Wireless World

March 1968 Three Shillings

The world's best loudspeaker?
Large-scale microelectronics

Wireless World

MARCH 1968 **VOLUME 74 NUMBER 1389**

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CONSUMER ELECTRONICS

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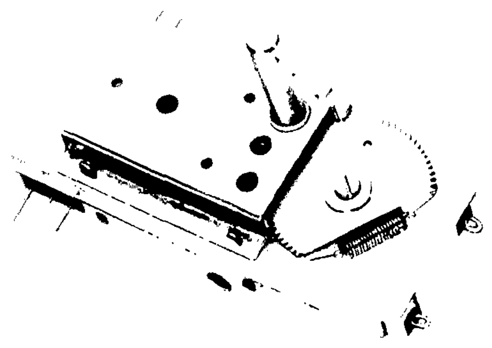

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WW—094 FOR FURTHER DETAILS

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 $33\frac{1}{3}$% 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. Monograph[1]). 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 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.

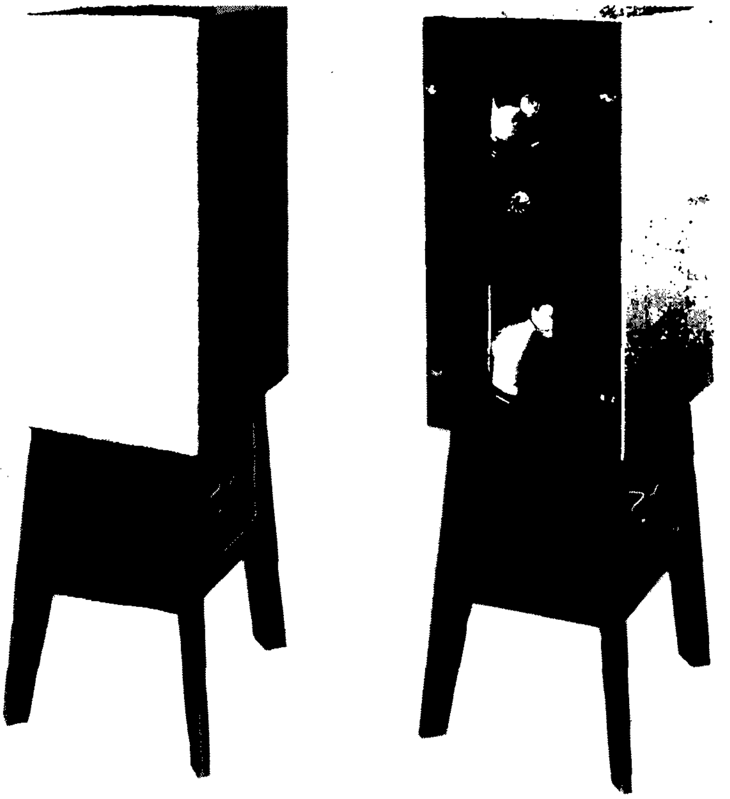
It was explained earlier that the existing low-frequency units were chosen on the basis that they were relatively free from colouration

† 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.

‡ 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.

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.



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.

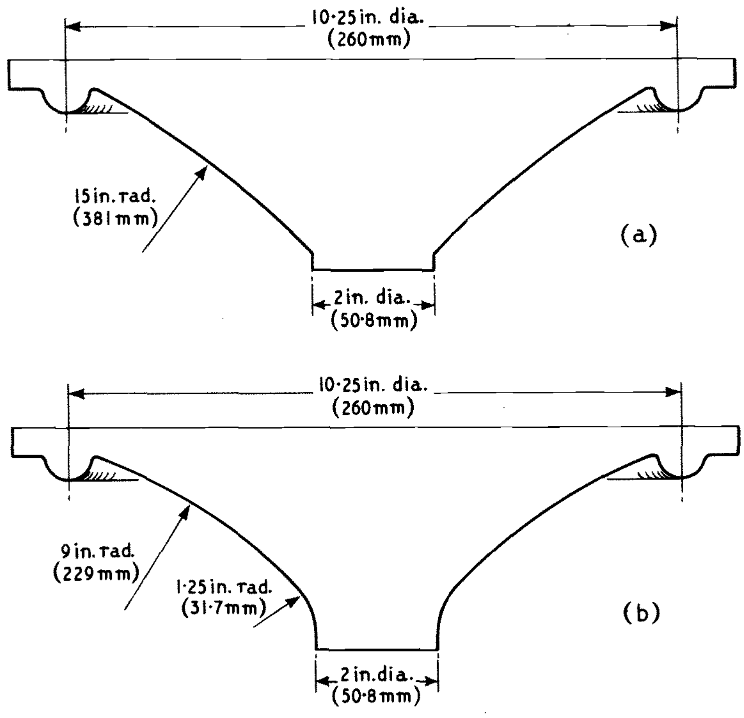
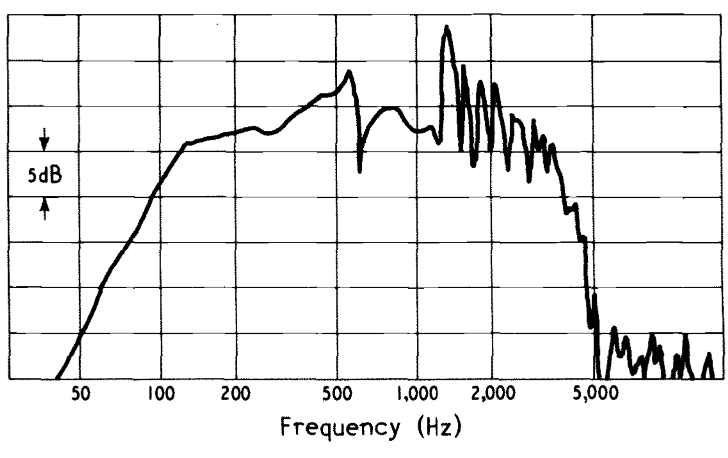


Fig. 1. (a) Shape of first mould; (b) shape of second mould.

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



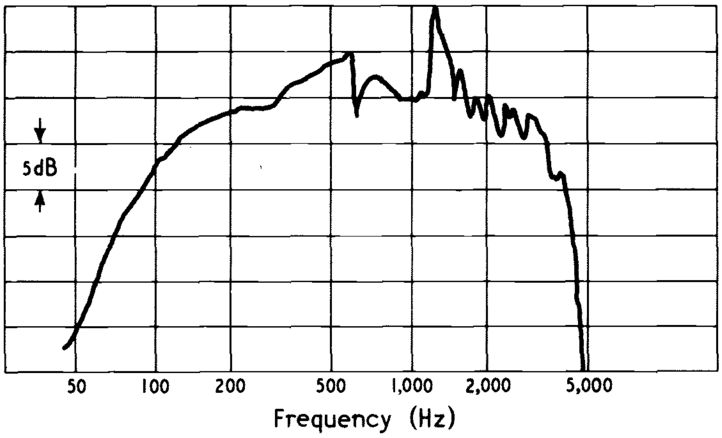
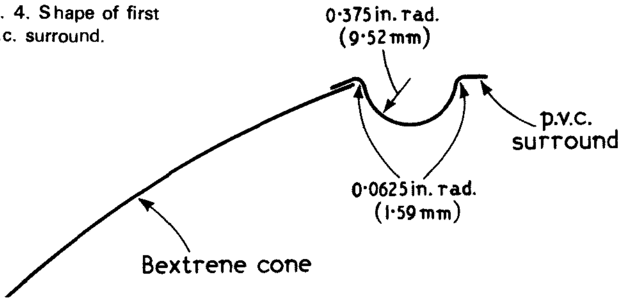


Fig. 3. Axial frequency characteristic of Bextrene cone from first mould.

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



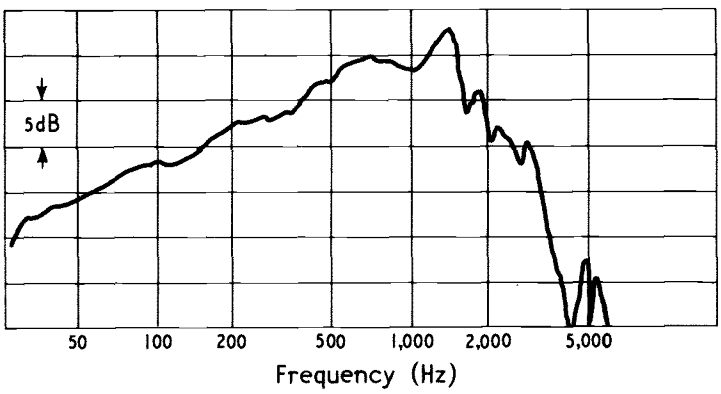


Fig. 5. Axial frequency characteristic of Bextrene cone from first mould. Fig. 1 (a). fitted with p.v.c. surround of shape shown in Fig. 4.

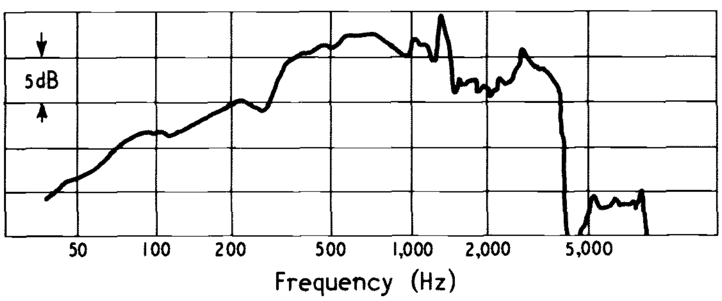
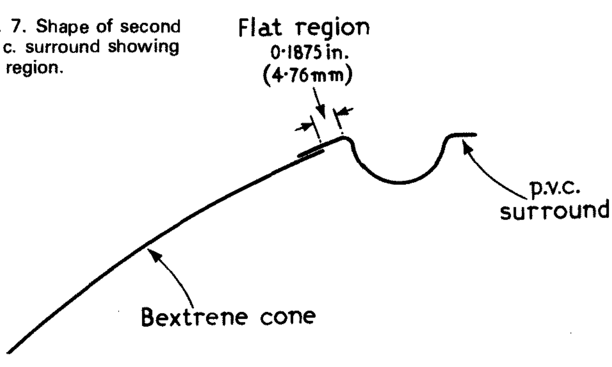


Fig. 6. Axial frequency characteristic of Bextrene cone from second mould, fitted with p.v.c. surround of shape shown in Fig. 4.

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 tests[3] 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 $\pm$ 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

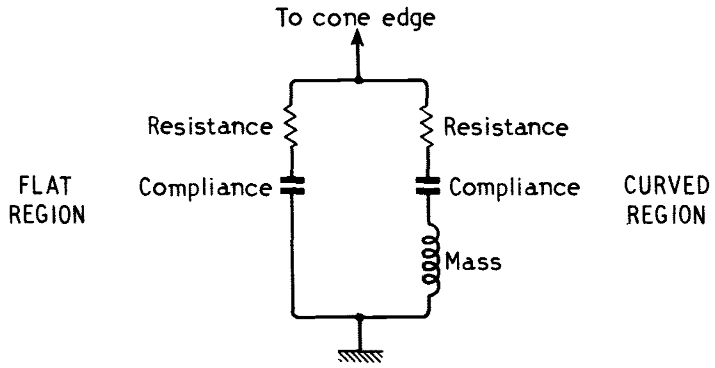


Fig. 8. Mechanical circuit diagram of surround.

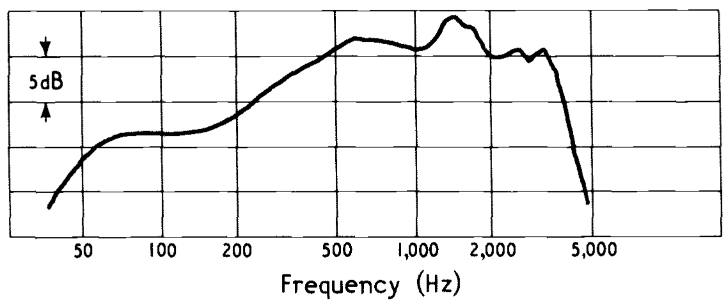


Fig. 9. Axial frequency characteristic of Bextrene cone fitted with p.v.c. surround of the type shown in Fig. 7.

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 some 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.

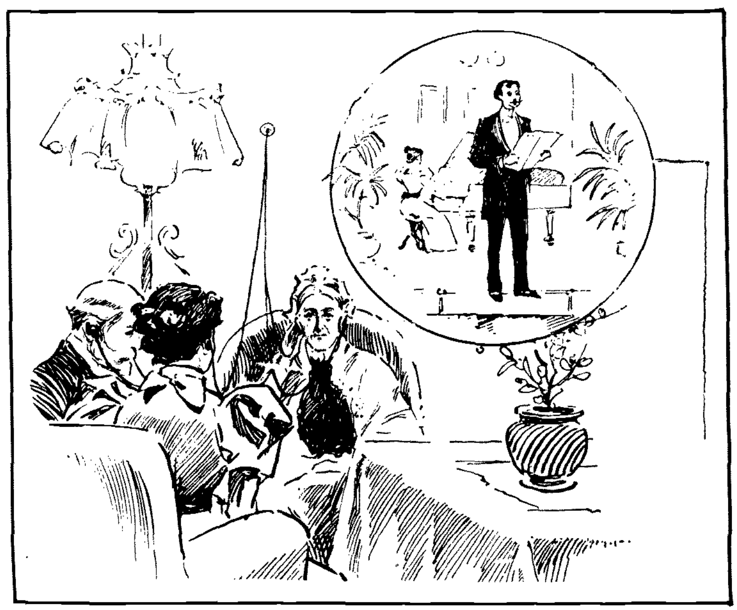
Rapid Servicing of Transistor Equipment by Gordon J. King. Intended for service technicians, students and amateurs, this book provides a guide to the servicing of domestic equipment employing transistors. Initial chapters include theoretical and practical discussions on transistors, how they are biased, 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. Pergammon 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 Paderewski 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 × 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.

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".

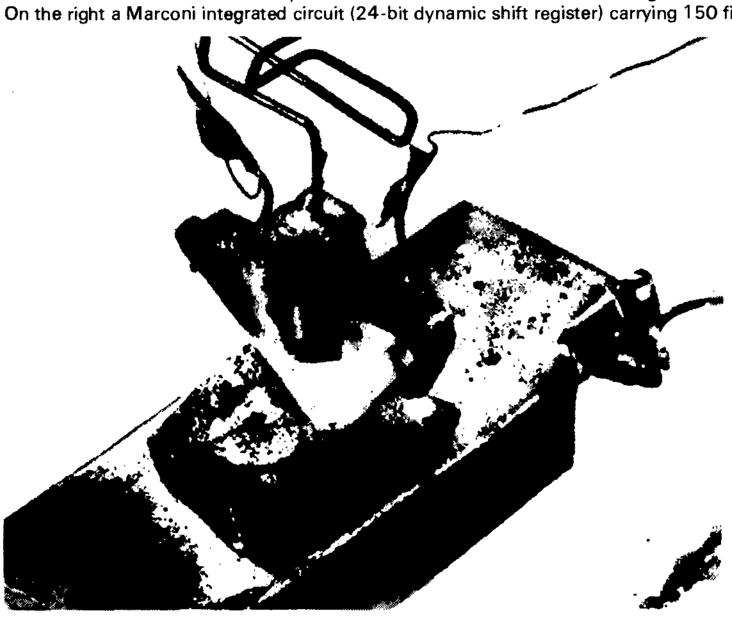
For the present it is perhaps reasonable to think of the more complex i.c. packages now commercially available—containing the equivalent of, say, fifty to several hundred discrete components—as a stage in our progress towards l.s.i. For example, there is the SGS-Fairchild Cµ L9989 binary counter, comprising 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.

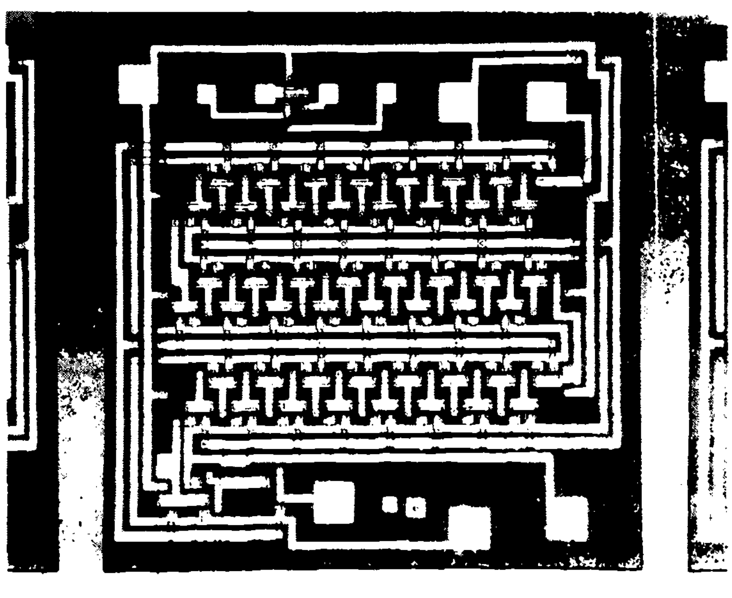
It can be seen that such products are really digital sub-systems—one step up in functional complexity from the gates and bistables that were the first elements to appear in integrated circuit form. As with the simpler i.cs, the main benefits to be gained from m.s.i. are greater economy and reliability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

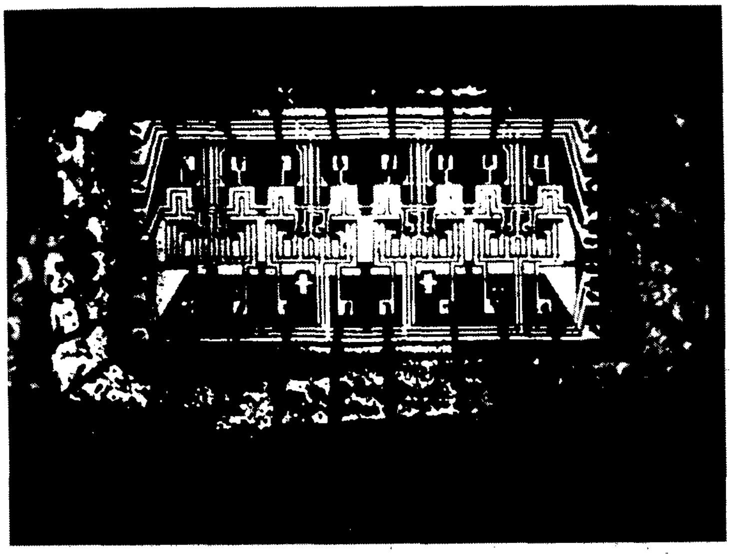
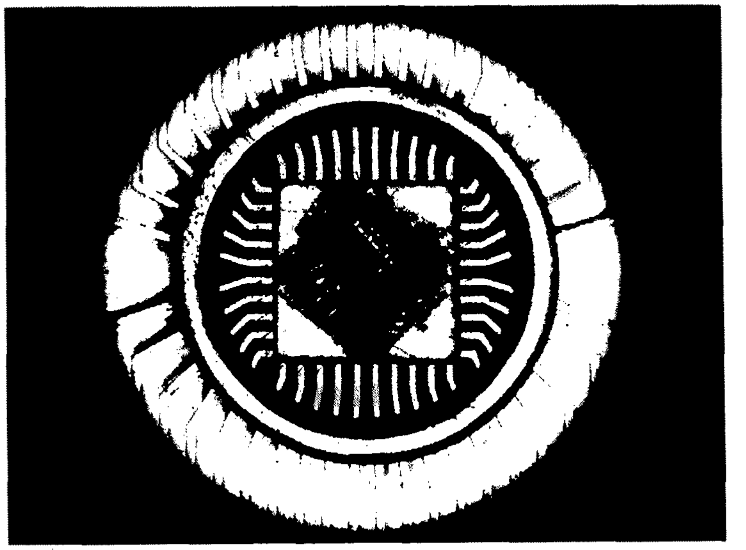
While the smaller integrated circuits are being manufactured predominantly in bipolar form, with increasing complexity of circuit the m.o.s. field-effect technology becomes more and more attractive and may eventually be the natural choice for m.s.i. and l.s.i. The two main advantages of m.o.s. over bipolar 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

* See note on D.G. Smee 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.

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 coordinatograph to produce a mask for an m.o.s. integrated circuit.

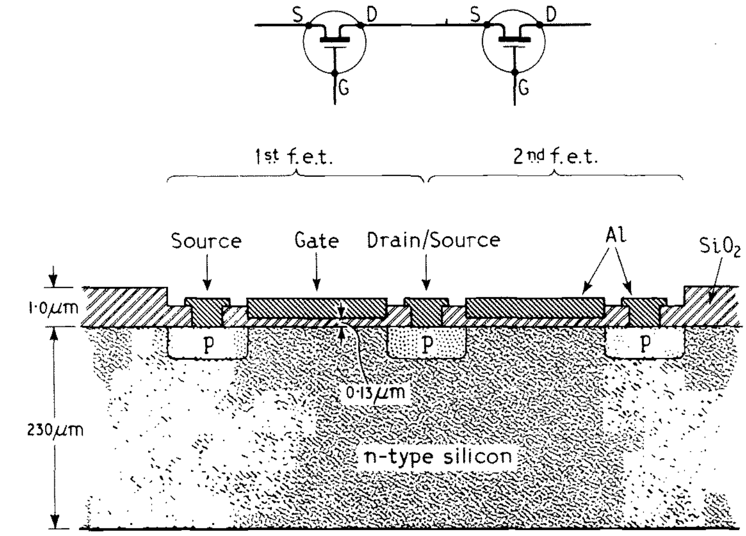


Fig. 1. Basic structure of a field-effect device in an m.o.s. integrated circuit (not to scale), showing how two of the devices can be easily connected in series by making one p-type region common to both.

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.

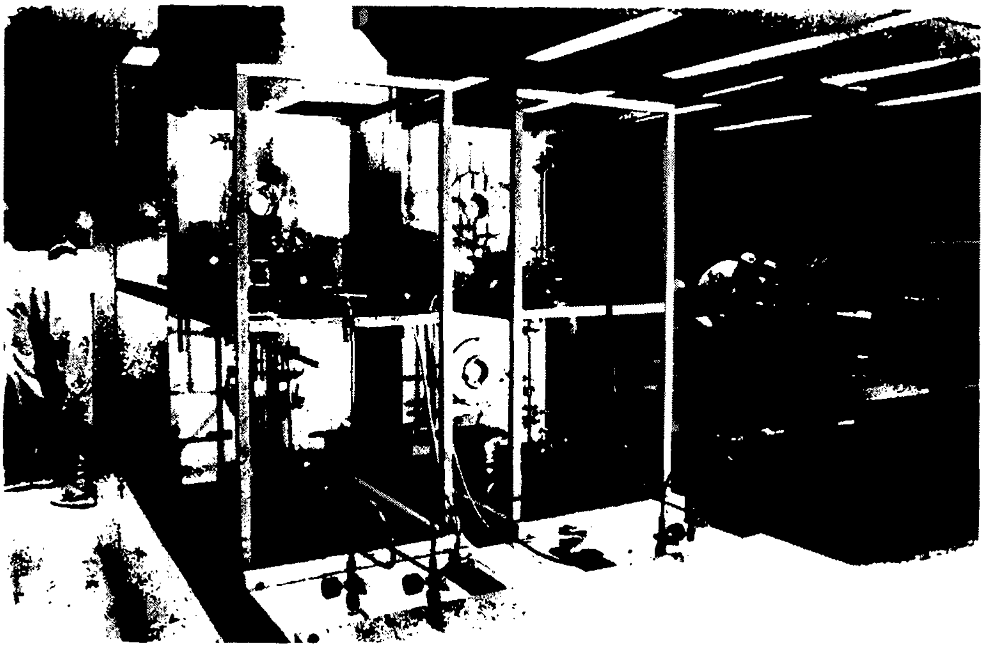
Two major problems in making and using the m.o.s. technique are: (a) the manufacturing difficulty of achieving uniformity of threshold voltage (the V_{GS} at which I_D is at a specified low value) in the production of a given i.c.; and (b) the susceptibility of the thin layer of gate-insulation oxide 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 1μm layer of silicon oxide (precise chemical name, silicon dioxide—SiO_2) on the slices of n-type silicon, which are approximately 230μm thick. This is done by passing oxygen over the slices while they are being heated to 1,200 °C in an electric furnace.

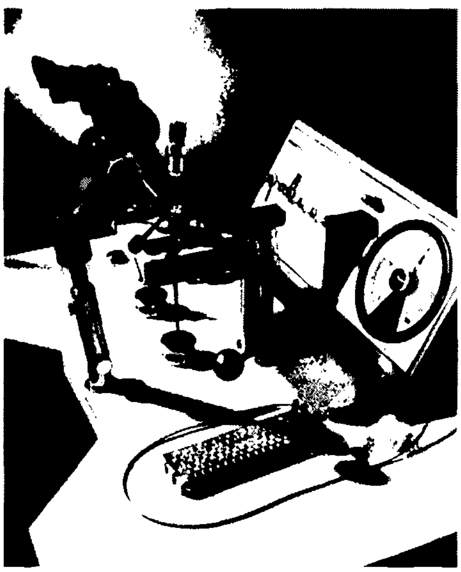
To obtain the type of structure shown in Fig. 1 it is necessary selectively to etch away areas of the oxide coating, diffuse an impurity (boron) into exposed parts of the n-type silicon to form the p-type source and drain, and, finally, evaporate areas of metal film on to the upper surface to form the 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-



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.

London Physics Exhibition

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 Elektromesstechnik (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 sub-systems, 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.

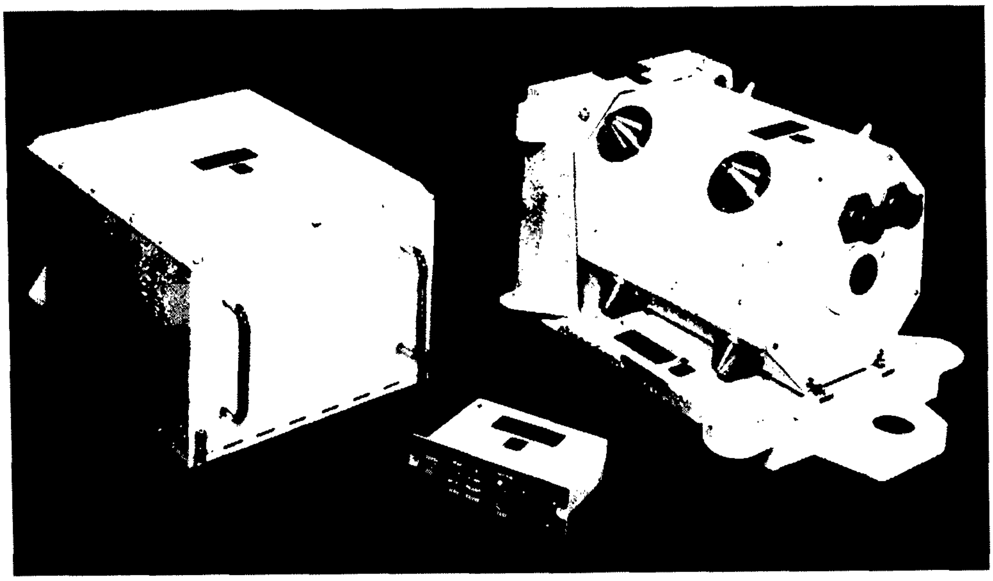
Not really an electrician's nightmare but the flight deck wiring of *Concorde* prototype 002 being built at B.A.C.'s Filton Division. A large proportion of the cables have been supplied by British Insulated Callenders Cables Ltd.

NAVIGATION

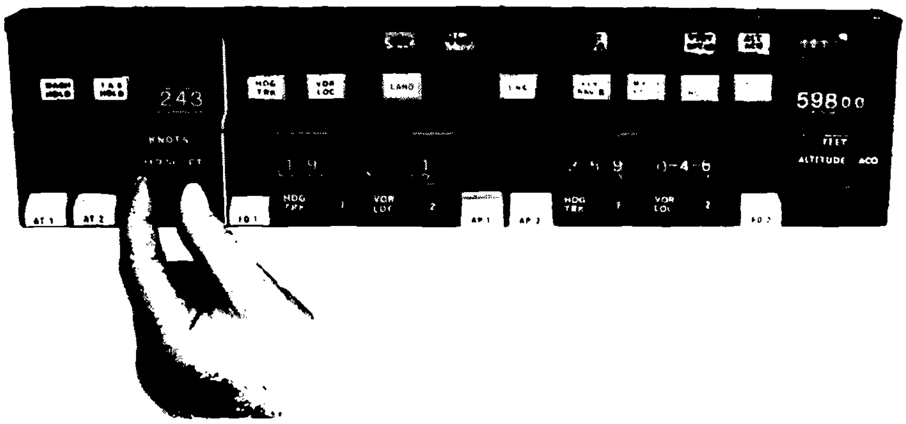
The degree of automation of the navigational equipment is such that *Concorde* does not carry a navigator, this function being performed by the pilots. Because of the long periods of acceleration and deceleration and other factors peculiar to this type of aircraft, conventional vertical gyroscopes are 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 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 cf the information that is vital to navigation.



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.

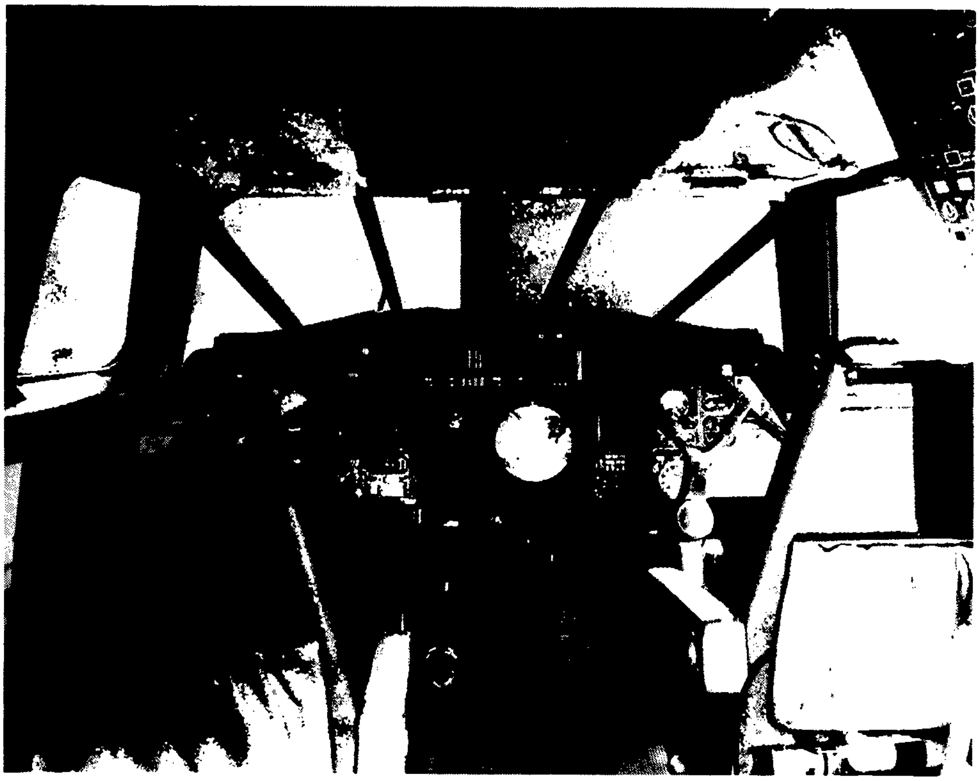
The prototype *Concordes* will carry two inertial platforms, although it is thought that three may be fitted to the first production aircraft. The navigation system to be described here is as used in the prototypes and has been developed by a consortium formed by Ferranti (U.K.) and SAGEM of France. 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, 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 feed 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 μs (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.

