paid to Engineers able to provide immediate contribution to a comprehensive work programme.

TRANSMITTER TEST ENGINEERS

Senior and Assistant Engineers to test Colour T.V. Transmitting equipment. This includes a wide range of U.H.F. Transmitters of powers up to 40 kW.

Applicants for the SENIOR ENGINEER posts should have an H.N.C. or equivalent, but candidates without such qualifications who have considerable experience of T.V. Broadcasting or other Transmitting equipment will be considered.

Applicants for the ASSISTANT ENGINEER posts should have an O.N.C. or equivalent trade or services qualification in electronic engineering. Some experience of test work on electronic equipment would be an advantage.

Attractive salaries will be paid, according to experience and qualifications.

Enquiries should be addressed to the Personnel Officer, Pye T V T Limited, Coldham's Lane, Cherry Hinton, Cambridge. Write or telephone Cambridge 45115.

Careers for VIDEO ENGINEERS

COLOUR AND MONOCHROME

Service and Commissioning Engineers

CROYDON AREA

Additional engineers are required with thorough knowledge of professional television equipment for studio and industrial applications, Video recording and some knowledge of colour television techniques. Training in the last two fields can be arranged.

Electronic Tests Engineers

WEYBRIDGE AREA

For work on colour equipment we seek services of experienced Video Engineers. An understanding of transistorised pulse circuitry is desirable.

Conditions of employment are attractive.

Apply in confidence to
Plant Personnel Officer,
Peto Scott Limited,
Addlestone Road,
Weybridge, Surrey.
Tel: Weybridge 45511.

PETO SCOTT
sound and vision

Government of LESOTHO REQUIRES TRAINING OFFICER (TELECOMMUNICATIONS)

for the Posts and Telecommunications Department, on contract for one tour of 24 months resident service in the first instance. Commencing basic salary according to experience in scale Rands 3324 rising to Rands 3684 a year (£Stg. 1939—£Stg. 2149) plus Inducement Allowance £Stg. 277—£Stg. 319 a year. Gratuity 25% of total salary drawn. Liberal leave on full salary. Free passages. Quarters provided at reasonable rental (or an allowance paid in lieu). Children's education allowances. Contributory pension scheme available in certain circumstances.

Candidates should possess at least Intermediate City and Guilds Group Course Certificate in Telecommunications, and be able

to give some formal classroom instruction as well as practical tuition in one or more of the following fields:

- (i) small manual and automatic telephone exchanges, including P.A.B.Xs:
- (ii) line transmission including carrier systems:
- (iii) subscribers installations:
- (iv) external plant, including local distribution planning.

Apply to CROWN AGENTS, M, Dept., 4, Millbank, London, S.W.1., for application form and further particulars, stating name, age, brief details of qualifications and experience, and quoting reference M3D/61523/

Another member is needed for the editorial team of

WIRELESS WORLD

Readers (25/35) with a flair for writing and an interest in the presentation of technical information are invited to send details of education and experience to the:

Editor-in-Chief,
Wireless World, Dorset House,
Stamford Street, London, S.E.1.

EDITORIAL ASSISTANT

'INDUSTRIAL ELECTRONICS', a leading monthly journal for users of electronics, require an editorial assistant to fill a vacancy in their team.

The work is interesting and stimulating; it involves a combination of desk work and visits to industrial plants.

Applicants should be able to write clearly and should preferably have had some formal training in electronics.

Applications should be made to The Editor, 'INDUSTRIAL ELECTRONICS', Dorset House, Stamford St., London, S.E.1.
(Phone 01-928 3333 Ext. 178)



PRODUCTION TEST ENGINEERS

Our activities in the field of telecommunications are substantially increasing, and as a result we have a need for a number of Production Test Engineers capable of fault finding on V.H.F. and U.H.F. mobile equipment involving both transistorised and valve circuitry.

There are also a limited number of vacancies for Systems and Microwave Engineers.

Selected applicants will be based either in Cambridge or Haverhill (Suffolk), and realistic salaries will be offered for these positions.

