Wireless World

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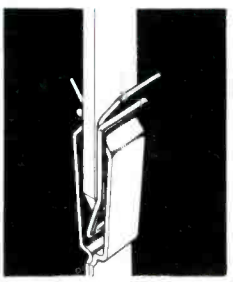

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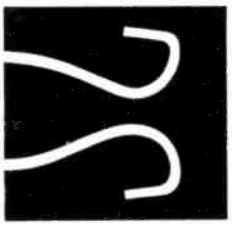

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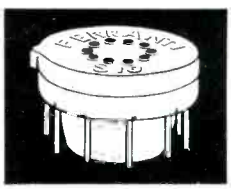

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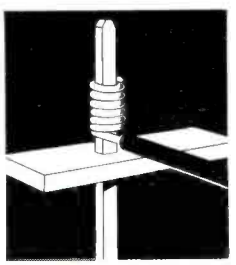

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Wireless World

Electronics, Television, Radio, Audio

Fifty-eighth year of publication

May 1968 **Volume 74 Number 1391**

This month's cover. *In clinically clean conditions at S.T.C's North Woolwich factory a submarine repeater undergoes one of many rigorous inspections. These repeaters, now being laid on the new £22 million Lisbon-Cape Town project, are required to go on working faultlessly for periods exceeding 20 years and so have to be manufactured to ultra-high standards. Undersea cable and repeaters are now an important British export—S.T.C. has about 50% of the current world market.*

Contents

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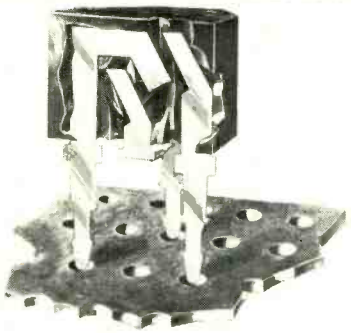

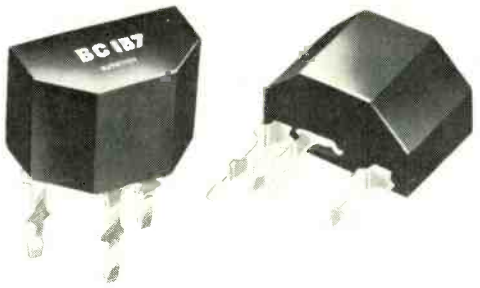

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Wireless World

What is an Engineer?

We make no apology for once again returning to the subject of the engineer; we are prompted to do so by two recent incidents. The first was when H.R.H. The Duke of Edinburgh was addressing a gathering of about 600 graduate and student members of the 14 constituent societies of the Council of Engineering Institutions. As recorded elsewhere in this issue the Duke stated, without any reservations, that he saw no reason why technicians should be forced to join a separate institution. This is particularly interesting in view of the efforts now being made by the C.E.I., of which the Duke is president, to "establish the qualifications of non-chartered engineers", and also of the possibility of setting up a technician counterpart to the C.E.I*.

The second was the announcement by the C.E.I. that the meeting to be addressed by the Duke would be attended by "young *professional engineers* [our italics] ..... drawn from the graduate and student sections of the professional engineering institutions". Was this a slip of the pen of the writer of the announcement or was it inspired prophecy? In the present situation no graduate or student would dare to call himself a professional engineer, which would of course be comparable to a medical student calling himself, a doctor.

Great efforts have been made, especially over the past few years, to improve the "image" of the engineer and to give him a status comparable with other professional men, for instance doctors, barristers and lawyers. But are we in danger of overplaying our hand? What is expected of an engineer? It would appear from pronouncements from the hierarchy of some institutions that their chartered engineers are the theorists who know the "how" and "why" of, for instance, electronic engineering but do not get their hands dirty as practising engineers. Whether we like it or not the term engineer conjures up in the mind of the layman one who gets down to doing the job. This fact was borne out by the remark of one of the students at the meeting addressed by Prince Philip who said that he told his friends he was a scientist, because to them, an engineer was one who "went around repairing television receivers". Where have we as engineers gone wrong? Have we tried to over glamorize the profession?

Speaking at the annual dinner of the I.E.E. at the end of February Sir John Wolfenden, chairman of the University Grants Committee, was deploring the shortage of suitable boys and girls to fill the vacancies in the technological disciplines in Universities. He blamed the prejudices of parents and schoolmasters and also the distorted "image" so often portrayed in the press. He instanced how that when a spacecraft is successfully launched it is hailed as a "triumph of science" but if it fails to go into orbit it is a "failure of engineering"! This image, he said, must be changed.

What is the answer to this whole question of the engineer in society? We would venture to say that it will not be solved by a proliferation of societies for various stratas of engineers, nor by merely raising the academic standards required for membership of the "professional" institutions.

The answer is in the hands of the professional institutions who should let the public see that the "general practitioner" is as much a professional as the "Harley Street specialist".

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* See "The Technician Engineering Scene" *W.W.* April 1968, p. 73.

30-watt High Fidelity Amplifier

Output stage using complementary transistors

by Arthur R. Bailey, M.Sc., Ph.D., M.I.E.E.*

It is only recently that matched complementary output transistors, capable of high dissipation, have been available at a reasonable price. In the past this has had the effect of concentrating high power amplifier design into two main streams. The first uses a driver transformer with a pair of identical output transistors in a series connection. The use of a driver transformer is undesirable mainly on account of the cost, as the bandwidth of a well designed component may well extend from the sub-sonic region up to several megahertz. Nevertheless a circuit that does not require the use of such a component will obviously be an advantage.

The alternative circuit that has been used by many designers is the quasi-complementary output stage. In this design identical output transistors are used and a complementary pair of driver transistors is arranged so as to give phase-inversion to the bases of the two output transistors. These two circuits are shown in Figs. 1(a) and 1(b) respectively. A correctly designed fully complementary output stage (Fig. 1(c) shows the basic arrangement) is capable of better performance than either of these common circuits and the reasons for this will be examined.

Compared with the quasi-complementary amplifier, the transformer-driven amplifier has the great advantage that the input impedances to the two sides of the output circuit are identical. This means that if a suitable quiescent current is used in the output transistors, cross-over distortion will be almost completely absent.

The quasi-complementary amplifier, however, gives greater overall distortion even if identical output transistors are used. This increase is due to the different input impedances of the two halves of the output stage in the quasi-complementary circuit. In the upper half of Fig. 1(b) the input impedance is due to two emitter-base junctions in series, whereas in the lower half the signal feeds into only one transistor. The effect of this is an extremely marked asymmetry between the input impedances of the upper and lower halves of the output stage.

*University of Bradford

Specification

Sensitivity	1.0 volt for 30 watts into 8-ohm load 0.8 volt for 20 watts into 16-ohm load
Rise time	approximately 0.7 microsecond
Distortion	below 0.1% over the whole of the audio-frequency range at rated power outputs
Load stability	unconditional
Abnormal load protection	provided adequate heat sinks are used the amplifier will not be damaged by operation into incorrect loads
Noise	better than 80 dB down on full power output
Hum	depends on layout if stray hum fields exist. Negligible hum in output if normally smoothed supplies are used.
Distortion generated	predominantly third harmonic, cross-over distortion being absent.

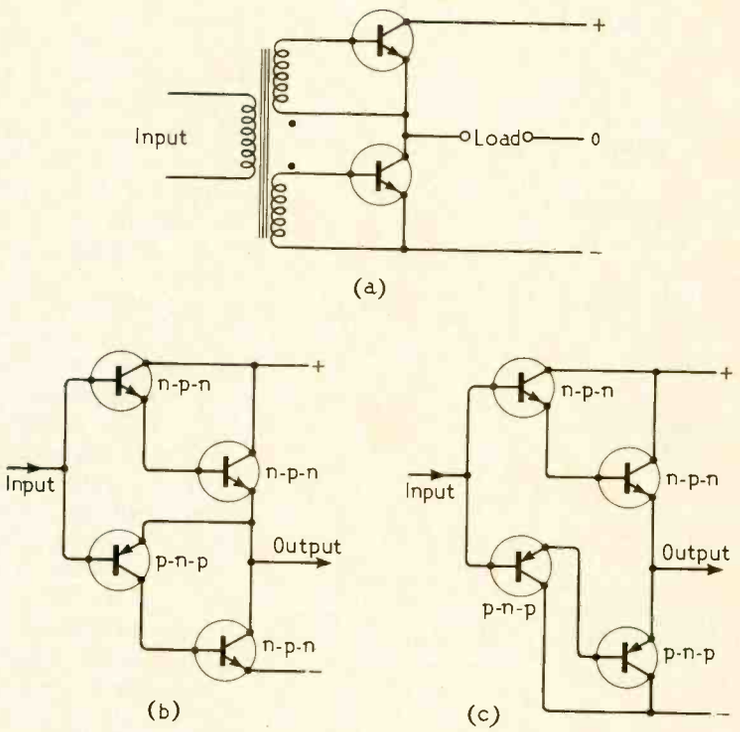


Fig. 1. Direct-coupled output stages: (a) with driver transformer; (b) quasi-complementary; (c) fully complementary.

Unfortunately the two input impedances cannot be equalized by the use of a series resistor as the curvature of the two stages is completely different. This dissimiliarity of curvature can be seen in Figs. 2 and 3, these being the transfer characteristics of the upper and lower halves of an output stage using matched transistors.

The dissimilarity in input impedance is most marked at low values of collector current. Hence in the case of a class B output stage there is an abrupt change in slope at the cross-over point, giving rise to the well known phenomenon of cross-over distortion. This distortion may not be particularly serious when measured on an r.m.s. basis, but as it unfortunately occurs mainly within a small part of the overall output swing, the peak value of the distortion can be surprisingly high. Also the distortion does not normally decrease appreciably as the output swing is reduced, since the effect is occurring at small signal levels. The overall effect is quite serious, therefore, and the ear seems to be very sensitive to such types of distortion.

This then is perhaps the reason why two amplifiers may sound quite different even though their "paper" performance may be identical on the basis of normal amplifier measurements. Very few valve amplifiers suffer from cross-over

distortion, and this may be the reason why the best valve amplifiers are difficult to evaluate on subjective tests. Certainly there are much greater subjective differences between the performances of current transistor amplifiers.

If cross-over distortion is present it would appear that the common 0.1 per cent harmonic distortion rule for an acceptable limit at peak output is no longer valid, and at least one manufacturer is working on the basis of far lower distortions being necessary.

There appear to be two ways of tackling this problem. The first is to use a larger value of overall feedback so as to reduce the effect to inaudible proportions. The main drawback with this method is that high values of overall feedback make the amplifier closer to instability, and it may be difficult, if not impossible, to achieve a reasonable stability margin. Stability may then be obtained by decreasing the cut-off frequency of a stabilizing step-network, but this has the effect of decreasing the available power at high frequencies as well as degrading the distortion characteristics at high frequencies.

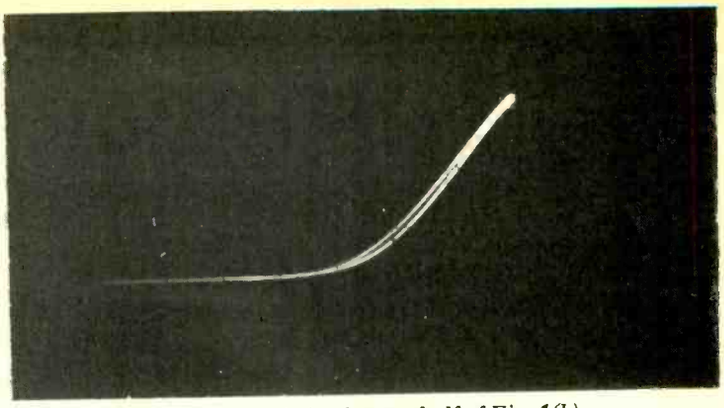


Fig. 2. Transfer characteristic of upper half of Fig. 1(b).