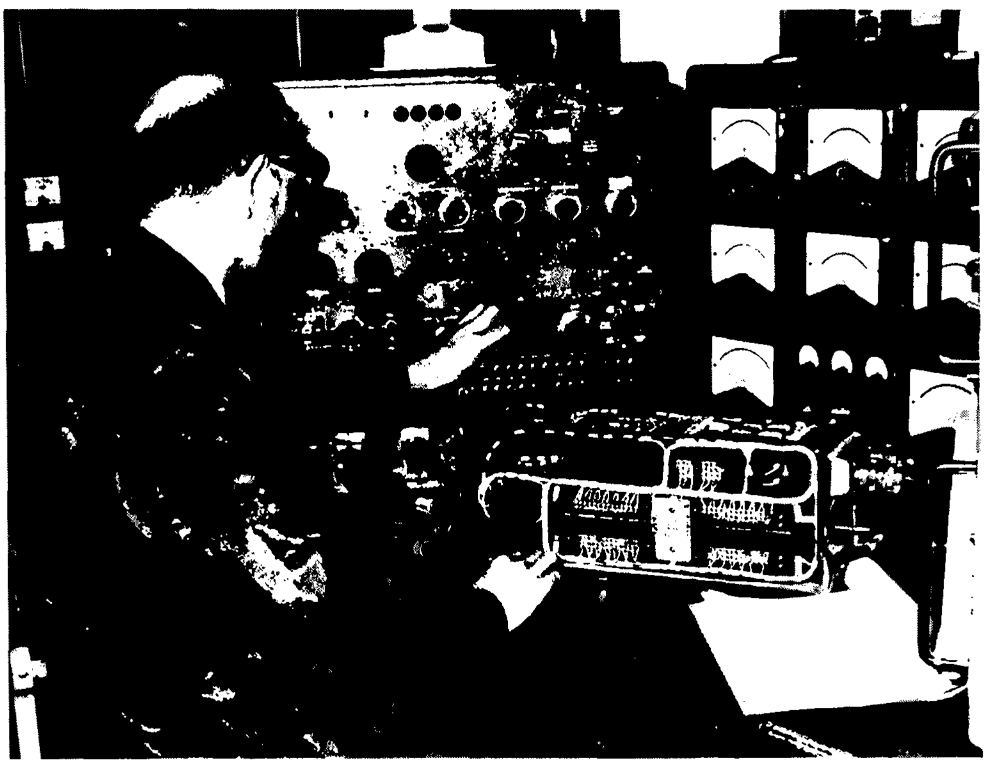
The automatic flight system described has been designed by a consortium including Société Francaise D'Equipment pour la Navigation Aérienne (S.F.E.N.A.) and the Navigation and Control Division of the Bendix Corporation of America headed by Elliott Brothers as prime contractors.

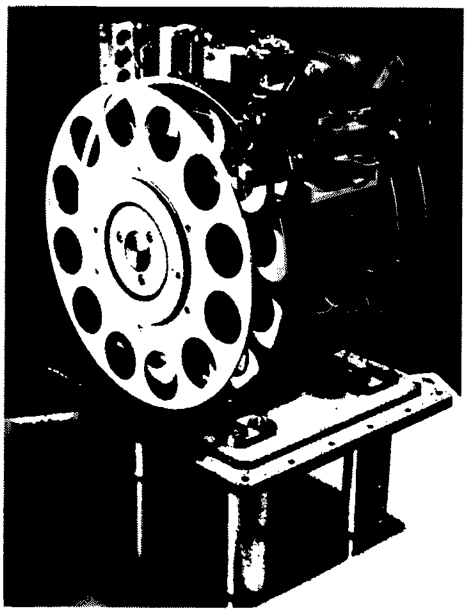
COMMUNICATIONS

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 μV 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 taxying. 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.

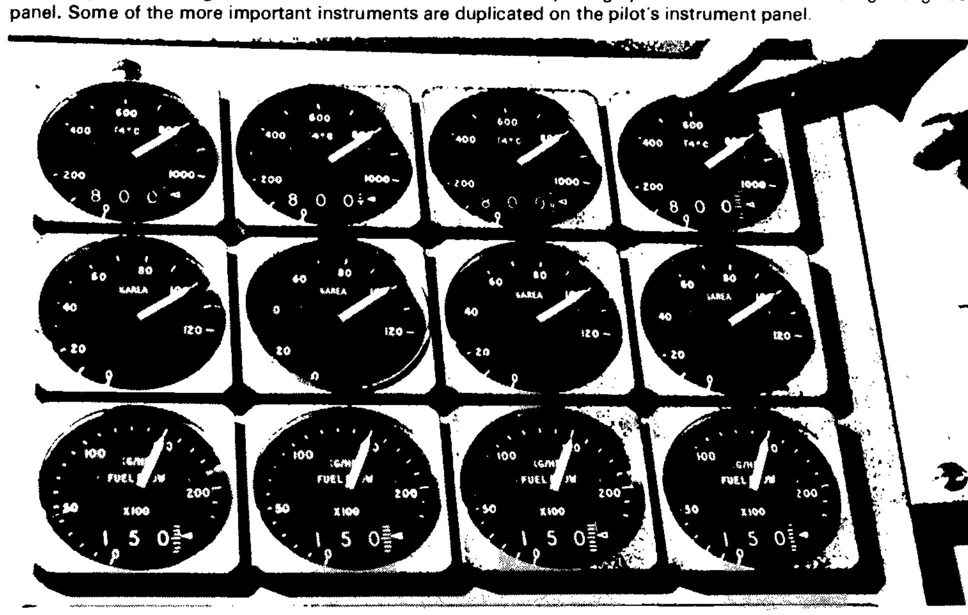
A good deal of the engine instrumentation is also being manufactured by Elliott's. These take the form of miniature indicators with, in many cases, a certain amount of the computing circuitry built into them. These instruments are mounted on the flight engineer's control panel with "essential service" 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°C$\pm$5°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 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

The control room of the experimental station at Carnarvon.

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 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.

Lord Jackson

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

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 Television 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.

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 electronics 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, Belling 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. Spagnoletti,** 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. Wilsox, 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 pieceparts 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 styli, 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 — Alexandra Palace
Physics Exhibition
(I.P.P.S., 47 Belgrave Sq., London, S.W.1)

BIRMINGHAM

Mar. 28 & 29 — Aston University
Technology, Industry, Education
(C. Fleetwood-Walker, Birmingham & Midland Inst., Margaret St., Birmingham 3)

CRANFIELD

Mar. 25-28 — College of Aeronautics
Aerospace Instrumentation Symposium
(N. O. Matthews, Dept. of Flight, College of Aeronautics, Cranfield, Beds.)

GLASGOW

Mar. 8-16 — Kelvin Hall
NORBEX—North British Engineering Exhibition
(Lintex Ltd., 226 Grand Bldgs, Trafalgar Sq., London, W.C.2)

HARROW

Mar. 12-14 — King's Head Hotel
Public Address Show
(Assoc. of Public Address Engrs, 394 Northolt Rd., South Harrow, Middx.)

OVERSEAS

Mar. 5-8 — Toulouse
Nuclear Electronics and Radioprotection Symposium
(Faculte des Sciences, Universite, 118 route de Narbonne, Toulouse)

Mar. 7-12 — Paris
Festival du Son
(Fédération Nationale des Industries Electroniques, 16 rue de Presles, Paris 15e)

Mar. 21-23 — Boston
Microwave Power
(International Microwave Power Inst., Box 342, Weston, Mass. 02193)

Mar. 25-29 — Paris
Colour Television Conference
(Colloque sur la Télévision en Couleur, 16 rue de Presles, Paris 15e)

Mar. 27-Apr. 7 — Rome
Electronics, Television & Radio Show & Convention
(Rassegna Internazionale Elettronica, via Crescenzio 9, 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 familiarity 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.

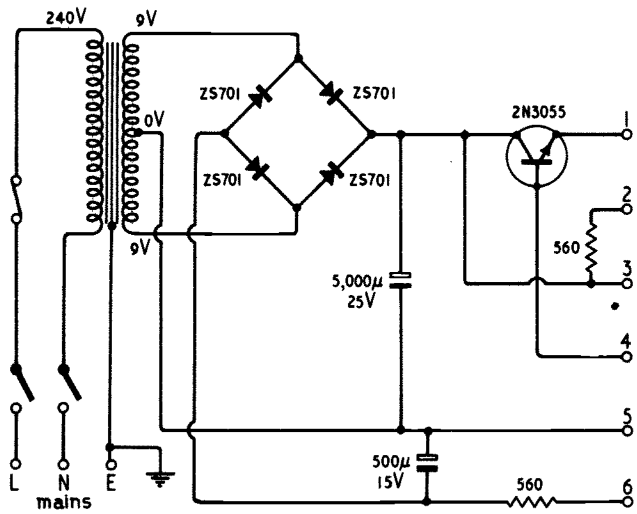


Fig. 1. A typical power supply for use with the stabilization module.

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.

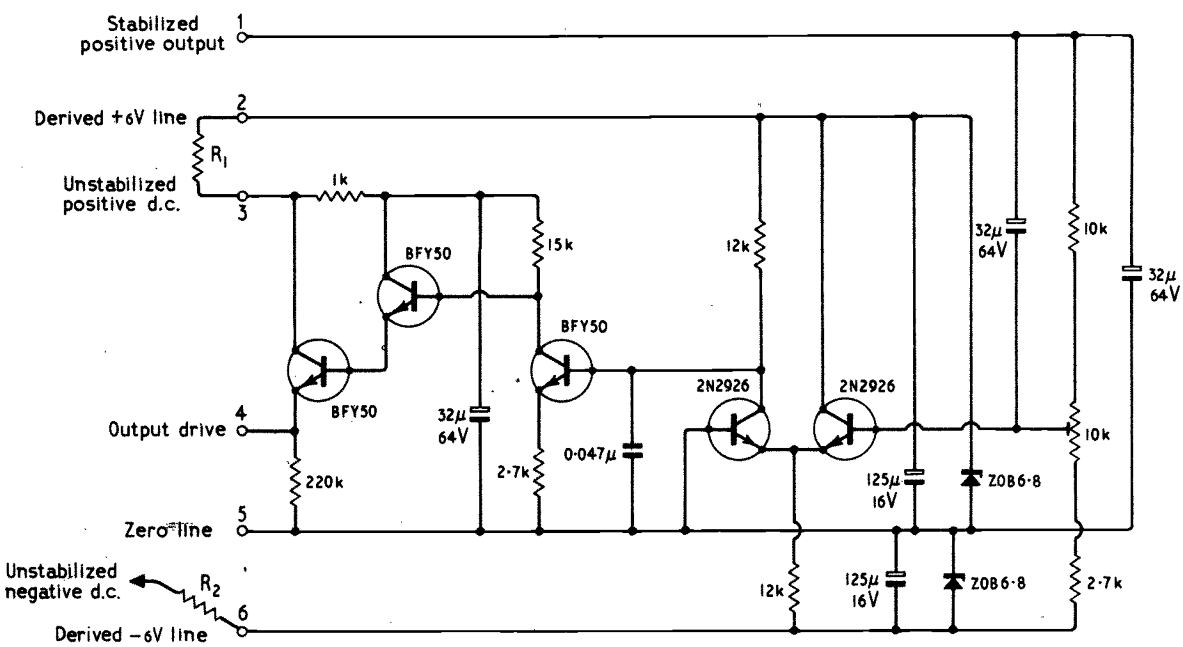


Fig. 2. Details of the stabilization module circuit including the two external resistors. All resistors are Erie EMI 5%; electrolytic capacitors, Mullard C426 series; potentiometer, Painton Miniflatpot; and the 0.047 μF capacitor, Mullard C280Ae. The output from the module is taken from terminal No.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

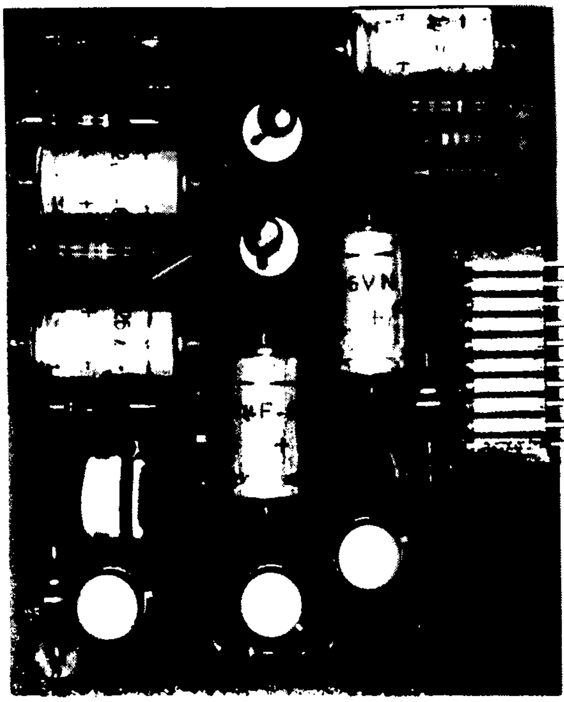


Fig. 3 The prototype module.

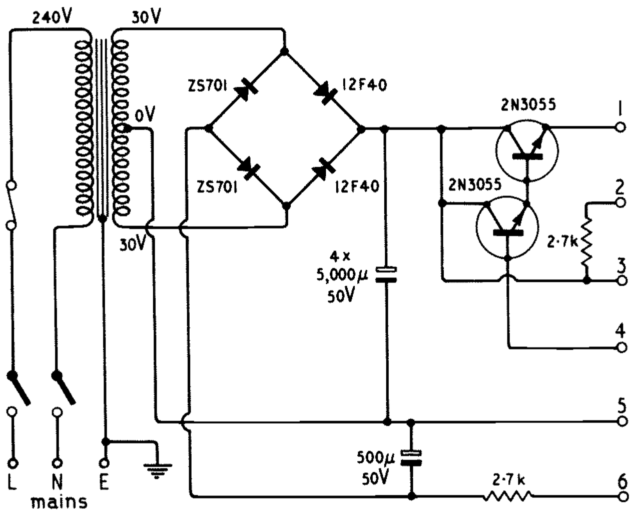
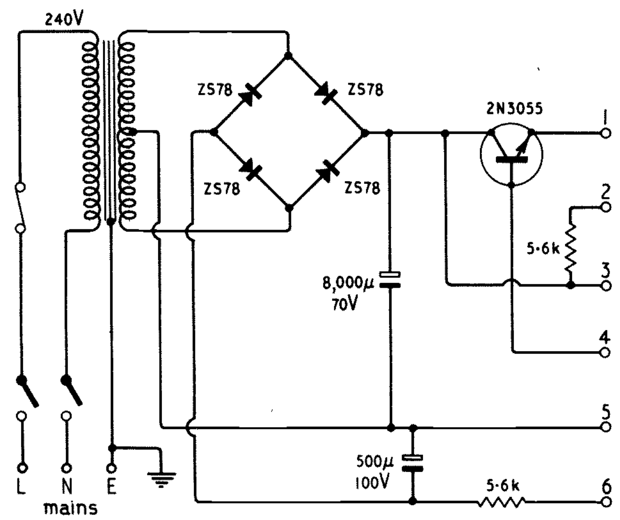


Fig. 4. Power supply giving an output of 24 V at 5 A. Output is taken from pins 1 and 5.

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 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.

*Amatronix Ltd.

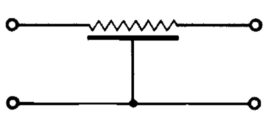
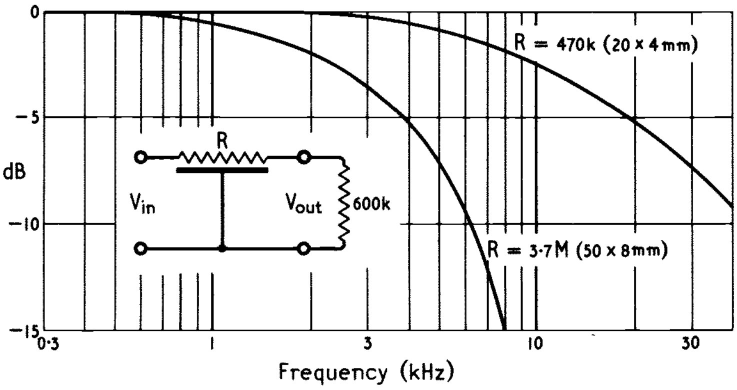


Fig. 1. Distributed RC transmission line.

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



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 $\sqrt{(-jR/\omega C)}$, 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

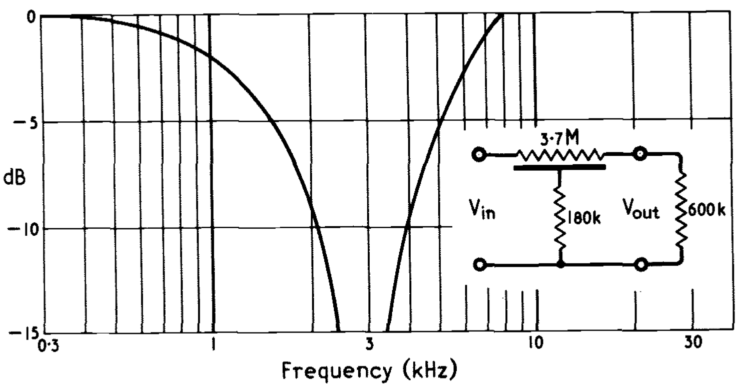


Fig. 3. Notch filter. A complete null is obtained only for one combination of frequency and earth-lead resistance.

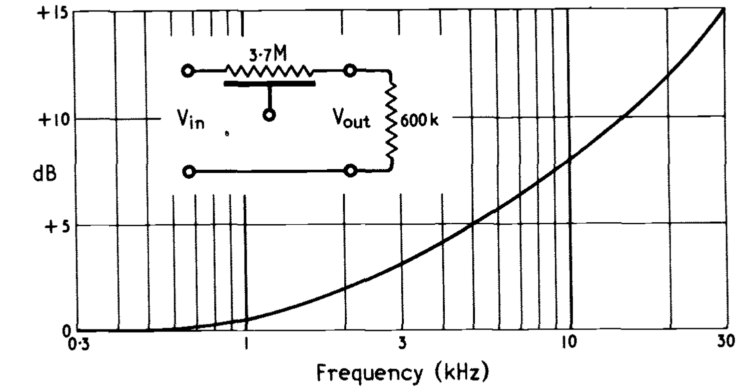


Fig. 4. Top-lift connection. When the "earth" is left off the response rises with frequency. The l.f. insertion loss depends on the resistance values.

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.

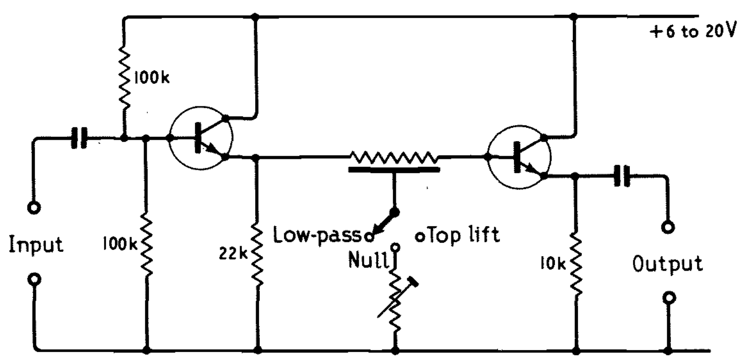


Fig. 5. Practical circuit giving low-pass, notch, and top-lift responses. Any good high-gain low level planar transistors (2N3707, BC109, BC168B, etc.) may be used.

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 × 8mm high stability carbon) against (frequency × 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 4.7kΩ (50 × 8mm) 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.

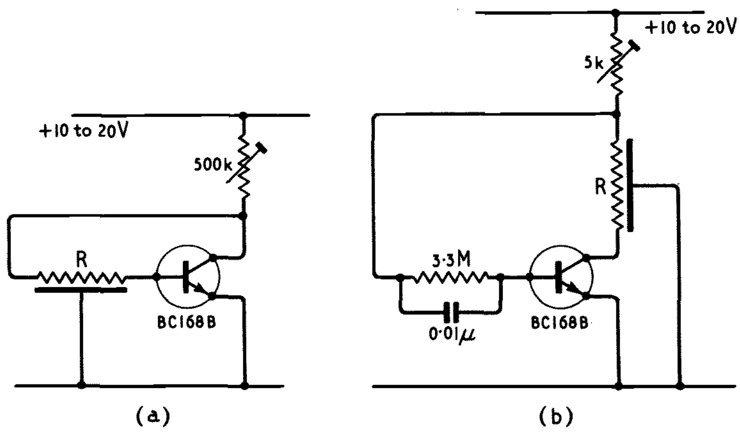


Fig. 6 Phase shift oscillators: (a) low-frequency, for R up to 5 MΩ; (b) high-frequency, for R down to 1 kΩ.

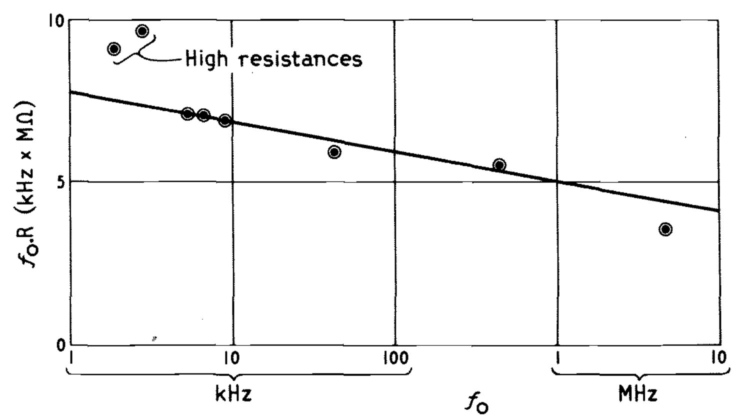
ACCIDENTAL KELVIN CABLES?

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. 7. Resistance-frequency product for oscillators plotted against frequency of oscillation for one size of resistor (50×8 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).

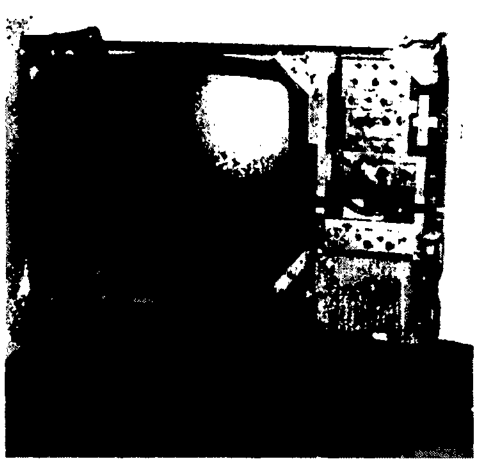
PAUL SPINK

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.

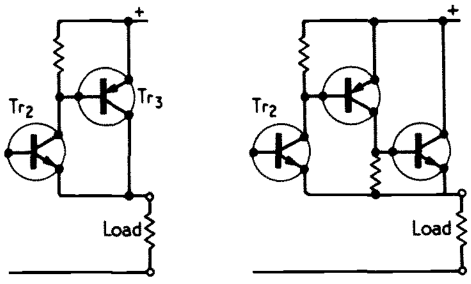
THOMAS PALMER

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



(a) (b)

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.

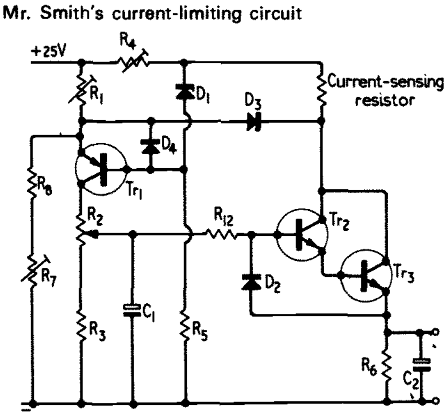
E. F. GOOD

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.

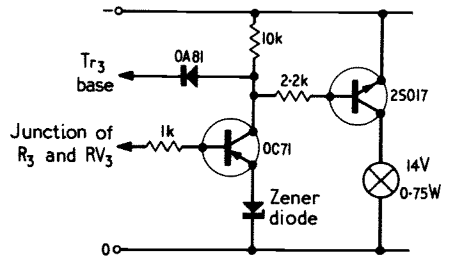
D. BOLLEN

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-hygroscopic 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

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 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.

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 *n*th 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 developed 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.

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

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

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

Time-Controlled Combination Lock

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

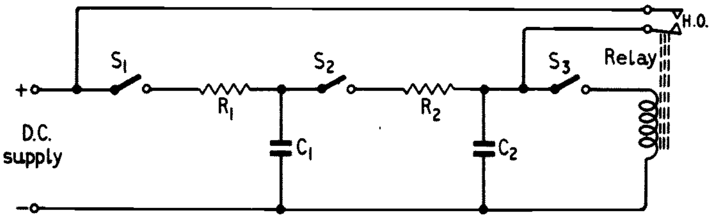
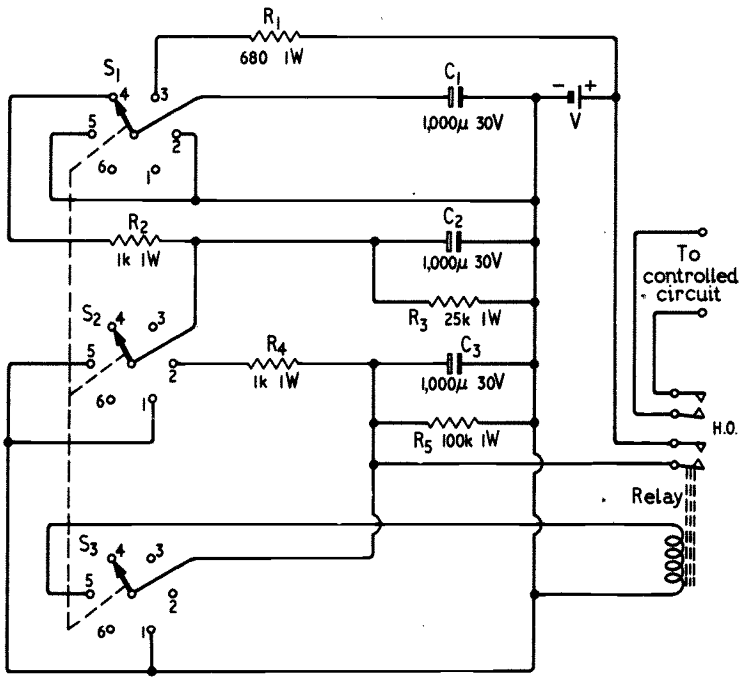


Fig 1. A simplified circuit diagram illustrating the principle involved.

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		4 ,,
11	5	C_1 & C_2 shorted, C_3 discharges through relay. Relay operates.	—
		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/m^2 (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.cs. 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 × 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 Vanmuysen (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 Whitsuntide 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 telegraphy. The contest is confined to R.S.G.B. members resident in the United Kingdom and British Commonwealth.

Faroes Activity.—Using several transmitters and a number of operators, the headquarters station (OY6FRA) of the Faroes 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 Faroes.

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. Wiejlaw 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. Higonnet. *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.

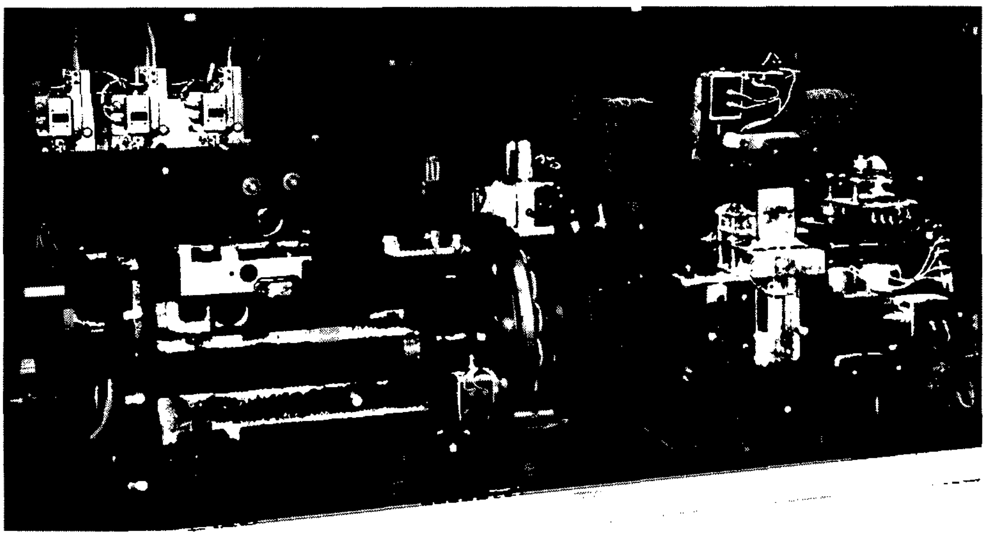
If photo-typesetting machines are to be economical in use they must be very productive (since they are expensive in first cost) and they must offer a wide choice of characters (so that jobs of different kinds may be run successively without the machines having to be stopped to change the character "matrices" 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 × 12 sizes) and the Model 713 a total of 6,144 (768 characters × 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 is

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.

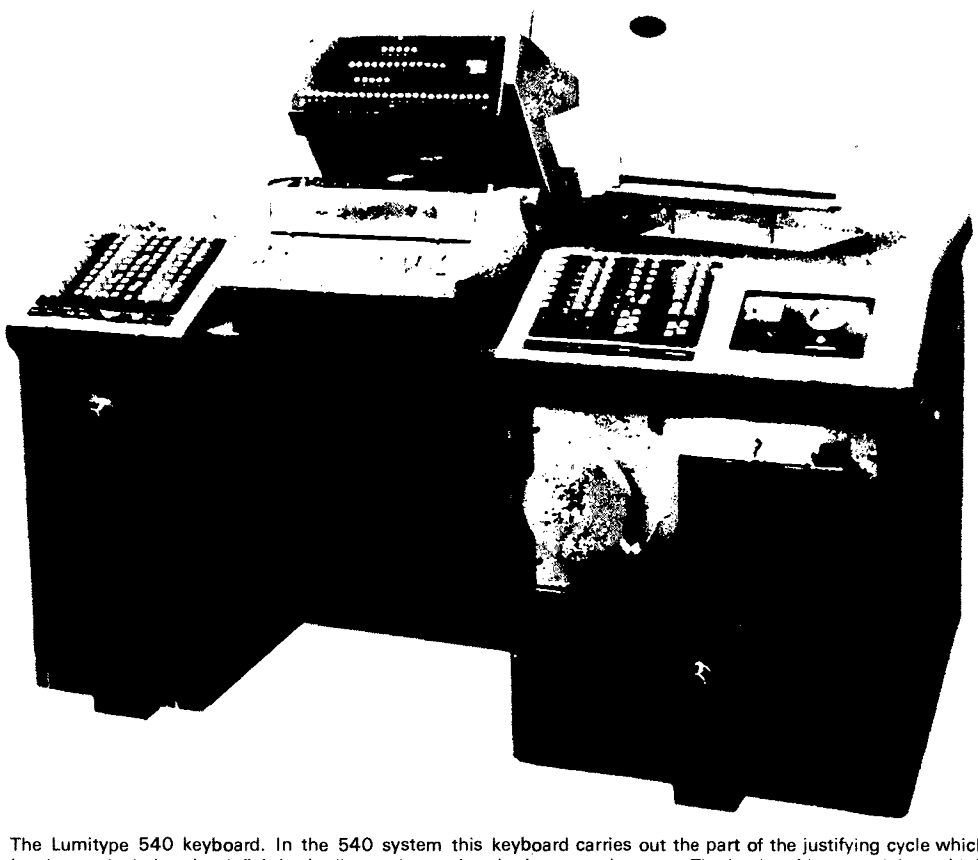
carried from fixation to fixation forward along the line; in crude terms, it must be obvious that the type in which the line is composed is designed to be read from left to right. At least since the time of the early Venetian printers these qualities have been so much a part of the design of most text 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.