All enquiries initially should be made to:

THE PERSONNEL MANAGER, PYE TELECOMMUNICATIONS LTD.,
NEWMARKET ROAD, CAMBRIDGE. Telephone: Cambridge (OCA3) 61222

RADIO ENGINEER GRADE II

GOVERNMENT OF TANZANIA

Qualifications: A.M.I.E.R.E., or M.I.E.E. (new regulations) and at least two years' qualified experience in the operation and maintenance of broadcasting studios and transmitting stations.

Duties: To be responsible to Radio Tanzania for the running of Studios and transmitter stations. This includes small installations and modifications to the general layout of equipment.

Age: preferably under 35 years.

Terms of Appointment: On contract for one tour of 21-27 months; Basic salary is in the scale £ Tanzania 918-1,314 p.a. (£ Sterling 1,071-1,533) p.a. subject to local income tax and in addition an allowance, normally tax free, ranging from £768 to £936 will be paid by the British Government direct to the Officer's bank account outside East Africa. Entry point according to experience. Terminal gratuity also payable. Free family passages, educational allowances. Generous leave.

Applicants, who must be nationals of the United Kingdom or the Irish Republic, should apply quoting RC 237/173/04 for further details giving full names, qualifications, age and experience to:-

The Appointments Officer,
Ministry of Overseas Development,
Room 301, Eland House,
Stag Place,
Victoria,
London, S.W.1.

BOOKS, INSTRUCTIONS, ETC.

MANUALS. Circuits of all British ex-W.D. 1939-45 wireless equipment and instruments from original R.E.M.E. instructions: s.a.e. for list, over 70 types.—W. H. Bailey, 167a, Moffat Road, Thornton Heath, Surrey. CR4 8PZ. [166]

TAPE RECORDING ETC.

TAPE to disc transfer, using latest feedback disc cutters: EPs from 21/-; s.a.e. leaflet.—Deroy, High Bank, Hawk St., Carnforth, Lancs. [170]

SERVICE & REPAIRS

REPAIRS.—Our modern service department equipped with the latest test equipment including a wow and flutter meter and multiplex stereo signal generator is able to repair Hi Fi and tape recording equipment to manufacturers' standard.—Telesonic Ltd., 92, Tottenham Court Rd., London, W.1. 01-636 8177. [21]

MISCELLANEOUS

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 METALWORKS, Ltd., Chapman St., Loughborough. [17]

GATESHEAD AND DISTRICT HOSPITAL MANAGEMENT COMMITTEE

SENIOR ELECTRONIC TECHNICIAN

Applications are invited for the above post, to carry out duties in the Gateshead district, N.W. Durham, Hexham district and Prudhoe groups of Hospitals. Qualifications should preferably include the H.N.C. (Electronics or Light Current Electrical Engineering) or City and Guild Telecommunications Engineering Certificate, or of similar academic level. The person to be appointed should have wide experience in the electronic field including telecommunication radio frequency transmission and reception, audio frequency systems, domestic and public entertainment, pulse generation, automatic control systems and electro-medical apparatus. Hospital experience would be an advantage.

The Technician will be based at Gateshead and be responsible to the Group Engineer, Gateshead and District H.M.C. for organising a system of routine maintenance covering a wide variety of electronic equipment. National Health Service conditions of service. Salary within the scale £980-£1,300 p.a.

Applications giving full details of age, education, experience, qualifications and present salary, together with names and addresses of three referees, should be sent to the Group Secretary, Gateshead and District Hospital Management Committee, Queen Elizabeth Hospital, Sheriff Hill, Gateshead, Co. Durham, NE9 6SU.

The 5 GeV Electron Synchrotron (NINA) is operational and is being used for research into high energy physics by University and resident groups. The Synchrotron is housed at Daresbury in north-west Cheshire.

EXPERIMENTALISTS

who have experience of radio frequency techniques at U.H.F. and S. Band or of high voltage pulse forming systems, or alternatively a strong interest and experience in electronics or accelerator physics, are required for the Machine Group.

For part of the time they will provide specialist advice as members of the operating crew of the synchrotron and some three shift working will be involved in this aspect of the work.

For the remainder of the time they will carry out research and development aimed at maintaining the linear accelerator and synchrotron in a high state of efficiency, and as a leader in the field of nuclear physics.