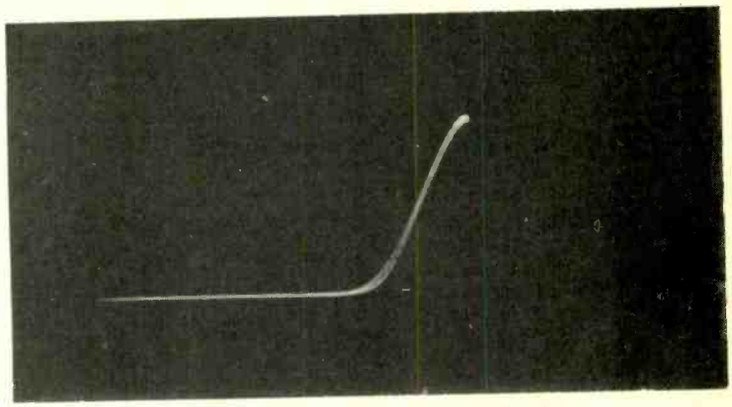


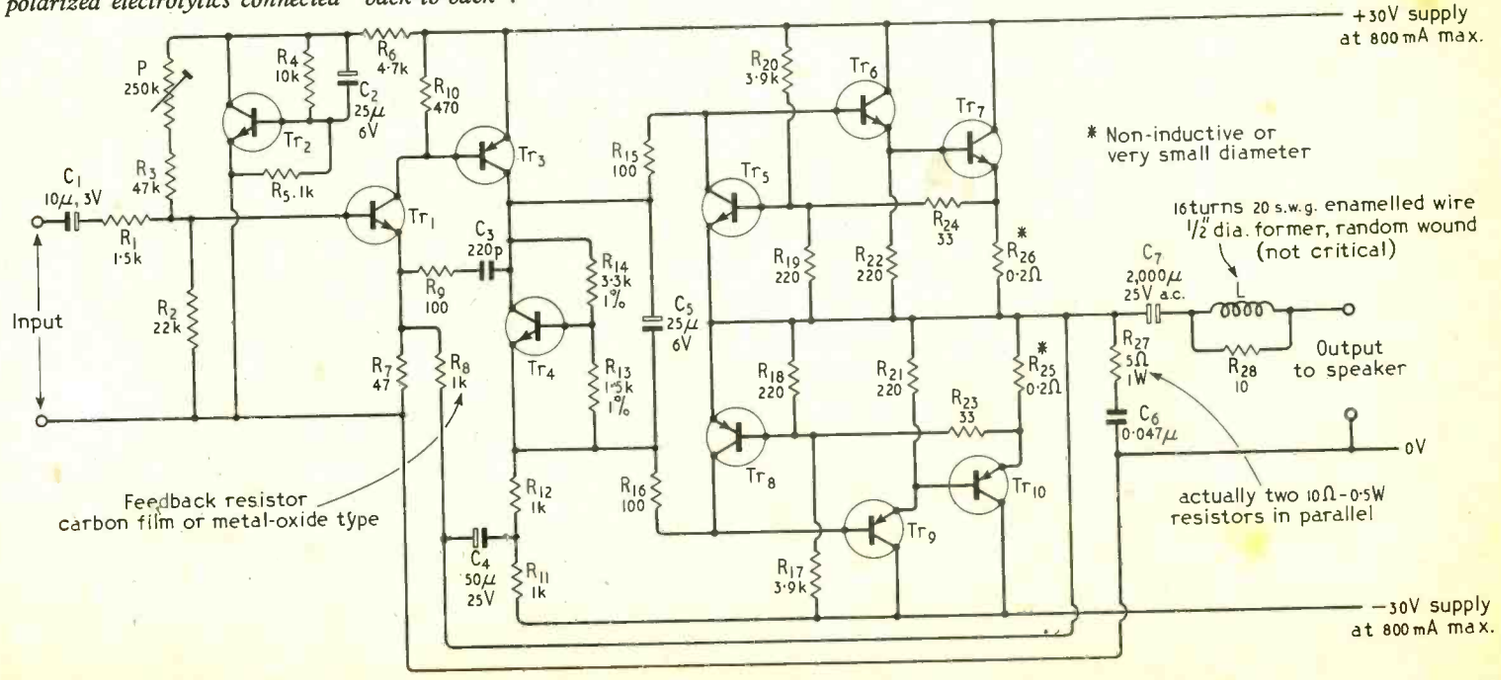
Fig. 3. Transfer characteristic of lower half of Fig. 1(b).

Complementary Symmetry Output Stage

In view of these considerations the author decided that the best line of approach was to use a fully symmetrical output based on complementary transistors. With such a symmetrical system, there is no difference between the input impedances in the upper and lower halves of the circuit. From the basic circuit in Fig. 1(c) it will be seen that both halves of the circuit have the same input impedance characteristics because of their identical configurations. By a suitable choice of standing quiescent current, cross-over distortion can be reduced to levels where it is extremely difficult to detect. This absence of cross-over distortion means that perfectly satisfactory results will be obtained if the overall distortion factor of the amplifier is similar to that commonly found in valve amplifiers, i.e. about the 0.1 per cent mark. In fact lower distortions than this are possible while maintaining both unconditional load stability and good high-frequency performance.

During the development of this amplifier it was discovered that the overall performance was not as good as might have been expected from the output stage characteristics. This distortion increase was traced to the common-emitter amplifier stage that drives the output stages. This is transistor Tr_3 in the complete amplifier circuit shown in Fig. 4. The effect was found to be caused by "Early effect"[1], the high collector voltage swing modulating the gain of the stage. In fact the overall distortion was approximately three times that which would have been expected. As this effect depends entirely on

Fig. 4. Circuit of complete power amplifier. The transistors used are: Tr_1—40361 (R.C.A.); Tr_2—BC109 (Mullard); Tr_3—40362 (R.C.A.); Tr_4—BC107 (Mullard); Tr_5—BC125 (Fairchild); Tr_6—40361 (R.C.A.); Tr_7—MJ481 (Motorola); Tr_8—BC126 (Fairchild); Tr_9—40362 (R.C.A.); Tr_{10}—MJ491 (Motorola). Note that C_7 is a reversible electrolytic and could be made up of two 4000-μF polarized electrolytics connected "back-to-back".



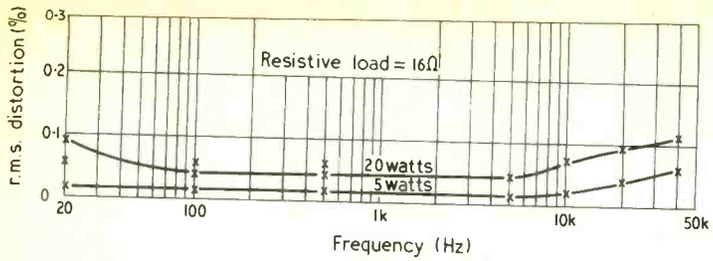


Fig. 5. Distortion characteristics of amplifier with 16-ohm load.

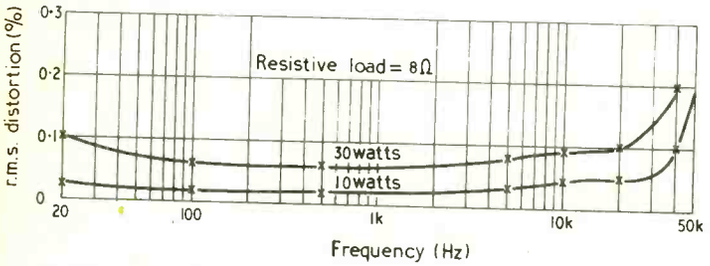


Fig. 6. Distortion characteristics of amplifier with 8-ohm load.

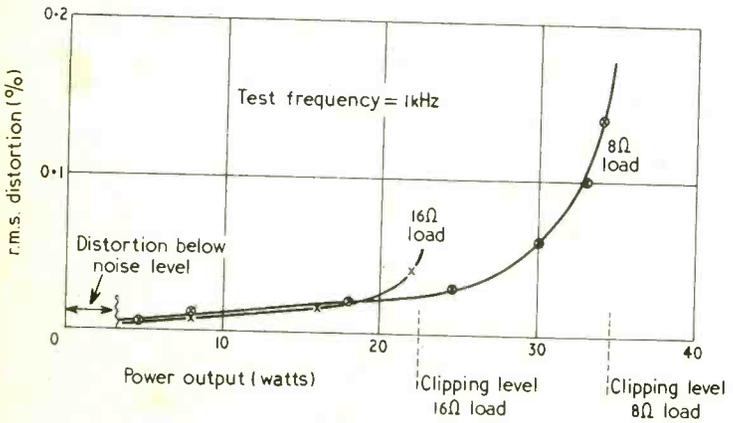


Fig. 7. Variation of distortion with output power level.

the design of the transistor in use, it was necessary to select a suitable transistor type for this position in the amplifier. This source of distortion seems to have been largely overlooked in the past, but it is obviously a possible source of extremely bad distortion. In addition, the high-frequency distortion was found to increase more rapidly than was expected and this was traced to the modulation of the collector-base capacitance of this transistor. The high collector voltage swing was causing non-linear capacitive feedback, and this in turn was increasing the high-frequency distortion. Again the only cure is by transistor selection. The type used appears to be the best currently obtainable, and the distortion introduced by these effects is below that of the output stage proper, over the whole of the audio-frequency range.

For low distortion at high frequencies, it is essential that the transistors should have as high a cut-off frequency as possible. Planar transistors are used in all but the output stage to give this bandwidth. The output transistors used have a cut-off frequency of several megahertz and this enables low distortions to be obtained at 20 kHz at full power output.

The design of the remainder of the amplifier circuit is fairly straightforward. The input stage is a common-emitter amplifier, but the current and voltage swings associated with it are very small, so there is little difficulty in the operation of this stage. To correct for the emitter-base voltage change of this input stage with temperature, a transistor is used to regulate the base supply current. This transistor Tr_2, operates as a rather crude temperature-sensitive Zener diode and also as a hum filter. The net effect is to stabilize the d.c. base current of the input transistor, the supply voltage to the base of this transistor decreasing with increased temperature. This stabilization of the d.c. operating conditions enables the amplifier to deliver full output over a wide temperature range.

The bias for the driver and output transistors is produced by means of a transistor, Tr_3, rather than a string of diodes as is commonly used. This is mounted in the heat sink of one of the output transistors, being as close to the output transistor as possible. This method of compensation works extremely well, and the transistor type is not critical provided a silicon one is used. The standing current in the output stage can easily be adjusted to its correct value (which is not critical) by slightly adjusting the ratio of the two resistors in the base circuit of the transistor.

For full power output from the amplifier the d.c. potential existing at the output of the amplifier proper should be as low as possible. This can be adjusted by the potentiometer in the base of Tr_1. If this is not done the amplifier will not be able to swing equally in the two output polarities.

The quoted figures for the amplifier were obtained using regulated supplies. Unless the amplifier is to be called on to deliver large sustained outputs, this is not really necessary. On the other hand, reduced mains voltage will severely restrict the power output of an amplifier with unregulated supplies. Commercially, a thyristor regulated supply is being utilized, and this has the two advantages of small heat dissipation and saving in components.

Constructional Points

The overall bandwidth of the amplifier is extremely wide and the stabilizing step-network necessary only becomes operative in the ultrasonic region. Equally the inductor in series with the output lead, which improves the stability with capacitive loads, need have only a very small inductance. This wide bandwidth gives exceptional high-frequency performance as can be seen from the distortion figures in Figs. 5, 6 and 7. Unfortunately, however, wideband amplifiers are very susceptible to layout,

Fig. 8. Layout of suitable printed-circuit board, actual size. (Courtesy Radford Audio Ltd.)