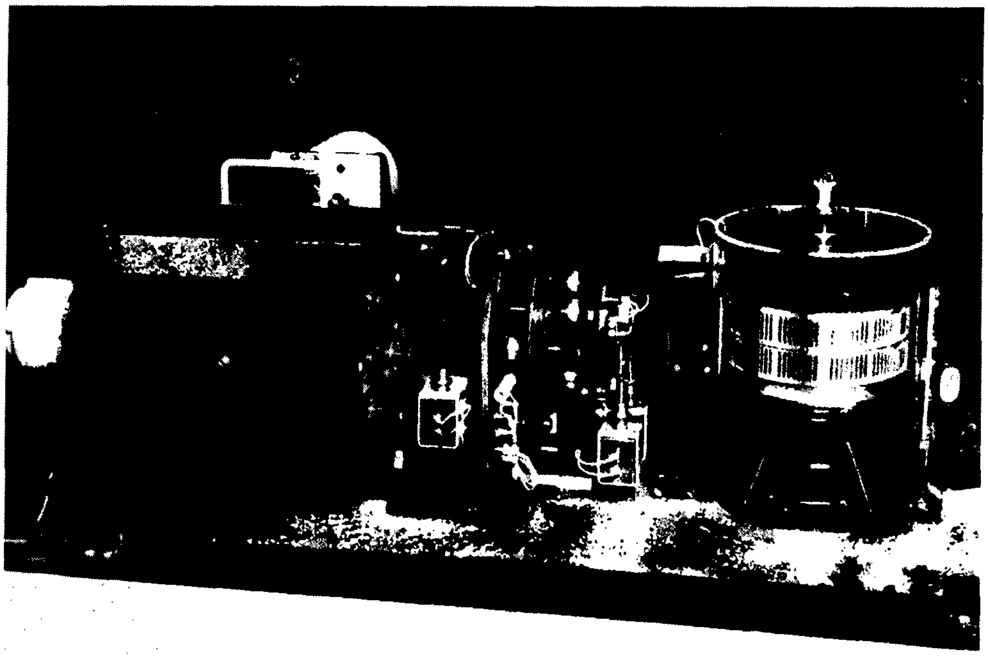
In most photo-typesetting systems the widths of characters are expressed on a "unit system" in which the body size of the type—which would be its depth from front to back if it were cast in metal—is divided into 18 "relative units" ("relative" because they change in absolute size with changes in the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

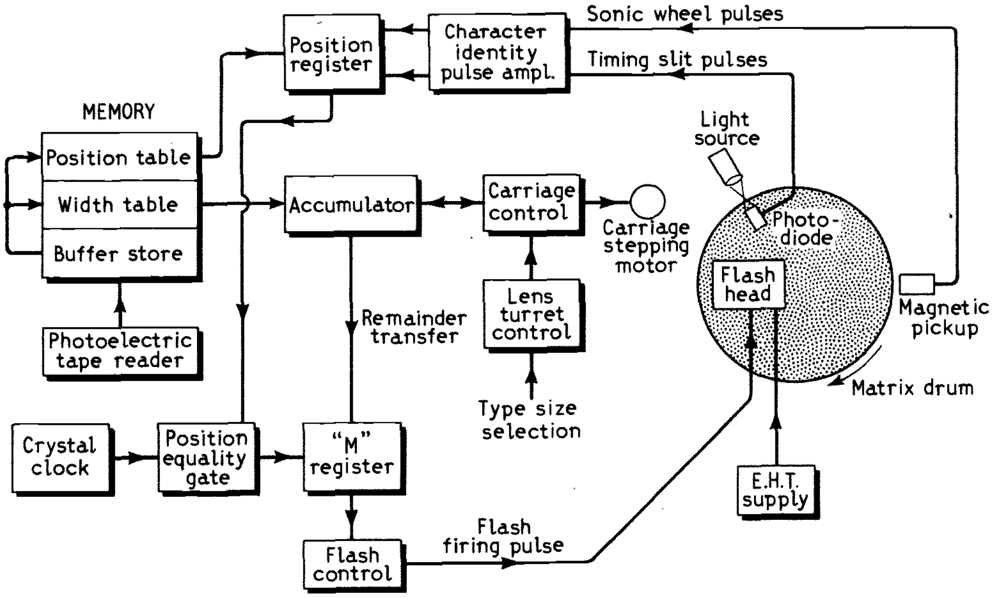
Associated with each group of eight characters (one above the other) on the matrix drum of the 713 is a timing slit, and on the base of the drum is a "sonic wheel" which, in conjunction with a magnet and a pick-up coil, provides a pulse at each complete revolution of the drum (Fig. 1). When a character 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

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

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.

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.

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.

Every $9\frac{1}{2}$ miles a repeater amplifier is inserted into the cable to compensate for cable losses. These amplifiers utilize a system of high- and low-pass filters to enable amplification to take place in both directions. Power 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.

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.

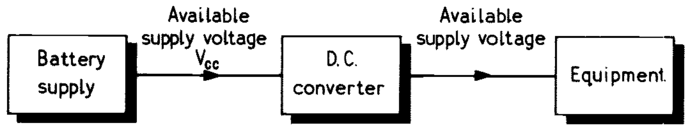


Fig. 1. Arrangement for operating equipment from batteries.

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.

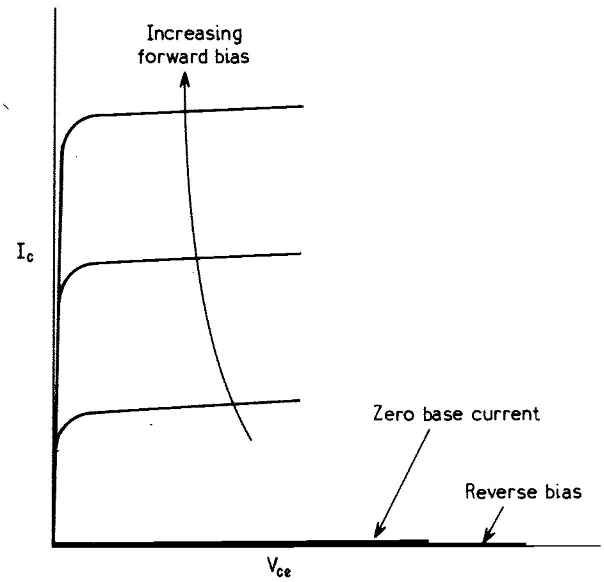


Fig. 2. Collector current vs. collector voltage characteristic of a transistor.

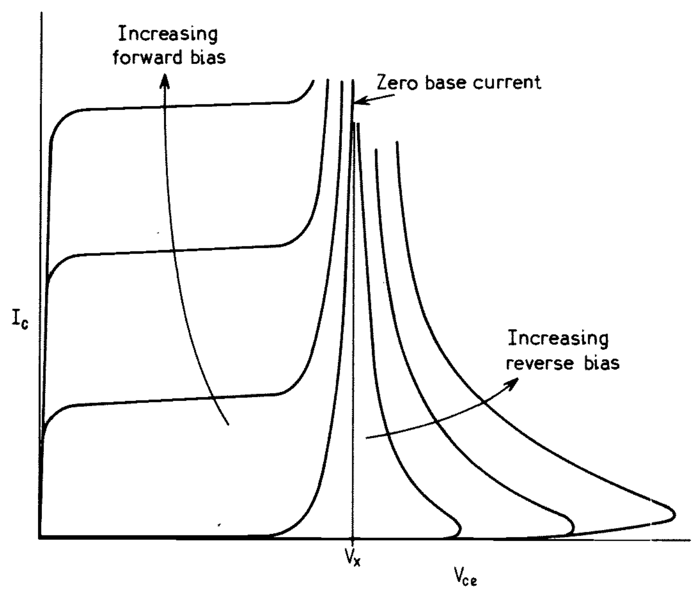
TRANSISTOR RATING

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



* Mullard Ltd.

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.

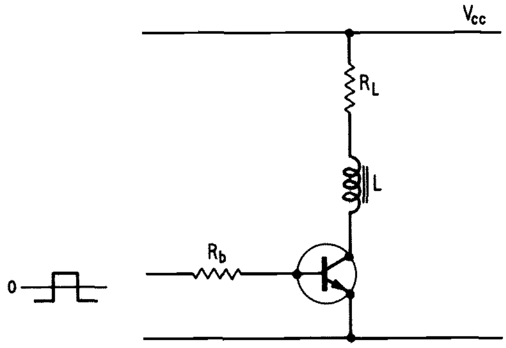


Fig. 4. Basic arrangement of transistor working into inductive load, as found in inverter circuit.

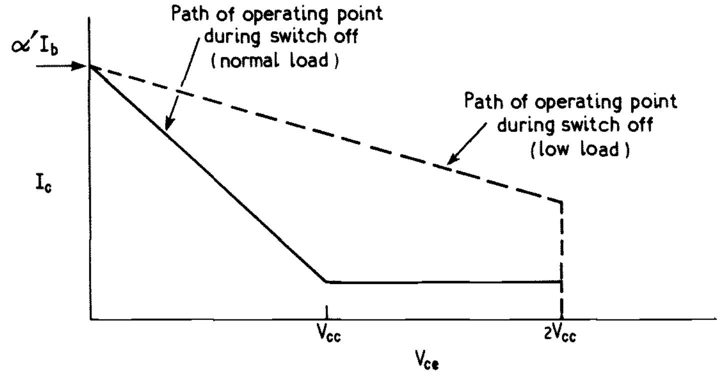


Fig. 5. Path of transistor operating point for normal and low loading.

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 principle[1] 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 $\frac{1}{2}L_pI_{CM}^2$.

During the output stroke, when the transistor is cut off, the reverse voltage rises rapidly until the secondary voltage reaches the value V_0. 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

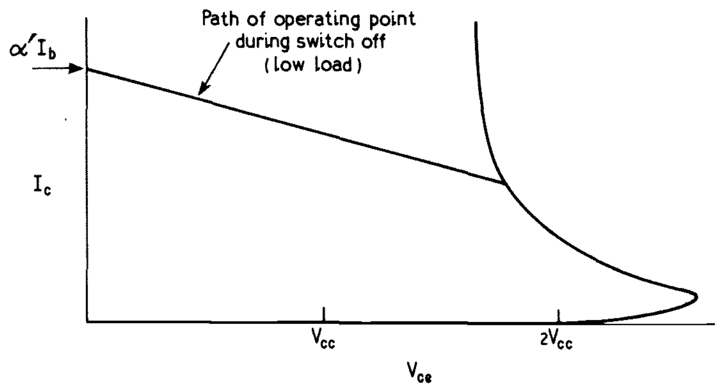


Fig. 6. For a no-load condition the path of the operating point is shown by the right-hand curve.

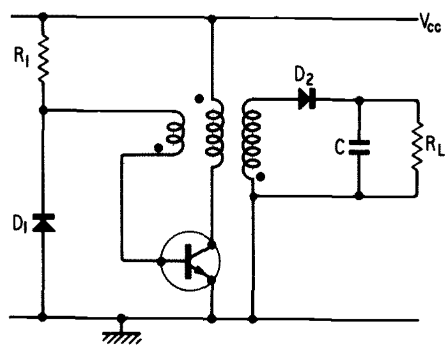


Fig. 7. Simple d.c. converter circuit using ringing choke principle.

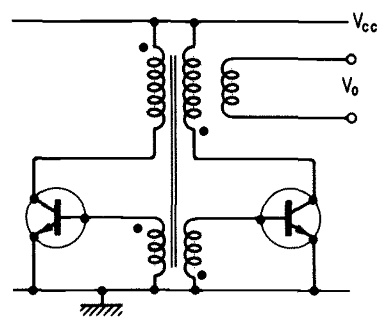


Fig. 8. Conventional single-transformer d.c. inverter circuit.

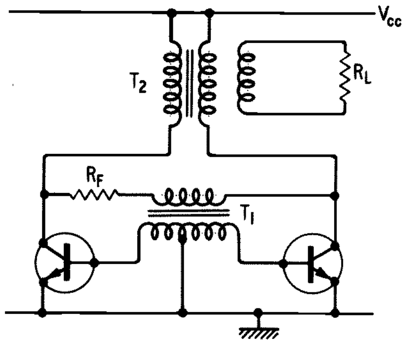


Fig. 9. Two-transformer inverter. One transformer controls switching while the other provides the correct voltage to the load.

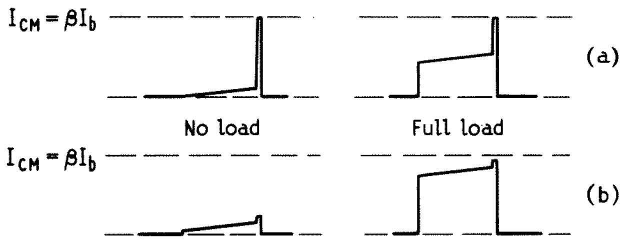


Fig. 10. Collector current for (a) single saturating transformer circuit, (b) two-transformer circuit.

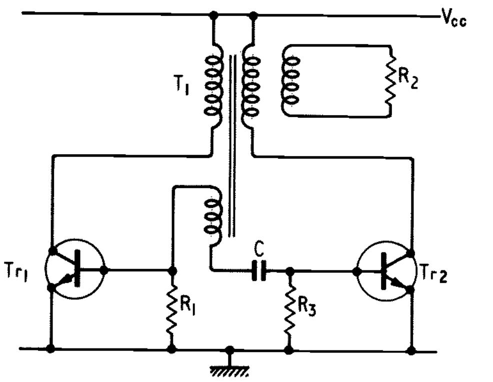


Fig. 11. Inverter with timing provided by *CR* arrangement in place of saturable transformer.

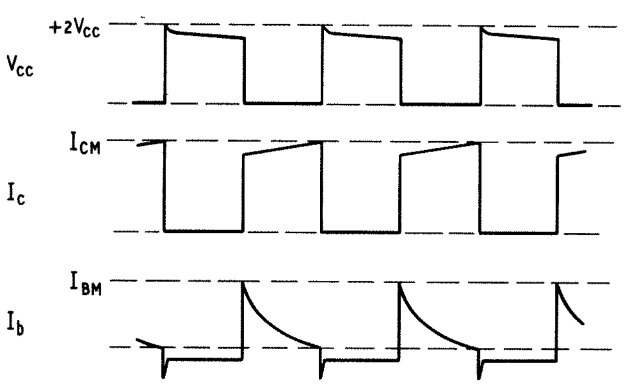


Fig. 12. Voltage and current waveforms in the inverter with *CR* timing.

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

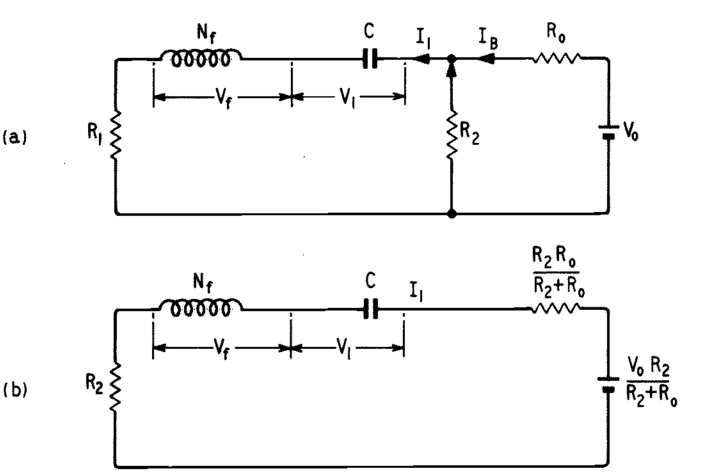


Fig. 8[2]. The transformer can either be of a non-saturable type, or of a saturable type. In the case of the non-saturable transformer circuit, a considerable variation of frequency with load will be experienced and the transformer size required to handle the same power will be three to four times as 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 circuit[3]. 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

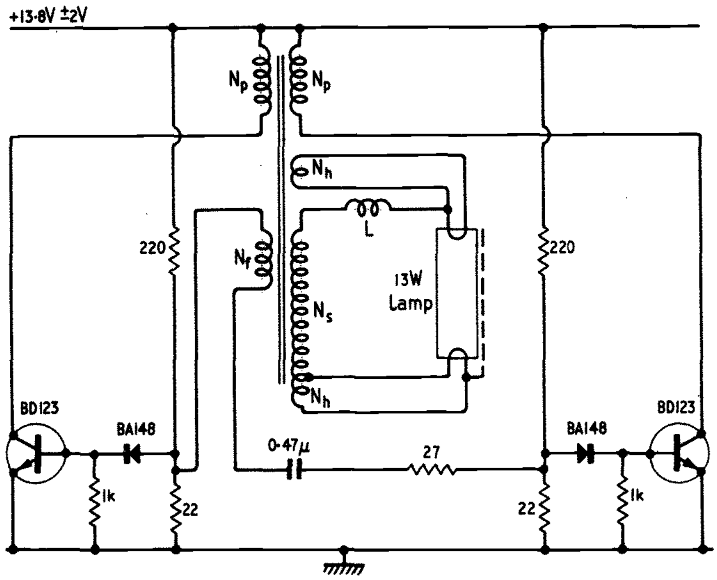


Fig. 14. Circuit of 13-watt fluorescent lamp inverter.

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

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

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

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

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

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

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 design[4] 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

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

$$I_1\ (\text{min})=I_B+\frac{I_BR_0+V_0}{R_2} \quad \ldots \quad (5)$$

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

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

and the number of turns for the feedback winding

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

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

$$C=\frac{1}{3{\cdot}2f\,R_2\left[1+\frac{R_0}{R_2+R_0}\right]} \quad \ldots \quad (10)$$

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

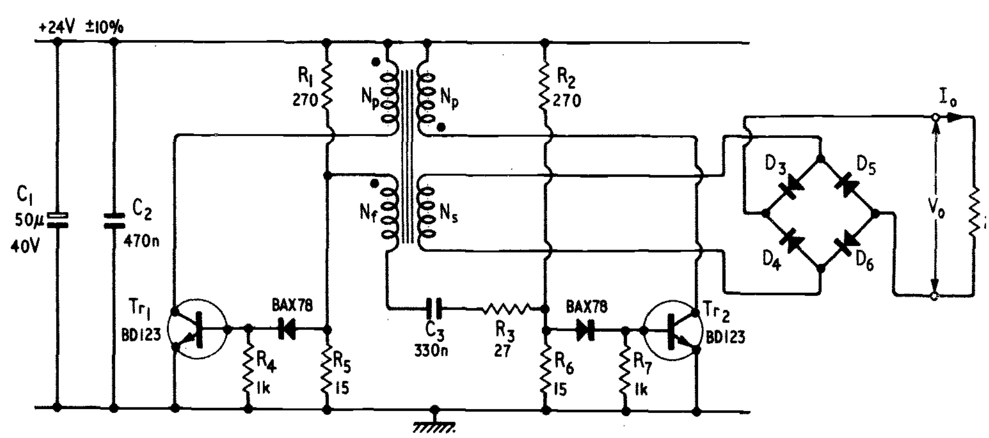


Fig. 15. Circuit of d.c. to d.c. converter capable of delivering 60W of output power from a 24V supply.

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

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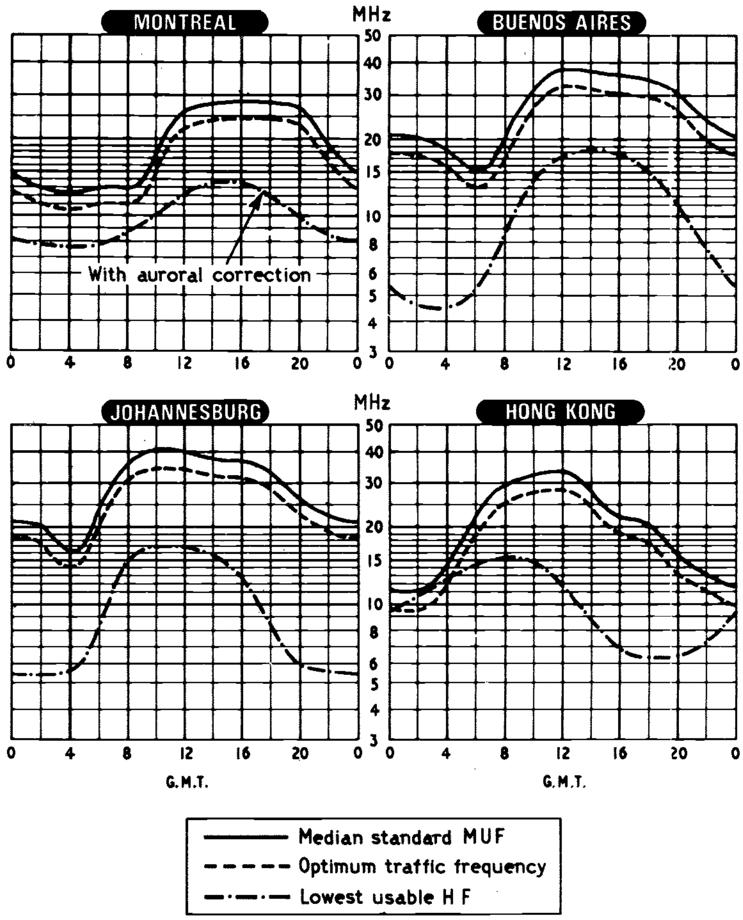
2. " The Design of Transistor Push-Pull D.C. Converters ", by W. L. Stephenson *et al. Electronic Engineering*, Vol. 31, No. 380, Oct. 1959, pp.585 to 589.
3. " Improved High Power D.C. Converters ", by J. R. Nowicki. *Electronic Engineering*, Vol. 33, No. 404, Oct. 1961, pp.637 to 641.
4. " A D.C. Inverter with CR Timing ", by J. R. Nowicki. *Electronic Engineering*, Vol. 34, No. 413, July 1962, pp.464 to 468.

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.



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 — Imperial College
Thick Film Technology
(I.E.R.E., 9 Bedford Sq., London W.C.1)

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

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

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

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

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

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

Sept. 9-12 — Queen Mary College, E.1
Elementary Particles
(I.P.P.S., 47 Belgrave Sq., London S.W.1)

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

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

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

BELFAST

Apr. 1-3 — Queen's University
Heavy Particle Collisions
(I.P.P.S., 47 Belgrave Sq., London S.W.1)

BIRMINGHAM

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

BRIGHTON

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

CAMBRIDGE

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

CARDIFF

Apr. 18 & 19 — Cathays Park
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 — The University
Semimetals and Narrow Gap Semiconductors
(I.P.P.S., 47 Belgrave Sq., London S.W.1)

EDINBURGH

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

FARNBOROUGH

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

HARWELL

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

LOUGHBOROUGH

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

MANCHESTER

Sept. 3-6 — Inst. of Science and Technology
Solid State Devices
(I.P.P.S., 47 Belgrave Sq., London S.W.1)

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

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

NOTTINGHAM

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

OXFORD

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

SWANSEA

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

WARWICK

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

OVERSEAS

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

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

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

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

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

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

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

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

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

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

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.R.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. & I.Mech.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. & I.Mech.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. 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.R.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 1915 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-pressurizing 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 10^7:1 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 guesstimators 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 junketings 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 £2,566. 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

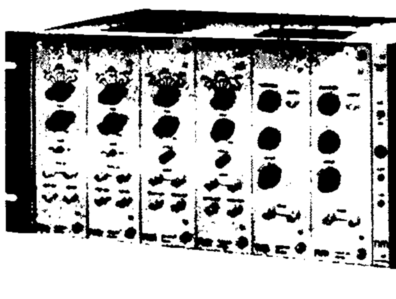
A NEW series of high value electrolytic capacitors, in which several new techniques have been used to increase capacitance, ripple current rating and working temperature without increasing can size, has been announced by Mullard. These capacitors, type 106 and 107, are suitable for use in applications 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 1,500μF 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

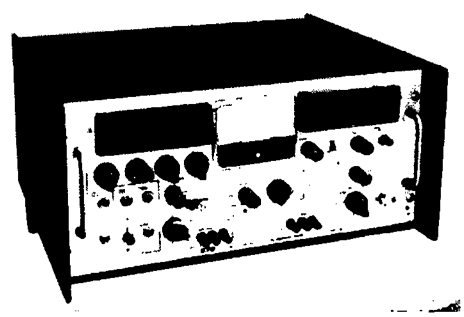
Bone Conduction Headset

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 400μV peak at normal conversation levels. The transducer should be terminated in a load impedance of 600 Ω for optimum performance over the telphony 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 $\pm$ 20 milliseconds in 0.01 ms steps. The instrument is portable and uses solid state circuits operating from a.c. mains. Its dimensions are $22\frac{1}{4}$ x $9\frac{1}{2}$ x 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.

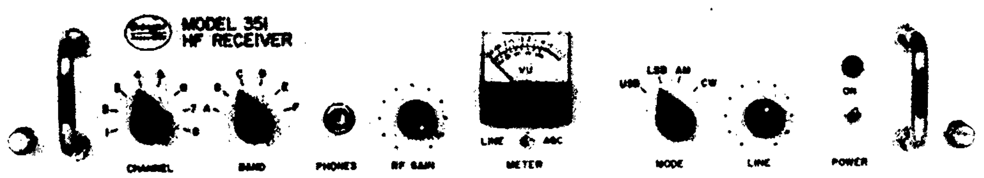
W.W. 305 for further details

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 Ω and 10 mW into 150 Ω. 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

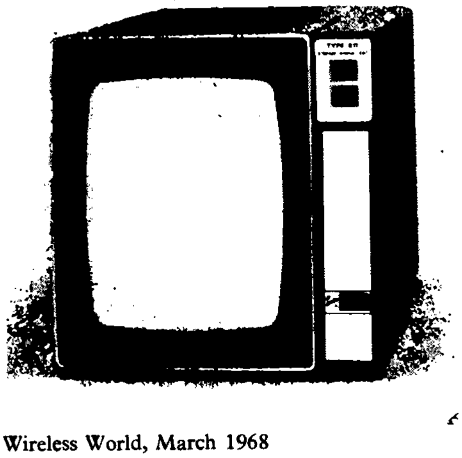
A NON-STICKY adhesive that is available in thermoplastic and thermosetting forms, supplied unsupported or applied to one or both sides of a plastic film, has been introduced by G. T. Schjedahl Co. It will bond plastic and plastic films, metals and metal foils, ferrites, natural and synthetic fabrics and rubber and wood. Visible evidence of setting is given as unsealed Schjel-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

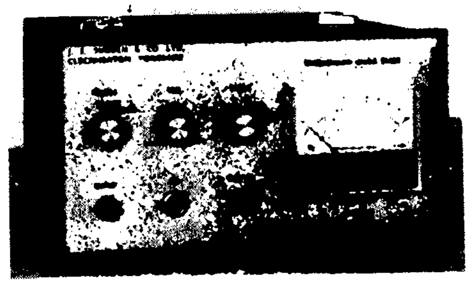
THE Tektronix type 611 storage display unit permits stored, non-fading, displays of alphanumeric and graphic information from digital computers and other data transmission systems. The Tektronix bistable storage c.r.t. is used eliminating the need for memory devices for refreshing the display and providing 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 ± 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 μs or 4 μs/cm whichever is the greater. Spot positional stability is quoted as being 0.1% or less of full scale/hour with a 75 Ω 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 Ω. The input impedance is 1.1 MΩ 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

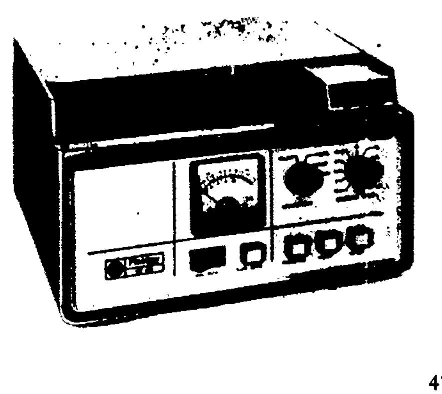
Log Plotting Unit for X-Y Recorders

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 dimen-

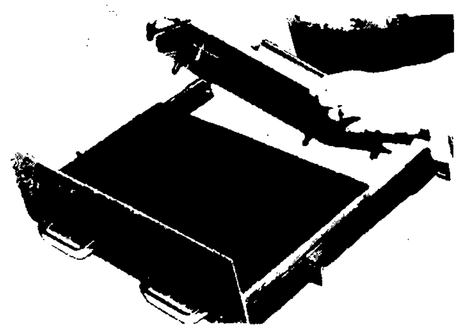


sions of the desk-top model are 7.375 inches high, 12.5 inches wide, and 11.5 inches deep. The rack-mounted CT80 unit is designed to fit into a standard 19 inch equipment rack and occupies 8.75 inches of vertical space. The Liaison Office Plessey Australia, The Plessey Company Ltd., Ilford, Essex.

W.W. 312 for furter 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

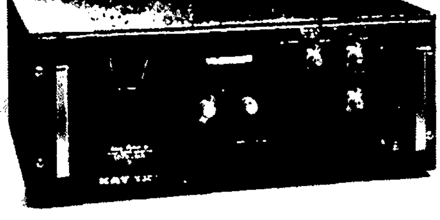
Rotary Stud Switch

TYPE 01 subminiature rotary stud switch with a fully adjustable stop mechanism is made by Radiatron, 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} Ω (between wafer and earth), while contact resistance is 4 MΩ. 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 μs 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 50 Ω) 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

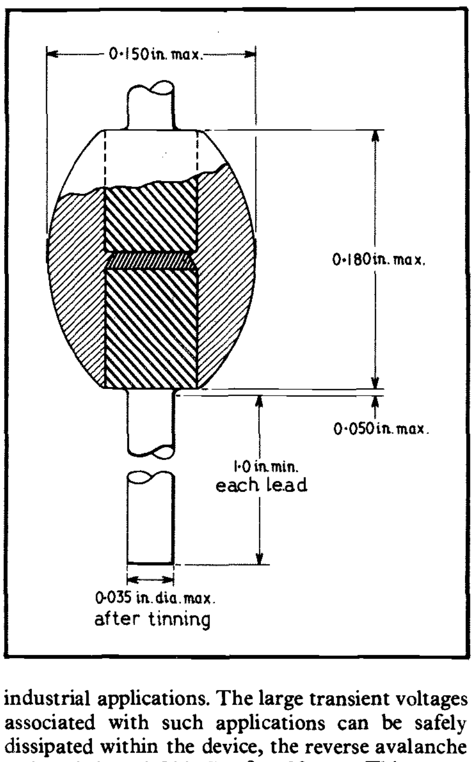
Wire-wound Resistors

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 kΩ 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

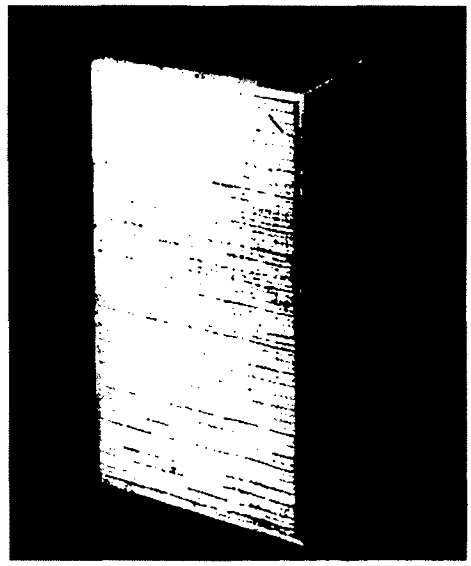
Transient Voltage Protected Rectifier

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



industrial applications. The large transient voltages associated with such applications can be safely dissipated within the device, the reverse avalanche rating being 1,000 W for 20 μs. This surge capability together with the 400 V rating make this device suitable for 250 r.m.s. applications. Higher and lower voltage units are available. The 1 amp rating holds good at up to 75°C ambient temperature, the maximum surge current being 100 A. Other features include a miniature glass encapsulation and dual heatsink construction. The devices are available from Jermyn Industries, Vestry Estate, Sevenoaks, Kent.