Appointments will be made on the following salary scales and starting salaries will be assessed according to age, experience and qualifications:-

Senior Experimental Officer	£1,977—£2,411;
Experimental Officer	£1,365—£1,734;
Assistant Experimental Officer	£803 (age 22)—£862 (age 23), £916 (age 24)—£970 (age 25), £1,017 (age 26 and above), rising to £1,243.

Additional payments are made for shift working.

Applicants should have a pass degree or H.N.C. in electrical engineering or applied physics or possess equivalent qualifications.

The superannuation scheme is non-contributory. Advice and assistance to obtain 100% house loans is available.

Write for application form, quoting reference number DL/210/M, to

Personnel Officer,
Science Research Council,
Daresbury Nuclear Physics Laboratory,
Daresbury, Nr. Warrington.

Closing date:—28th February, 1968.

Science
Research
Council

DARESBURY NUCLEAR
PHYSICS LABORATORY

Trained in electronics? Interested in aircraft?

Combine both these interests at the Marconi London Airport Service Depot.

Technicians at the depot undertake major servicing of all types of Marconi airborne electronics equipment including navigational aids and V.H.F and U.H.F communication systems. During 1968 there will be an expansion into a new building giving excellent opportunities for rapid promotion.

Applicants should possess a City and Guilds Certificate in telecommunications, equivalent qualification or experience.

Marconi



THE QUEEN'S AWARD TO INDUSTRY

1968-1969

Please write quoting reference WW/AV/7, giving details of age, qualifications and relevant experience to: Mr B K Overy, Divisional Personnel Officer, c/o Directorate of Personnel, English Electric House, Strand, London WC2.

The Marconi Company Limited

AN 'ENGLISH ELECTRIC' COMPANY

RADIO SYSTEMS DIVISION

AUTOMATED DYNAMIC TESTING

DEVELOPMENT ENGINEERS

are required by our Test Gear Department for work on fully automated systems, for carrying out dynamic tests on electronic equipments of advanced design. The project includes:

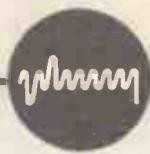
Punch Tape Control Programmable Stimuli and Response Logic Functions

Engineers will work on individual facets of the project, as part of a team, and will be required to embrace conventional measuring methods and advanced digital techniques in new approaches to measurement problems. This is a new and sophisticated technique of production testing calling for SENIOR AND INTERMEDIATE ENGINEERS

Micro Miniaturisation D.C.—400 MHz Dynamic Testing Print Outs

capable of exploring new fields and carrying through to a practical conclusion. Salaries will be negotiated individually and there are generous staff benefits. To apply please send a brief career history, quoting ref. ILF/359/E to The Technical Staff Manager, The Plessey Company Limited, Ilford, Essex.

PLESSEY ELECTRONICS



DEVELOPMENT ENGINEERS

We are a Public Company in the Radio Industry and require Development Engineers for our planned expansion programme. We have a young enthusiastic management team and the successful candidate will be expected to play a full part in furthering the progress of the company by being involved in the preparation of the new models on which the company's expansion will be based.

Applicants must be qualified in radio and/or telecommunication engineering with at least five years experience of RF, IF, FM and audio layout design.

Realistic salaries will be offered to suitable candidates.

Please apply to:—

Personnel Manager,
DANSETTE PRODUCTS LTD.,
Dansette House,
Honeypot Lane,
Stanmore, Middx.

Telephone: 01-907 0021



RESEARCH ASSISTANT

An electronic or electrical engineer with H.N.C. qualifications is required by BISRA to work in the Automatic Control Section of the Plant Engineering Division at our Battersea Laboratories.

The emphasis will be on the practical nature of the work; the ability to construct electronic equipment being particularly important.

Salary will be according to age and qualifications. Conditions of employment in our well-equipped laboratories are good and include a subsidised canteen. There is a contributory pension scheme.

Applications, briefly outlining career history and present salary, should be sent in confidence to:

Mr. A. B. Driver,
Personnel Officer,
BISRA—The INter-Group Laboratories of the
British Steel Corporation,
24, Buckingham Gate, London, S.W.1.

Please quote reference PE/AC/1 in your reply.