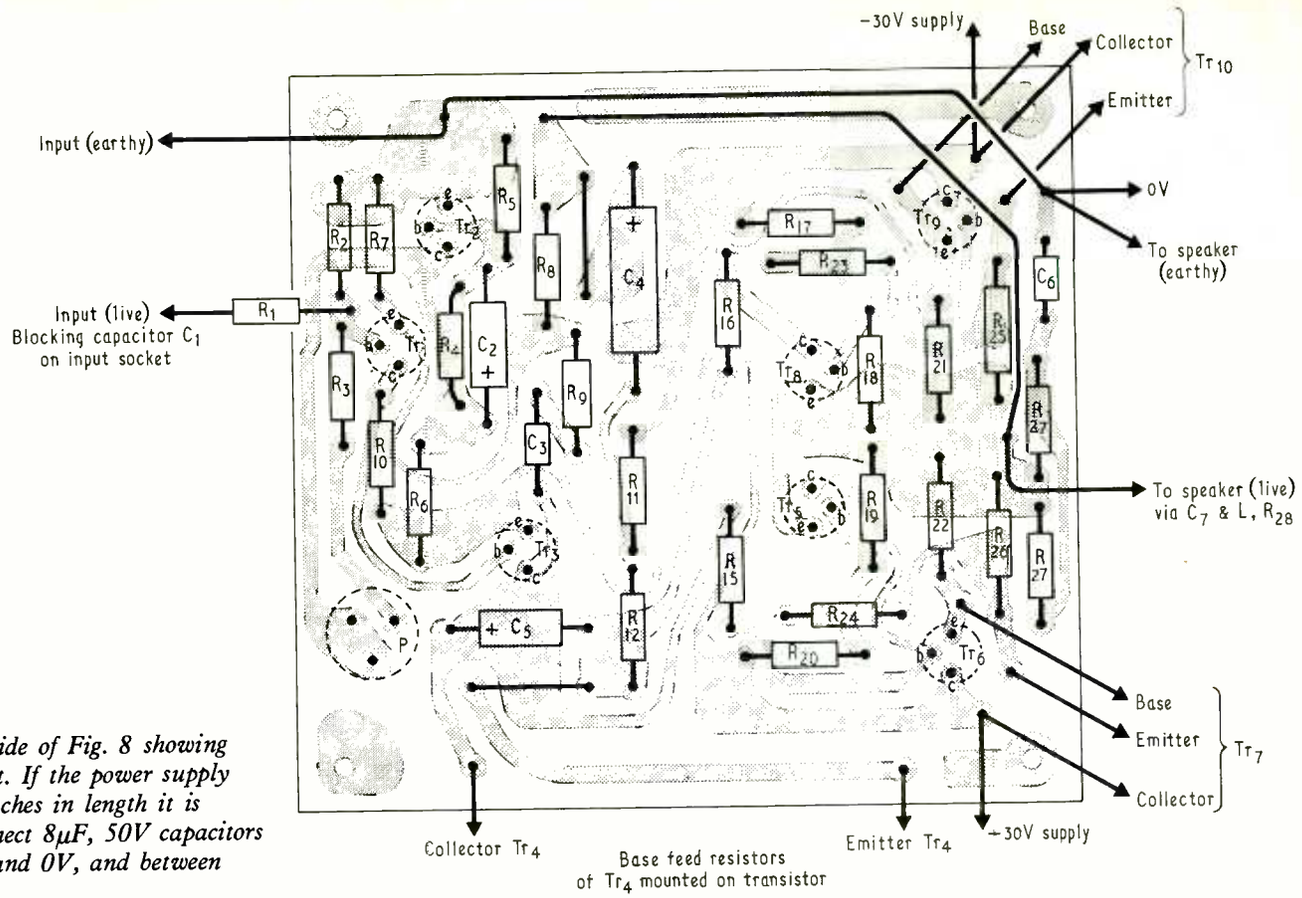


Fig. 9. Reverse side of Fig. 8 showing component layout. If the power supply leads exceed 6 inches in length it is advisable to connect 8μF, 50V capacitors between +30V and 0V, and between −30V and 0V.

particularly common coupling leads. Provided lead lengths are kept *very* short there should be no difficulty, but the author experienced tremendous variations in high-frequency stability when "rats-nest" construction was used. For this reason the safest course is to use a printed-circuit, so that the strays can be kept to a minimum. The design of a suitable board along with its component layout is shown in Figs. 8 and 9. The performance details given were measured using this particular layout. The leads to the output transistors should be as short as possible, preferably no longer than 3 to 4 inches. The size of the heat sinks for the output transistors is a matter of personal choice, the author having used sinks of finned aluminium about 4in. by 4in. square. This size is not really necessary for high-fidelity use, and sinks of half this size would be adequate provided that extended periods of testing were not undertaken.

The overall performance of the amplifier is very good, considerably better in fact (on paper) than the best valve amplifiers. Unfortunately, listening tests have shown that the performance of the amplifier is only slightly, if any, better than the best valve amplifiers. Extensive listening tests indicate only a very slight improvement in audible results, the subjective effects being almost identical. It would therefore appear that any further improvement will be of no real benefit for high-fidelity applications, the main need for work here definitely being in the field of loudspeakers, discs, etc.

Owing to the absence of cross-over distortion, the distortion at low levels is very difficult to measure and the curves appear in Fig. 7. The wide bandwidth can be seen from the curves in Figs. 5 and 6, where it will be observed that the amplifier will deliver full power output from 20 Hz to 20 kHz with less than 0.1 per cent of distortion. Indeed it is possible to obtain about 15 watts of power at 200 kHz. The square-wave tests are far better than with any known valve amplifier. Even with pure capacitive loads there is no tendency whatever towards instability. The waveforms are shown in Figs. 10, 11, 12, and 13.

The protection circuits of the amplifier operate very satisfactorily, short-circuits and 50 microfarad capacitors giving no distress to the amplifier whatever. One word of caution is necessary however; extended tests on low impedance reactive loads and short-circuits can cause high junction temperatures in the output transistors because of the finite heat-sink size. Unless one uses very large heat sinks, it is therefore undesirable to run the amplifier at full drive for extended periods when applying such abnormal load conditions. If 16-ohm load opera-

Fig. 10. Square-wave response, 1kHz and 8-ohm load.

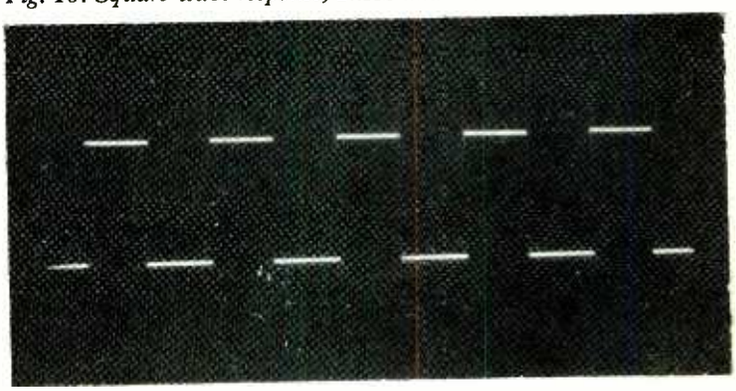
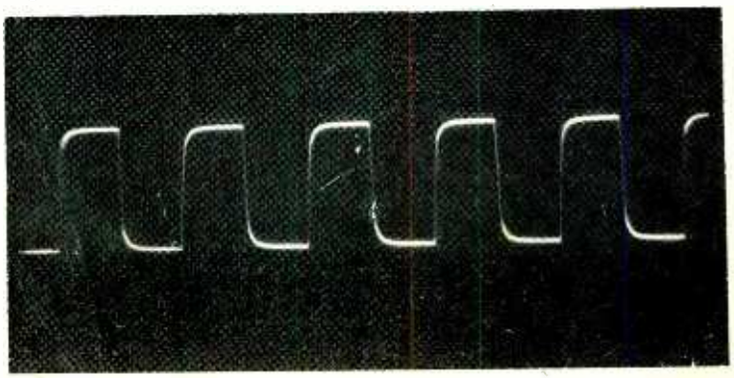


Fig. 11. Square-wave response, 50kHz and 8-ohm load.



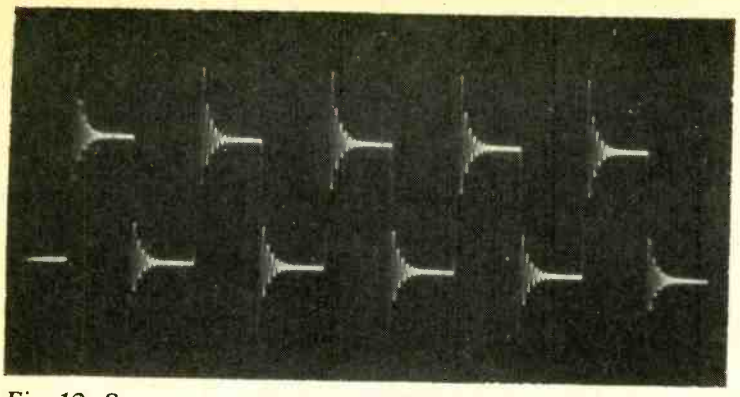


Fig. 12. Square-wave response, 10kHz and 0.1-μF load.

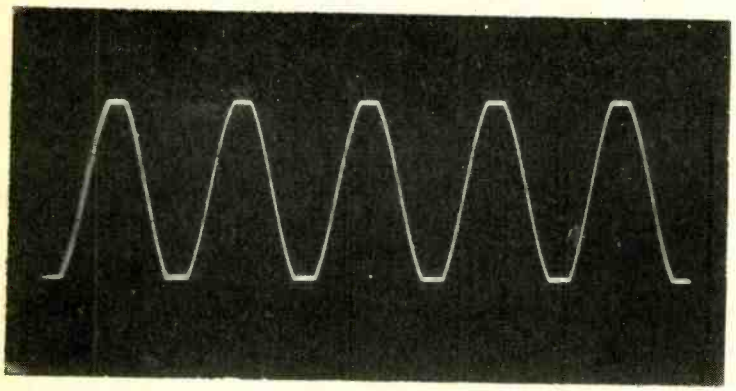


Fig. 13. Overdrive with sine-wave input, showing clean limiting (1kHz and 8-ohm load).

tion only is to be used, then the emitter resistors in the output stage can be increased up to 0.4 ohm, with a corresponding halving of the transistor dissipation under abnormal load conditions.

The specification is shown on page 94. The overall sensitivity may be either doubled or halved by doubling or halving the value of the 1000-ohm feedback resistor. This has the effect of increasing the sensitivity at the expense of distortion if the increased amplification is felt to be necessary. With the increased feedback the overall distortion is halved, and even with this value of overall feedback the amplifier is still unconditionally load stable.

When the amplifier is operated in the reduced feedback condition for 500-millivolt sensitivity, the author cannot hear any difference in performance as compared with the halved distortion characteristic obtained with the 2-volt sensitivity. It appears therefore that no further improvement in amplifier performance will be detectable until other limiting factors are greatly improved. In fact the author has a sneaking suspicion that this may be the end of the road so far as amplifier design for sound reproduction is concerned, further improvements being limited to power and cost.

In conclusion the author would like to acknowledge the interest and comments of the many readers who wrote to him after the publication of the previous article on transistor amplifier design. There were often delays in replying, but short of employing a full-time secretary such delays are sometimes inevitable. One obvious question is whether the earlier germanium circuit sounds as good as the one just described. Personally the author cannot hear any appreciable difference, but on such a controversial point it is unwise to be dogmatic!

Reference

1. "The Transistor" by E. Wolfendale. Heywood & Co., London (1963), p. 24.

Announcements

A special course entitled **"Tape Transport and Systems"** has been organized by the Department of Electronics and Communications Engineering, Northern Polytechnic, Holloway Road, London, N.7. The course comprises twelve lectures to be held each Thursday from 6.30 to 9 p.m. commencing 25th April.

The I.E.E. and I.E.R.E., in collaboration with the University of Southampton, are arranging a conference on **computer aided design.** It will be held under the aegis of the United Kingdom Automation Council at Southampton University from 15th to 18th April 1969.

Home Radio (Components) Ltd, of 187 London Road, Mitcham, Surrey, have been appointed as **retail stockists for Lektrokit** electronic rack and chassis construction systems manufactured by A.P.T. Electronic Industries Ltd.

Cole Electronics Ltd., Lansdowne Road, Croydon, Surrey, have been appointed U.K. distributors for **Bosch television test equipment.** The range of equipment includes level oscilloscopes, video test signal generators, group delay test sets, colour bar generators etc.

The Ever Ready Company (Great Britain) Ltd has acquired from the receiver of Royston Industries the factory and assets relating to the telecommunications section of **Burndept Electronics Ltd,** at Erith, Kent. The company will continue under the name Burndept Electronics (E.R.) Ltd.