W.W. 317 for further details



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 Barmeston 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

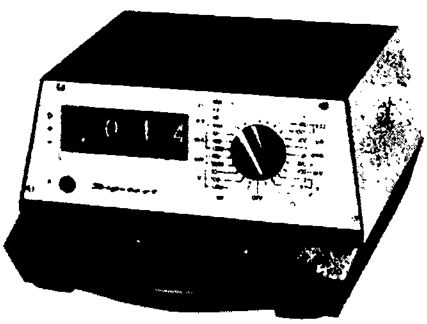
X-Band Hot Carrier Diodes

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 hermatically 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 frequency of 3 GHz. The HP 2511 can withstand 15 x 10^{-7} Joules and the peak power dissipation (1 μs 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

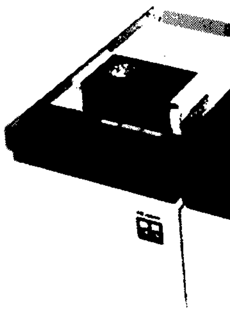
POWER FOR this instrument may be obtained from one of three separate sources; from the mains—100/140 V or 200/270 V, 50-60 Hz; from an internal 12 V accumulator which will give five hours of continuous operation on one charge (charging unit built in); or from ten U2 dry cell batteries giving 25 hours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



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

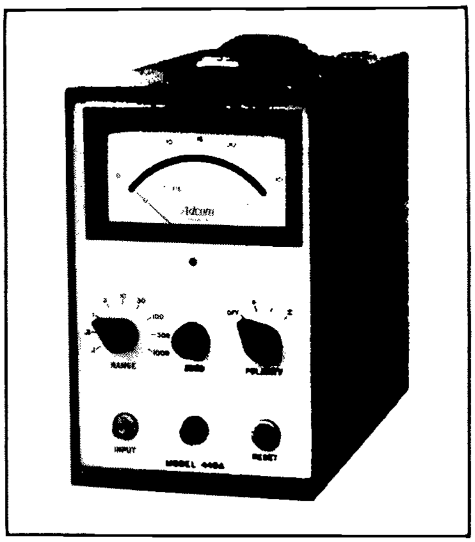
ZERO DRIFT on the model 602 electrometer from Keithley Instruments of America is less than 1 mV per day and the input impedance is $10^{14}\,\Omega$. As a voltmeter the instrument has nine ranges with f.s.ds of 1 mV to 10 V at an accuracy of $\pm 1\%$ f.s.d. excluding noise and drift; zero offset is less than 300 μV/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 ohmeter 23 ranges are available from 100—$10^{13}\,\Omega$, accuracy

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 μV 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 μs 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

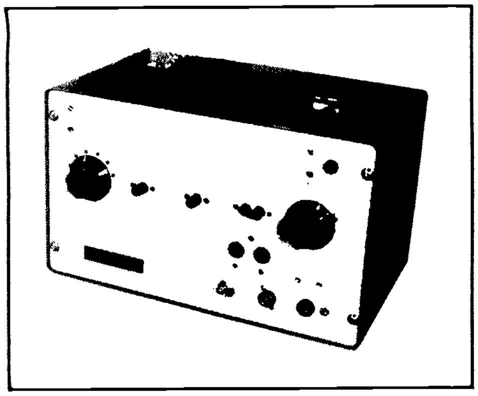


provided and the response is d.c. to 1 MHz. There is no limitation on the input risetime and no recovery period is required. Accuracy on the taut-band meter is 1.5% of f.s.d. while an electronic output of 0 to +5 V (at up to 2 mA) is accurate to 1%. Applications of this instrument include the detection 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 75 Ω (negative sync). The signal characteristics are as



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 x 7.75 x 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

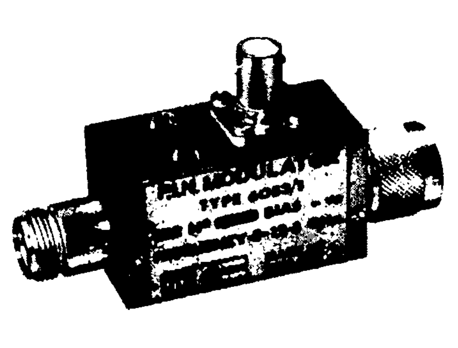
Parametric Amplifiers

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 x 9 x 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

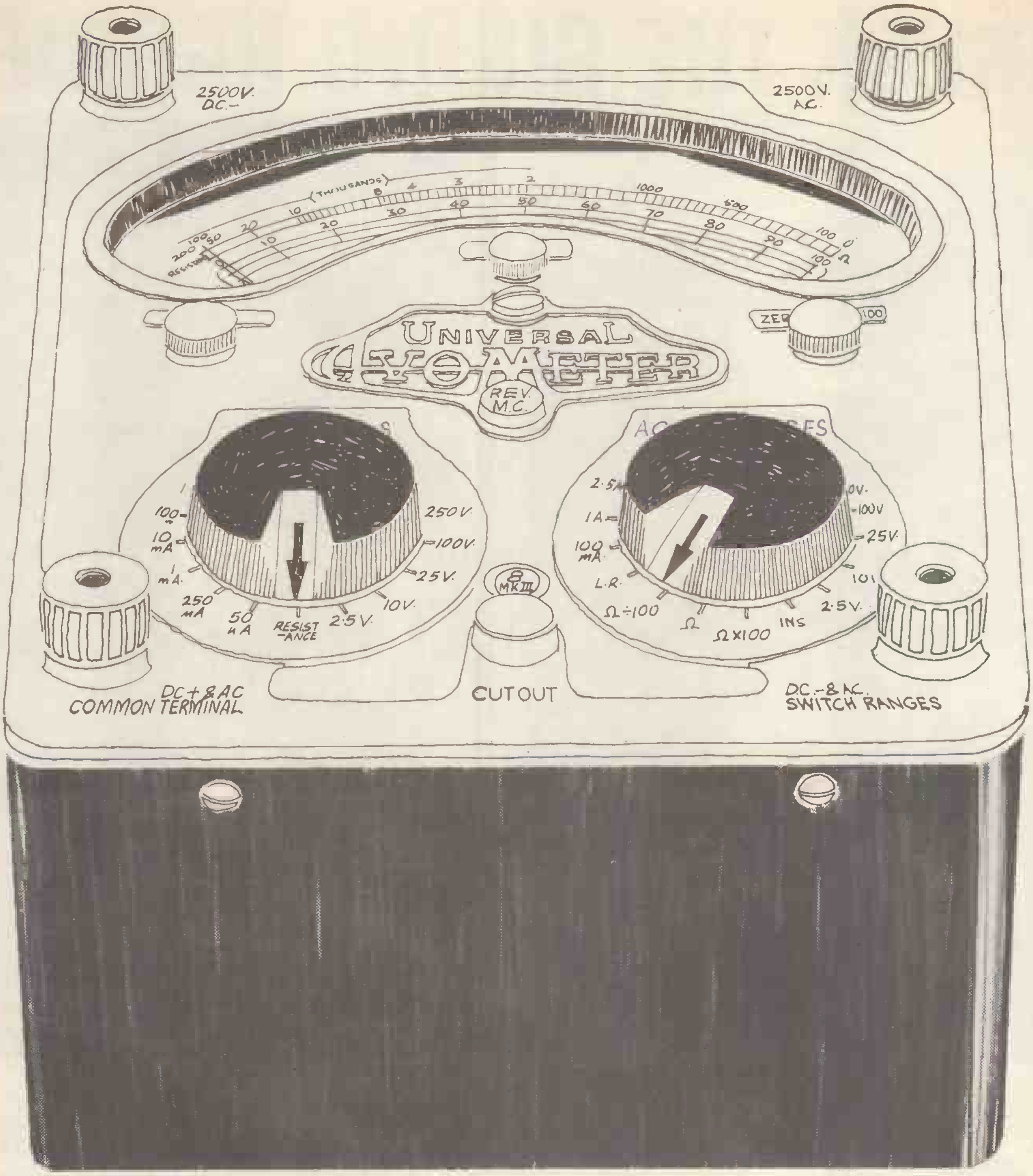
PIN Diode Modulator

THIS variable r.f. reflection type attenuator (Sanders Type 6503/1) consists of a length of coaxial 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 50 Ω 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

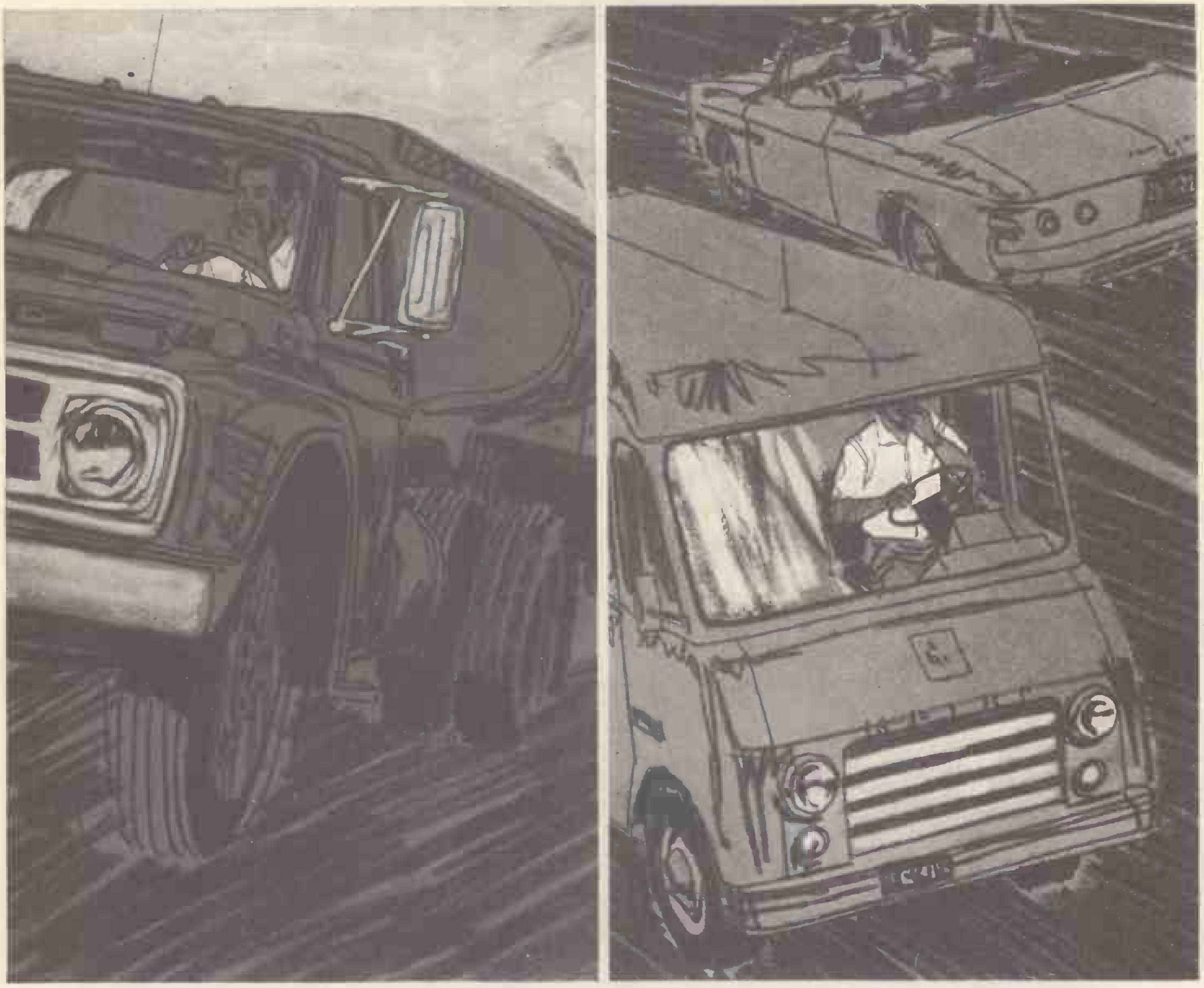
After all, you're only human, and those two big knobs on the Model 8 Avometer are terribly tempting. Just by twiddling them, you can have over 30 calibrated ranges at your command–11 current, 15 voltage, 5 resistance, and a 30dB power scale. Twiddle yourself a good combination of accuracy (1%fsd/dcA, 2%fsd/dcV, 2¼%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.

AVΩ MEANS BASIC MEASUREMENTS ALL OVER THE WORLD

A2

WW—005 FOR FURTHER DETAILS

BREAK THE SOUND BARRIER



MODEL 488 SONO-BAR

MODEL 419 RANGER II

SHURE MICROPHONES—
WORLD STANDARD WHEREVER
RELIABILITY AND
SOUND QUALITY ARE PARAMOUNT

WITH PROVED **SHURE** SETTING THE WORLD'S STANDARD IN SOUND

NOISE CANCELLING MICROPHONES

When the chips are down, and noise levels are high, Shure Noise Cancelling microphones with their exclusive Controlled Magnetic cartridges, distance-discrimination design, and specially tailored response get the message through . . . *even when noise level is so high the operator cannot hear himself!* They have been field-tested and proved in such ear-shattering environments as: drop forges, helicopters, police power boats, "hard surface" gyms among cheering crowds, motorcycles, jets revving up, fire engines, etc.

SHURE MODEL 488 SONO-BAR

Rugged, impact resistant "Armo-Dur" case. Four types: High or low impedance; transistorized for direct replacement of carbon microphone; and FAA Certified Transistorized Aircraft version.

SHURE MODEL 419 RANGER II

New small size. Only about half the size and weight of conventional mobile communications microphones. Unsurpassed for use with portable or miniaturized equipment.

Please send me details of Shure microphones. Please recommend the best model for use with my equipment.........................

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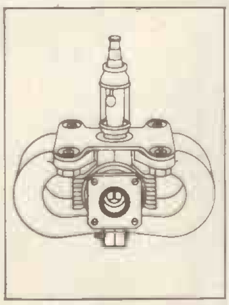
WW—006 FOR FURTHER DETAILS

Safe Journey

. . . when your radar is fitted with EEV magnetrons

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.



ENGLISH ELECTRIC VALVE COMPANY LIMITED CHELMSFORD, ESSEX. TELEPHONE: 61777

AP298

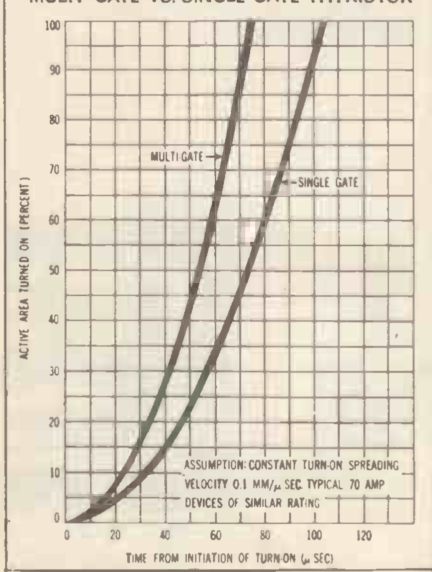
WW—007 FOR FURTHER DETAILS

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

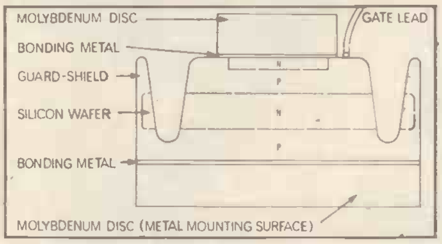
start here: Exclusive Multi-Gate Thyristors When thyristors are to be operated with steeply rising current pulses and/or high repetition rates, great care must be exercised in establishing the operating conditions and selecting the device to be utilized. A self-saturating reactor may be introduced into 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 reapplied off-state voltages because of the lower junction temperature at the instant of current commutation.

MULTI-GATE VS. SINGLE GATE THYRISTOR



MIM-Protection IR's epitaxial thyristors offer the exclusive feature of metal-ion 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 forward 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 commutating 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.

Stop here. Now you know, thanks to

IOR

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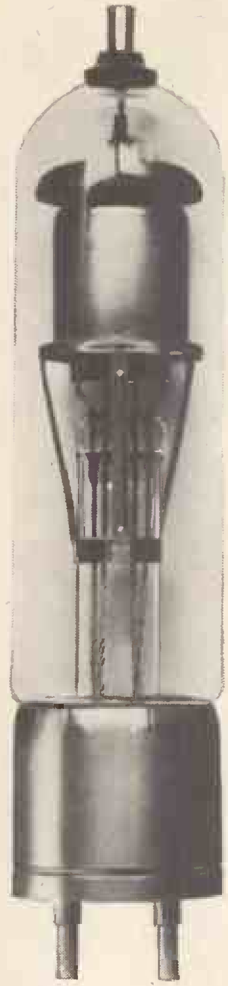
WW—008 FOR FURTHER DETAILS



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
AH221	CV5 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.

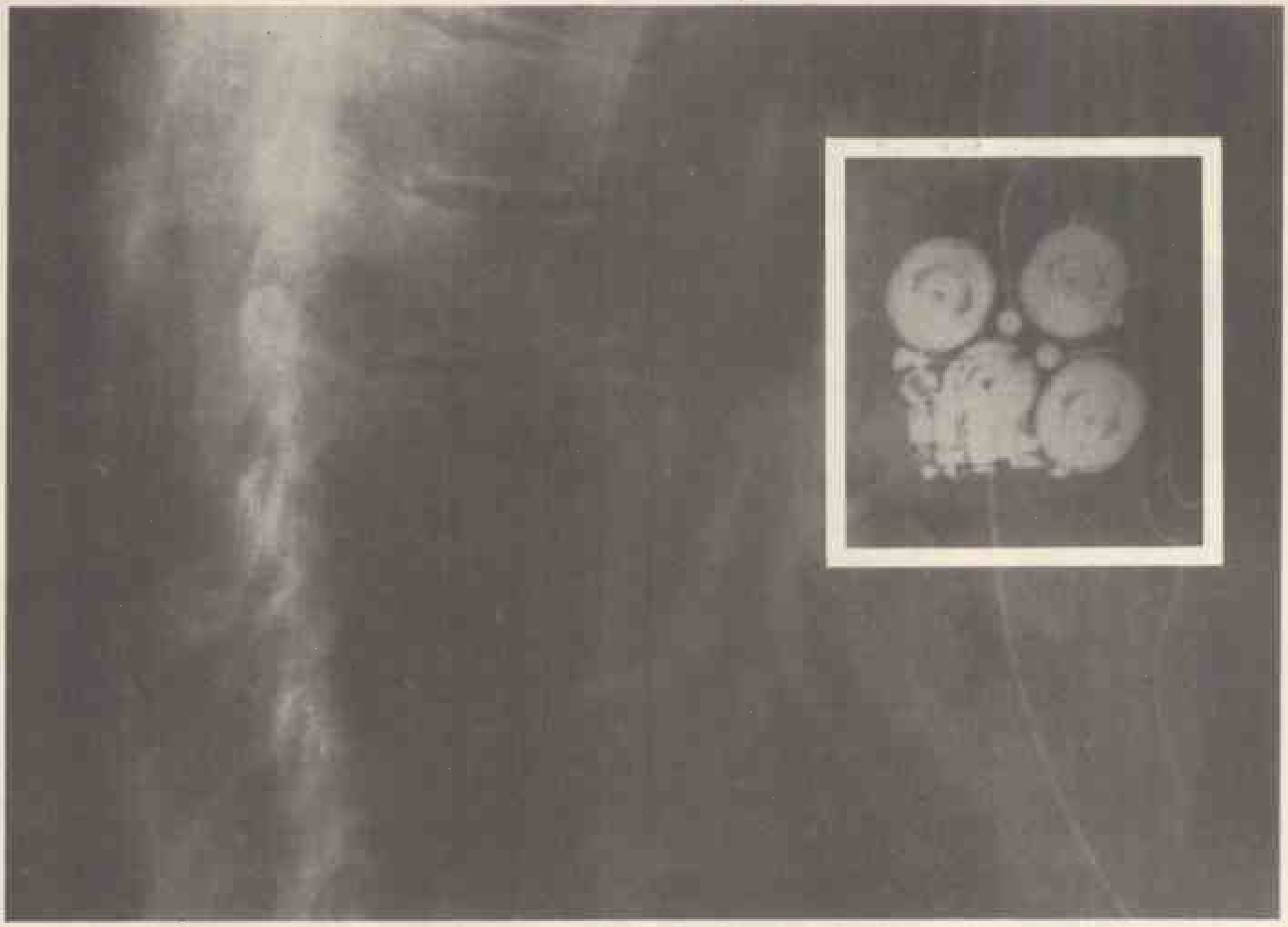
This range of Mercury Vapour Rectifiers is available from your local EEV stockist. English Electric Valves production methods ensure the reliability and performance you are looking for and prices are competitive.

Coventry Factors Ltd, Coronet House, Upper Well Street	Coventry Tel: Coventry 21051
Downes & Davies Ltd, G.P.O. Box 555, 72 Chapeltown Street	Manchester 1 Tel: Ardwick 5292
Edmundson Electronics Ltd, 60-74 Market Parade, Rye Lane, Peckham	London SE15 Tel: New Cross 9731
Gothic Electrical Supplies Ltd, Gothic House, Henrietta Street	Birmingham 19 Tel: Central 5060
Harper Robertson Electronics Ltd, 97 St George's Road	Glasgow C3 Tel: Douglas 2711
Smith & Cookson Ltd, 49/57 Bridgewater Street	Liverpool 1 Tel: Royal 3154-7
The Needham Engineering Co. Ltd, P.O. Box 23, Townhead Street	Sheffield 1 Tel: Sheffield 27161
Wireless Electric Ltd, Wirelect House, St Thomas Street	Bristol 1 Tel: Bristol 294313

ENGLISH ELECTRIC VALVE COMPANY LIMITED CARHOLME ROAD, LINCOLN, TELEPHONE: 26352

WW—009 FOR FURTHER DETAILS


MADE IN BRITAIN
3D



Doctors needed a battery they could trust inside you while it worked to save your life!

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.

If you're considering a battery system for a new product, think of what Mallory can do for you. If you have portable power problems our sales and application engineers are at your service. Contact our Manager, U.K. Sales, at Mallory Batteries Limited, Gatwick Road, Crawley, Sussex—Crawley 26041—or get in touch with our nearest industrial distributor.

BIRMINGHAM Messrs. Hawnt & Co., 112/114 Pritchett Street, Birmingham, 6. Aston Cross 4301
BRISTOL Wireless-Electric Ltd., "Wirelect House", St. Thomas Street, Bristol, 1. Bristol 294313
BURNHAM—BUCKS Gawt Distributor Services Ltd., The Red House, High Street, Burnham, Bucks. Orchard Grove 694
CARDIFF South Wales Wireless Installation Co. Ltd., 121 City Road, Cardiff. Cardiff 23636
COVENTRY Coventry Factors Ltd., Upper Well Street, Coventry. Coventry 21051
CRAWLEY S.A.S.C.O., P.O. Box 20, Gatwick Road, Crawley, Sussex. Crawley 28700
GLASGOW British Electrical & Mfg. Co. Ltd., 183 St. Vincent Street, Glasgow, C.2. City 4131
Harper Robertson Electronics Ltd., 97 St. George's Road, Glasgow, C.3. Douglas 2711
S.A.S.C.O., Factory 13B, Carbrain Industrial Estate, Cumbernauld, Glasgow. Cumbernauld 410
HARLOW Standard Telephones & Cables Ltd., Electronic Services Sub-Division, Edinburgh Way, Harlow, Essex. Harlow 26811
HITCHIN S.A.S.C.O., Hunting Gate, Wilbury Way, Hitchin, Herts. Hitchin 2242
Roberts Electronics Ltd., 17 Hermitage Road, Hitchin, Herts. Hitchin 50551/2
LEEDS A. C. Farnell Limited, 81 Kirkstall Road, Leeds, 3. Leeds 35111
LONDON British Electrical & Mfg. Co. Ltd., 10 Rushworth Street, London S.E.1. WATerloo 7731
Cables & Components Ltd., Coronation Road, Park Avenue, London N.W.10. ELGar 2266
Edmundsons Electronics, 60-74 Market Parade, Rye Lane, London S.E.15. New Cross 9731
Lugton & Co. Ltd., Mr. Lun, Radio House, 209-212 Tottenham Court Rd., London W.1. Museum 3261
NEWCASTLE British Electrical & Mfg. Co. Ltd., Clavering Place, Newcastle-upon-Tyne, 1. Newcastle 22416
J. Gledson & Co. Ltd., Newbiggin Lane, Westerhope, Newcastle-upon-Tyne, 5. Newcastle 869033
NORTHAMPTON E.M.F. (Electrical) Ltd., Dunster Street, Northampton. Northampton 37316
POYNTON Scientific Furnishings Ltd., Electronics Division, Poynton, Cheshire. Poynton 2215
SHEFFIELD Needham Engineering Co. Ltd., P.O. Box 23, Townhead Street, Sheffield, 1. Sheffield 27161
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WW—011 FOR FURTHER DETAILS

Outstanding British Equipment by Heathkit

(All models available as easy-to-build kits or Ready-to-use).

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.

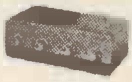
Kit **£8.10.0** Ready-to-use **£12.5.0**

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-1U and XIR-1U

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-1U (Master)
Kit **£11.9.6** Ready-to-use **£17.9.6**

Model XIR-1U (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.

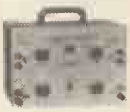
Kit **£7.13.6** (incl. P.T.)

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. × 8½ × 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 × 23 × 14½in., 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

4½in. 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 0·11μF 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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MANUFACTURERS OF THE WORLD'S LARGEST-SELLING ELECTRONIC KIT-SETS

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See all these models, and many more . . .
in the latest HEATHKIT Catalogue

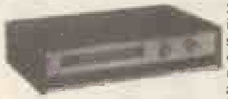
LOW-COST TRANSISTOR STEREO AMPLIFIER, TS-23

Incorporates all the essential features for good quality sound reproduction from record, radio and other sources ● 16 transistor, 4 diode circuit ● Good frequency response ● 3 watts r.m.s. (15 ohms) each channel ● 6 position selector switch easily handles your record, radio or tape inputs—stereo or mono ● Separate controls provide bass boost, treble cut, amplifier balance and volume ● Printed circuit board construction ● Compact, slimline styling ● Measures 3¾in. high x 13in. wide x 8in. deep ● Beautiful walnut veneered cabinet (optional extra) ● Attractive Perspex front panel.

KIT £17.15.0 (less cabinet) **KIT £18.19.0** (with cabinet)

Walnut veneered cabinet £2/5/- extra. Ready to-use price on request

TRANSISTOR AM-FM STEREO TUNER, AFM-2



● 18 Transistor, 7 diode circuit ● AM-LW/MW, FM Stereo and FM Mono tuning ● Automatic stereo indicator light ● Stereo phase control for maximum separation, minimum distortion ● Automatic frequency control for positive "lock-in" tuning ● Automatic gain control for even, steady volume ● Preassembled and aligned "front end" FM unit ● Separate AM and FM printed circuit boards ● Self-powered ● Low-silhouette styling—matches AA-22U amplifier ● Handsome fully finished walnut veneered cabinet, available as optional extra. Comprising: AFM-2T RF Tuning Heart kit £7/17/6 incl. P.T., AFM-2A IF Amplifier and power supply kit £24/9/6.

TOTAL PRICE KIT £32.7.0 incl. P.T.

Optional extra: Walnut veneered cabinet £2/5/- extra

THE AVON COMPACT MINI SPEAKER SYSTEM

The ideal compact system for bookshelf or other small spaces ● 6½in. bass speaker ● 3⅜in. totally enclosed treble unit ● Speakers rigidly mounted to 1/16in. thick aluminium alloy plate ● Inductor-capacitor cross-over unit ● Strongly constructed, fully finished walnut veneered cabinet ● Cabinet resonances are minimised by stout internal bracing and special acoustic absorbent filling ● Suitable for use with amplifiers having an output impedance of 8-16 ohms, and power output of 5 to 15 watts. ● Fast, easy assembly ● Gives best possible performance relative to smallest possible size ● Frequency response 50 c/s-19,000 c/s. ● Size: 7¾in. wide x 13¼in. high x 8¾in. deep. Comprising: Walnut veneered cabinet kit £8/18/-. Loudspeakers and cross-over network kit £4/18/- incl. P.T.

TOTAL PRICE KIT £13.16.0 incl. P.T.

Ready to-use price on request

TRANSISTOR FM STEREO TUNER, TFM-1S

(Mono version TFM-1M available)

● 14 transistor, 5 diode circuit for cool instant operation ● Mono TFM-1M and Stereo TFM-1S models available ● Automatic frequency control ● Stereo phase control to maximise stereo separation, minimise distortion ● 4-stage IF section ensures high sensitivity and selectivity ● Filtered outputs for direct "beat-free" stereo recording ● Automatic stereo indicator light ● Prealigned, preassembled "front-end" tuner and one circuit board for fast, simple assembly. Cabinet £2/5/- extra. Comprising: TFM-T1 RF Tuning Heart Kit, £5/16/- incl. P.T., TFMA-1M (Mono) IF Amplifier, Power supply £15/3/-. Kit or TFMA-1S (Stereo) IF Amplifier, Power supply £19/2/- Kit.

TOTAL PRICE KIT (Stereo) £20.19.0 incl. P.T.
TOTAL PRICE KIT (Mono) £24.18.0 incl. P.T.

Optional extra: Walnut veneered cabinet £2/5/- extra.

All models must perform to published specification when assembled in accordance with the instruction manual. ***ALL MODELS COVERED BY MONEY BACK GUARANTEE.***

BERKELEY SLIM-LINE SPEAKER SYSTEM

● Specially designed to obtain optimum performance from the slim elegant cabinet ● Beautiful walnut veneered, fully finished cabinet ● Makes attractive addition to any room ● Stood on end uses only 17in. x 7¾in. of floor space ● Two specially designed loudspeakers give adequate power handling for most applications ● 12in. low resonance unit and 4in. Mid/High frequency unit covers 30-17,000 c/s. ● Build it in an evening ● Professional attractive styling ● Use one for mono and a pair for stereo ● Outstanding performance at a low price ● Shelf or floor standing ● Use vertical or horizontal ● Designed to harmonize with modern or traditional decor.

KIT £19.10.0 Ready-to-Use £24.0.0

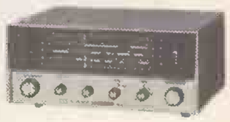
LOW-COST SPEAKER SYSTEM SSU-1 (not illustrated)

●Build it yourself in an evening ●All wooden parts accurately pre-cut, drilled and sanded ●Wide frequency response ●Two specially designed loudspeakers ●Hi-Fi on a budget ●Glue, sandpaper, etc. are included in kit ●Use one for mono, two for stereo ●Finish it to match your own furnishing ●16 page instruction manual ●7in. or 15in. legs optional extra, 14/6 ● Use vertical or horizontal.

KIT £11.17.6 (less legs)

Ready to-use price on request

LOW-COST SHORTWAVE RECEIVER, GR-64E



● 4 bands—3 short wave bands cover 1 Mc/s to 30 Mc/s, plus 550 kc/s to 1,620 kc/s AM broadcast band ● Built-in 5in. permanent magnet speaker for a big, bold sound ● Illuminated 7in. slide-rule dial with extra logging scale ● Easy to read lighted bandspread tuning dial for precise station selection ● Relative signal strength indicator aids pin-point station tuning ● 4-valve superhet circuit plus two silicon diode rectifiers ● Variable BFO control for code and SSB transmissions ● Built-in external antenna connections ● Built-in AM rod antenna ● Fast, simple circuit board construction assures stability ● Handsome "low-boy" styling —charcoal grey cabinet, black front panel, and green and white band markings ● Headphone jack for private listening. Power requirements: 115, 230 v. 50-60 c/s A.C. 30 watts. Dimensions: 13¼in. wide x 6in. high x 9in. deep.

KIT £22.8.0 Ready-to-Use £27.8.0

GENERAL COVERAGE RECEIVER, GR-54E

Powerful 6 valve-6 diode circuit. 3 SW bands cover 2 Mc/s to 30 Mc/s plus 550 kc/s to 1550 kc/s AM broadcast band and 180 kc/s to 420 kc/s aeronautical and radio navigation band. Tuned RF stage. ½ lattice crystal filter. Switchable USB LSW mode position. Built-in 4in. x 6in. PM speaker. Power req.: 120/240 v. 50-60 c/s AC.

KIT £50.1.0 Ready-to-Use £63.6.0

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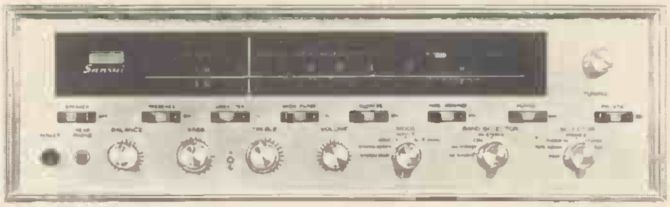

MODEL 1000A
AM/FM Multiplex Stereo Tuner Amplifier

This is a high-quality, tubed unit that uses the latest Nuvistor devices and power tubes. Other features include High-cut and Low-cut Filters for virtually interference-free enjoyment, a Muting switch that further reduces noise, and an Automatic Frequency Control switch to eliminate 'drift'.
RMS power: 40/40 W.
Music power: 100 W (IHFM).
Harmonic distortion: 1.0% at 1000 Hz RMS rated power output.
Overall frequency response: 20—20,000 Hz ± 1 dB.
FM sensitivity: 1.8 µV (IHFM).

MODEL 250
AM/FM Multiplex Stereo Tuner Amplifier

A high-performance, tubed unit with many studio-equipment features. And at a modest price.
RMS power: 10/10 W.
Music power: 22 W (IHFM).
Harmonic distortion: 1.5% RMS rated power output.
Frequency response: 30—20,000 Hz ± 2 dB at normal listening level.
FM sensitivity: 4.0 µV (IHFM).
AM sensitivity: 30 µV (IHFM).
MODEL 220— AM/FM Stereo Tuner Amplifier
A similar model to the 250, but without multiplex.

MODEL 500A
AM/FM Multiplex Stereo Tuner Amplifier

A tubed unit with a similar performance to the 1000A, but giving a lower power output.
RMS power: 23/23 W.
Music power: 50 W (IHFM).
Harmonic distortion: 1.0% at 1000 Hz RMS rated power output.
Frequency response: 20—20,000 Hz ± 1.5 dB at normal listening level.
FM sensitivity: 2.0 µV ± 3dB (IHFM).