NEWCASTLE REGIONAL HOSPITAL BOARD

ELECTRONIC ENGINEER

in Regional Engineer's Department. He will be responsible to Regional Engineer for advice and guidance on the selection, use and maintenance of all electronic equipment in hospitals in the North East and in Cumberland. There are two electronic technicians in a small, well equipped laboratory under his control and he will supervise electronic technicians employed by hospital management committees in eight outstations. He will advise the Regional Engineer on choice, design and development of electronic equipment and controls needed in mechanical and electrical projects, as part of the Board's capital programme of £6 million per annum. This is a new section of the Board's staff and the work may grow.

Applicants must be Chartered Electronic Engineers with wide practical and administrative experience. Work will demand breadth of vision, initiative, energy and tact. Hospital experience not essential.

Salary within the scale £1,640 to £2,300 according to age and experience.

Applications, giving details of age, qualifications, experience, present salary and three referees to the Secretary of the Board, Benfield Road, Walker Gate, Newcastle upon Tyne, NE6 4PY, by 29th February 1968.

ENTHUSIASTS Have you considered a career in Technical Authorship? If you have sound experience in electronics or communications and ability to write clear concise English we would train applicants as Technical Authors. The commencing salaries range from £1,300 to £1,700 depending on experience with the prospects of high future rewards and earnings.

Box No. 5039, c/o Wireless World

ARTICLES FOR SALE

A VO electronic multimeter, as new, £17.—Knight, 33, Furness Rd., London, N.W.10. [204]
EDDYSTONE VHF communications receiver, model 770R (Mark I), as new.—Craig, 16, George Reith Ave., Glasgow, W.2. [1989]
VACUUM pumps, gauges, etc. recorders, general scientific and laboratory equipment, catalogue.—V. N. Barrett & Co., Ltd., Ol-654 6470. [69]
COMPUTER panels containing transistors, diodes, etc., 8 for 20/-, postage 2/6; dismantled from ex-govt. computer; satisfaction guaranteed.—N. R. Bardwell & Co., 81-83, Sellers St., Sheffield, 8. [206]
FOR sale:—Scott 25-tube, also one with expander unit, Midwest 18-36 and one 18-38; offers, please.—Details from: Percival, 6, The Staithes, Lowestoft, Suffolk. [208]
THE world's smallest wireless microphone rifle, bullet size, using hearing aid type battery, £7/10; shirt button size ultra sensitive microphone 20/-.—Box W.W. 213, Wireless World.

RADIO TECHNICIANS

A number of suitably qualified candidates are required for unestablished posts, leading to permanent and pensionable employment in Cheltenham and other parts of the U.K. including London. There are also opportunities for service abroad.

Applicants must be 19 or over and be familiar with the use of Test Gear, and have had practical Radio/Electronic workshop experience. Preference will be given to candidates who can offer "O" level and GCE passes in English language, Maths and/or Physics, or hold the City and Guilds Telecommunications Technical Intermediate Certificate or equivalent technical qualifications.

Pay according to age, e.g. at 19—£828, at 25—£1,076 (highest age pay on entry).

Prospects of promotion to grades in salary range £1,169-£1,941. There are a few posts carrying higher salaries.

Annual leave allowance of 3 weeks 3 days rising to 4 weeks 2 days. Normal Civil Service sick leave regulations apply.

Application forms available from:—

Recruitment Officer (BT),
Government Communications Headquarters,
Oakley, Filton Road,
Cheltenham, Glos.

ENGINEERS

IBM will train you for a responsible career in data processing

To become a successful IBM Data Processing Customer Engineer, you need more than engineering qualifications. You need to be able to talk confidently and well to any level of customer management, and to have a pleasing personality in your work. As a DPCE, you work in direct contact with your customers, on some of the world's most advanced data processing equipment.

You must have a sound electronic and electro-mechanical background, such as ONC/HNC Electronic or Electrical, or Radar/Radio/Instrument Fitters course in the Armed Services.

You will get thorough training on data processing equipment throughout your career. Starting salaries depend on experience and aptitude, but will not be less than £1,100 a year. Salary increases are on merit—you could be earning £1,900 within 3-5 years. Drive and initiative are always well rewarded at IBM; promotions are made on merit and from within the company.