Aveley Electric Ltd, of South Ockenden, Essex, have been appointed U.K. representatives for **Systron Donner products,** previously handled by Dynamco Ltd.

A marketing agreement has been signed between the **Decca Navigator Company** and **Atlas Electronik,** of Bremen, whereby Decca will handle the non-European sales of the Atlas AN 6014 survey echo sounder. This instrument is unusual in that two frequencies are employed, 30 kHz and 210 kHz, giving very high penetration and an accurate narrow beam.

Radiall S.A., of Paris, have formed a new company to market their products in the U.K. The company, Radiall Microwave Components Ltd, will operate from Station Approach, Grove Park Road, Chiswick, London, W.4.

Add-a-Vision, the electronic viewfinder for film cameras developed originally by the Livingston Group which recently went into liquidation, is now being produced and marketed by Prowest Electronics Ltd, of Maidenhead.

T. J. Sas & Son Ltd, of Victoria House, Vernon Place, London, W.C.1, have been appointed U.K. distributors for the COBEM range of motors manufactured in Belgium.

Greenray Industries Inc., the American manufacturers of oscillators, have appointed G. A. Stanley Palmer, Island Farm Avenue, West Molesey Trading Estate, Surrey, as U.K. agents for their products.

The Copenhagen firm **Radiometer A/S** have appointed Omega Laboratories Ltd., 57 Union Street, London, S.E.1, as sales and service agents in Britain for their range of test equipment. This follows the recent collapse of the Livingston Group who used to fulfil this function.

Semicomps Ltd., have added semiconductors produced by **Motorola** to the range of products marketed by them.

The American company, **Electro Scientific Industries** have appointed D. A. Pitman Ltd, of Mill Works, Jessamy Road, Weybridge, Surrey, as U.K. representatives for their complete range of precision laboratory standard measuring instrumentation.

The Marconi Company have signed an agreement with the Sylvania Division of G.T. & E. International for marketing their microelectronic microwave devices in the U.K.

S.C.E.E. Ltd, of Reddicap Trading Estate, Sutton Coldfield, Warwickshire, have changed the name of the company to Cressall Printed Circuits Ltd.

The West German company **SABA Gmbh** and **General Telephone & Electronics International,** of the U.S.A., have agreed on a programme of technical and economic co-operation aimed at providing research and export facilities for SABA and further European engineering facilities for GT & E.

Sensitive F.E.T. Voltmeter

50 MΩ input resistance volt/ohmmeter utilizing f.e.ts in a balanced circuit employing negative feedback

by D. E. O'N. Waddington, A.M.I.E.R.E.*

The transistor millivoltmeter is now a firmly established instrument for measuring alternating voltage from a few hertz up to several megahertz. To date very few circuits exist for high input resistance millivoltmeters which measure direct voltage. This is almost certainly because of design problems. Simple direct coupled transistor amplifiers are temperature sensitive and consequently suffer from zero drift. Balanced circuits[1] offer a considerable improvement in performance but, because of leakage current effects, the input resistance is limited to a few tens of thousands of ohms. It is possible to side-step the problem[2] by chopping the input voltage with some form of switch thus converting it to alternating voltage for subsequent amplification and detection. This type of circuit has its own problems, not the least of which is noise and, unless synchronous detection[3] is used, there is no way of knowing the polarity of the input. For some time it has been apparent that the f.e.t. should provide the answer as its characteristics are very similar to those of a thermionic valve, i.e. high input impedance, $\beta \rightarrow \infty$, etc. But, until fairly recently, prices have been prohibitive. Now reasonably priced junction f.e.ts are readily available.

Specification

Voltmeter ranges	30 mV to 1000 V in nine ranges
Accuracy	±5%
Input resistance	50 MΩ
Ohmeter ranges	1 k, 10 k, 100 k and 1 M
Power supply	27 V at 7.25 mA

The basic amplifier used is a modification of the well known long tailed pair, but instead of a single stage for each half of the pair, a two stage amplifier of the type shown in Fig. 1 is employed. The voltage gain of this circuit is approximately equal to $(R_1+R_2)/R_2$ and provided that this is set fairly low (e.g. <5), changes in f.e.t. and transistor parameters have very little effect. Two of these amplifiers are combined to make the long tailed pair used (see Fig. 2). The voltage gain of each half of the amplifier is now approximately $(R_1+R_2+R_4)/(R_2+R_4)$ and $(R_3+R_2+R_4)/(R_2+R_4)$ so that if $R_1=R_3$ and $R_2=R_4$ the effective gain of the amplifier will be $(R_1+R_2)/R_2$. In order to set the gain precisely, a variable resistor R_5 in series with a fixed resistor R_6 is shunted across R_2 and R_4. This method of gain control has the advantage that adjustment does not affect the meter "zero". In order to ensure that the resistance of the "tail" has negligible effect on the gain setting components and at the same time to keep the supply voltage within reasonable limits, a transistor Tr_5, connected as a constant current source, is used. The absolute value of the current provided in this way is not critical so long as it is not affected at all by the input signal. As the performance of the circuit would deteriorate if this current were to change drastically (e.g. very low battery voltage), a Zener diode is used to stabilize the base voltage thus keeping the current sensibly constant.

*Marconi Instruments Ltd.

The voltmeter zero is set by adjusting R_7 so as to balance the currents through each half of the circuit. To achieve this balance it is essential that a matched pair of f.e.ts is used. Matching of the transistors, on the other hand, is not really necessary.

Voltmeter Ranges

Although it is not so important to have logarithmically compatible meter scales for direct voltage measurement where dBs are seldom if ever used, it was decided that scales in the sequence 1, $\sqrt{10}$, 10, $10\sqrt{10}$, etc., should be used. This choice helps to simplify the range switching as will be seen.

The amplifier just described serves two functions—voltage amplifier and resistance transformer. The voltage gain is set to be $\sqrt{10}$, the input resistance is very high, $10^9\Omega$ and the output resistance is only a few ohms. As there is only 1 mA flowing through each of the output transistors, it is only possible to

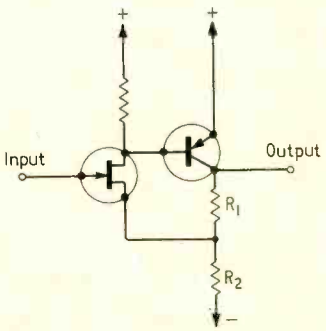


Fig. 1 The basic two-stage amplifier used to make up the long tailed pair.

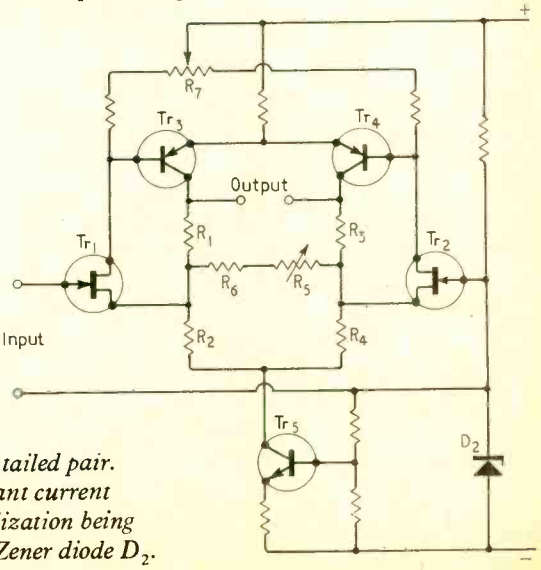


Fig. 2 The long tailed pair. Tr_5 forms a constant current source, base stabilization being performed by the Zener diode D_2.

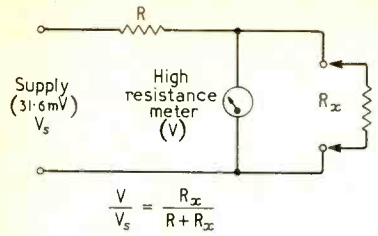


Fig. 3 The technique employed to measure resistance. $V/V_s = R_x/(R+R_x)$ where R_x is the unknown resistance.

divert up to about 500 μA through the meter but the available voltage swing is up to ± 5 V. In this design a 100 μA meter movement is used. For the lowest range the meter resistance was made up to 1 kΩ thus giving a full scale sensitivity of 100 mV for the meter on its own and 31.6 mV with the amplifier. Ranges up to 1 V are obtained by switching resistors in series with the meter as shown in Fig. 3. In order to obtain yet higher voltage ranges, the input is switched so as to give an attenuation of $\sqrt{1{,}000}$:1, the 100, 300 and 1,000 mV ranges are then used to give f.s.ds of effectively 3 V, 10 V and 30 V. The 100 V, 300 V and 1,000 V ranges are obtained in a similar manner by switching the input to give an attenuation of 1,000:1. It will be noticed that the most sensitive meter/amplifier combination is only used for the 31.6 mV range. In this way, zero drift effects on all other ranges are reduced by a factor of at least $\sqrt{10}$ and thus become insignificant.

For a long time the author has felt that it would be very useful to possess an ohmmeter which applied so little potential to the circuit under test that it did not "switch on" semiconductor junctions. This would make it possible to measure true resistance values with transistors or diodes connected in circuit.

TABLE ONE

Meter scale calibration in terms of the percentage of full scale deflection.

Ohms ranges

Ω	%	Ω	%	Ω	%	Ω	%
20	95.5	2.5	71.4	0.9	47.4	0.35	26
10	91	2	66.6	0.8	44.4	0.3	23
8	89	1.8	64.0	0.7	41.2	0.25	20
6	85.8	1.6	61.5	0.6	37.5	0.2	16.7
5	83.2	1.4	58.2	0.5	33.4	0.15	13.2
4	80	1.2	54.4	0.45	31	0.1	9.1
3	75	1	50.0	0.4	28.5	0.05	4.8

0–1 V range

V	%	V	%	V	%	V	%
0.05	5	0.3	30	0.6	60	0.9	90
0.1	10	0.4	40	0.7	70	1	100
0.2	20	0.5	50	0.8	80	–	—

0–3 V range

V	%	V	%	V	%	V	%
0.2	6.3	1	31.6	1.8	56.9	2.6	82.3
0.4	12.6	1.2	38	2	63.3	2.8	88.6
0.6	18.9	1.4	44.3	2.2	69.7	3	94.9
0.8	25.3	1.6	50.6	2.4	76	–	—

This millivoltmeter provided the opportunity as 31.6 mV is sufficiently low not to switch on most junctions. To measure resistance, therefore, the necessary excitation voltage is picked off from the potential divider which supplies the base of the constant current source. The actual metering circuit is of the form shown in Fig. 3. This method relies on the meter resistance being very high in comparison with the resistance being measured. The meter calibration is shown in Table 1.