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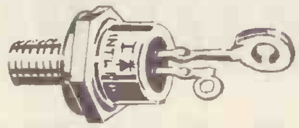

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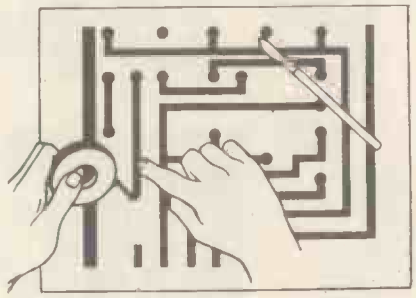

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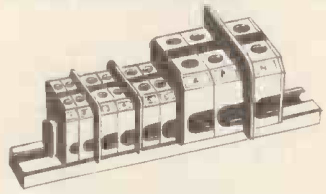

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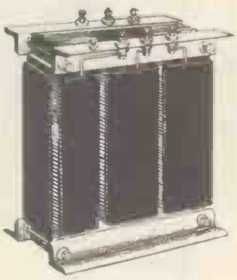

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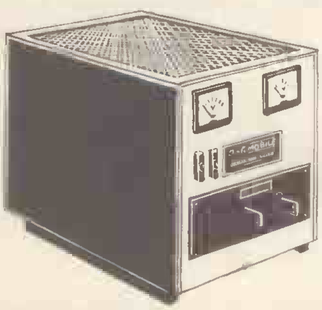

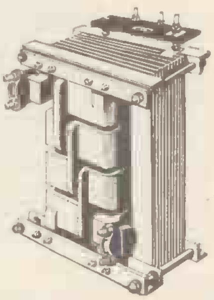

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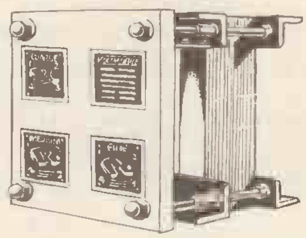

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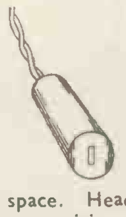
MAGNETIC RECORDING

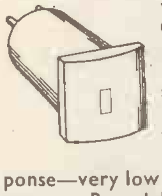
HEADS

TYPE "A"



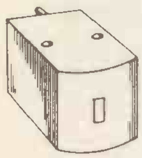
Standard 1/2 track, Record/Playback and Erase. Many special versions can be made to customers' requirements such as narrow track—raised track—or cut-away for cine use. Ideal head for dictating machines, etc. Size $\frac{3}{8}$in. dia. by $\frac{5}{8}$in. long. The round body makes for easy azimuth adjustment and takes up a minimum of space. Head has internal screen and fly leads for easy wiring.

TYPE "R"



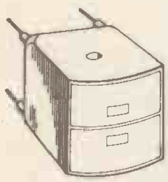
Size is $\frac{7}{16}$in. square at the front with body $\frac{3}{8}$in. dia. by $\frac{5}{8}$in. long. Curved front $1\frac{1}{4}$in. radius. This head is available in a wide range of Record/Playback impedances. Also available as Erase. This novel design possesses many advantages over comparable types — 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"



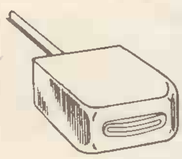
Exactly as Type R except body is $\frac{7}{16}$in. square along its length providing simple mounting arrangements. The Erase versions of R and DR types are double field heads. These are not just double gaps but two Erase heads in one, giving better than 60dB erasure of a saturation (+6dB on full record level), 1 k/c recording at $3\frac{3}{8}$ i.p.s.

TYPE "X"



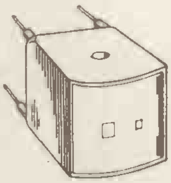
1/1 — 1/2 — 2/2 and 2/4 Heads for $\frac{1}{4}$in. tape. Record/Playback and Erase Heads for high quality tape recorders. Size only $\frac{1}{2}$in. cube and available in a whole range of impedances. Excellent HF performance, efficient screening and very low crosstalk are features of the R/P head, Mounting brackets are available for twin or triple head assemblies.

TYPE "T"



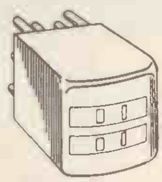
Built into a deep drawn mumetal case ensures complete shielding. Type T is the protruding pole type with special narrow track (as narrow as .002in.) and can be made as a Record/Playback or Erase Head, or combined Record / Playback / Erase Head, or even Record/Playback and self-oscillatory Erase Head. 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.

SINGLE TRACK COMBO TYPE "X"



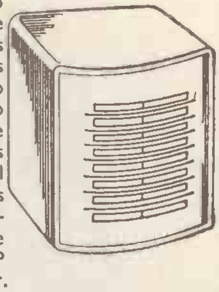
Designed as a combined Record/Playback/Erase Head for the commercial market. such as telephone answering machines. Built into $\frac{1}{2}$in. cube deep drawn mumetal case it incorporates the R/P features of R-Type head. The Erase track is made wider than the R/P track to ensure complete erasure and to overcome machine to machine alignment tolerances.

TYPE "Z"



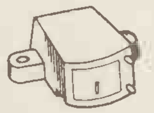
A brand new concept in combination head design incorporating all the best features of the X-Type Head combined with integral erase facilities. Accurate gap alignment between tracks makes this head eminently suitable for high quality stereo use. The one-piece deep drawn mumetal case (only $\frac{1}{2}$in. cube) ensures complete screening across the front as well as the sides.

MULTITRACK



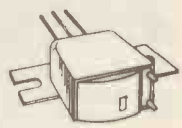
Available to special order in Two-Four-Eight or Sixteen tracks, or to specification. These tracks are located by precision machined slots and track dimensions and positions remain consistent. The track to fixing base dimensions are held to tight limits and any tolerances are non-cumulative as each track 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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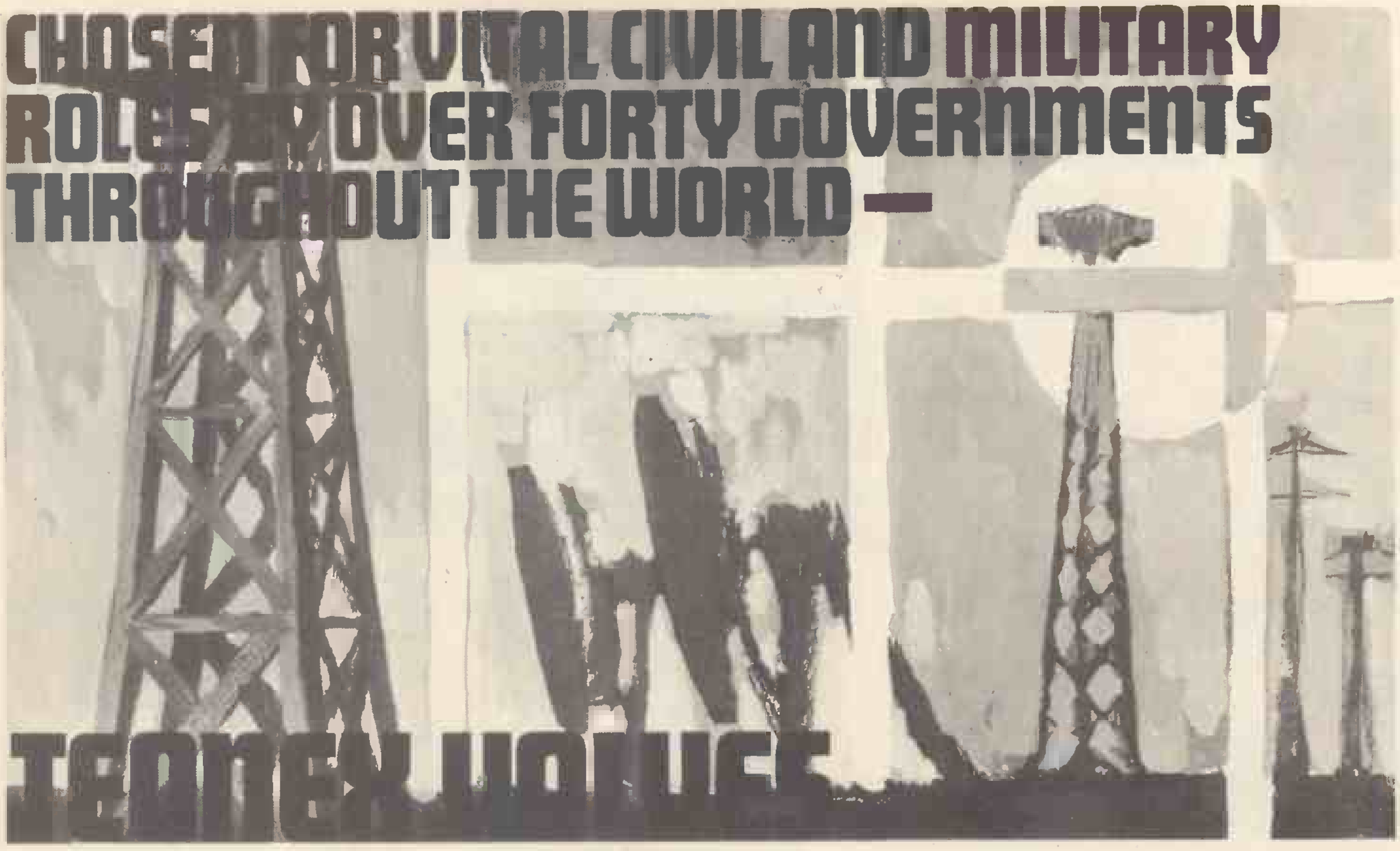

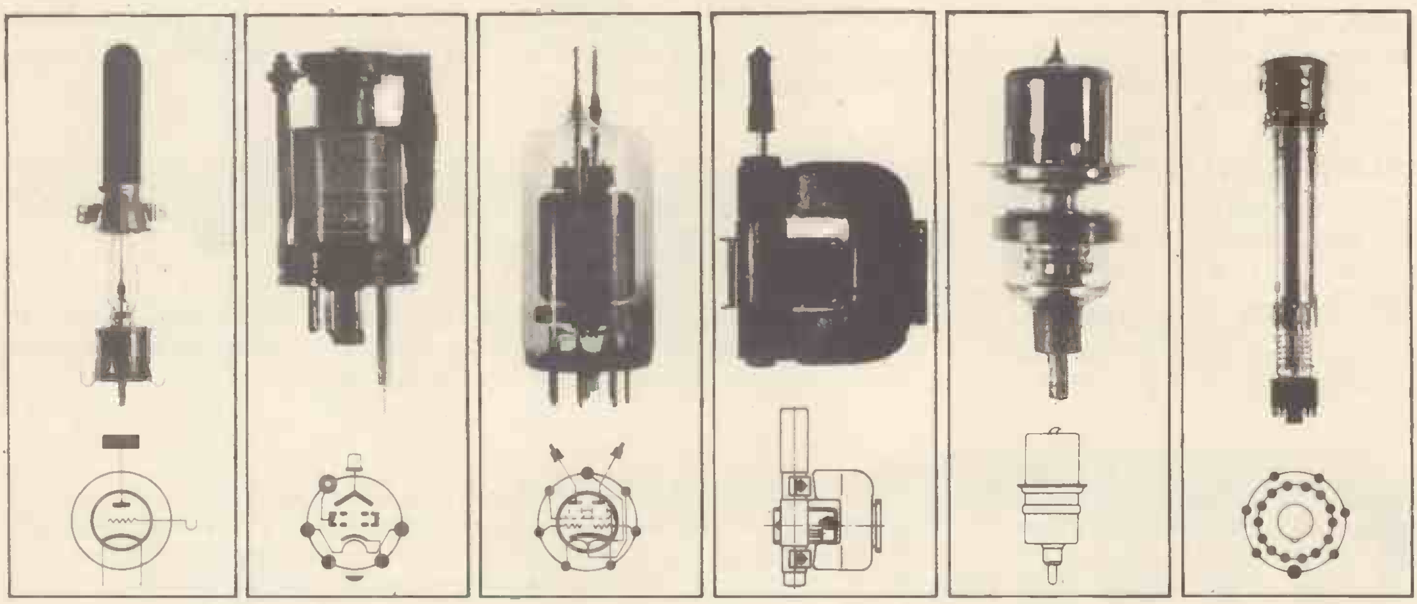

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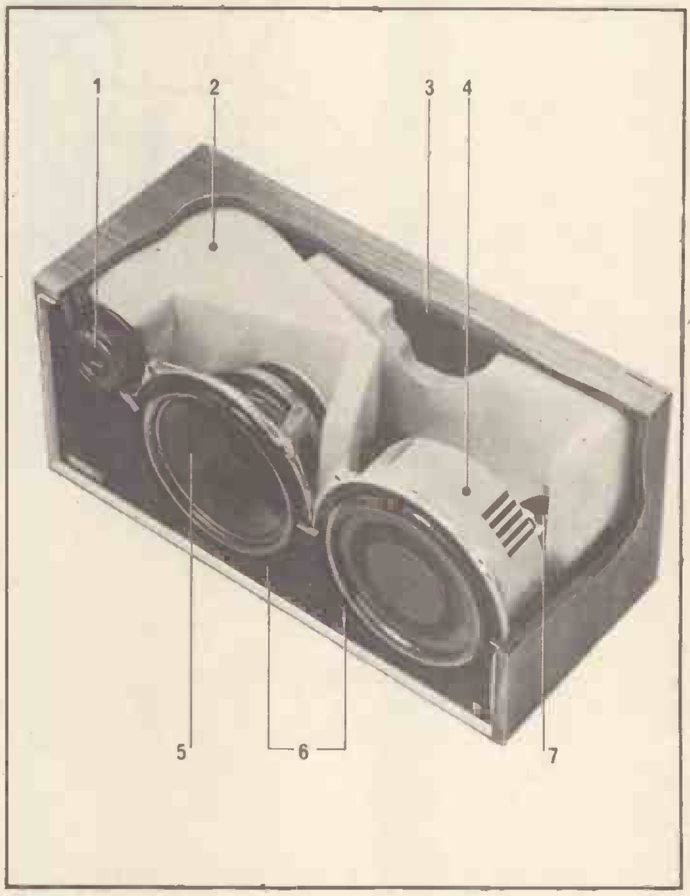

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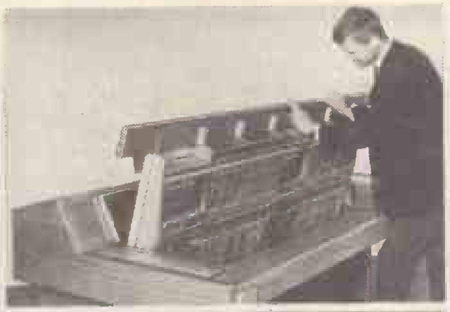

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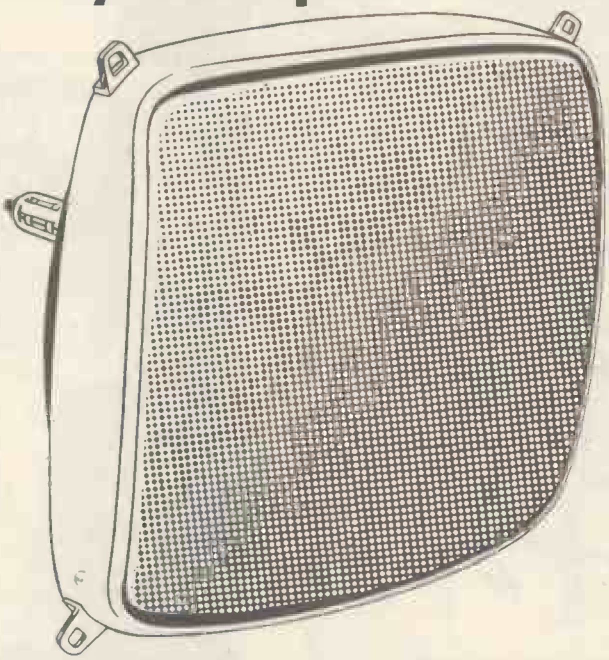

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★ LARGE RANGE OF A.C. & D.C. COILS.

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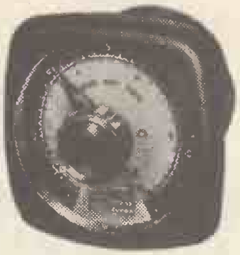

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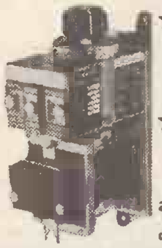

★ Fully adjustable up to 200 seconds. Fitted with 15 amp. S.P.D.T. switch.
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★FOR BATCHING, CONVEYORS, MACHINE TOOL CONTROL, PACKAGING, SORTING, etc.
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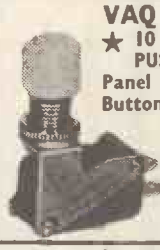

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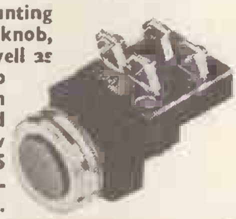

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★ 15/10 AMPS. c/o
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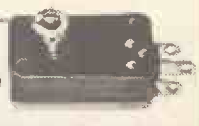

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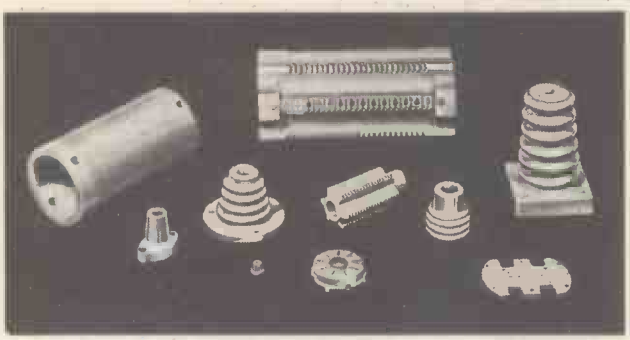
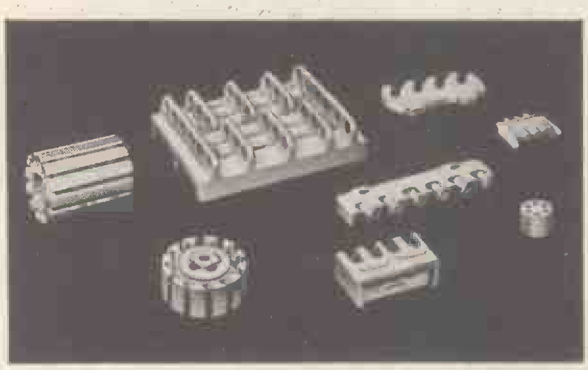


Frequelex—for high-frequency insulation.



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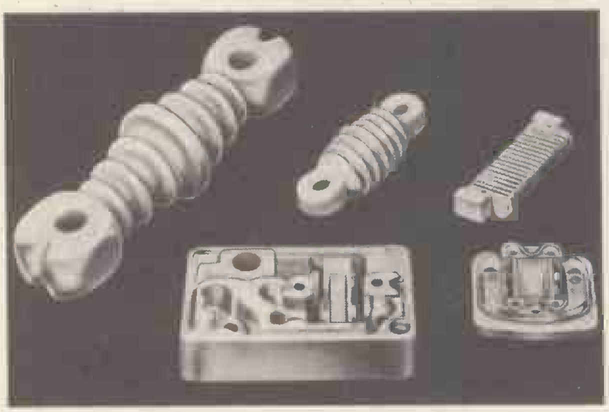

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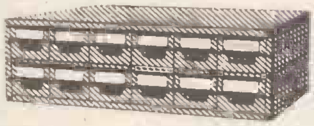

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—electronically speaking!

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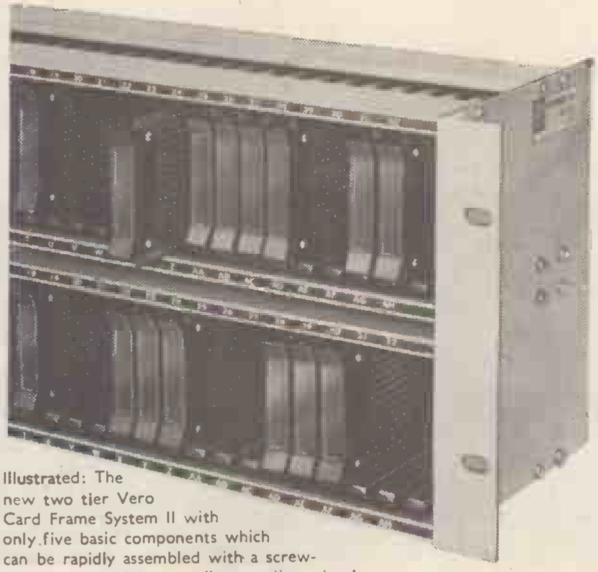

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Technical literature is available.
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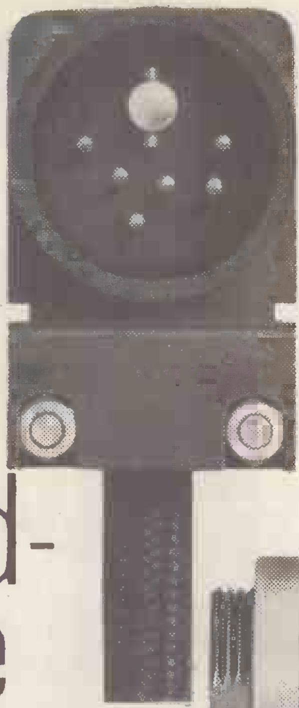
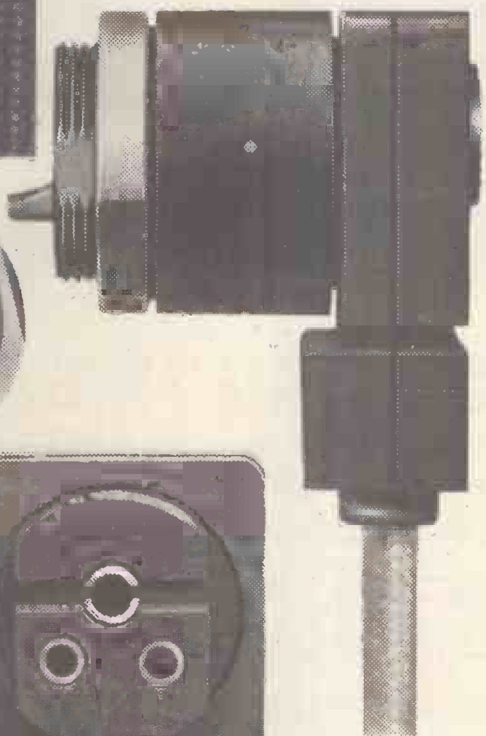
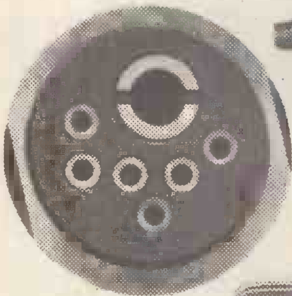
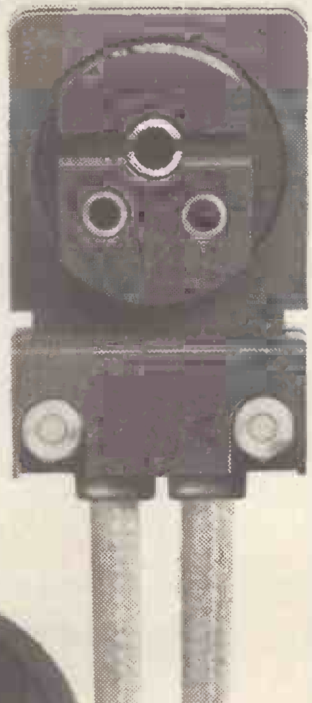
STUMPI

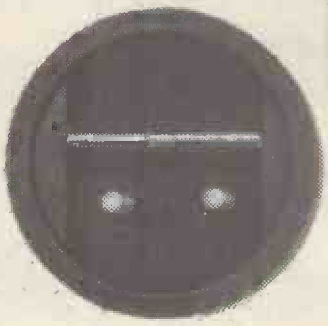
a new connector for the weight-and-space race











— a new connector specifically designed for a new Military project and for the race toward ever lighter, smaller equipment. It uses the very latest materials to achieve brand new standards in compact, efficient design. Just look at these features :

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2. Compact design and positive coupling with the tip of one finger — low height feature making it ideal for use on portable equipment or as low voltage, medium power connectors.
3. "Split shell" construction of cable unit housing for ease of wiring. Elimination of strain on cable joint by means of right-angle contacts.
4. Crimp type contacts in cable unit, with full width cable clamp and sealing grommet.

The Stumpi range is a new conception in design, fully sealed, meeting the requirements of DEF.5325, and is initially available in three shell sizes with nominal contact ratings of 5, 20, 40 and 60 amps.

Approximately twice full size

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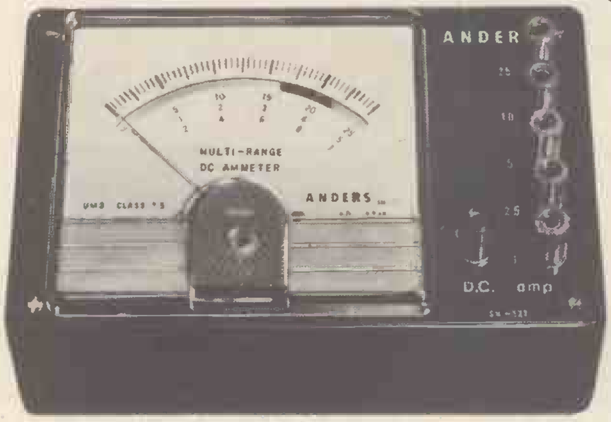
A.C. accuracies within 2.5% F.S.D. Mirror scale approx. 3.5" Case dimensions $7\frac{1}{4}$" x $4\frac{1}{4}$" x 3". Dual connection terminals. Supplied complete with robust leads. Models marked with an asterisk have varistor protection against 50% overload.



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RANGES: 50, 100, 250, 500 and 1,000 Microamperes. £9.2.6 *nett*

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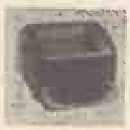

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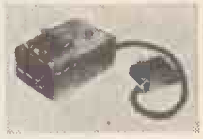

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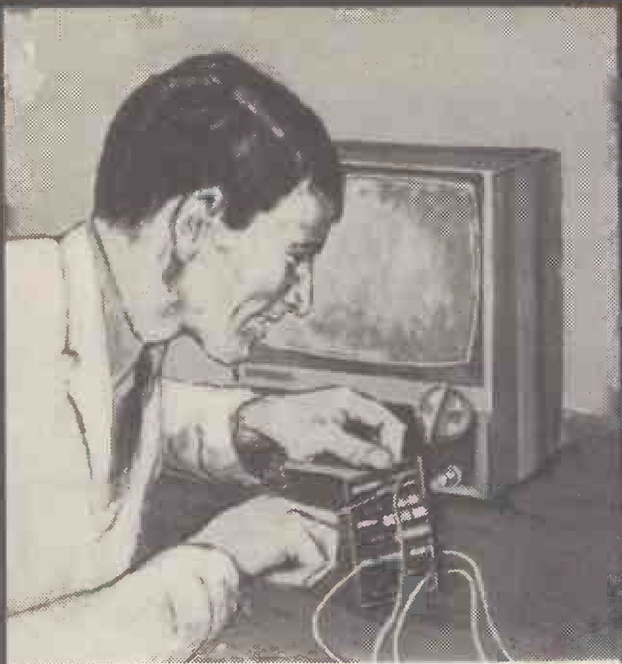

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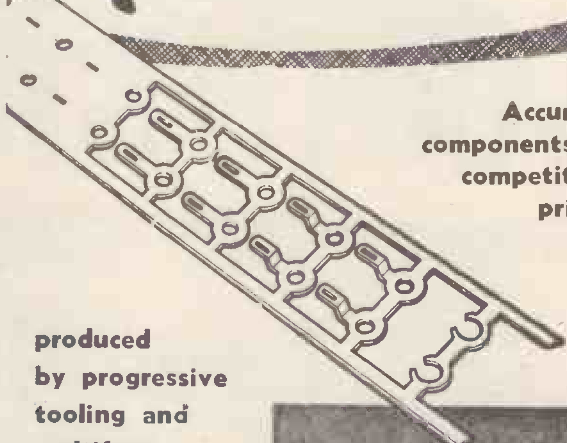

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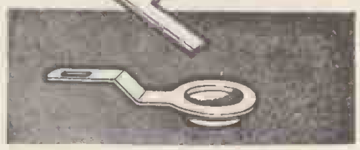

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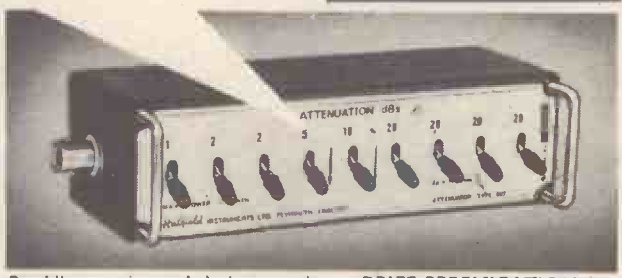
WW—062 FOR FURTHER DETAILS

INSTANT SELECTION from 1 to 100 dB ATTENUATION



Providing precise, switched attenuation from 1 to 100 dB in steps of 1 dB over the range 0-300 MHz, this new Hatfield RF Attenuator is exceptionally neat and compact and is housed in a die-cast aluminium box fitted with nine switches, nine attenuator pads and two BNC co-axial sockets. Only 5½in. × 1⅞in. × 2½in. it is small enough to be used in multiples, if required, without occupying excessive bench space, and offers a versatile and accurate tool for the engineer and laboratory. Type 687A 50 ohms impedance, Type 687B 75 ohms impedance, and Type 687E 600 ohms impedance.

Write or 'phone for further details and ask for a copy of the new Hatfield Short Form Catalogue.

BRIEF SPECIFICATION:

Attenuation: 0 to 100 dB in steps of 1 dB.

Switch Sequence: 1, 2, 2, 5, 10, 20, 20, 20, 20.

Step Accuracy: 1, 2, 5, and 10dB steps: ± 0.1dB at 300 MHz above residual. 20dB steps: ± 0.2dB at 300 MHz above residual.

Insertion Loss: 0.15dB at 50 MHz, 0.25dB at 100 MHz, 0.4dB at 250 MHz.

Frequency Range: D.C. to 300 MHz. (DC to 1 MHz for Type 687E). Max. input 0.5W.

HATFIELD INSTRUMENTS LTD., Dept. W.W., Burrington Way, Plymouth, Devon.
Telephone: Plymouth (0752) 72773/4. Grams: Sigjen, Plymouth.

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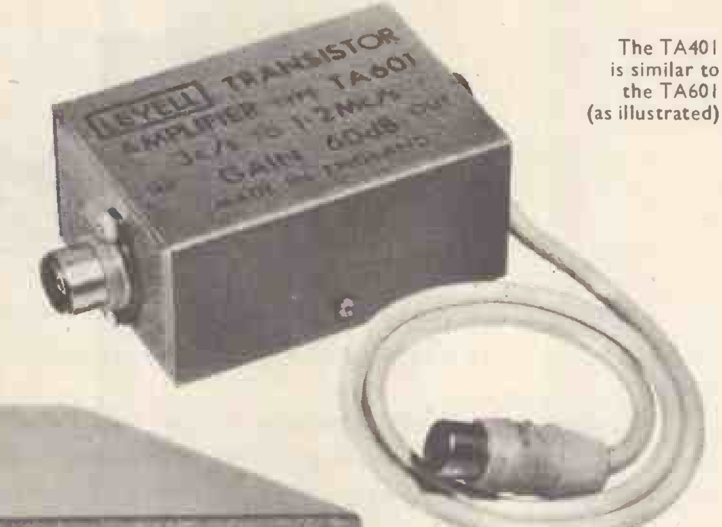

The TA401 is similar to the TA601 (as illustrated)

TA605 ACTUAL SIZE

SPECIFICATIONS

	TYPE TA401	TYPE TA601	TYPE TA605
GAIN	40dB ±0.1dB	60dB ±0.1dB	20, 30, 40, 50 and 60dB ± 0.2dB.
BANDWIDTH ±3dB	1Hz-3MHz	3Hz-1.2MHz	20–40dB, 1Hz-3MHz; 50dB, 2Hz-2MHz; 60dB, 4Hz–1.5MHz.
BANDWIDTH ±0.3dB	4Hz–1MHz	10Hz–300kHz	20–40dB, 4Hz–1MHz; 60dB, 10Hz–300kHz.
INPUT IMPEDANCE	>5M Ω, <40pF from 100Hz to 1MHz	>1M Ω, <50pF from 100Hz to 300kHz	>5MΩ, <40pF from 100Hz to 300kHz.
INPUT NOISE	<15μV, zero source; <50μV, 100kΩ source	<15μV, zero source; <40μV, 100kΩ source	As TA401 and TA601 at 40dB and 60dB.
POWER SUPPLY	PP3 battery, life 100 hours		PP9 battery, life 1,000 hours, or A.C. Power Unit.
AVAILABLE OUTPUT	1V up to 1MHz, 300mV at 3MHz, into load of 100kΩ and 50pF		1.5V up to 2MHz, 1V at 3MHz, into 100kΩ and 50pF.
OUTPUT IMPEDANCE	100Ω in series with 6.4μF		
SIZE & WEIGHT	3″ × 1¾″ × 1¼″ 7 oz.		2½″ × 4″ × 5½″ 2½ lb.
PRICE with Battery and input lead	£17.0.0	£17.0.0	£27.0.0 (Optional A.C. Power Unit £7.10.0 extra)

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WW—064 FOR FURTHER DETAILS

LONDON ENGLAND

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Mr. Harold J. Leak wishes to engage, as his personal technical assistant, an engineer of high vitality, competence and ambition.