If you are between 21 and 31 and would like this chance to become part of a rapidly expanding and exciting computer industry, write to IBM.

However, if you are between 18 and 21, IBM can offer you the chance of a challenging career as a Junior Customer Engineer.

You need five G.C.E. 'O' levels, an aptitude for mechanics, a good understanding of electrics, a clear logical mind, and the ability to get on well with people.

Send details of training, experience and age to Mr. D. J. Dennis, IBM United Kingdom Limited, 389 Chiswick High Road, London W4, quoting reference E/WW/262.

IBM

Electronic/instrumentation technician engineers

The Atomic Energy Research Establishment at Harwell has vacancies for Technician Engineers in several sections giving instrumentation support to the scientific work of the establishment.

The posts are in the following fields:

- (i) Assistance in applied research, development, design, commissioning and diagnostics of instrumentation, data processing and control as applied to scientific research.
- (ii) Assistance in design, development diagnostic work and commissioning of electronic control equipment associated with particle accelerator machines or research reactors.
- (iii) Assistance in experimental and development work concerned with research on semiconductor radiation detectors, special semiconductor devices and microelectronic techniques for nucleonic and other applications.
- (iv) Design and development of electromagnetic devices and the application of these to a variety of equipment; e.g. solid-state DC to DC converters.

For this stimulating and interesting range of work we are looking for technicians who possess qualifications in Electronics or a related subject at least equivalent to

O.N.C. and who preferably either hold, or are currently studying for, a higher qualification. In addition applicants should have served a recognised apprenticeship or have had equivalent training. Appointments will be made in the Technical Class Grades II and III depending on age and experience. Salary scales are shown below.

is dependent on the shift system being worked and varies between 12½% and 20% of salary.

SALARY Technical Class Grade II; £1,375 to £1,595 per annum.
Technical Class Grade III; £1,040 (at age 23) to £1,230 (at age 28 or over on entry) to £1,375 per annum.

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PARTICLE ACCELERATOR OPERATORS are also required to join small teams engaged in the control and fault rectification of these machines. The work is novel and interesting and calls for sound technical judgement. Applicants should have served a recognised electrical engineering apprenticeship or have had equivalent training and possess an appropriate Ordinary National Certificate or equivalent qualification. The work involves the use of:

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INSTRUMENTS for sale: Solartron laboratory amplifier Model AWS-51-A, bandwidth 5c/s-800 Kc/s, gain 94 d.b., 15c/s-350 Kc/s, £30; Muirhead Wigan Decade Oscillator, Type D-105-A, 10c/s-111 Kc/s in 1 c/s steps, £40; Dawe wide range oscillator, Type 400 B, 20 c/s-200 Kc/s with output V.V., £25; Dawe wide range oscillator, Type 400 C, 1 c/s-1 Kc/s with output monitor scope, £20; Muirhead volt ratio box, Type A-202-A, resistance 50 Kn, max. voltage 1 kv, £5; these instruments are in good condition and working order, from private laboratory; postage not included.—Box WW1987, Wireless World.

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FLEMING diode & magnetic detector.—Rasmussen, 164, Lowell, Redwood City, California, U.S.A. [205]

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PATENTS

THE proprietors of Patent No. 950,830 for "Improvements in Antennae" desire to commercialise exploitation in the United Kingdom by licence or otherwise. Replies to: Sydney E. McCaw & Co., Saxone House, 52-56, Market St., Manchester 1. [1985]

BOOKS

"ULTRASONIC delay Lines." C. F. Brocklesby, B.Sc., A.R.C.S., A.M.I.E.R.E., J. R. Paice, R. W. Gibson, B.Sc. (Eng.), Grad. I. Mech. E. The authors are members of a team which has been working on ultrasonic delay lines since the early days at the Mullard Research Laboratories. This is the first book to be written specifically on the subject, which has important applications in radar, radio and television, electronic computers, pulse-forming networks, correlation techniques and multi-channel communication systems. The early chapters discuss basic principles and the various types of delay lines are then covered. The chapter on electronics for delay lines deals fully with the design of broad-band amplifiers, oscillators, etc., either with transistors or valves. The last two chapters are devoted to the delay line measurements and the many applications of delay lines. Among the five appendices there is one containing nearly 60 curves which give the characteristics of many delay line materials. The final appendix discusses one of the latest developments, ceramic transducers. 65/- net, 66/3 by post.