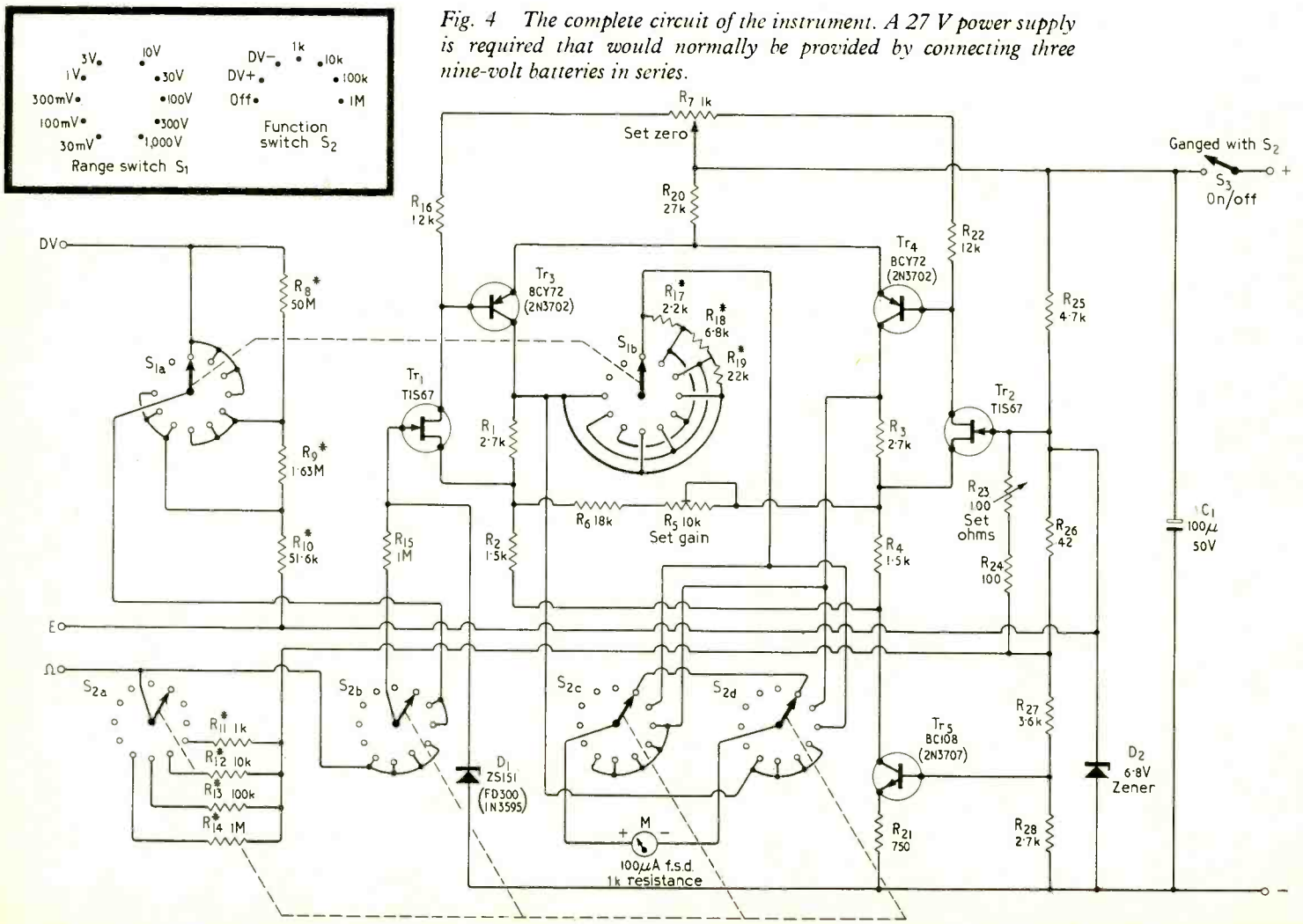


Fig. 4 The complete circuit of the instrument. A 27 V power supply is required that would normally be provided by connecting three nine-volt batteries in series.

Practical Considerations

The construction of this meter is not critical. It should be remembered that the circuit includes, and depends on high value resistances for its performance (some of the order of 10^9 ohms e.g. input resistance of the f.e.t.). The leakage resistance across paxolin circuit board and switches may be much less than this. The critical components are best mounted on ceramic stand-off insulators and it is advisable to use a ceramic switch wafer for the input range switch. Ideally the two f.e.ts should be in the same encapulation but, as neither dissipates much power, keeping them in the same draught-proof box appears to be adequate. External a.c. fields could prove troublesome so it is advisable to enclose the circuit in a metal box and to screen the input lead. One unforeseen effect encountered by the author during setting up was a mysterious input voltage which appeared to depend upon the position of the instrument. This was traced to photo-electricity developed by the input diode.

While it is relatively easy to obtain the low value resistors to the required degree of accuracy, the 50 MΩ may constitute a problem. The author found that the easiest way out was to obtain a 50 MΩ cracked carbon resistor, measure it and to adjust the values of R_9 and R_{10} to suit. Metal oxide resistors should be avoided in building this circuit as most types generate thermo-electric voltages which could cause problems.

Input Protection

Fig. 4 shows the protection circuit used. With a high positive input, the gate source diode of Tr_1 is turned on hard and the current flow into it is limited to a safe level by the 1 MΩ series resistor R_{15}. For large negative voltages protection is provided by D_1 in a similar manner.

The performance of the diode used here is very important as, if the effective reverse resistance is not high enough, a voltage will be developed across the input divider chain by current flowing through this diode from the negative rail. If none of the recommended diodes can be obtained, the best thing to do is to try out several until a suitable one is found.

The method of testing the diode is to connect the diode into the meter circuit in its normal position. Switch on, and with the input short circuited, set the zero on the most sensitive range. Remove the short circuit and connect a 2.2 MΩ resistor across the input. If the leakage of the diode is low enough, the meter zero will not shift by more than 0.5%. Care should be taken to ensure that a.c. pick up or thermal or photo-electric effects do not affect the measurement.

All resistors should be 5% cracked carbon $\frac{1}{2}$ W. For greater accuracy the tolerances of the resistors marked with an asterisk in Fig. 4 should be tightened, in particular R_{17}, R_{18} and R_{19} should be selected to be 2.162 kΩ, 6.838 kΩ and 21.62 kΩ.

The accuracy of a meter of this type depends mainly upon the accuracies of the resistors used and the accuracy to which the gain may be set. In practice it would appear that 5% is relatively easy and, if 1% resistors are used, 2% accuracy may be obtained with a fair degree of confidence. The zero drift is very small—of the order of 2% of f.s.d. on the most sensitive range over a period of three hours with an ambient temperature change of about 5°F.

References

1. "Transistor Multirange D.C. Millivoltmeter", *Mullard Technical Communications*, Vol. 5, No. 48, June 1961.
2. "D.C. Nano-ammeter and Microvoltmeter" by D. Bollen, *Wireless World*, Vol. 75, No. 5, May 1967, p. 206.
3. "A Transistor D.C. Chopper Amplifier" by P. L. Burton, *Electronic Engineering*, Vol. 29, August 1957, p. 393.

Transversal Filter

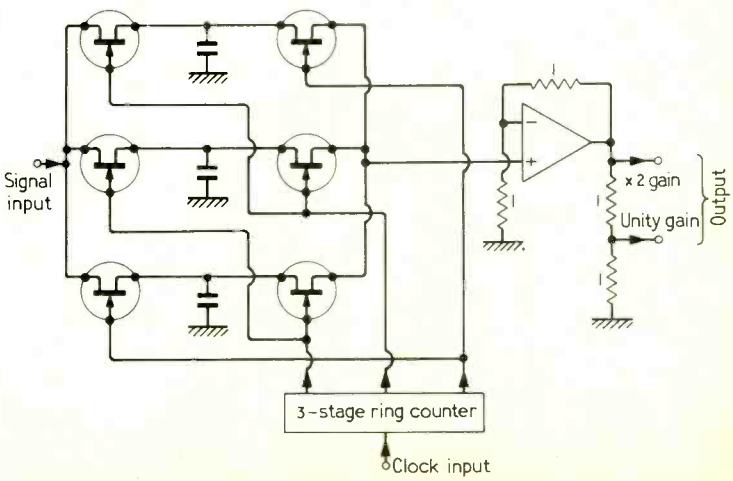
Tapped delay-line principle

A transversal filter with individual delay sections made up of hybrid thin film and integrated circuit networks, was demonstrated to us by A.E.I. The transversal filter is a tapped delay line, the outputs taken from the taps being added, with weighting, in a summing amplifier. It is mainly used for the equalization of the combined amplitude and phase distortion suffered by signals in transit, and has particular application in television and high speed data links. Earlier filters for this purpose employed bulky *LC* networks that only approximated the required delays and often caused dissipation problems.

Individual delay sections of the line are made up from gated capacitance store delay networks of the type shown in the simplified circuit. In principle, the input signal charges a capacitor selected by an electronic commutator or switch and after a delay the charge on the capacitor is read out into a high impedance amplifier. In the circuit shown a three stage ring counter controls six m.o.s.ts., forming the commutator, which in turn control the charge and discharge of the capacitors. The delay is variable by altering the sampling time (clock rate) and is equal to two clock periods. The delay obtained with the circuit shown could be varied between 2 and 70μs for signal frequencies from 1.5Hz to 6kHz.

The transversal filter demonstrated will accept a variety of analogue and digital input signals and was seen equalizing severe distortion on a pulse train resulting from its having been passed through an all-pass phase shift network substituted for the transmission medium. It is thought that the filter could easily be automatically controlled and would then compensate for varying transmission conditions without the need for manual adjustment.

Simplified circuit of the gated capacitance store. A delay of two sampling periods is obtained.



Physics Exhibition

Some of the more interesting of the developments seen at Alexandra Palace, London, where there were 150 exhibitors

Semiconductor doping by ion implantation

Three organizations, Associated Semiconductor Manufacturers, United Kingdom Atomic Energy Authority and the Services Electronics Research Laboratories, had exhibits concerned with doping semiconductors by the use of ion beams. Although the technique is still very much in its infancy initial results are very promising. In the process ions obtained from the desired impurity material are accelerated to a high velocity.

After being mass analysed in a powerful magnetic field to remove unwanted ions they are allowed to bombard the semiconductor slice through a slot in an opaque mask. The ion beam will not be of uniform density, so to ensure an even distribution in the semiconductor slice the beam is magnetically scanned in both the x and y directions.

The technique has a number of advantages over doping using the conventional diffusion methods; for instance, the depth that the impurity ions penetrate can be accurately predicted and controlled by altering the energy of, and the orientation of the crystal lattice relative to, the ion beam. The impurity material to be planted does not have to be chemically soluble, as is the case with diffusion, a feature that widens the choice of possible dopants considerably and, who knows, could lead to the development of entirely new devices. The maximum temperature that the crystal is subjected to is in the region of 650°C, well below that at which diffusion takes place, resulting in few unwanted impurities being introduced and in bulk carrier lifetime, under the implanted region, being less degraded than for higher temperature processes. The heating is carried out after ion implantation has taken place to allow those parts of the crystal that have suffered radiation damage to recrystallize epitaxially and to render the impurity ions electrically active. The directional property of the ions penetrating the crystal is such that the lateral spread of impurities through the slit in the mask is very much less than with diffusion, which after all, is essentially a three-dimensional process. In bi-polar transistors "push-over" effect, the tendency for the base region to push into the collector region during diffusion, is entirely eliminated, a fact that allows very narrow width bases with a high impurity content to be fabricated, reducing base resistance.

Work carried out at the U.K.A.E.A. in collaboration with A.S.M. has produced what is called an autoregistered m.o.s.t. The transistor is a p-channel device with parallel thermally diffused source and drain regions 37 microns apart. The gate electrode is placed between the source and the drain regions on the stable gate oxide, before ion implantation. The source and drain regions are now extended up to the gate by implanting boron ions through the oxide on either side of the gate into the silicon below. The metal of the gate electrode acts as a mask against the ion beam (autoregistration). The device is annealed at 500°C to repair damage and make the implanted boron electrically active. The precise alignment of the gate electrode (better than 0.2 microns) results in a fifteen times reduction in gate/drain feedback capacitance.

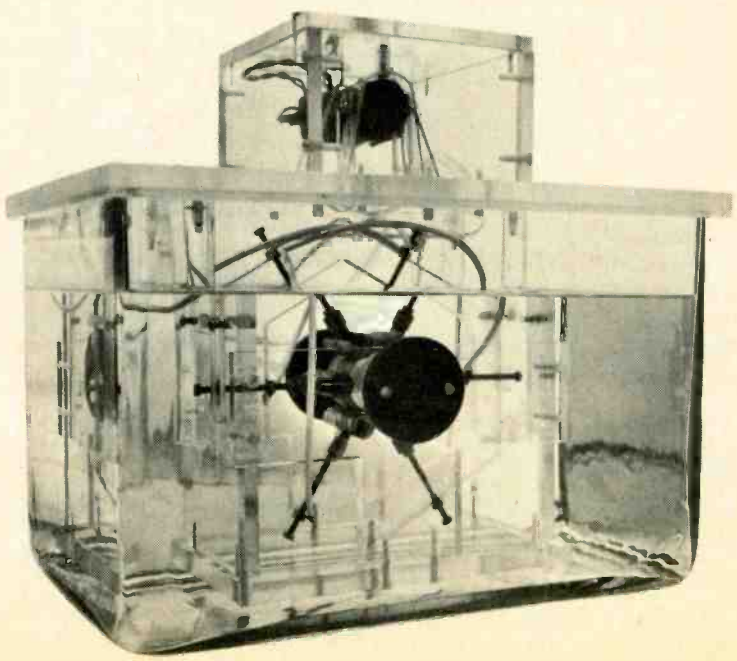
Many other devices have been made which include high voltage diodes with breakdown voltages approaching the theoretical maximum, variable capacitance diodes with closely controlled CV characteristics and an h.f. bi-polar transistor.