The applicant must be capable of designing transistor amplifiers and stereo FM tuners, along guide lines given by Mr. Leak. He must also be capable of carrying out original work, again as guided, on loudspeaker transducers.

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Solid State U.H.F. Fixed Station

for 450 to 470 Mc/s

The Pye F450T u.h.f. base station has a fully transistorised transmitter and receiver, for maximum reliability and minimum size.
The equipment is frequency-modulated, operates from 450 to 470 Mc/s, with 40 to 60 kc/s channel spacing, and is suitable for use with mobile and Pocketfone radiotelephones.

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MR15

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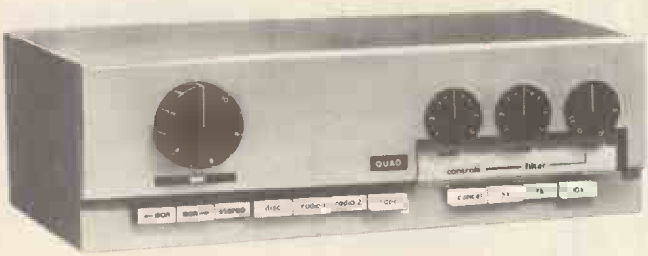

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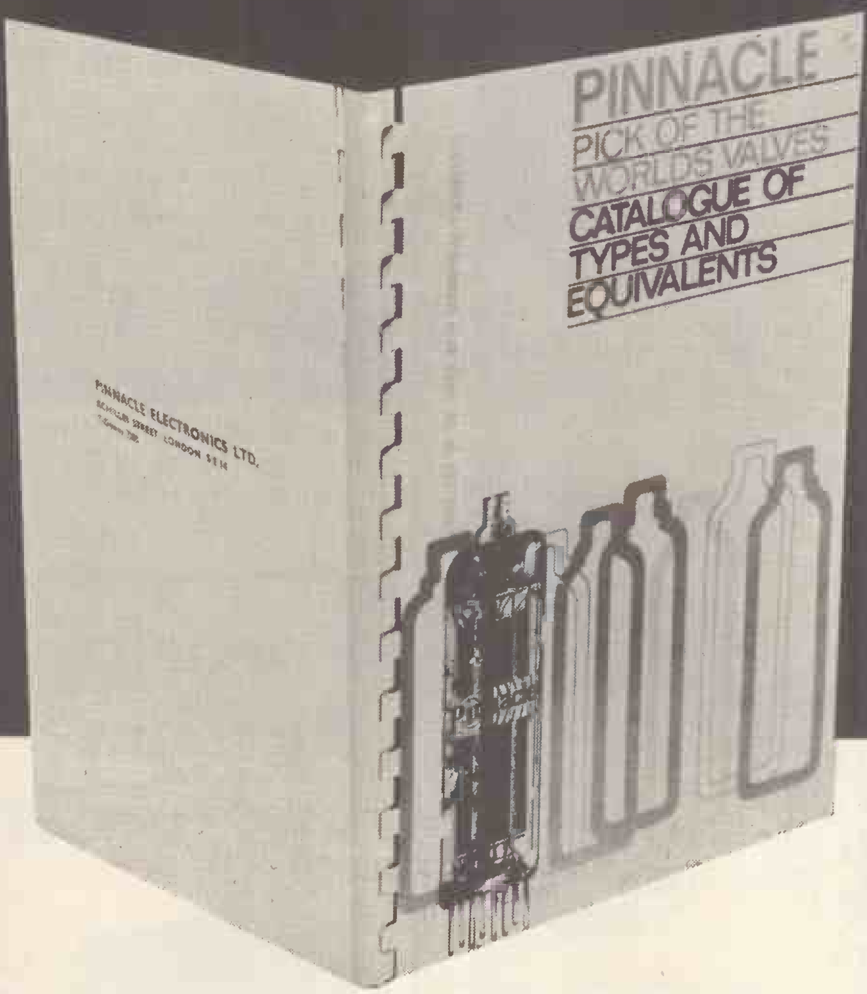

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Audix

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SOUND SYSTEMS and ELECTRONICS

●HIGH PERFORMANCE ●COMPACT MODULAR CONSTRUCTION ●RACK OR CONSOLE MOUNTING

MODULAR AUDIO MIXERS

Model MXT/6 Assemblies offer a combination that will fulfil every requirement for pre-amplifiers and mixing. From 4 to 22 channels can be utilised each with its own independent Gain control and with overall Master Gain, Treble and Bass controls.

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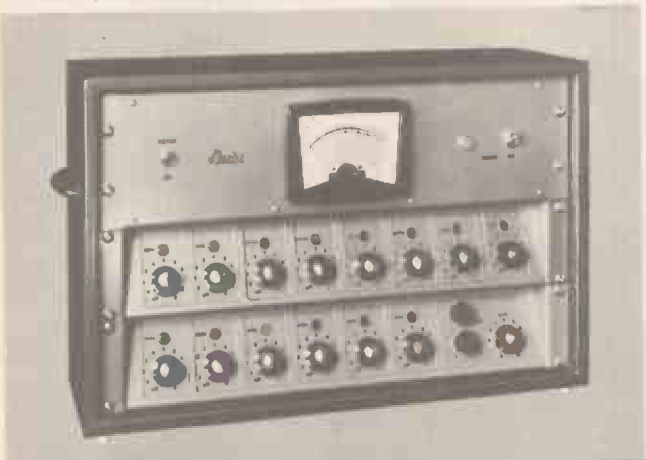
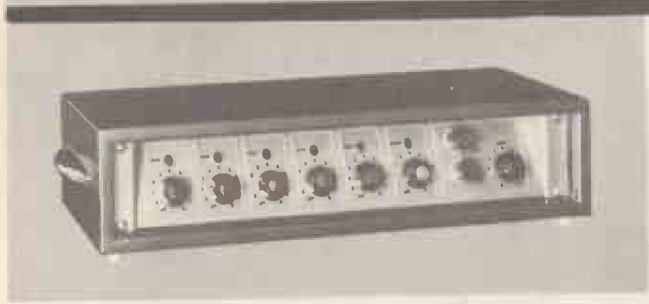
Audio Power Amplifiers having outputs of from 10 to 80 watts and to operate in conjunction with MXT/6 Mixing Assemblies. Silicon Transistorised throughout—stable—high performance—overload and output protection—distortion better than .5% 20 Hz to 15,000 Hz—output 15 ohm and 100 volt to line.





For mounting in Cabinet Rack or Console on 19" standard panels—finished gun metal two tone blue or to requirements—Microphone, Tape, Gramophone, Radio and Priority Tone Signal Modules.

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WW—077 FOR FURTHER DETAILS

Some of the many TR and TB Cells available from EEV

TR CELLS

TYPE NO.	SERVICE TYPE	BAND	FREQUENCY RANGE (MHz)	PEAK POWER (kW)	MAXIMUM V.S.W.R.	MAXIMUM INSERTION LOSS (db)	MAXIMUM RECOVERY TIME TO 6db (μs)
BS390	CV9442	S	2925-3075	1250	1.33	1.0	15
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

TB CELLS

TYPE NO.	SERVICE TYPE	BAND	RESONANT FREQUENCY (MHz)	OPERATING POWER (kW)	MAXIMUM LOADED Q	MAXIMUM V.S.W.R.
BS310	CV6070	X	9375	5-200	6.5	1.1

SOLID STATE WAVEGUIDE SWITCHES
(a suitable 'drive unit' BS402 is available from EEV)

TYPE NO.	BAND	FREQUENCY RANGE (MHz)	BAND WIDTH (MHz)	ATTENUATION AT CENTRE FREQUENCY (db)	MAXIMUM PEAK PULSED LINE POWER (kW)	TYPICAL OPERATING VOLTAGE (V)	MAXIMUM OPERATING CURRENT (mA)
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

TR LIMITER CELL

TYPE NO.	SERVICE TYPE	BAND	FREQUENCY RANGE (MHz)	PEAK POWER (kW)	MAXIMUM V.S.W.R.	MAXIMUM INSERTION LOSS (db)	MAXIMUM RECOVERY TIME TO 3db (μs)	MAXIMUM LEAKAGE, HIGH POWER SPIKE (erg/pulse)
BS814	CV6192	X	9000-9700	200	1.3	0.8	3.0	0.02

EEV can provide you with any type of TR & TB cell you want, whether your radars are marine, airborne or high power. The standard range, which also includes microwave switches for use in S- and X-band duplexer systems, covers narrowband, broadband and tunable types. If, however, you have something special in mind EEV can probably make that too. Details of the standard range are available on request.

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Wireless World

MARCH 1968 **VOLUME 74 NUMBER 1389**

CONTENTS

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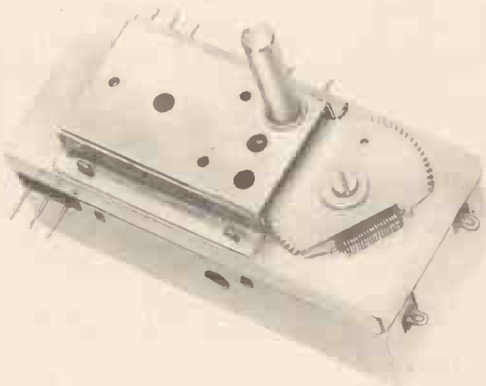

AM/FM modules give you design flexibility

Mullard now offer you in a single can any major circuit function found in a portable or mains radiogram. Take the LP1169 AM/FM tuner for example. It covers 87.5 to 108MHz on FM, short, medium and long wavebands on AM, operates on 9V, is fully screened and has a.f.c. All in one module.

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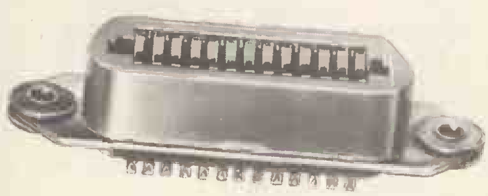

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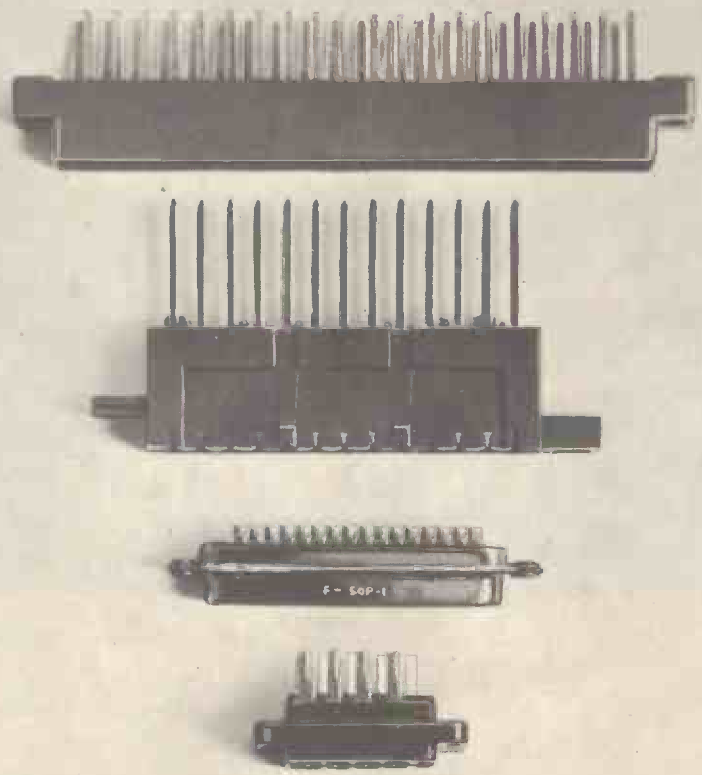

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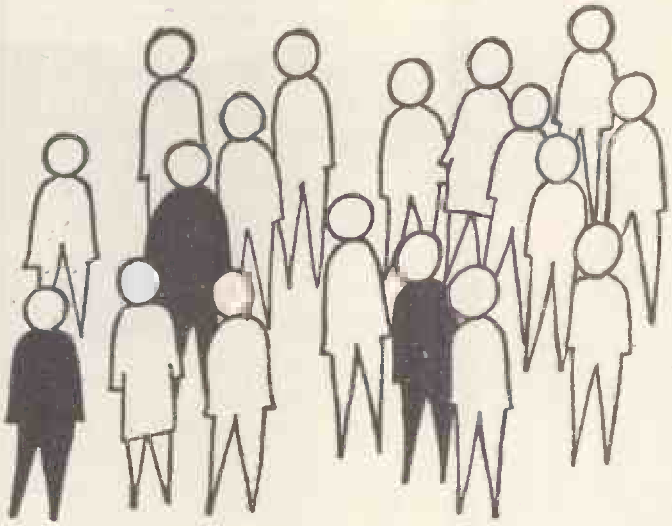

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MST designs reduce demands for space, and need for standby equipment. Installation costs are decreased.

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Covers 85 Kc/s. to 30 Mc/s. in 8 switched ranges. Effective length of film scale is 50ft. Output level variable in 1 dB steps from 1μV to 100mV (75Ω). Also 1V Outputs down to 0.1μV from an outlet at 7.5Ω. Int. mod. at 400 c/s., 1 Kc/s., 1.6 Kc/s. and 3 Kc/s. FM at frequencies above 394 Kc/s. Variable mod. depth and deviation. Crystal calibrator 200 Kc/s and 2 Mc/s. Monitor speaker for beat detection. Fully metered, blower cooled, Panclimatic. A.C. mains 100 to 150 and 200 to 250 volts, 45 to 100 c/s. 17 × 20½ × 17½in. Weight 117 lbs. Fully tested and guaranteed. Fraction of original cost. £65. Carr. 50/-.

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Type 3. 30 v. 2 a., tapped at 12, 15, 20 and 24 v. to give 3-4-5-6-8-9-10 v., etc.
Type 5. 0-6-9-15 v. 4 a. Ideal for chargers.

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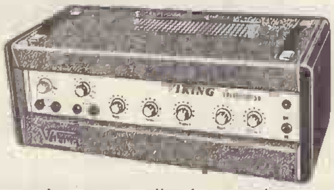

50 WATT AMPLIFIER
An extremely reliable general purpose valve amplifier. Its rugged construction yet space age styling and design makes it by far the best value for money.

TECHNICAL SPECIFICATIONS
4 electronically mixed channels, with 2 inputs per channel, enables the use of 8 separate instruments at the same time. The volume controls for each channel are located directly above the corresponding input sockets.

SENSITIVITIES AND INPUT IMPEDENCES
CHANNEL 1 4mV. AT 470K. } These 2 Channels (4 inputs) are suitable for
CHANNEL 2 4mV. AT 470K. } microphone or guitars.
CHANNEL 3 200mV. AT 1m. } Suitable for most high output instruments
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TONE CONTROLS ARE COMMON TO ALL INPUTS.
BASS BOOST +12 dB AT 60 Hz/s. **BASS CUT** −13 dB AT 60 Hz/s. **TREBLE BOOST** +11 dB AT 15 KHz/s. **TREBLE CUT** −12 dB AT 15 KHz/s.
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TOTAL DISTORTION AT RATED OUTPUT 3.2% } AT 1 KHz/s.
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NEGATIVE FEED BACK 20 dB AT 1 KHz/s.
SIGNAL TO NOISE RATIO 60 dB.
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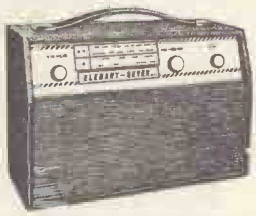
VALVE LINE UP: Double purpose ECC83 x 3, EL34 x 2 and GZ 34.

PRICE
27 gns.
P. & P. 20/-

'ELEGANT SEVEN' MK III

SPECIAL OFFER



- ★ De luxe wooden cabinet size 12½×8½×3½in.
- ★ Horizontal easy to read tuning scale printed grey with black letters, size 11½×2in.
- ★ High "Q" ferrite rod aerial.
- ★ I.F. neutralization on each separate stage.
- ★ D.C. coupled push pull output stage with separate A.C negative feedback
- ★ Room filling output 350 mW.
- ★ Ready etched and drilled printed circuit board back printed for foolproof construction.
- ★ Fully comprehensive instructions and point-to-point wiring diagram.
- ★ Car aerial socket.
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- ★ 5in. P.M. Speaker.
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SPECIFICATIONS. Elegant styled cabinet (sizes 16in. wide, 5in. high, 8½in. deep) in black rexine 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 2×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 monoral position). Output matches into standard 3 ohms speaker system. Suitable 10in.×6in. speakers are available at 29/6 each + 5/- P. & P.
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- ★ High Q internal ferrite rod aerial on both wavebands.
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- ★ Fingertip controls.

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A.C. mains 240v. Size 7in. × 4½in. × 1¾in.
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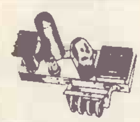
3 TO 4 WATT AMPLIFIER



3-4 watt Amplifier, built and tested. Chassis size 7×3¼×1in. 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.

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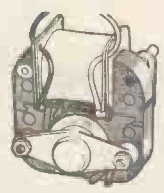

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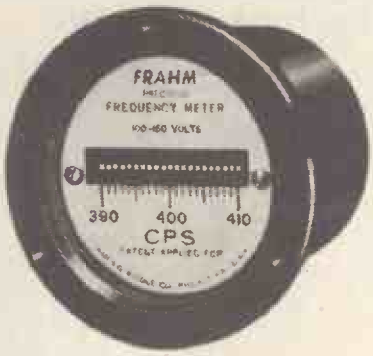

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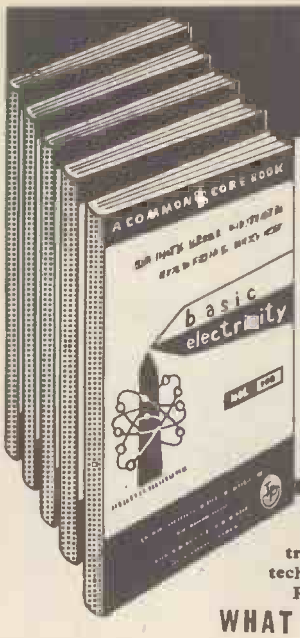

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3A4 3/6
3A5 8/-
3B7 5/-
3D6 3/9
3Q4 5/3
3Q5GT 6/6
3S4 4/9
3V4 5/6
5R4GY 8/9
5U4G 4/9
5V4G 8/-
5Y3GT 5/-
5Z3 7/6
5Z4G 7/6
6/30L2 12/6
6A8G 7/6
6AC7 3/-
6AG7 5/9
6AK5 4/9
6AK6 6/-
6AL5 2/3
6AM4 16/6
6AM6 3/3
6AQ5 4/9
6AR6 20/-
6AT6 3/9
6AU6 5/6
6AV6 5/-
6BA6 4/6
6BE6 4/3
6BH6 6/6
6BJ6 7/-
6BQ5 4/6
6BQ7A 7/-
6BR7 9/-
6BR8 8/-

6BS7 16/6
6BW6 7/-
6BW7 5/6
6C6 3/9
6C9 10/9
6CD6G 19/6
6CH6 6/-
6CW4 12/-
6D3 7/6
6D6 3/-
6F1 9/6
6F6G 4/-
6F12 3/3
6F13 3/6
6F14 15/-
6F15 10/9
6F17 12/6
6F18 8/6
6F23 11/6
6F24 10/-
6F28 10/6
6F32 3/-
6G6G 2/6
6H6GT 1/6
6J5G 3/9
6J5GT 4/6
6J6 3/-
6J7G 4/9
6J7GT 8/6
6K6GT 5/-
6K7G 1/8
6K7GT 4/6
6K8G 3/-
6K8GT 7/6
6L1 10/-
6L18 7/6
6L19 19/-
6LD20 6/6
6N7GT 7/-
6P1 12/-
6P25 12/-
6P26 12/-
6P28 25/-
6Q7G 5/-
6Q7GT 8/9
6R7G 5/6
6SA7GT 7/-
6SC7 6/6
6SG7 7/9
6SH7 3/-
6SJ7 5/-
6SK7 4/6
6SN7GT 4/6
6SQ7GT 6/-
6ST7 12/6
6U4GT 9/6
6U5G 5/-
6U7G 7/-
6V6G 3/6

6X4 3/6
6X5GT 5/3
6Y7G 12/6
7B6 10/9
7B7 7/-
7C5 40/-
7C6 6/-
7H7 5/-
7R7 12/6
7V7 5/-
7Y4 6/6
9BW6 9/6
9D7 7/6
10C1 9/-
10C2 12/-
10D1 7/-
10D2 11/8
10F1 15/-
10F9 9/-
10F18 9/-
10LD11 10/-
10P13 14/6
10P14 15/6
12A6 5/-
12AC6 8/-
12AD6 9/-
12AE6 7/6
12AT6 4/6
12AT7 3/6
12AU6 4/9
12AU7 4/6
12AV6 5/9
12AX7 4/6
12AY7 9/9
12BA6 5/-
12BE6 5/3
12E1 17/6
12J5GT 2/6
12J7GT 6/6
12K5 8/-
12K7GT 3/6
12K8GT 7/9
12Q7GT 3/6
12SA7GT 6/9
12SC7 4/-
12SH7 3/-
12SJ7 5/-
12SK7 3/-
12SQ7GT 8/-
12SR7 5/-
12Y4 2/-
14H7 9/6
14S7 19/6
18 12/6
19 10/6
19AQ5 5/-
20D1 13/-
20D4 20/5

20F2 11/6
20L1 13/-
20P1 17/6
20P3 17/-
20P4 17/6
20P5 17/-
25A6G 7/6
25L6G 4/9
25Y5 6/-
25Y5G 8/6
25Z4G 6/3
25Z5 7/-
25Z6G 8/6
30C1 7/-
30C15 12/-
30C17 13/-
30C18 9/6
30F5 11/6
30FL1 15/-
30FL12 15/-
30FL14 12/6
30L1 6/-
30L15 14/-
30L17 13/-
30P4 11/6
30P4MR 13/-
30P12 11/-
30P19 11/-
30PL1 15/-
30PL13 15/-
30PL14 15/-
30PL15 15/-
35A5 15/-
35L6GT 6/3
35W4 4/6
35Z3 10/-
35Z4GT 4/6
35Z5GT 5/6
50A5 21/10
50B5 6/3
50C5 5/9
50CD6G 41/-
50L6GT 6/-
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85A2 8/6
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90AV 67/6
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305 16/6

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956 2/-
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AZ41 6/6
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CY1C 6/6
CY31 7/9
D15 15/6
D63 5/-
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DAC32 7/-
DAF91 3/3
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DF33 7/9
DF91 2/6
DF96 6/-
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DH63 5/-
DH76 3/6
DH77 3/9
DH81 10/9
DK32 7/6
DK40 10/6
DK91 4/9
DK92 7/6
DK96 6/6
DL33 6/6
DL35 4/9
DL92 4/9
DL94 5/6
DL96 6/-
DM70 6/-

DM71 9/9
DW4/350 8/6
DW4/500 8/6
DY86 5/9
DY87 5/9
E80F 24/-
E83F 24/-
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EA50 1/6
EA76 13/-
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EAF42 7/6
EB41 4/9
EB91 2/3
EBC3 20/6
EBC33 6/-
EBC41 7/3
EBC81 6/3
EBC90 3/9
EBC91 5/-
EBF80 5/9
EBF83 7/-
EBF89 5/9
EBL21 10/3
EC52 4/3
EC53 12/6
EC54 6/-
EC70 4/9
EC86 11/6
EC88 11/-
EC91 4/-
EC92 6/6
ECC31 15/6
ECC32 4/6
ECC33 29/1
ECC34 29/6
ECC35 4/9
ECC40 9/6
ECC81 3/6
ECC82 4/6
ECC83 4/6
ECC84 6/-
ECC85 5/-
ECC88 7/-
ECC189 9/-
ECF80 7/-
ECF82 6/9
ECF86 8/6
ECH3 23/3
ECH21 9/6
ECH33 22/8
ECH35 6/-
ECH42 8/9
ECH81 5/6
ECH83 7/-

ECH84 6/6
ECL80 6/-
ECL82 6/-
ECL83 9/-
ECL84 12/-
ECL85 11/-
ECL86 7/9
ECLL800 23/9
EF22 6/6
EF36 3/-
EF37A 7/-
EF39 5/-
EF40 8/9
EF41 9/-
EF42 3/6
EF50 2/6
EF54 6/-
EF80 4/6
EF83 9/9
EF85 4/6
EF86 6/3
EF89 4/9
EF91 3/8
EF92 2/6
EF97 8/-
EF98 9/-
EF183 6/3
EF184 6/3
EH90 7/6
EL32 3/-
EL33 12/-
EL34 9/6
EL35 10/-
EL36 8/9
EL37 16/6
EL41 8/-
EL42 7/6
EL81 8/-
EL83 6/9
EL84 4/6
EL85 7/6
EL86 8/-
EL91 2/6
EL95 5/-
ELL80 13/-
EM71 14/-
EM80 5/9
EM81 6/9
EM84 6/-
EM85 11/-
EM87 6/6
EY51 6/6
EY81 7/-
EY83 9/-
EY84 9/6
EY86 6/-
EY87 6/-
EY88 7/6

EY91 3/-
EZ35 5/3
EZ40 6/-
EZ41 6/6
EZ80 3/9
EZ81 4/3
EZ90 3/6
FW4/500 6/6
FW4/800 8/6
GZ30 7/6
GZ32 9/-
GZ33 12/6
GZ34 10/-
GZ37 14/6
HABC80 9/6
HL2 7/6
HL13C 4/-
HL22 10/6
HL23DD 5/-
HL41DD 19/6
HL42DD 8/-
HL133DD 9/6
HN309 26/6
HVR2 8/6
HVR2A 8/6
IW3 5/6
IW4/350 5/6
IW4/500 6/-
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KF35 12/6
KL35 11/6
KLL32 21/7
KT2 5/-
KT8 15/-
KT32 4/9
KT36 29/1
KT41 19/6
KT44 5/6
KT61 12/-
KT63 4/-
KT66 16/6
KT74 12/6
KT76 7/6
KT88 27/6
KTW61 5/6
KTW62 12/6
KTW63 5/-
KTZ41 6/-
L63 3/9
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MHLD6 12/6
ML6 6/-
MU12/14 4/-
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N78 38/4
N339 25/-
P61 2/6
PABC80 7/6
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PC88 8/6
PC95 6/9
PC97 5/9
PC900 9/-
PCC84 6/-
PCC85 6/9
PCC88 10/6
PCC89 11/-
PCC189 8/3

PCF80 7/-
PCF82 6/-
PCF84 8/-
PCF86 8/-
PCF801 8/6
PCF802 9/6
PCF805 9/6
PCF806 11/6
PCF808 12/6
PCL81 9/-
PCL82 6/6
PCL83 10/3
PCL84 8/3
PCL85 8/3
PCL86 8/3
PCL88 15/-
PEN45 7/-
PEN45DD 19/6
PEN46 4/-
PEN383 9/6
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PEN/DD 4020 17/6
PFL200 13/6
PL33 9/-
PL36 9/-
PL38 19/9
PL81 7/6
PL81A 7/6
PL82 5/9
PL83 6/-
PL84 6/3
PL500 13/6
PL504 15/-
PM84 9/3
PX4 14/-
PY80 5/-
PY81 5/-
PY82 5/-
PY83 5/6
PY88 7/3
PY800 6/-
PY801 6/-
PZ30 9/6
QP21 5/-
QQVO3/10 30/-
QS150/15 9/6
R10 15/-
R11 19/6
R12 6/6
R16 34/11
R17 17/6
R18 9/6
R19 6/9
R52 7/6
RK34 7/6
SP13C 12/6

SP42 12/6
SP61 2/-
TDD2A 12/6
TDD4 7/6
TH4B 10/-
TH233 6/9
TP2620 7/6
TY86F 11/10
UABC80 5/3
UAF42 9/6
UB41 10/6
UBC41 6/6
UBC81 6/6
UBF80 5/6
UBF89 5/9
UBL21 9/-
UC92 5/6
UCC84 8/-
UCC85 6/6
UCF80 8/3
UCH21 9/-
UCH42 8/6
UCH81 6/-
UCL82 7/-
UCL83 9/6
UF41 7/-
UF42 9/-
UF80 6/9
UF85 7/3
UF86 9/-
UF89 5/6
UL41 9/-
UL46 9/6
UL84 6/-
UM80 5/-
UR1C 6/6
UU5 7/-
UU8 16/6
UU12 4/3
UY1N 10/3
UY21 9/-
UY41 6/6
UY85 5/6
U10 9/-
U12/14 7/6
U16 15/-
U17 5/-
U18/20 6/6
U19 40/-
U22 5/9
U25 12/6
U26 11/-
U31 6/3
U33 13/6
U35 16/6
U37 34/11
U45 15/6
U50 5/-
U52 4/9
U76 4/6
U78 3/6
U101 19/6
U107 17/6

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U281 8/9
U282 12/3
U301 12/6
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W729 10/-
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X66 7/6
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AC155 6/6
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AC169 6/6
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ACY17 3/4
ACY18 5/3
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BA130 2/-
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BCY34 5/-
BCY38 5/-
BCY39 5/-
BCZ11 3/6
BC107 4/-
BC108 3/9
BC109 4/6
BC113 5/-
BC115 3/-
BC116 5/-
BC118 4/6
BD119 9/-
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BFY52 5/-
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BF154 5/-
BF159 5/-
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BF173 2/6
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BY105 10/6
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GD4 6/6
GD5 5/6
GD6 5/6
GD8 4/-
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GD10 4/-
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GD12 4/-
GD14 10/-
GD15 8/-
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GET103 4/-
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GET113 4/-
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GET115 17/-
GET116 7/6
GET118 4/6
GET119 4/6
GET573 8/6
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GET897 4/6
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OA5 1/9
OA9 2/6
OA10 6/6
OA47 2/-
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OA95 1/9
OA182 2/-
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OA211 13/6
OAZ200 12/-
OAZ201 10/6
OAZ202 9/-
OAZ203 9/6
OAZ204 9/-
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OAZ210 7/-
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OC19 25/-
OC22 5/-
OC23 7/-
OC24 14/6
OC25 5/-
OC26 5/-
OC28 5/-
OC29 16/6
OC30 7/-
OC35 10/-
OC36 7/6
OC38 11/6
OC41 10/-

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OC43 12/6
OC44 2/-
OC44PM 8/3
OC45 1/9
OC45M 8/-
OC46 3/-
OC65 22/6
OC66 25/-
OC70 2/3
OC71 2/-
OC72 2/-
OC73 16/-
OC74 8/-
OC75 2/-
OC76 3/-
OC77 3/4
OC78 3/-
OC78D 3/-
OC79 8/-
OC81 2/-
OC81D 2/-
OC81M 5/-
OC82 2/3
OC82D 2/6
OC83 2/-
OC84 3/-
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OC139 12/-
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OC170 2/6
OC171 3/4
OC172 4/-
OC200 5/-
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OC204 10/6
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LP15 (AC113, AC154, AC157, AA120). 12/6.
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1—OC81D and 2—OC81, 7/6.
1—OC82D and 2—OC82, 8/6.
1—OC83D and 2—OC83, 8/6.
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2 C Lock/2 C Lock, 12/6.
4 C Lock/4 C Lock, 17/6.
Stop/4 C Lock, 12/6.
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Low Capacitance 8 C Muirhead, 17/6.
Stop/2 C Lock, 7/6.
Stop/4 C Non Lock, 10/6.
2 C Lock/6 C Lock, 17/6.

TRANSISTORS ASZ 20 7/6 ea. GET 875 special low gain selection 6/- ea. 2S002 15/- ea. V30-30P 15/- ea. Diode SX645 15/- ea.

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PRESSURE TRANSDUCERS. SE. LABS 152A, 20 p.s.i., with transformer, £15 each.

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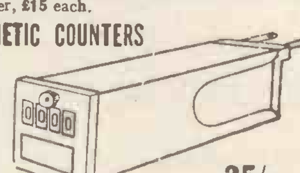

3¼ × 1in., 10 counts per second with 4 figures. The following D.C. voltages are available, 6 v., 12 v., 24 v., 50 v. or 100 v. **35/-**

MAGNETIC COUNTERS, with zero reset 230 v. A.C. or 110 v. Veeder Root 6 fig. 65/- ea. Counting Insts. flush type 48 v. D.C., 90/- ea., post 3/-.