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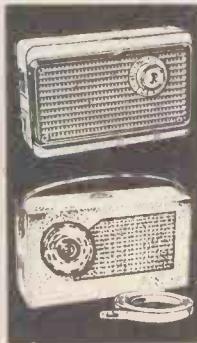
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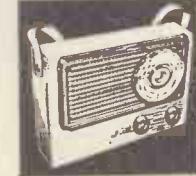
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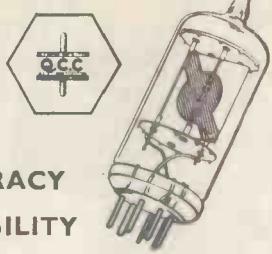
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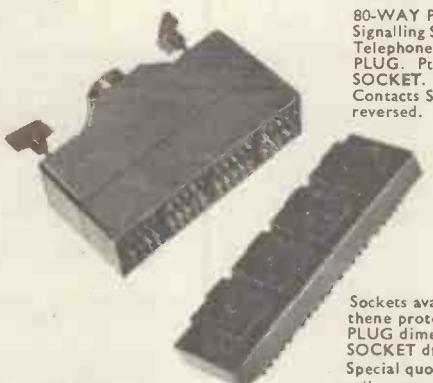


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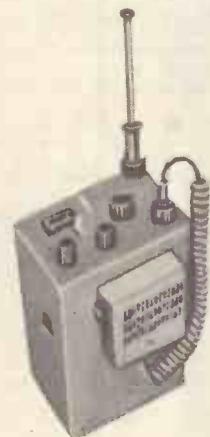
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Send 6d. stamp for extensive list of low-priced
Electronic Components, Instruments & Equipment.
Please include 1/- postage & packing on all orders
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Dept. WW9.

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WW—137 FOR FURTHER DETAILS

LANCASHIRE COUNTY COUNCIL

Tenders are invited for the supply of the following:
20 No. Hudson F.M.660 Radiomobile Sets.

Tender documents are obtainable from the County
Surveyor and Bridgemaster, County Hall (P.O.
Box 9), Preston, on payment of a deposit of £5 0s. 0d. (refunded on receipt of a tender not
subsequently withdrawn). Cheques must be made
payable to "Lancashire County Council."

Tenders to be received by the Clerk of the County
Council, County Hall, Preston, by 10.00 a.m. on
Tuesday, 9th April, 1968.

423/97 Wireless World.

WW—138 FOR FURTHER DETAILS

CLASSIFIED ADVERTISEMENTS

Use this Form for your Sales and Wants

To "Wireless World" Classified Advertisement Dept., Dorset House, Stamford Street, London, S.E.1

PLEASE INSERT THE ADVERTISEMENT INDICATED ON FORM BELOW

- Rate: 6/- PER LINE. Average seven words per line.
- Name and address to be included in charge if used in advertisement.
- Box No. Allow two words plus 1/-.
- Charge etc., payable to "Wireless World" and crossed "& Co."
- Press Day 4 March for April 1968 issue.