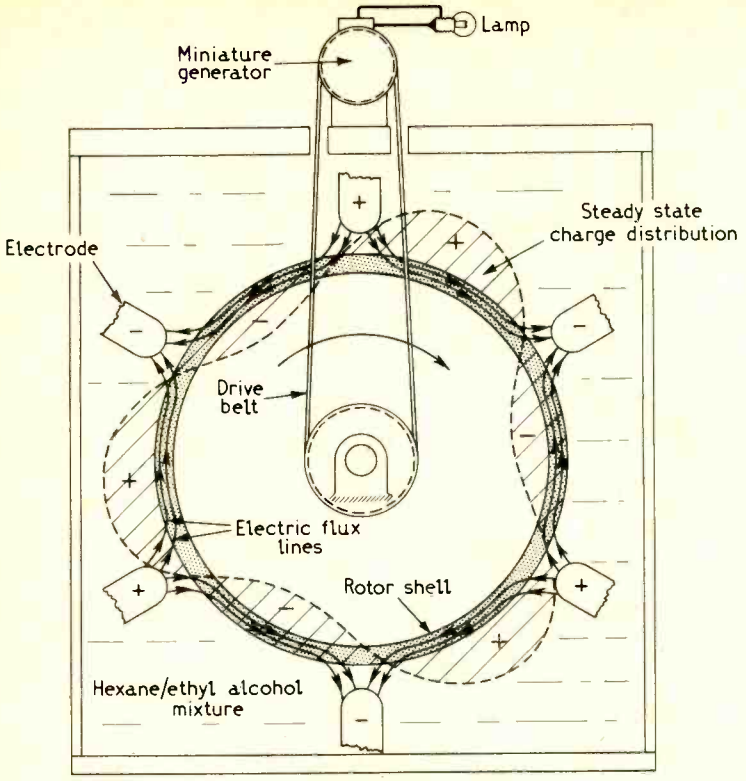
Dielectric motors

The School of Engineering Science, University College of North Wales, demonstrated a novel type of electric motor, on which they have been doing research. Described as a dielectric motor, it comprises an insulated high permittivity cylindrical rotor and fixed electrodes, all immersed in a bath of semi-insulating fluid, a hexane/ethyl alcohol mixture.

When a suitable voltage is applied to the electrodes, charge carriers migrate through the fluid and establish a distributed charge layer on the rotor surface as shown by the shaded area

The dielectric motor, fully immersed in a tank of hexane/ethyl alcohol mixture and above, in a separate compartment, a small electric generator which it drives via a belt and pulleys.





Symmetrical pattern of the electrical charge layer distributed round the high permittivity rotor, illustrated by the cross hatch area in this end-on diagram of the dielectric motor.

in the diagram. The electrical stress and charge distribution patterns are symmetrical around the rotor, and the motor exists in a state of unstable equilibrium. If the rotor is given a small angular displacement (i.e. started mechanically) the resultant disturbance of the associated distributed charge is followed by conduction in the fluid in an attempt to re-establish the charge distribution equilibrium. The axes of charge maxima on the rotor and the nominal electric stress can thus be displaced from one another so that a net torque acts on the rotor. Rotation continues until steady-state conditions are established, depending on the time constant of this process. The time constant is significant because of the high resistivity of the fluid. An optimum conductivity exists for maximum torque.

Rotational speeds in excess of 2,500 r.p.m. were observed for an unloaded motor when a voltage of 10kV was applied. Power input was then one or two watts. The rotor speed varies approximately linearly with the applied voltage. The motor was coupled via a belt drive to a miniature generator, and with approximately 20kV applied between the electrodes of the motor, the output from the generator approached $\frac{1}{2}$W, sufficient to light a torch bulb. Power input was then about 5W.

The dielectric motor is not inherently self-starting and has no preferred direction of rotation, but at high electrical stress, random fluctuations in conduction near the rotor can result in its starting without external assistance. Maximum torque is achieved by the choice of a suitable fluid. The alcohol-doping level is critical, and if this level is either increased or decreased, the rotor speed for a given applied voltage is reduced.

Optical store

A large capacity random access store being developed by I.C.T. relies on a simple kaleidoscopic effect for its operation, information being permanently stored as a pattern on a photographic plate. For read-out a spot of light 0.178mm in diameter is formed on the face of a short-persistence c.r.t. The position of this spot on the tube face is determined by a servo system which locates it in any one position in a 256 × 256 matrix, covering an area 58.4mm square. The size of the light spot is reduced by a factor of four in a minifying lens and focused into one end of an internally mirrored tunnel of square cross-section. The tunnel dimensions are so arranged that the multiple reflections that take place within it form 69 geometrically related apparent light sources when viewed from the far end. These are focused by a projection lens on to the photographic plate. Movement of the spot on the c.r.t. face within the 58.4mm square matrix causes each of the 69 spots to take up the corresponding position within 69 squares on the photographic plate. Each of these squares is coupled to a photo multiplier via a light collecting material.

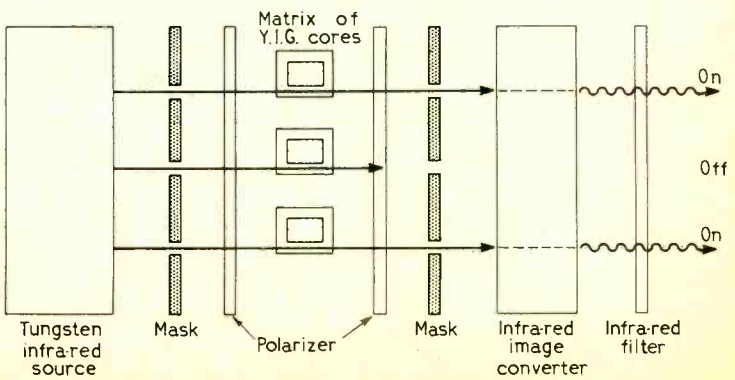
Each of the 69 squares on the photographic plate contains a 256 × 256 matrix (measuring 25.4mm square), and each matrix consists of a pattern of opaque and transparent areas forming the stored information. With the spot in a given position each photo multiplier reads one bit from each matrix, the combined parallel output being in the form of a 69-bit word. The store capacity is therefore 63,536 (256 × 256) 69-bit words or almost 4.5 million bits. The time between successive accesses is less than 3μs.

An interesting feature of the servo system that positions the c.r.t. spot is that movement of the c.r.t. electrodes due to vibration or ageing or, in fact, movement of the whole c.r.t. is automatically compensated for and does not affect the correct operation of the store. Part of the light output of the c.r.t. is diverted and formed into two bands (one horizontal and the other vertical) of one spot diameter wide. These bands are projected on to two Gray coded plates, one specifying the x and the other y matrix address. The address demanded by the interrogating computer is compared with the spot address as defined by photocells reading the coded plates and the difference is used to drive the spot to the correct position within the matrix. The coded plates are rigidly fixed in relation to the photographic plate (which is interchangeable between stores) rendering the system immune to effects caused by changes in the c.r.t. geometry. It is thought that the new store will be at least 50% cheaper than a ferrite core store of comparable capacity.

Magnetic visual display

Television bandwidth compression and visual presentation of computer data are among possible applications of a magnetically controlled display device being developed at the University of Sussex under the sponsorship of N.R.D.C., on whose stand it was exhibited. The principle is based on the ability of yttrium iron garnet (y.i.g.) crystals when they are magnetized to produce the Faraday effect (rotation of the plane of polarization of

Principle of the magnetic display. The light pattern (right) depends on the magnetic states of the cores.



electromagnetic radiation in a magnetized material). The y.i.g. elements used in the display are cut from the bulk material in such a way that they have square hysteresis loops and can be switched between two stable magnetic states, in a manner similar to the switching of ferrite cores in stores. An array of these elements is wired so that individual elements can be selected (magnetized) by coincident-current pulse techniques. The crystal material is transparent to radiation in the near infra-red region, so that by placing an infra-red source behind the array and by interposing correctly oriented polarizers as shown in the diagram it is possible to obtain an infra-red pattern corresponding to the magnetic states of the individual y.i.g. elements. This pattern is then converted into a visible light pattern, and the visual information so produced is retained (without electrical regeneration) until the states of the elements are changed. The time required for an element to be switched between states is 3μs. The digital addressing of the display, of course, makes it very suitable as a data output device, and it is the storage facility which suggests the idea of television bandwidth compression since this would allow one television field to be compared with the next and only the *difference* between them transmitted.

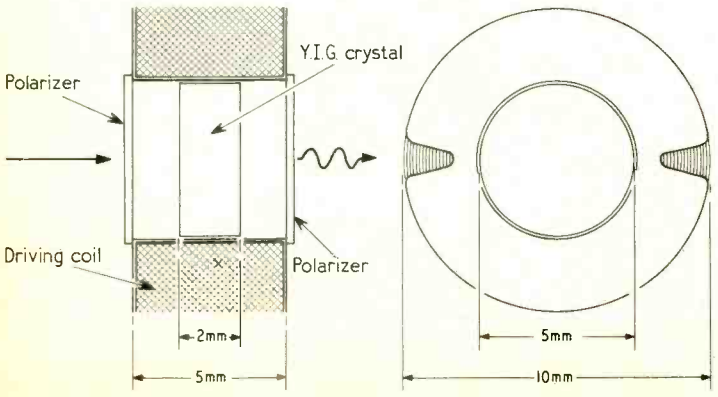
The work being done is a feasibility study to demonstrate the basic principle of the display.

Light modulator

Faraday effect in an yttrium iron garnet crystal is exploited in an anfra-red modulator developed by Mullard which was demonstrated in an optical communications link with an effective range of 2km. Faraday effect is the rotation of the plane of polarized light in a material by applying a magnetic field.

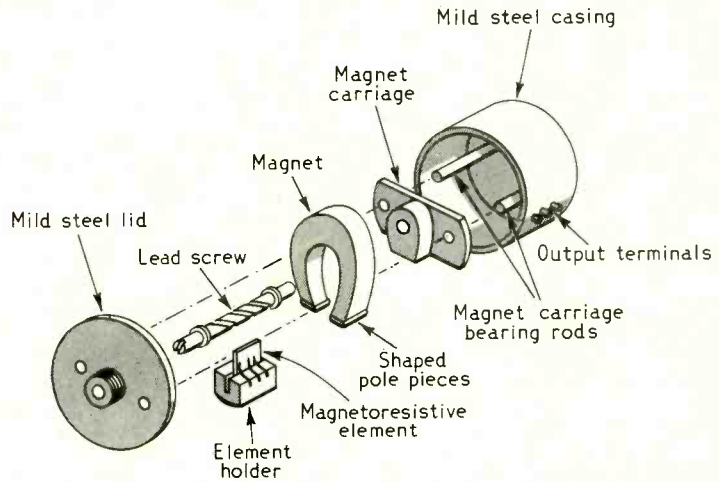
The y.i.g. modulator operates in the 1.1 to 4.5 micron region at modulation frequencies of up to 100kHz and consists of a single crystal 5mm in diameter and 2mm thick wound with a suitable coil (see diagram). Infra-red radiation generated by an incandescent bulb is passed through the crystal via a polarizing filter. The beam is subjected to polarization-modulation by passing modulating current through the coil. This is converted to intensity modulation by passing the beam through a further polarizing filter. The beam is then focused on to the receiving photo-cell and amplified in the normal way. The maximum modulation depth obtainable is determined by the saturation Faraday rotation and the thickness of the crystal. For the crystal specified the modulation depth for a rotation of $\pm\theta$ is sin 2θ and is therefore linear (within 5%) with drive current for modulation depths of up to 50%. The coil used consisted of 1000 turns of 46 s.w.g. enamelled copper wire and required a drive current of 12mA r.m.s. for 50% modulation.