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Volts 5/0/5 2½in. MC	25/-
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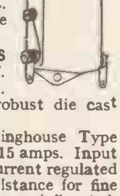
PORTABLE VOLTMETERS. 0/250 Moving Iron A.C./D.C. 6in. scale, in polished wood case, £7/10/-.

MINIATURE BUZZERS (as illus.), 12 volt with tone adjuster, 7/6.



HIGH NOTE BUZZERS 24 v. A.C./D.C. with tone adjuster, 2¼in. dia. Bakelite case, 10/6. Post 2/-.

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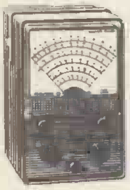

High quality instrument with 28 ranges. D.C. volts 1.5-1,500 v. A.C. volts 1.5-1,500 v. Resistance up to 1,000 megohms. 220/240 v. A.C. operation. Complete with probe and instructions £15. P. & P. 6/-. Additional Probes available: R.F. 35/- H.V. 42/6.

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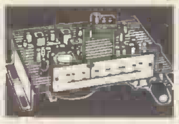

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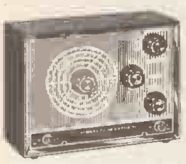

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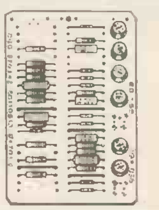

Five assorted printed circuit boards with transistors, diodes, resistors, condensers, etc. Guaranteed minimum 20 transistors. Ideal for experimenters. 5 Boards for 10/-. P. & P. 2/-.

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4 band receiver covering 550 Kc/s to 30 Mc/s. continuous and electrical band spread on 10, 15, 20, 40 and 80 metres. 8 valve plus 7 diode circuit. 4/8 ohm output and phone jack. SSB-CW ● ANL ● Variable BFO ● S meter ● Sep. band spread dial ● IF 455 Kc/s ● audio output 1.5 W. ● Variable RF and AF gain controls. 115/250 V. A.C. Mains. Beautifully designed. Size: 7 × 15 × 10in. With instruction manual and service data. £3/10/0. Carriage 12/6.

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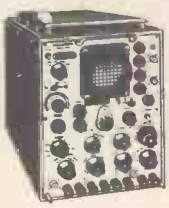
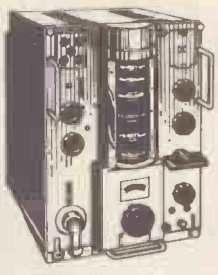


An extremely high quality oscilloscope originally costing £400. Switched beam. Identical Y1, Y2 Amplifiers D.C. to 9 Mc/s. Sensitivity 3mV/CM to 100 V/CM. Time base 10µsec. to 10 M/secs. Calibrator. X amplifier D.C. to 2.5 Mc/s. Z Modulation. 110/200/250 v. A.C. Supplied in good working order. £65, carriage £2, or available as received from Ministry unserviced £50. carriage £2. (Handbooks £2 extra.)

ADMIRALTY B.40 RECEIVERS



Just released by the Ministry. High quality 10 valve receiver manufactured by Murphy. Coverage in 5 bands 650 Kc/s-30 Mc/s. I.F. 500 Kc/s. Incorporates 2 R.F. and 3 I.F. stages, bandpass filter, noise limiter, crystal controlled B.F.O. calibrator, I.F. output, etc. Built-in speaker, output for phones. Operation 150/230 volt A.C. Size 19½ × 13½ × 16in. Weight 114 lb. Offered in good working condition. £22/10/-, carr. 30/-. With circuit diagrams. Also available B41 L.F. version of above. 15 Kc/s-700 Kc/s. £17/10/-, carr. 30/-.

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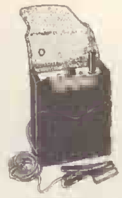

94-104 Mc/s. Transistorised Operates from 9 v. battery. Complete with additional secret tie-clip microphone. List £12/10/-. ONLY £6/15/-. P. & P. 2/6.

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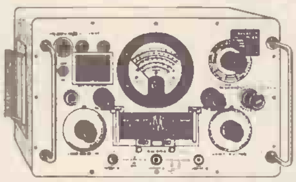

High quality 97 range instrument which measures A.C. and D.C. Voltage. Current, Resistance and Power output. Ranges D.C. volts 250mV-10,000 v. (10 megΩ-110megΩ input). D.C. current 10µA 25 amps. Ohms: 0-1,000 megΩ. A.C. volt 100 mV-250 v. (with R.F. measuring head up to 250 Mc/s). A.C. current 10µA-25 amps. Power output 50 microwatts-5 watts. Operation 0/110/200/250 v. C. Supplied in perfect condition complete with circuit lead and R.F. probe £25. Carr. 15/-.

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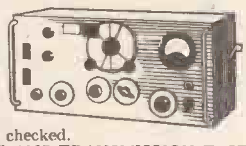
MARCONI TEST EQUIPMENT



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0-20 Kc/s. Output 5K or 500 ohms. 200/250 v. A.C. Offered in excellent condition, £12/10/-. Carriage 10/-.

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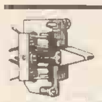

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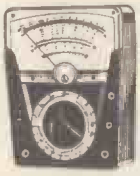

MODEL TE-70. 30,000 O.P.V. 0/3/15/60/300/600/1,200 v. D.C. 0/6/30 / 120 / 600 / 1,200 v. A.C. 0/30μA / 3/30 / 300 mA. 0/16K/160K/1.6M/16 Meg. Ω. £5/10/-. P. & P. 3/-.

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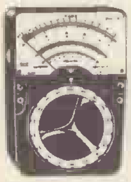

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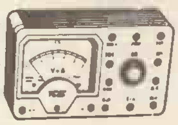

MODEL PT-34. 1,000 O.P.V. 0/10/50 / 250 / 500 / 1,000 v. A.C. and D.C. 0/1/100/500 mA. D.C. 0/100 KΩ 39/6. P. & P. 1/6.

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With automatic overload protection. Mirror scale. Ranges 0/10/50 / 200 / 500 / 1,000 v. D.C. and A.C. 0-500μA. 10 mA. 250 mA. Current 0/20K, 200K, 2 megohm. Decibels −20 to +22dB. £5/10/-. P. & P. 2/6.

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It has the fullest capacity for checking on A, B and Ico. Equally adaptable for checking diodes, etc. Spec.: A: 0.7-0.9967. B: 5-200. Ico: 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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An extremely high quality oscilloscope with time base of 10c/sec. to 20 m/sec. Internal Y amplifier. Separate mains power supply 200/250V. Supplied in excellent condition with cables, probe, etc., as received from Ministry. £8/19/6. Carriage 30/-

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8", 3 ohm speakers in metal case. Black crackle finish to match our 88 Receivers. Available Brand New and Boxed with leads. 59/6. Carr.-7/6.

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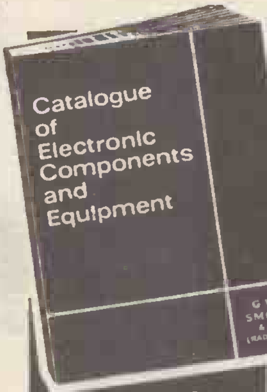
LAB 80 Mk. II less cartridge. £23 10 0 Carr. 7/6



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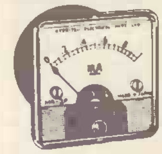

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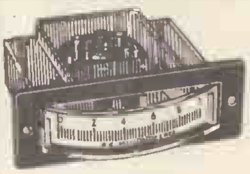
		50mA	25/-	10V D.C.	25/-	300V A.C.	25/-
		100mA	25/-	20V D.C.	25/-	500V A.C.	25/-
		150mA	25/-	50V D.C.	25/-	'S'Meter 1 mA	29/6

POST EXTRA. Larger sizes available—send for lists

NEW RANGE OF "SEW" EDGEWISE METERS



MODEL PE70. Dimensions 3 17/32 × 1 11/32 × 2½in. deep overall. Available as follows:

50 microamp	57/6	200 microamp	52/6
50-0-50 microamp	55/-	500 microamp	49/6
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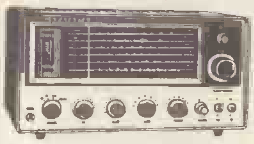
100-0-100 microamp	52/6	300 volt A.C.	45/-
		VU meter	62/6

Post extra.

LAFAYETTE MODEL HA-500 SSB/AM/CW 80 THROUGH 6 METER RECEIVER



New outstanding Ham Bands only receiver covering the 80/40/20/15/10/6 metre bands. Incorporates 10 valves, product detector, two mechanical filters, S Meter, dual conversion on all bands, crystal calibrator, V.F.O. noise limiter, aerial trimmer, I.F.s 2,608 Mc/s. and 455 Kc/s. Output 8 ohms and 500 ohms. Operations 220/240 volts A.C. Supplied brand new and guaranteed with handbook 42 Gns. Carr. 10/-. 100 Kc/s. crystal, 35/-.

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Covering 550 Kc/s-30 Mc/s. Incorporates variable BFO for CW/SSB reception. Built in speaker and phone jack. Metal cabinet. Operation 220/240v. A.C. Supplied brand new, guaranteed with instructions. £12/10/-. Carr. 7/6.

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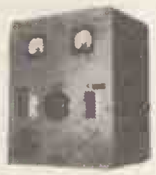

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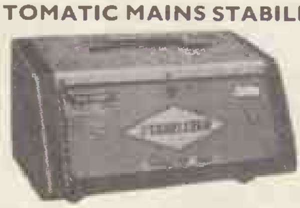

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Beta 5-300

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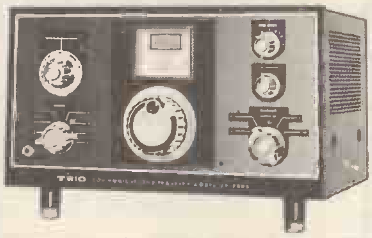
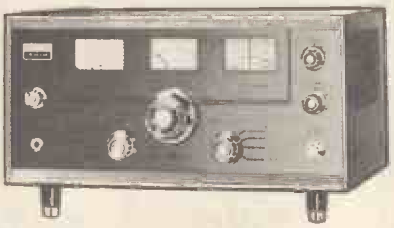
MODEL JR-500SE



This high performance receiver is made especially to cover the amateur bands and utilises a crystal controlled double heterodyne circuit for extra sensitivity and stability. **Brief spec.:** Covers all the amateur bands in 7 separate ranges between 3.5 and 29.7 Mc/s. Circuit uses 7 valves, 2 transistors and 5 diodes plus 8 crystals, output 8 and 500 ohm and 500 ohm phone jack. Special features: Crystal controlled oscillator ● Variable BFO ● VFO ● AVC ● ANL ● S meter ● SSB-CW ● Stand-by switch ● Special double gear dial drive with direct reading down to 0 kH. ● Remote control socket for connection to a transmitter. Audio output 1 watt. For use on 115/250 V A.C. Mains. Superb modern styling and control layout—finished in dark grey. Cabinet size 7×13×10in. Weight 18 lb. Fully guaranteed, complete with instruction manual and service data.

Lasky's Price £61.19.0 Carriage and Packing 12/6.

MODEL 9R-59DE



Brief Spec.: 4 band receiver covering 550 Kc/s to 30 Mc/s continuous and electrical band spread on 10, 15, 20, 40 and 80 metres. 8 valve plus 7 diode circuit. 4/8 ohm output and phone jack. Special features: SSB-CW ● ANL ● Variable BFO ● S meter ● Sep. band spread dial ● IF frequency 455 Kc/s ● audio output 1.5 W ● Variable RF and AF gain controls. For use on 115/250 V AC. Mains. Beautifully designed control layout finished in light grey with dark grey case. Size: 7×15×10in. Weight 19 lb. Fully guaranteed, complete with instruction manual and service data.

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Can now be built for **£8.19.6** Post 5/- extra.

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5 mA DC ..	22/6	5 mA DC ..	25/-	5mA DC	32/6	5 mA DC ..	35/-	5 mA DC ..	35/-
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1 mA S Meter	29/6			500µA	37/6	500µA	42/6		
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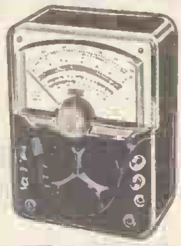
TEST EQUIPMENT

TMK Model 500



A compact and reliable instrument designed for use in the production, servicing and maintenance of electronic, radio and T.V. equipment. Measures a wide range of voltages, currents, resistance and audio power. **Specification:** Movement sensitivity 30µA. D.C. volts range: 0-0.25, 1, 2.5, 10, 25, 100, 250, 500, 1,000 volts at 30K OPV. A.C. volts ranges: 0-2.5, 10, 25, 100, 250, 500, 1,000 volts at 15K OPV. dB scale: 6 ranges −20 to +56dB. D.C. current: 0-50µA, 5, 50, 500mA. 12A. Resistance ranges: 0-60K, 6, 60M/c. Test buzzer for continuity testing. Size 6¼in.×3¾in.×2¼in.

Lasky's Price £8.17.6 Post Free

Model C-1000 Mili Tester

A really tiny meter with "big" meter performance. Brief Specification: Movement sensitivity 400 µA: DC volts ranges: 0-10, 50, 250, 1,000 volts, +3% fsd at 1K OPV. AC volts ranges: 0-10, 50, 250, 1,000 volts +4% fsd at 1K OPV. DC current: 0-1, 100 mA. Resistance range: 0-150K ohms. Size 2¼in. × 3¼in. × 1in.

Lasky's Price 39/6 Post 2/6

TRANSISTOR SIGNAL INJECTOR

MODEL C-3003

Self-contained 1¼in. dia. 5in. long, with light and test probe. For fault finding in radios, amplifiers, etc. Complete with batteries and extension probe.

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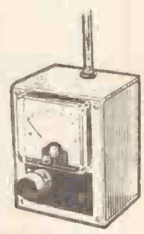
FIELD STRENGTH METER



Designed for checking the radiation from adjacent transmitter. A sensitive and compact unit that requires no battery or other power supply. Frequency range: 1 to 250 Mc/s. Telescopic aerial extends to 9½ in. In metal case. Size: 3½ × 2½ × 2 in., with 1¾in. square meter, also earpiece for audible check. Magnet in base, for attaching the meter to metal shelf, car body, etc.

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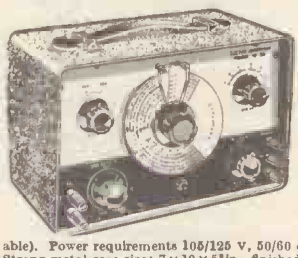
NEW SPECIALISED TEST GEAR

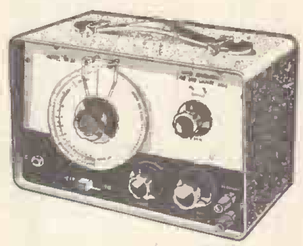
RF SIGNAL GENERATOR Model TE-20



A new high quality factory tested and callibrated RF Signal Generator offering a full frequency range cover of 120 Kc/s to 260 Mc/s in 6 bands plus one harmonic band. Dual High/Low RF output terminals provided and separate variable Audio output. Etched circular scale—accuracy ± 2%—read against hair-line on perspex cursor. Power "on" pilot light fitted. **Brief Specification:** Frequency range (6 fundamental bands) A. 120-320 Kc/s, B. 320-1,000 Kc/s, C. 1-3.4 Mc/s, D. 3.2-11 Mc/s, E. 11-38 Mc/s, F. 36-130 Mc/s. Harmonic Band 130-260 Mc/s. Frequency accuracy ± 2%. Output—RF (high) 100,000µV max., RF (low) 100µV max. Audio output 400 c.p.s., 8V approx. (adjustable). Power requirements 105/125 V, 50/60 c/s A.C. Valve line-up: 12BH7A, 6AR5 and selenium rectifier. Strong metal case size: 7×10×5¼in., finished in grey crackle with leather carrying handle. Complete with test leads and instruction book.

Lasky's Price £12.10.0 Post 5/-

AUDIO GENERATOR Model TE-22



A new factory tested and callibrated low distortion Sine wave and Square wave Audio Generator suitable for use with most oscilloscopes. **Brief Specification:** Frequency range-Sine wave 20 c/s to 200 Kc/s in 4 switched ranges 20-200 c/s, 200-2 Kc/s, 2 Kc/s-20 Kc/s, 20 Kc/s-200 Kc/s. (Two scales 10-90 and 20-200 on etched circular dial with hair-line cursor) Square wave range 60 c/s to 30 Kc/s. (read on same scales as Sine waves). Frequency response 60 c/s-150 Kc/s ± 1.5 dB. Distortion less than 2%. Output voltage: load impedance 1 M/ohm-7 V. (max.), load impedance 10 K/ohm-5 V. (max.). Variable output amplitude control. Valve line-up : 6BM8, 12AT7, 6X4. Power requirements 105/125 V, or 220/240 V., 50/60 c/s A.C. Strong metal cabinet size 7×10¼×5¾in., finished in grey crackle with leather carrying handle. Power "on" pilot light fitted. Complete with test leads and instruction book.

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VALVE VOLT METER — Model TE-65

An essential item for all service workshops and laboratories. An extremely sophisticated instrument permitting a far more accurate degree of measurement than normal test meters and also compared to any other Peak-Peak VVM at present available. **Brief Specification:** D.C.V. range 0-1.5, 5, 15, 50, 150, 500, 1,500 V. A.C.V. (2 ranges) 0-1.5, 5, 15, 50, 150, 500, 1,500 V. R.M.S., 0-1.4, 4, 14, 40, 140, 400, 1,400, 4,000 V.P.-P. Resistance: ×10, 100—1K—10K—100K—1M—10M (0.2 ohms—1,000 M/ohms). Decibels −10 db to +65 db. Power requirements 105/125 V, 220-240 V., 50/60 c/s A.C. Valve line-up: 12AU7, 6AL5. Strongly made, cabinet size: 8¼×6×5¼in. with carrying handle. Complete with standard probe and instruction book.

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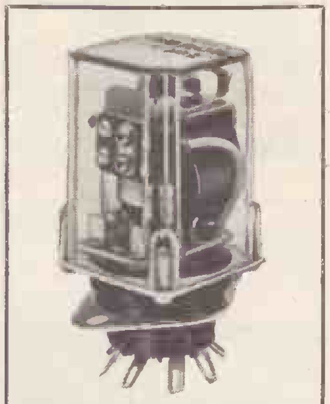

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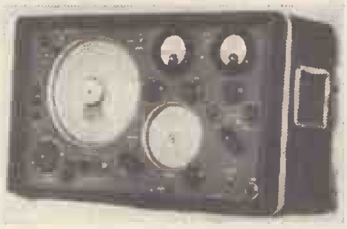

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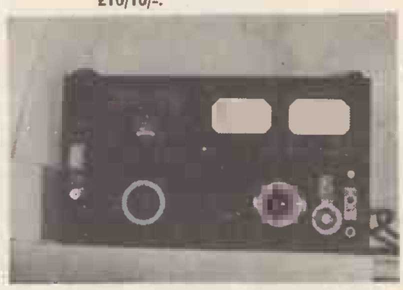

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AC128 6/6
AC176 7/6
ACY17 8/6
ACY18 5/6
ACY19 6/6
ACY20 5/-
ACY21 6/-
ACY22 3/6
ACY28 4/6
AD140 16/-
AD149 16/-
AEY11 15/-
AEY12 12/6
AF102 18/-
AF114 6/6
AF115 6/-
AF116 6/6
AF118 10/-

AF124 7/6
AF125 6/6
AF126 6/-
AF127 6/-
AF139 10/-
AF178 12/6
AFY19 22/6
AFZ11 17/-
ASY26 6/6
ASY28 6/6
ASZ21 12/6
ASZ23 30/-
AU101 30/-
BC107 6/-
BCY31 13/6
BCY33 7/6
BSY25 4/-
BSY27 6/6
BSY28 5/-
BSY51 7/6
BYZ10 12/-
BYZ11 10/6
BYZ12 10/-
BYZ13 6/-
BYZ15 20/-
BYZ16 15/-
CR74 17/6

CR81 105/-
CR81/20 9/6
CR81/30 10/-
CR81/35 11/6
CR81/40 12/6
CR83/O5 6/-
CR83/20 10/-
CR83/30 11/6
CR83/40 12/6
CS4B 25/-
GET102 6/-
GET103 4/6
GET105 8/6
GET111 9/-
GET115 9/-
GET116 8/6
GET872 6/-
GET880 9/-
GEX54 2/6
GJ6M 4/6

GT43 5/-
JK9A 22/6
JK10A 15/-
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HPF105 10/6
RAS508AF 12/6
SCR51 12/6
SX645 15/-
Z Range Zener diodes 3/6 ea.
Z2A range 7/6 ea
ZL range 5/- ea.
Z8 range 7/6 ea.

Q81200 10/-
Q81202 8/-
QV04/7 8/-
QQZ04-15 57/6
R10 17/6
RG1-240A 28/-
SP61 3/3
STV280/40 24/-
STV280/80 90/-
SU2150A 10/-
811E12 10/-
TDO4-20 70/-
TP22 5/-
TP25 5/-
TT11 3/-

UCH81 6/9
UCL82 8/3
UCL83 10/6
UF41 10/6
UF89 6/9
UL41 9/9
UL84 7/-
UU5 7/-
UU9 8/6
UY21 10/6
UY41 7/6
UY85 5/9
V246A/1K 190/-
VL8631 35/-

1D8GT 6/-
1GOGT 6/-
1L4 2/6
1LA6 6/-
1LC6 7/-
1LH4 4/-
1R5 6/-
1S4 5/-
1S5 4/6
1T4 3/-
2A3 5/-
2D21 4/9
3A4 4/-
3A108A 35/-
3A146J 55/-

5X4G 8/6
5Y3GT 5/9
5Y3WGTB 9/-
5Z4G 7/7
6AB7 4/-
6AC7 3/-
6AG5 2/6
6AG7 6/-
6AH6 11/6
6AJ7 3/-
6AK5 5/-
6AK6 6/-
6AK7 6/-
6AK8 6/5

6BW7 11/6
6C4 3/6
6C5G 2/6
6C5GT 6/-
6C6 4/-
6C8G 6/6
6C21 80/-
6CH6 7/-
6CL6 9/-
6CW4 13/9
6D6 3/-
6F23 13/-
6F5GT 8/-
6F6G 4/-
6F7 6/-

6K25G 24/-
6L5G 6/-
6L6GA 9/-
6L6G 6/9
6L7G 4/-
6L34 3/-
6N7G 5/9
6P25 19/6
6S7 7/-
6SA7 7/-
6SA7GT 6/6
6SC7 7/-
6SC7GT 5/-
6SG7 7/-
6SJ7 5/-
6SJ7GT 6/6
6SJ7Y 6/6
6SK7 7/-
6SL7GT 5/6
6SN7GT 4/6
6SQ7GT 6/-

MANY OTHERS IN STOCK include Cathode Ray Tubes and Special Valves. U.K. P. & P. up to 10/- 1/-; to £1 2/-, over £1 2/- in £, over £3 post free. C.O.D. 4/- extra.

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THE VALVE WITH A GUARANTEE

20FL13 9/3
30FL14 16/-
30L15 17/3
30L17 17/3
30P12 14/9
30P19 16/-
30PL1 14/-
30PL14 18/4
33A/101K 9/-
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35T 17/6
35W4 5/-
35Z3 11/3
35Z4GT 7/6
35Z5GT 6/-
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50CD6G 31/6
50L6GT 8/6
57 6/-
58 6/-
59 6/-
75 5/6
76 5/-
77 6/6
78 5/-
80 5/6
81 9/-
83 10/-
84 5/-
85A2 8/-
282A £5
307A 5/6
313C 25/-
357A 70/-
368AS 30/-
393A 276
446 8/-
703A 30/-
705A 20/-
715B 50/-
717A 3/-
803 22/6
807 9/-
808 8/-
813 75/-
815 35/-
829B 50/-
830B 4/-
832A 45/-
843 5/-
866A 16/-
884 10/-
954 4/6
955 2/6
956 2/-
957 5/-
958A 4/-

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4043C 35/-
4313C 20/-
5676 10/-
5678 10/-
5696 6/-
5704 9/-
5726 7/-
6057 10/-
6060 5/6
6064 7/-
6065 8/-
6080 22/-
6146 28/-
6013A 25/-
8020 15/-
9001 3/-
9002 4/6
9003 8/-
9004 2/6
9006 2/6
C.R. Tubes
E4504/B/16 70/-
O9J 75/-
VCR97 32/6
VCR139A 30/-
VCR517 50/-
VCR517B 55/-
VCR517C 45/-
3EG1 40/-
2FP7 25/-
5CP1 30/-
88D 80/-
5FP7 26/7
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G816 12/6
931A 62/6
6097C 350/-
Special Vlvs.
ACT6 £8
ACT9 £16
CV1031 70/-
CV2339 £20
K301 £4
KRN2A 70/-
1B24 25/-
2J22 £2/10/-
WL417A 30/-
3J/92/E £37/10/-
714AY £4
725A £7/10/-

RADIO FREQ. THERMO-COUPLE METER

350 mA 2in. round plug-in	14/6
1 amp. 2in. round proj.	17/6
1 amp. 2½in. sq. panel	22/6
5 amp. 2in. round panel	17/6

P. & P. 3/- each

D.C. MOVING COIL METERS

50µA. 2in. round proj.	25/-
200µA. 2in. round panel, sealed calibro-30	22/6
750-0-750 µA. 2in. round plug-in	20/-
1 mA. 2½in. square panel	30/-
1 mA. 2in. round panel sealed	27/6
5 mA. 2in. round clip-fix panel or proj.	20/-
5-0-5 mA. 1½in. round panel	17/6
10-0-10 mA. 2½in. round panel	17/6
0-30 mA. 2½in. round panel	17/6
10 mA. 2¾in. sq. panel	25/-
2.5 mA. 2¾in. sq. panel	25/-
50mA. 2¾in. sq. panel	25/-
75 mA. 2½in. plug in	14/-
100 mA. 1½in. proj.	17/6
100 mA. 1½in. round panel	17/6
100 mA. 2½in. round panel	19/-
100 mA. 3½in. round panel	25/-
2 amp. 2½in. round panel	22/6
5-0-5 amp. 2½in. round panel	25/-
8 amp. 2½in. round panel	25/-
25 amp. 3½in. round proj.	27/6
50 amp. 2½in. round panel	27/6
20 VDC 2in. square panel	19/-
80VDC 2¾in. round panel	22/-
150 VDC 4in. round panel	25/-
1.5 KV with res. 2in. round panel	27/6
0-1500 v. 2½in. elects. plug in, round panel	30/-

MOVING IRON METERS

15 VAC 2½in. round panel	27/6
500 VAC 2½in. round clip fix	25/-

METERS. 4½in. × 4½in., 4in. long, mirror scale panel mounted, calibrated 0-1 mA. 55/-. P. & P. 3/-.

LABORATORY TYPE VOLT - METERS. 160 v. A.C./D.C. 8in. mirror scale in wooden boxes, 9½in. × 8½in. × 3½in. with carrying handle, brand new 32/-. P. & P. 3/-.

MINIATURE METERS. General Electric 1½in. round flush, clip mounted: 1 mA D.C., 22/6; 25 mA D.C., 20/-. P. & P. 65 mA. D.C., 18/-. 3/-. 150 mA. D.C., 15/-.

"S" METER FOR H.R.O. RE-CEIVERS. Brand new, £2/10/-. Carriage paid U.K.

SUB - MINIATURE "PENNY SIZE" METERS. 1in. round, flush ring nut mounted 500µA FSD, calibrated 0-1 mA. 20/-. P. & P. 3/-.

COMPLETE V.F.O. UNIT from TX53. Freq. range in 4 switched bands from 1.2-17.5 Mc/s. Two V.T. 501s as oscillator and buffer. 807 as driver, two 5130s as voltage stabilizers. Output sufficient to drive two 813s in parallel. Slow motion drive directly calibrated in Mc/s. Provision for crystal control, metering of buffer and driver stage. Power requirements 400 v. and 6.3 v. D.C. Can also be used as low power transmitter. In excellent condition with valves and circuit diagram. £5/19/6. P. & P. 15/-.

CR150 RECEIVER, 2 Mc/s-60 Mc/s.. with specially built PSU for mains, £49/10/-.

SPARES FOR AR.88D. RECEIVERS. Ask for your needs from our huge selection.

VARIOMETER for No. 19 sets, 17/6. P. & P. 3/-.

TELEPHONE HANDSETS. Standard G.P.O. type; new 12/-. P. & P. 2/-.

INSET MICROPHONE for telephone handset, 2/6. P. & P. 2/-.

LIGHTWEIGHT, LOW RESISTANCE, HEADPHONES. Type H.S. 33. Largley used by pilots. Brand new. 27/6. P. & P. 3/-.

FIELD TELEPHONES TYPE "F" Housed in portable wooden cases. Excellent for communication in- and out-doors for up to 10 miles. For pair including batteries and 1/6th mile field cable on drum. Completely new, £6/10/-. Slightly used, £5/10/-. Carriage 10/-.

FIELD TELEPHONES TYPE "L" As above but in portable metal cases. Per pair including batteries and 1/6th mile field cable on drum. £4/10/-. Carriage 10/-.

FIELD 10 LINE MAGNETO TELEPHONE SWITCHBOARD (YA-6733). Withstanding all climatic conditions. Price on application.

HARNESS &"A" "B" control units, junction boxes, headphones, microphones, etc.

29/41FT. AERIALS each consisting of ten 3ft., ⅞in. dia. tubular screw-in sections. 11ft. (6-section) whip aerial with adaptor to fit the 7in. rod, insulated base, stay plate and stay assemblies pegs, reamer, hammer, etc. Absolutely brand new and complete ready to erect, in canvas bag, £3/9/6. P. & P. 10/6.

FOR EXPORT ONLY

Installation Kits for C11/R210 Sets

53 TRANSMITTER made up to "as new" standard. All spares available.

COLLINS TCS. Complete installations and spare parts.

FIELD TELEPHONE SETS TYPE "J" YA 7815. Portable. Ideal for tropical climates.

R.C.A. TRANSMITTER TYPE ET 4336. 2-20 Mc/s., complete with M.O., Cryst. mult. and speech ampl. Fully tested and guaranteed. All spares available.

BC 610E TRANSMITTER. Complete with speech amplifier BC 614E. Aerial tuning unit BC 939A, exciter units, tank coils, etc. Fully tested and guaranteed. All spares available.

No. 19 HP SETS. Amp output increased to 25 watts. Complete installations supplied.

RONTGENS/HOUR MICRO - AMMETERS. FSD 100µamp. 3in. × 3in. × 1in. width with switching dials, 32/6. P. & P. 3/-.

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PEN RECORDERS

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 kc/s.

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 3½in. wide. Curvilineatrace

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

Packing and carriage 15/-.

These are also available as decibel meters. Type 19A/C.T.A. Range +3/0/ −3dB 6 + with current of 500μA at 0dB. Movement resistance 1900 Ω £45

MICROWAVE DIODES

Cartridge Type

3000 mc/s: 1N21. 4/-; 1N21B, 6/-; 1N28. 20/-.
6,000 mc/s.: CS2A. 5/-; CV101, 5/-; CV102. 5/-; CV291. 12/-.
9,375 mc/s.: 1N23. 4/-; 1N23A. 4/-; 1N23C. 8/-; IN23CR. 20/-; 1N23WE. 100/-; CS10B, 70/-.
10,000 mc/s.: CS3A (CV253). 20/-.
12,000 mc/s.: CS3B. 17/6; CS4B, 37/6; CS9B. 30/-; CS10BR. 70/-; CV111. 8/-; CV112. 8/-; CV2226. 70/-; CV2258, 85/-; CV2355, 200/-; S1M2 (CV2154). 37/6; S1M5 (CV2155). 37/6.
34,860 mc/s.: VX3136 (CV2391), 65/-.

AVALANCHE SILICON RECTIFIERS

Type RAS508AF. 960 p.i.v. at 6 amps. max., stud mounted 10/6

HEADPHONES No. 10 ASSY. (OR CANADIAN No. 1 ASSY)

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. 3/6 per set.

THYRISTORS

Type 3/40. 400 p.i.v.. 3 amps., stud mounted; Gate voltage 3.0 v. at 20 mA 7/6
Blue Spot, 200 p.i.v., 5 amps., stud mounted; Gate voltage 3.25 v. at 120 mA 12/6
Green spot, 400 p.i.v., otherwise as above 17/6

TEXAS SILICON FULL-WAVE BRIDGE RECTIFIERS

1B20K10 100 p.i.v. 2 amps., dimensions 1.4 × 1.4 × .6in. ... 25/-
1B40K10 100 p.i.v. 4 amps., dimensions 1.4 × 1.4 × .6in. ... 30/-
1B100M10, 100 p.i.v. 10 amps., dimensions 2¼ × 2¼ × 1in. ... 85/-
Postage 1/6 per rectifier.