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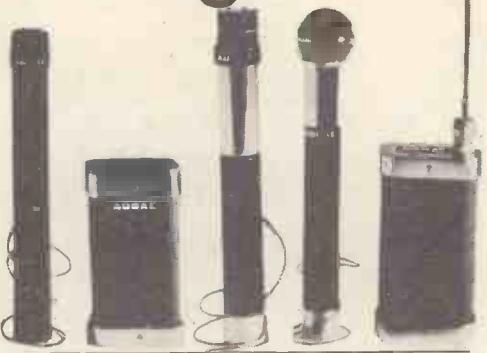
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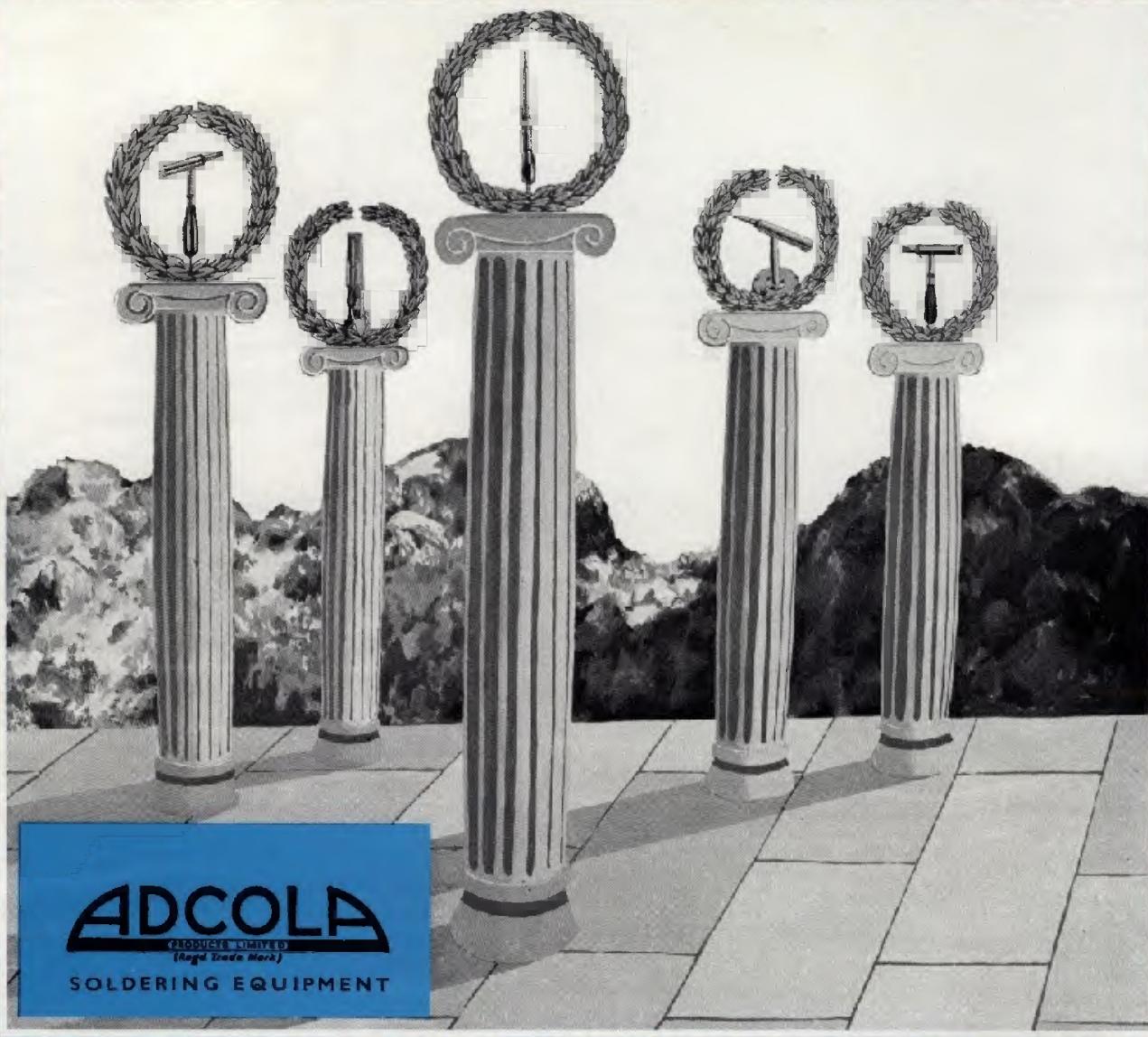


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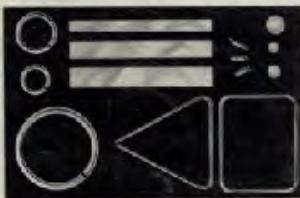


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**we make these products to help
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A complete range of products for the soldering of printed circuits, including:
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3

3a automatic soldering machine

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5

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2

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4

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6

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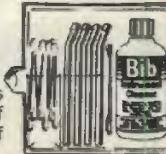
B

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C

tape head maintenance kit size E



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D

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