Showing the construction of the y.i.g. modulator.



Magnetoresistive potentiometer

A potentiometer without wiping contacts, offering long life, low noise and high electrical resolution, was shown in experimental form by G. V. Planer Ltd. It is based on the magnetoresistive effect (increase of resistivity of semiconductor materials when they are placed in a magnetic field) and arises from new techniques in producing thin film elements of high sensitivity to magnetic fields. The potentiometer comprises two such elements of indium antimonide joined in series, and a leadscrew mechanism for moving a permanent magnet with respect to them so that one element is entering the field while the other is emerging. (In another version the elements are moved with respect to a fixed permanent magnet.) The shape and thickness of the elements and/or the geometry of the magnetic field (flux density 2 tesla)



Exploded view showing potentiometer construction.

are adjusted to give the required potentiometer law. A linear type was actually shown. The resistance values of the elements available at present range from 100Ω to 2-3kΩ but higher values are said to be possible. The power rating is $\frac{1}{2}$ watt.

Parametric 'electrometer' amplifier

The well-known low noise characteristic of parametric amplification is utilized in an equipment developed by Devices Ltd. for use in measuring small voltages or currents, as required in physiological or electrochemical work. It is a transistor d.c. amplifier with a performance comparable to that obtained with electrometer valve amplifiers, but avoids the $1/f$ noise associated with valve circuits by using a low-frequency parametric input stage. The parametric elements are silicon diodes and the pump frequency is 4MHz. This input circuit is coupled to the succeeding stages by a transformer, thereby allowing the input to be isolated from earth—a useful facility for some measurements. Input resistance of the amplifier is greater than 10^{11} ohms and input current is 10pA. The bandwidth of the amplifier is approximately 20kHz.

Waveform recovery from noise

Various techniques exist for recovering repetitive signals from noise of amplitude greater than the signal level, and they are usually based on the principle of integration over an interval of time: the signal values are integrated while the noise values average to zero. If the signal is sinusoidal a phase-sensitive detector can be used. An apparatus for use on non-sinusoidal

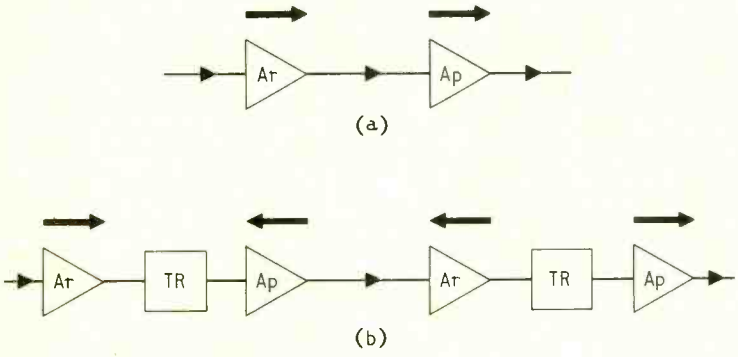
repetitive signals, known in American jargon as a boxcar integrator, was demonstrated by Brookdeal Electronics Ltd. In this a high speed gate regularly samples the signal at a given point in the repetition cycle, and this sampling point is made to gradually scan the signal waveform so that successive values of the cycle are sampled. The open period of the gate can be adjusted from 50ns to 5ms. The gate is connected in a negative-feedback loop which acts to hold the voltage sampled to zero and as a result the negative feedback voltage is accurately proportional to the sampled value of the signal, with a linearity of better than 0.1%. The feedback voltage is then integrated over a number of signal cycles, averaging the noise towards zero, and the output of the integrator is fed to the y channel of a pen recorder. The x-direction movement of the pen recorder is synchronized with the scanning of the signal waveform, so that a facsimile of one cycle of the signal waveform is gradually drawn as the scan proceeds. Of course, the improvement obtained in signal-to-noise ratio depends on the number of cycles of the signal waveform over which integration is performed at a given sampling point.

New signal processing method

To demonstrate their work on signal processing using time reversal techniques to effect phase correction, the City University showed apparatus which reduced the method to its simplest form, and which consisted essentially of two identical tape decks modified to reproduce in the reverse direction as well as in the forward direction.

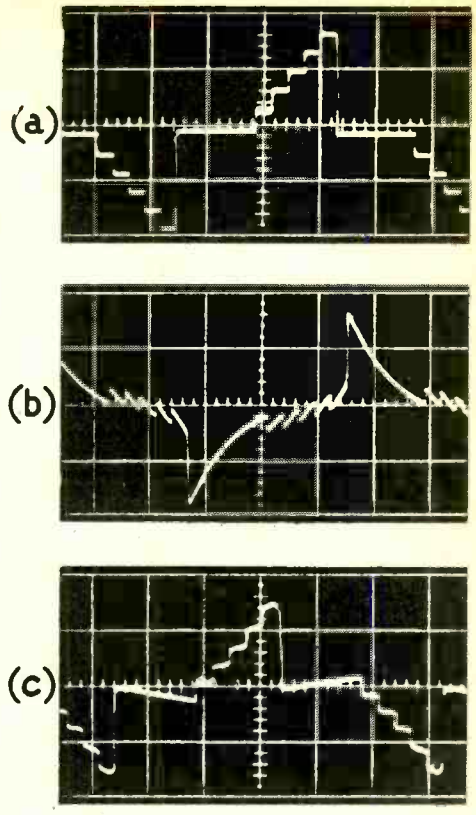
During recording on a conventional tape recorder, equalization is applied to provide a level amplitude characteristic over the working frequency range. Normally no attempt is made to equalize the phase distortion, introduced by filtering and by the

Fig. 1. The conventional recording cycle is illustrated in (a), while in (b) the recording cycle of the time-reversal method is shown. In the diagram (b), TB = time reversal.



recording process itself. These recorders therefore are not suitable for recording signals where preservation of the waveform is of importance. By using the "time reversal" method this disadvantage can be overcome. When recorded through a conventional tape recording process as illustrated in Fig. 1(a), the original waveform from a waveform synthesizer, shown in Fig. 2(a), receives the severe phase distortion shown in Fig. 2(b). If the recording is now played back and re-recorded in reverse, phase errors present in the first recording introduced by the recording process, will again be present, but this time the reverse-recorded waveform will be distorted by exactly the same degree of error in the opposite sense, thus cancelling out the original phase error. For example: Assuming a phase distortion angle of 60° lead is produced in the forward recording, this becomes a 60° lag in the reverse recording. It now only remains to reverse the tape again and play back to obtain a waveform close to the original but with some amplitude distortion, as

Fig. 2. The original waveform (a) is reproduced as (b) after conventional tape-recording, and as (c) when tape-recorded with time reversal.



shown in Fig. 2(c). The complete time-reversal recording cycle is illustrated in Fig. 1(b).

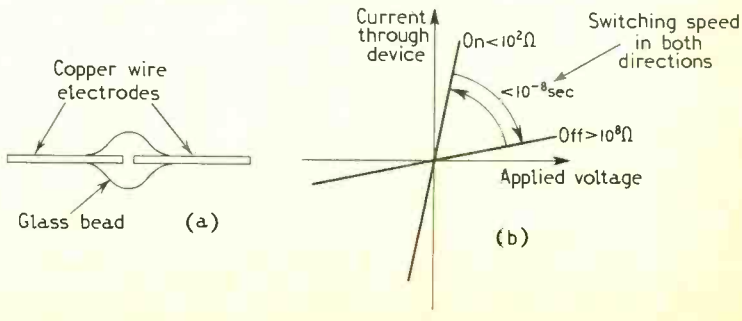
Time reversal techniques can be applied to any linear system that can be divided into two identical halves, and where, with the aid of suitable storage or recording devices, signals can be reversed in direction before passing through the second half. Readers will recognize the similarity between this technique and the PAL colour television system, where chrominance channel phase errors are cancelled out by reversal of the R-Y signal phase and storage on successive lines.

Vitreous state devices

Perhaps a new name in electronics, vitreous state devices are solid state devices which make use of the imperfections in vitreous materials for the transport of electrons. Standard Telecommunications Laboratories demonstrated a two-terminal component in which they exploit the novel type of electrical properties peculiar to these materials, comprising two metal electrodes separated by a thin layer of special glass. The device can be in either of two resistive states: an "off" state with a resistance in excess of $10^8\ \Omega$, and an "on" state with a resistance of less than $10\ \Omega$.

It is essentially a fast switch. Switching from the "off" to the "on" state takes place when the terminal voltage exceeds

Vitreous switch (a) and simplified switching characteristics (b). Both states of the switch are stable at zero volts.

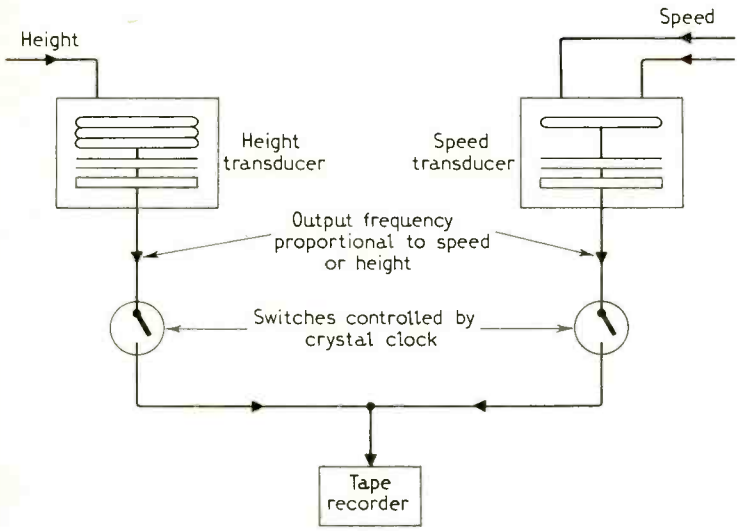


a critical value, typically 20V, and switching from the "on" to the "off" state is effected by a step-edged pulse from a low impedance source. Switching speed was given as being better than 10^{-8} second in both directions. In its application as a memory element, the device will retain imformation indefinitely under open-circuit, short-circuit or load conditions.

Cheap portable data-logging system

Developed by the University of Reading, a prototype data-logging system was demonstrated, which could be used in a sailplane to record its height and speed. This information could then be subjected to computer analysis to determine the sailplane's performance. The equipment's principal advantage in this application is its light weight (20lb for the complete system including transducers, recorder and batteries). It also has the added attraction of low cost.

A cheap commercial tape recorder is used to record one quantity per second with an accuracy of $\pm$ 1 part in 5,000, the quantity recorded being converted to frequency by a suitable transducer. The transducers shown were all phase-shift oscillators in which the frequency was controlled by a single *RC* time constant. In the height and air-speed transducers the capacitance of a parallel-plate capacitor was varied by the movement of aneroid capsules similar to those used in standard aircraft equipment. A temperature transducer used a fixed capacitor and thermistor. All the transducers were adjusted to a frequency range of 4-10kHz to suit the recorder. Although the calibration curves of these transducers are not quite linear, it was said that this could easily be corrected by the computer.



Schematic diagram showing the set-up of the cheap portable data logging system.

This photograph shows the complete airborne equipment comprising transducers, tape recorder and batteries.

To avoid the necessity of maintaining a constant tape speed, each transducer signal is gated for a defined time and the gated signals are recorded in turn on the tape with blank tape between. All gating signals are obtained by counting down from a 5kHz crystal oscillator so that the record, for example, of height is the number of cycles contained in the "height-pulse" on the tape. For analysis, the tape is played back into a squaring circuit which interrupts a computer once per cycle. The computer counts the cycles in each pulse and stores each count for subsequent processing. Because the lowest data frequency used is 4kHz, there is room on the same track of the tape for a speech channel with a bandwidth of, say, 100—3,500Hz.