24-WATTS 210-240V. SOLDERING IRONS

Recently imported extremely attractive and sturdily built soldering irons, with angle bits. Chromium-plated steel body and polished wooden handle. No Bakelite or breakable plastics used in construction.

Price 16/-
Spare bits 1/3
Spare heating element 3/-

Handling and postage 2/-.

CATHODE RAY TUBES

2AP1—2in. screen. Green Trace Medium Persistence Oscilloscope Tube. EHT required 500 to 1,000 v. Sensitivity approx. 100v. DC/in to 200v. DC/in. 6.3v. heaters. USM11 Base. Overall length 7¾in.
PRICE 40/-

3AFP31=DH7-91—2¾in. screen Flat Face Green Trace Medium Persistence Oscilloscope Tube. EHT required 700-1,000v. Suitable for symmetrical and asymmetrical operation. Sensitivity Y=30v. DC/in; X=50v. DC/in. 6.3v. heaters. B9G Base. Overall length 10in.
PRICE 110/-

3AP1—3in. screen. Green Trace Medium Persistence Oscilloscope Tube. EHT required 600v., sensitivity approx. 45 to 47v. DC/in. 2.5v. heaters. USM7 Base. Overall length 11¼in. 40/-

3BP1—3in. screen Green Trace Medium Persistence Oscilloscope Tube. EHT required 1500 to 2000v. Sensitivity approx. 100-150v. DC/in. at 150v. and 150-200v. DC/in at 2000v. 6.3v. heaters. B14A base. Overall length 10½in.
PRICE 55/-

4SP31—4in. screen Flat Face Green Trace Medium Persistence TWIN GUN Oscilloscope Tube. EHT required 1000 to 1800v. Sensitivity Y=26v. DC/in; X=40v. DC/in. 6.3v. heaters. B12F Base. Overall length 12in.
PRICE 200/-

Please consult our Catalogue for full range of Cathode Ray Tubes.

Tube holders: B9G, 2/-; B12F, 7/6; B14A. 6/6; USM7. 2/6; USM11, 6/6.

ZENER DIODES

5% 260mW		15% 260mW		5% 1 Watt
OAZ200 4.7v	10/-	OAZ208 4.3v.	6/6	Z2A24CF 2.4v.
OAZ201 5.1v	9/6	OAZ209 4.7v.	6/6	Z2A27CF 2.7v.
OAZ202 5.6v.	7/-	OAZ210 6.2v	6/-	Z2A30CF 3.0F
OAZ203 6.2v.	7/-	OAZ211 7.5v.	6/-	Z2A36CF 3.6v.
OAZ204 6.8v.	7/-	OAZ212 11.0v.	6/6	Z2A160CF 16.0v.
OAZ205 7.5v.	7/-	OAZ213 12.0v.	6/6	Z2A300CF 30.0v.
OAZ206 8.2v.	7/-			All at 5/6.
OAZ207 9.1v.	9/6			

5% 10-WATT STUD MOUNTED

Z4.7v.; 25.1v.; Z5.6v.; Z6.2v.; Z6.8v.; Z7.5v.; Z8.2v.; Z9.1v.; Z11.0v.; Z12v.; Z14v.; Z15v.; Z16v.; Z18v.; Z20v.; Z24v.; Z27v.; Z30v.; Z33v.; Z36v.; Z43v.; Z47v.—all at 7/6.

DRY REED INSERTS

Glass dry reed inserts approx. ⅛in. dia. × 1in. long with axial leads. One "make" contact of 100mA capacity at 50v. Can be operated by permanent magnet or 30-50 Amp-turns relay coils. PRICE 18/-. per doz. post free.

BEEHIVE TRIMMERS

30pF and 50pF, 15/- per dozen, in any combination. 2/- P.P.

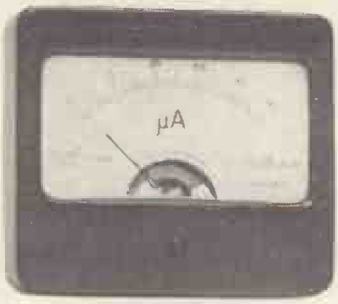
SLIDEWIRE WHEATSTONE BRIDGE

Battery powered Portable Resistance Bridge. Range 0.5 to 50 ohms with multiplier settings of 0.1-1-100-1000, providing a measuring range of 0.05 to 50.000 ohms. Accuracy in the middle 3 ranges—0·5% approx.
PRICE £15 15

COUNTER TUBES

GR10A—10-way register-indicator tube 45/-.
GC10/4B—bi-directional 10-way computing tube, double pulse. 50/-.
GC10B—scale of ten counter. 35/-.
GC10D—scale-of-ten counter for single pulse operation. 55/-.
GS10D—Bi-directional 10-way selector tube. 55/-.
GS10H—as GS10D but physically small. 40/-.

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



The Meters are calibrated for use on anti-magnetic panels, in vertical position.
At present only the sizes listed below are available ex-stock. We hope to increase the range in the near future to include further sizes and types.

RANGE	70DA	85DA	120DA
40μA	—	58/-	82/-
60μA	66/-	53/-	78/-
100μA	62/-	49/-	74/-
150μA	—	44/-	—
250μA	54/-	42/-	65/-
400μA	52/-	—	—
600μA	49/-	36/-	60/-
1mA	46/-	—	—
2.5mA	—	—	58/-
25mA	—	—	58/-
40mA	46/-	34/-	—
60mA	—	—	58/-
100mA	—	34/-	—
150mA	46/-	—	—
250mA	46/-	34/-	—
400mA	46/-	—	—
600mA	46/-	34/-	—
1A	46/-	—	58/-
1.5A	—	—	58/-
2.5A	46/-	—	58/-
4A	—	35/-	—
10A	—	35/-	60/-
40A	—	39/-	64/-

Type 70DA and 70DV. 80mm. square flange. Flush mounted. 68mm. dia. body. 40mm. depth from the panel.

Type 85DA and 85DV, 85mm. dia. flange. Flush mounted. 67mm. dia. body. 48mm. depth from the panel.

Type 120DA and 120DV. 120mm. square flange. Flush mounted. 68mm. dia. body. 40mm. depth from the panel.

RANGE	70DV	85DV	120DA
6V	82/-	—	—
10V	—	40/-	—
15V	—	—	62/-
25V	—	40/-	—
40V	82/-	—	—
60V	82/-	—	62/-
100V	—	—	62/-
150V	82/-	46/-	—
250V	53/-	46/-	65/-
400V	—	47/6	69/-
600V	58/-	50/-	77/-

WW—114 FOR FURTHER DETAILS

TRANSISTORS

OC16	20/-	OC71	3/6	OC141	12/6	ACY17	8/6	AF125	6/6	BCZ11	10/-	MAT101	8/6	2N1302	7/-
OC23	12/6	OC72	5/-	OC170	5/-	ACY18	5/6	AF126	6/-	BFY50	8/6	MAT120	7/9	2N1304	6/-
OC24	15/-	OC73	7/6	OC171	6/-	ACY19	6/6	AF127	6/-	BFY52	6/6	MAT121	8/6	2N1756	15/-
OC25	7/6	OC75	6/-	OC200	7/6	ACY20	5/-	AF178	12/6	BSY26	5/-	V30-30P	20/-	2N2068	20/-
OC26	6/-	OC76	5/-	OC201	10/-	ACY21	6/-	AF186	17/6	BSY28	5/-	2G309	5/-	2N2926	5/6
OC28	12/6	OC77	8/-	OC202	13/-	ACY22	3/6	AFY19	22/6	BSY65	5/-	2G371A	4/6	2S002	20/-
OC29	14/9	OC78	5/-	OC203	10/6	AD140	16/-	AFZ11	17/-	GET103	5/-	2G381	3/6	2S003	20/-
OC35	13/-	OC78D	5/-	OC204	12/6	AD149	16/-	AFZ12	10/-	GET104	8/-	2G403	8/6	2S004	15/-
OC36	12/6	OC81	5/-	OC205	15/-	AF102	18/-	ASY26	6/6	GET113	4/-	2N410	3/6	2S005	50/-
OC42	5/-	OC81D	3/-	OC206	22/6	AF114	6/6	ASY28	6/6	GET115	8/6	2N412	3/6	2S006	20/-
OC43	9/-	OC83	5/-	AC107	10/-	AF115	6/-	ASZ20	7/6	GET116	10/-	2N696	5/6	2S012	140/-
OC44	4/-	OC84	5/-	AC126	6/6	AF116	6/6	ASZ21	12/6	GET872	6/-	2N697	7/6	2S018	60/-
OC45	3/6	OC122	12/6	AC127	7/6	AF117	5/-	BC107	7/6	GET875	6/-	2N706	3/4	2S102	22/-
OC58	12/6	OC139	7/6	AC128	6/6	AF118	10/-	BCY30	7/-	GET880	9/-	2N753	6/6	2S103	25/-
OC70	4/-	OC140	9/6	AC176	7/6	AF124	7/6	BCY33	7/6	JTX4A	6/6	2N1132	21/-	2S731	13/-

TRANSISTOR COMPLEMENTARY PAIRS

AC128/AC176 Germanium	13/-
2N697/2N1132 Silicon	27/-
ASY26/ASY28 Germanium	12/-

SPECIAL OFFER OF TRANSISTOR SETS

For AM/FM and S.W. Receivers:
Two AF125 (Mixer and Oscillator); two AF126 (IF); one AC126 (Audio); two AC128 (push/pull output).
Price of a complete set of 7 transistors, 21/- post paid.

SPECIAL OFFER OF GERMANIUM TRANSISTORS

2G371A; 2G381. 25/- per doz. assorted.

Current Production — ZaeriX — First Quality

Prices in U.S. dollars.

OA2	0.36	3BP1	5.60	6AK5	0.42	6CY5	0.45	310A	2.52
PA3	0.69	3E29	6.30	6AS7G	1.40	6J4	0.73	311A	3.50
OC3	0.55	5U4G	0.35	6BU6	0.22	6J5GT	0.42	328A	2.80
OD3	0.52	5U4GB	0.45	6B4G	1.50	6J6	0.26	329A	2.80
1B3GT	0.42	5V4G	0.59	BGA6	0.21	6L6GC	0.58	807	0.77
2C40	7.70	5Y3GT	0.42	6BE6	0.26	6SL7GT	0.45	811A	4.20
2D21	0.45	5Z4G	0.49	6BG6G	0.70	6SN7GT	0.38	813	9.80
3B28	3.50	5Z4GT	0.52	6C5GT	0.56	6V6GT	0.38	829B	6.30
						6X5GT	0.35	832A	5.95

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5U4GB 6/6, 5U8 8/-, 5V4G 7/6, 5Y3GT 5/-, 5Z4G 7/-, 5Z4GT 7/6, 6/30L2 12/6, 6A6 4/-, 6A8G 5/6, 6AB4 6/6, 6AB7 4/-, 6AC56GT 10/-, 6AC7 4/-, 6AD4 15/-, 6AF4A 9/-, 6AF6G 11/-, 6AG5 2/6, 6AG7 6/-, 6AH6 10/-, 6AJ5 9/-, 6AJ8 5/3, 6AK5W 9/-, 6AK6 10/-, 6AL5 3/-, 6AM6 4/-, 6AN8 10/-, 6AQ5 5/6, 6AQ6 10/-, 6AR6 6/-, 6AS6 6/-, 6AS7G 15/-, 6AT6 4/6, 6AU4GT 9/-, 6AU5GT 20/-, 6AU6 5/-, 6AU8 9/-, 6AV5GA 11/-, 6AV6 5/-, 6AW8A 12/6, 6AX4GT 8/-, 7AX5GT 12/6, 6AX7 11/-, 6B4G 15/-, 6B7 5/-, 6B8 7/-, 6B8G 2/6, 6BA6 4/-, 6BE6 4/6, 6BG6G 12/-, 6BH6 7/6, 6BJ6 7/6, 6BK4 20/-, 6BK7A 9/-, 6BL7GTA 10/-, 6BL8 6/6, 6BM8 6/-, 6BN6 7/6, 6BQ6G 11/-, 6BQ7A 7/-, 6BR7 15/-, 6BS7 25/-, 6BW6 12/-, 6BW7 10/-, 6BX7GT 13/-, 6BY6 10/-, 6BZ6 6/-, 6BZ7 10/-, 6C4 4/-, 6C5GT 6/6, 6C6 4/-, 6C8G 8/-, 6C9 (Sylvania) 15/-, 6C21 100/-, 6CA4 5/-, 6CA7 9/6, 6CB6 5/-, 6CD6GA 20/-, 6CH6 8/-

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IMPERIAL 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

PAN American require Radio Technician for project and maintenance duties involving ground-based U.H.F. and VHF 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 fare holiday travel privileges, superannuation scheme, etc.—Write to Pan American, Personnel Supervisor, London Airport, Hounslow, Middlesex. [2992

EXPERIMENTAL 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

APPLICATIONS 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 217—£711-£1,004+ £75 London Weighting. Applications to Dr. B. W. Watson, Department of Medical Electronics, St. Bartholomew's Hospital, London, E.C.1. [1967

VACANCY 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 qouting 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.
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TEMple Bar 5557-8.

RADIO 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 Saudia 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

TECHNICAL 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 Inner 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.Ae.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, electro 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.

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.

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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. [66

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. [70

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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

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METALWORK, all types cabinets, chassis, racks, etc., to your own specification, capacity available for small milling and capstan work up to 1in bar. PHILPOTT'S 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;
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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

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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.

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Marconi

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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.

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Box No. 5039, c/o Wireless World

ARTICLES FOR SALE

AVO 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., 01-654 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 23-tube, also one with expander unit, Midwest 18-36 and one 18-38; offers, please.—Details from: Percivall, 6, The Staithe, 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.

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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.

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Recruitment Officer (RT),
Government Communications Headquarters,
Oakley, Priors Road,
Cheltenham, Glos.

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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.

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Technical Director, Television Applications Ltd., 9/11 Windmill St., London, W1

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DEMONSTRATION cabinet to house four decks and ancilliary equipment. Record Storage 5ft. 6in. plate glass top, £45.—A. L. Stamford, Ltd., 98, Weymouth Terrace, London, E.2. Tels.: 01-739 5003, 01-363 0042. [1991

HEATHKIT Mohican communications RX GC-1U with power unit; total cost £50, only 6 months old, still has 6 months' guarantee and is in brand new condition; a bargain at £30.—G. Headridge, 31, Crescent St., Dundee, Scotland. [207

MARCONI signal generator, type 995A, 1.5-220 MHz, FM/AM, little used, perfect, now surplus to requirements; cost £325 in 1964; manual, £110.—Westrex Co., Ltd., Service Division, Coles Green Rd., London, N.W.2. Tel. 01-452 5401. [1983

QUANTITIES of Barretter valves, CL33, CY31 and CIC, wanted, new and boxed; have for exchange new 6AQ5 EL84, 6BR7 and ECC8 valves, or will buy for cash.—Harringay Photographic, 435, Green Lanes, London, N.4. 01-340 5241. [1910

PLANAR transistors 2N2369 650 MHZ, 6/6; PEP5 500 MHZ, 5/6; E88CC, 10/6; tape pre-amp, less valves, £4 o.n.o.; F.M. tuner less crystals, £3; precision resistors; details and lists, s.a.e.—Box WW210, Wireless World.

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ULTRASONIC amplifiers by British maker, 35 watt models, 200/245v mains operation components include: 2-EL34 and 1-ECC81 valves 2 by 100 diodes, 1 mains transformer topped 200/220/240/250/230v, 0.85 amp, 1 mains transformer 220/240v-450v also O.P. trans., 6ft mains lead c/w Bulgin connector. Price (incl. carriage U.K.) £3/10 each.—J. Black, 44, Green Lane, Hendon, N.W.4. [1984

ROTAX rotary converters, input 24V d.c.; output 115V, 3ph., 400 cycles, 1.8 amps, £6; carbon pile voltage regulators, type 1036, 24V, 30/-; TCC Metal-pack tubulars, 0.05mfd./500v, 0.1mfd/350v, £2 per 100. TCC base mounting 0.02mfd/11 KV, 27/6; Ditto, 0.1mfd., £2; Redifon transmitter inductances, £4; capacitors, U.S.A. make, 0.5mfd., 7.5KV, 25/-; LF chokes in stock; carriage paid.—Box WW1988, Wireless World.

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, 1c/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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BBC Television requires fully qualified and experienced technicians as Holiday Relief Film Recordists (£29 14s. per week) and Assistant Film Recordists (£21 18s. per week) for the summer months.

Initial appointment for two months. Possbiility of extension for further four months.

Based in London.

Write, giving age and full particulars of relevant experience, to General Manager, Film Operations and Services, Television Film Studios, Ealing Green, London, W.5.

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Southall, Middlesex.

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SILICON RECTIFIERS: 0.5A at 70°C. 400 P.I.V, 3/-. 800 P.I.V, 3/3, 1,250 P.I.V, 3/9, 1,500 P.I.V. 4/-.

SEMI-CONDUCTORS: OA5, OA81, 1/6. OC44. OC45 1/9. OC71, OC72, OC73, OC81, OC81D, OC82D, OC170, OC171, 2/3. OC140, AF115, AF116, AF117, 3/-.

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Fully guaranteed devices at competitive prices

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2N696	5/-	2S104	7/6	BFY52	5/6	NKT262	4/6
2N697	5/-	2S131	6/6	BFY53	5/6	NKT264	4/6
2N698	4/6	2S501	5/6	BS740	8/-	NKT271	4/6
2N706	4/6	2S502	5/6	BS741	8/-	NKT272	4/6
2N706A	4/6	2S503	5/6	BSX19	5/6	NKT274	4/6
2N708	5/-	2S731	4/6	BSX20	5/6	NKT275	4/6
2N726	5/-	2S732	4/6	BSY26	4/6	NKT281	5/6
2N727	5/-	2S733	4/6	BSY27	4/6	NKT603	6/6
2N743	4/6	AC107	6/-	BSY28	4/6	NKT613	6/6
2N744	4/6	AC126	4/-	BSY29	4/6	NKT674	6/-
2N753	4/6	AC127	4/-	BSY38	4/6	NKT677	6/-
2N914	6/6	AC128	4/-	BSY39	4/6	NKT713	5/6
2N916	6/6	ACY17	4/-	BSY95A	4/6	NKT734	5/6
2N929	8/-	ACY18	4/-	BY100	4/6	NKT736	6/6
2N930	8/-	ACY19	4/-	BYZ10	9/6	NKT773	5/6
2N1090	6/6	ACY20	5/6	BYZ11	8/-	NKT781	6/-
2N1091	6/6	ACY21	5/6	BYZ12	6/6	OA5	2/-
2N1131	9/6	ACY22	4/-	BYZ13	5/6	OA9	2/-
2N1132	9/6	ACY28	4/-	GET102	4/-	OA47	1/6
2N1302	4/6	AD140	6/-	GET103	4/-	OA81	1/6
2N1303	4/6	AD149	8/-	GET113	4/-	OA85	1/6
2N1304	5/6	AF114	4/-	GET116	6/6	OA182	2/-
2N1305	5/6	AF115	4/-	GET118	4/-	OA200	2/-
2N1306	6/6	AF116	4/-	GET119	4/-	OA202	2/-
2N1307	6/6	AF117	4/-	GET120	6/6	OC22	8/-
2N1308	8/-	AF118	4/-	GET573	8/-	OC23	8/-
2N1309	8/-	AF119	4/-	GET587	8/-	OC24	8/-
2N1507	6/6	AF125	4/-	GET873	8/-	OC25	6/6
2N1613	6/6	AF127	4/-	GET881	4/6	OC26	6/6
2N1711	6/6	AFZ12	5/6	GET887	4/6	OC28	6/6
2N1893	8/-	ASY55	4/6	GET889	4/6	OC30	8/-
2N1899	8/-	ASY58	4/6	GET890	4/6	OC35	6/6
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2N2194A	5/6	BC107	5/6	GET897	4/6	OC38	10/6
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2N2411	6/6	BCY33	6/6	NKT213	6/-	OC76	3/-
2N2412	6/6	BCY34	6/6	NKT214	4/6	OC77	4/-
2N2483	5/6	BCY38	6/6	NKT215	4/6	OC78	3/-
2N2484	5/6	BCY39	6/6	NKT219	6/-	OC78D	3/-
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2N2904	8/-	BCY71	10/6	NKT224	5/-	OC81D	3/-
2N2904A	8/-	BCY72	6/6	NKT225	5/-	OC82	3/-
2N2905	8/-	BF115	4/6	NKT229	6/-	OC82D	3/-
2N2905A	8/-	BFX12	6/6	NKT238	6/-	OC83	3/-
2N2906	8/-	BFX13	6/6	NKT239	6/-	OC84	4/-
2N2906A	8/-	BFY10	5/-	NKT240	6/-	OC200	6/6
2N2907	8/-	BFY11	5/-	NKT241	6/6	OC202	6/6
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Post & Packing 1/- per order. Quantity discounts available.

A. MARSHALL & SON (LONDON) LTD.,
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MAINS TRANSFORMERS
1VA TO 2·5 KVA

AUTO TRANSFORMERS
20 watts to 5,000 watts

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WW—133 FOR FURTHER DETAILS

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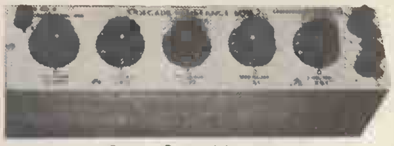

CAPACITY 15pf to 111μF
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SERVO AND ELECTRONIC SALES LTD.
NOW OFFER A
RECONDITIONING SERVICE FOR INDUSTRIAL INSTRUMENTS
Moving Coil Multi-range Meters, Electrical and Electronic Test Equipment of all kinds. Estimates given for all repairs.
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STOCKS WANTED
OSMABET LTD.
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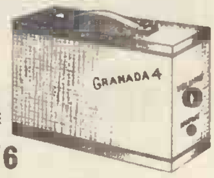
SELMER TRANSISTOR AMPLIFIER

ONE WATT
POWER OUTPUT
Portable Cabinet size 12×4×9 ins. fitted 7×4 Speaker, Volume Control Standard Jack Socket. Uses PP9 battery. Will increase the volume and performance of Transistor Radios, Record Players, Tape Recorders etc. Ideal for Guitar practice.



OUR PRICE **79/6**
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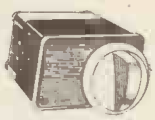

SMITHS PRECISION
SIX MINUTE DELAY
ACTION SWITCH
Clockwork actuated
10/6 EACH Post 2/6 (3 or more post free).
Separate switching up to 6 mins. 15 amps. 250 volts. MADE FOR ROLLS WASHERS. Ideal photographic timer, sequence switching operations, etc., etc. Brand new units at a fraction of their value.

SPECIAL PURCHASE
STELLA RECORD PLAYER
Amplifier and Loudspeaker—all transistor—top performance of discs at 33⅓, 45 and 78 r.p.m. LP xtal cartridge. Smart red or blue plastic cabinet.
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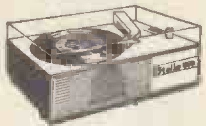
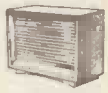


OUR PRICE **£8.5.0**
Post 5/-.

"SONOCOLOR" CINE RECORDING TAPE
Superior quality 5" reel, 900ft. L.P. with strobe markings, also cine light deflector-mirror. Suitable all tape recorders and cine projectors. List 28/-. OUR PRICE **14/-** EACH Post 2/6

THE INSTANT BULK TAPE ERASER AND RECORDING HEAD DEMAGNETISER
200/250 A.C. Leaflet S.A.E. **35/-** Post 2/6

TRANSISTOR BOOSTER—
DOUBLE YOUR VOLUME!
Black plastic cabinet speaker with 20ft. lead for transistor radio, intercom, mains radio, tape recorder.
Size: 7¼in. x 5¼in. x 3in. **30/-** Post 2/6



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Redundant or Surplus stocks of Transformer materials (Laminations, C. cores, Copper wire, etc.), Electronic Components (Transistors, Diodes, etc.), P.V.C. Wires and Cables, Bakelite sheet, etc., etc.
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RESISTORS
½ watt carbon film 5%
All preferred values in stock from 10 ohms to 10 megohms, 2d. each.
Send S.A.E. for free sample.

CAPACITORS
Mullard Miniature Metallised Polyester P.C. Mounting, all 250V. D.C. working. 0.01mf., 0.022mf., 0.047mf., 0.1mf., 0.22mf., all at 6d. each. Hunts tubular 0.1mf. 200V. working at 3d. each. Send 6d. stamp for extensive list of low-priced Electronic Components, Instruments & Equipment.
Please include 1/- postage & packing on all orders under £1.

Dept. WW9.
BRENSAL ELECTRONICS LIMITED,
CHARLES STREET, BRISTOL, 1.

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 incuded in charge if used in advertisement.**
- **Box No. Allow two words plus 1/-.**
- **Charges etc., payable to "Wireless World" and crossed "& Co."**
- **Press Day 4 March for April 1968 issue.**

NAME ....

ADDRESS ....

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REMITTANCE VALUE..............................ENCLOSED

Please write in block letters with ball pen or pencil.

NUMBER OF INSERTIONS....................

INDEX TO ADVERTISERS

Appointments Vacant Advertisements appear on pages 99-110

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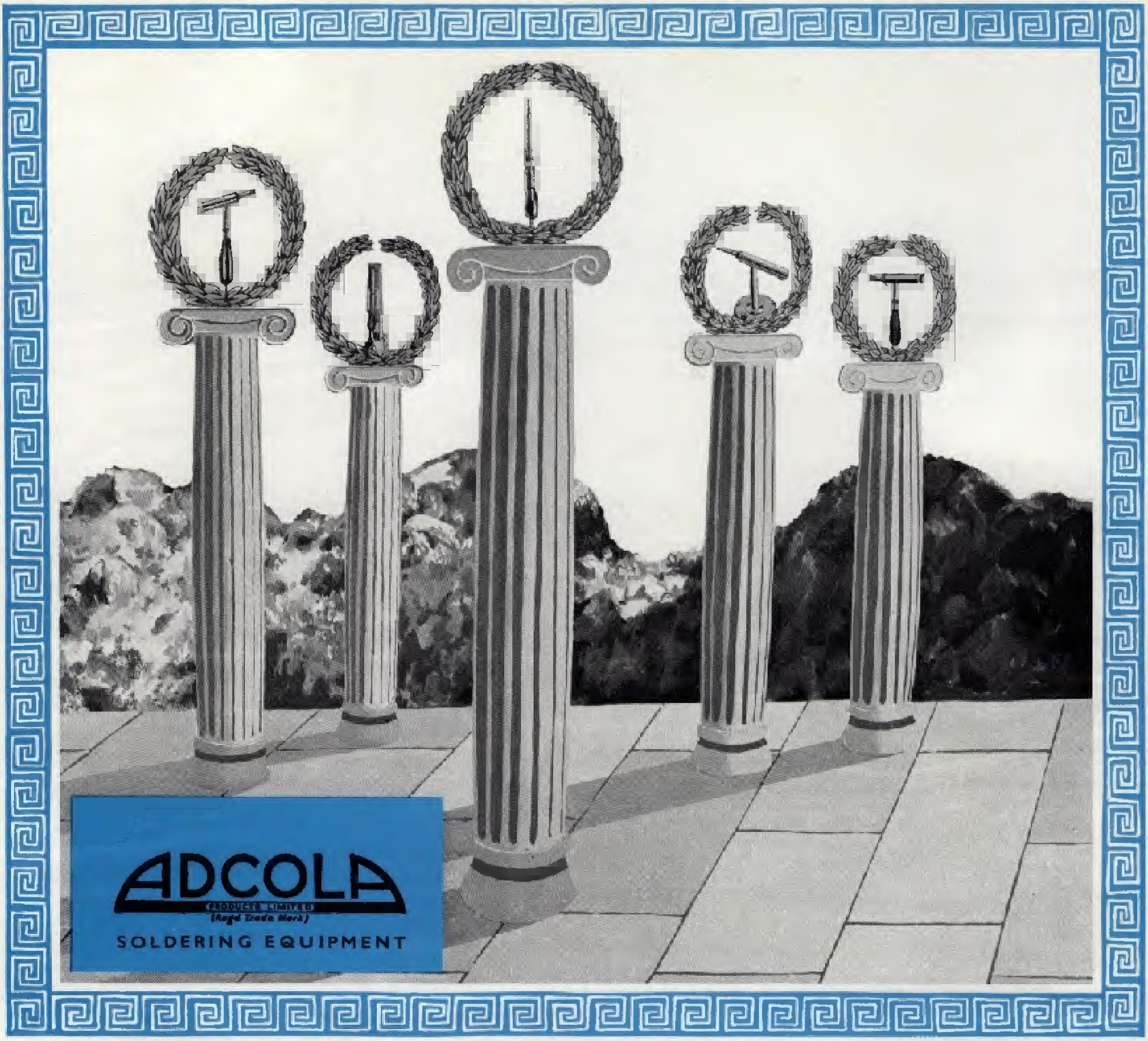
ADCOLA
PRODUCTS LIMITED
(Regd Trade Mark)
SOLDERING EQUIPMENT

In addition to Ersin Multicore 5 Core Solder we make these products to help industry and laboratories

1966

special products for the soldering of printed circuits

A complete range of products for the soldering of printed circuits, including:
P.C. 2 Dip Cleaner P.C. 10A Activated Surface Preservative P.C. 21A Printed Circuit Liquid Flux P.C. 51 Finishing Enamel. Solid Solder Wire, Solder Sticks, Solder Ingots and Ersin Multicore 5-core Solder Wire for direct application to panels. 1

Mark 2 solderability test machine

Incorporates many new features, including semi-automatic electrical timing, proportional temperature control, remote controlled specimen lowering system and a temperature meter calibrated to an accuracy of 0·25% full scale deflection at the test temperature.
The machine can reduce production costs by instantly checking the solderability of components with wire terminations.
It complies with B.S.I. and proposed M. of D. and International Solderability Test Specifications. 2

solder tape, rings, preforms, washers, discs, and pellets

Made in a wide range of solid or cored alloys. Tape, rings and pellets are the most economical to use. 3

liquid fluxes

7 standard non-corrosive Ersin Liquid Fluxes, all comply with D.T.D. and Mil specifications.
Arax Acidic Liquid Flux, the residue is easily removed, is faster than zinc chloride types but much less corrosive. In 1-gallon or 5-gallon non-returnable containers. 4

3a automatic soldering machine

Specially designed for manufacturing processes involving repetitive soldering operations. An exact quantity of Ersin Multicore Solder is automatically fed at each downward stroke. It can be operated by foot treadle or compressed air system, or may be connected to form part of an automatic assembly sequence. 5

Arax 4-core acid cored solder

Used in 38 industries it has replaced tinman's and blowpipe solders, fluid and paste fluxes and killed spirits for rapid and precision soldering in metal fabrication processes.
Arax Flux—exclusive to Multicore—has the fastest speed of flux in any cored solders. Flux residue is easily removable with water or, where flame heating is employed, is entirely volatilised. Residue will not contaminate plating baths. No pre-cleaning is necessary and the speed ensures that the solder will flow between the laps by capillary action, thus using the minimum amount of solder. Not recommended for wire to tag joints in radio or electrical equipment. 6

Bib accessories can be supplied in bulk packings at very competitive prices

wire stripper and cutter

Strips insulation without nicking wires, cuts wires and cables cleanly. Model 3 is semi-permanently adjusted. Model 8 incorporates a unique 8-gauge selector. A

recording tape splicer

Precision made, chrome plated complete with razor cutter. Provides quick and accurate tape editing. Standard model for $\frac{1}{4}$" tape. NEW $\frac{1}{2}$" type is available for computer and video tape. B

instrument cleaner

Anti-static. Specially formulated for cleaning delicate instrument panels, plastic, chrome, glass and printed surfaces. Antiseptic, non-toxic, non-flammable, does not smear. Used and recommended by leading electronic manufacturers.
In 1-gallon and 5-gallon containers and 4 fl. oz. bottles. C

tape head maintenance kit size E

Cleans tape heads and all parts of the tape path of magnetic tape decks. Applicator and Polisher Tools and Sticks are available separately. D

For further information please apply on your Company's note paper mentioning the product references Dept. WW, Multicore Solders Limited, Hemel Hempstead, Herts. Telephone: Hemel Hempstead 3636

WW—002 FOR FURTHER DETAILS