Sensitive TV camera tube

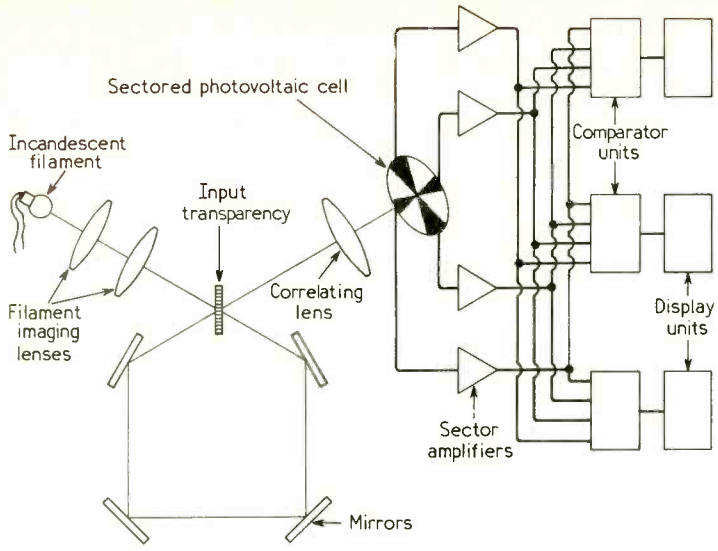
Most of the English Electric Valve stand was devoted to a demonstration of a new 3-in Image Isocon tube producing pictures from a scene too dark to be discernible by the naked eye. It was housed in a specially designed prototype TV camera. First announced at last year's International Broadcasting Convention in London, the Image Isocon is capable of producing good TV pictures when the photocathode illumination is only 10^{-3} lux, and even when the photocathode illumination falls as low as 10^{-5} lux, acceptable pictures can still be produced.

Designated P880, the tube is designed for special television purposes and can handle scenes having a very wide range of light levels. The image section is the same as in a normal image orthicon tube, but the scanning beam is made to follow a helical path to the target by two pairs of "steering" electrodes. On reaching the target, the beam divides in three ways. One part lands on the target to neutralize the charge at that point. Another part is specularly reflected and ultimately discarded, and a third part is scattered. This third beam of scattered electrons does not possess the helical motion of the original forward beam. Its magnitude is dependent only upon the charge present at that point of the target. Returning from the target to the gun, and influenced by the axial magnetic field, this beam passes through the steering electrodes and so acquires a helical motion. The radius of this helical path is such that the beam passes through the aperture in the separator electrode and enters a conventional image orthicon electron multiple system.

Thus it is the beam of scattered electrons which provides the signal. The magnitude of the beam increases with the light level, unlike the image orthicon where the specularly-reflected beam (the beam which is used) has its maximum value for zero light input. Signal-to-noise ratio of the Isocon is much better than that of an image orthicon and it is claimed that noise in the darker parts of the picture is virtually eliminated. In the demonstration booth the Image Isocon camera was mounted on a fixed tripod and focused on an inanimate subject, so that it was not possible to judge if a moving picture would be affected by lag.

Autocorrelation pattern recognizer

An apparatus capable of distinguishing between different photographic transparencies (e.g. letters of the alphabet or human faces) by means of optical autocorrelation was demonstrated by Hawker Siddeley Dynamics Ltd. The image of an incandescent lamp filament is focused on to the transparency and the resulting transmitted light pattern is directed by mirrors back through the same transparency. What then emerges



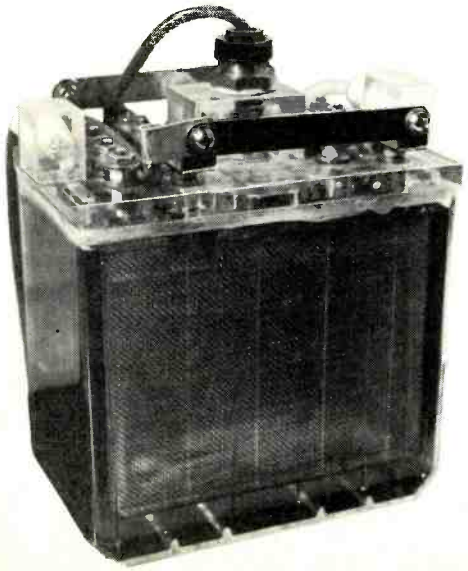
Principle of autocorrelation pattern recognizer.

is an optical pattern across which the variations of light intensity represent correlation coefficients between different parts of the original subject—a spatial autocorrelogram. This is then focused on to a detecting device—a photovoltaic cell divided into four sectors. The outputs from the four sectors are amplified and fed to three comparators. Each comparator is set to accept a code of voltages, and deviations from this code are detected and the moduli added. The output of each comparator is thus an indication of the total deviation from the pattern for which that comparator was adjusted to accept. The comparator outputs are fed into a display unit which has acceptance limits preset, and this indicates recognition.

Hydrogen/oxygen fuel cell

A fuel cell which, while measuring only $17.5 \times 17.5 \times 9$ cm, can deliver a current of 100A at 0.6V continuously, was shown by Research and Development Laboratories of Manchester. Fuel cells are devices which continuously convert energy from various chemicals directly into electrical energy, and in this instance the cell was a low-temperature, low-pressure, hydrogen/oxygen unit and the electrolyte was a 30% potassium hydroxide solution. Four hydrogen electrodes and five oxygen electrodes were interleaved alternately. The cell operates at a constant temperature (normally 60°C) and the electrodes are supplied by oxygen and hydrogen gas at a pressure $4kN/m^2$(3cmHg) above atmospheric, via a manifold in the cell lid. A $0.99m^3$ (3.5 cu.ft) capacity cylinder of each gas was estimated to give 30A for 7 hours.

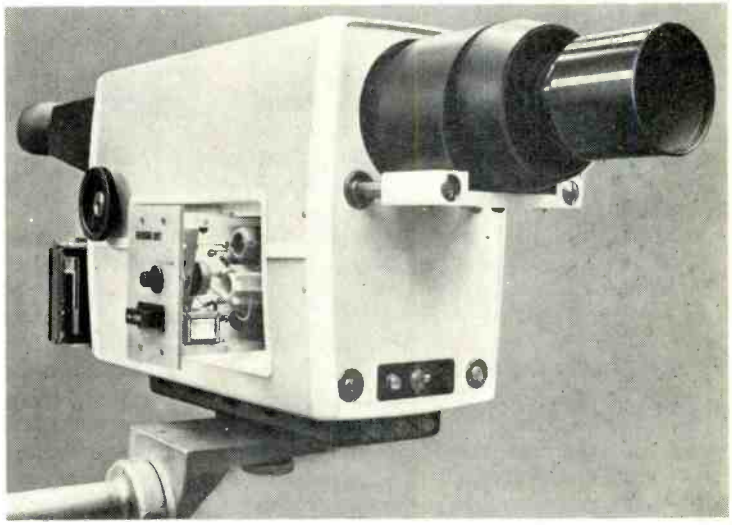
The overall efficiency of the cell is 60%. There is no intermediate stage in the conversion process where energy must be expended to produce heat and there are no moving parts. The only by-product of the reaction is water and since this causes dilution of the electrolyte, some arrangement is necessary for removing the excess volume of liquid and adding sufficient potassium hydroxide pellets to bring the solution up to full strength. Batteries of up to 3kW output have been produced.



The top manifold, through which the hydrogen and oxygen gases are fed in, distinguishes the fuel cell from the otherwise conventional "battery" appearance.

High-speed electron-optical camera

A camera with electronic shuttering shown by John Hadland (P.I.) Ltd. presents on a fluorescent screen a sequence of frames showing the development of some high speed event such as the build-up and decay of ignition of a flash tube. The shuttering can be at any speed from 10^5 to 6×10^7 frames per second and the actual number of frames presented—



The high-speed camera showing the shuttering sine-wave oscillator module on the left.

to the eye almost simultaneously—can be anything from 8 to 32. This is achieved by means of an image converter tube, the English Electric Valve Company type P856, which uses a sinusoidal shuttering technique developed by U.K.A.E.A. There are three pairs of deflector plates between anode and screen. The first pair of plates act as shutter plates: when a sinusoidal oscillation is applied to them they deflect the electron beam up and down across a slit in an aperture plate. The beam can only pass through the plate when it is traversing the slit and this results in repetitive shuttering. Because the electron beam is moving as it passes the slit it produces blurred pictures on the fluorescent screen. To arrest this blurring movement a second sinewave of the same frequency and amplitude, but of different phase, is applied to a second pair of deflectors on the far side of the aperture plate. As shuttering takes place each time each sine wave passes through zero voltage there are two exposures per cycle. Images are produced in superimposed pairs at the screen. To separate them a staircase voltage is applied to a third set of deflectors, and the staircase is synchronized so that its steps occur between alternate exposures. Thus two rows of pictures are produced, the framing rate being twice the frequency of the applied sine waves and the number of pictures twice the number of steps.

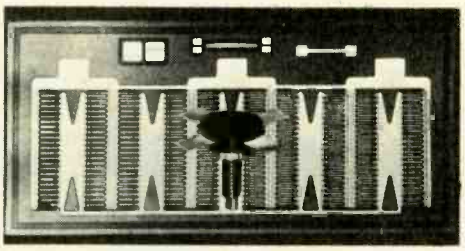
Sinewave oscillators for different shuttering speeds are provided as plug-in modules, as can be seen in the photograph.

Europe's Show-case for Components

Paris exhibition is truly international

"For the first time I feel proud to be French," said the proprietor of a small Paris firm, an agency handling imported equipment, as we walked round the huge 11th International Electronics Components Exhibition at the Porte de Versailles, Paris. He was in fact contrasting the intransigence of the French Government in world affairs with the realistic and outward-looking attitude of the French electronics industry, which has sacrificed its pride and deliberately opened itself to competition in order to run a first-class international exhibition displaying the best components technology from all over Europe. This is, however, consistent with the French Government's open-door policy of encouraging foreign firms to set up plants in the country so that France can benefit from the advanced technologies they bring in. Notably this means American technology. As a result the native French electronics firms are feeling severe competition. Some have been taken over, in varying degrees, by American giants (for example, 40% of the semiconductor firm SESCO is owned by General Electric), while others are defensively merging (for example, C.S.F. and Thomson-Brandt). Yet another U.S. semiconductor manufacturer, Motorola, is opening a factory in France. This is near Toulouse and will have close links on fundamental research with Toulouse University —in fact a former professor of physics at the University, Dr. E. J. Cassignol, has been appointed general manager of the plant.

At one time it would have been possible for the British components industry to transform their R.E.C.M.F. Exhibition into an international show of the calibre of Paris, but the opportunity was lost through insularity or fear of competition on the part of those in charge. Now the more progressive of the British components manufacturers regard Paris as *the* show at which they must be present before all others.



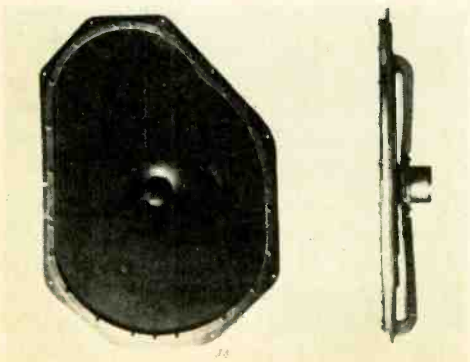
Motorola r.f. power transistor, also showing electrode structure on the chip.

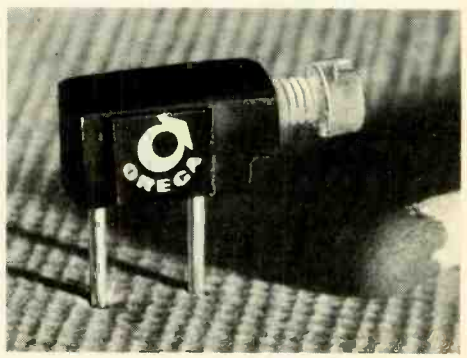
The following notes are on items selected as being of particular interest to Wireless *World* readers. British exhibitors are not mentioned as information on their products will be given in other ways.

Loudspeakers. One gets used to seeing strange loudspeakers in France, but the oddest looking one at the exhibition was in fact a Japanese moving-coil unit, shown by Hi-Fa of Paris and on the Japanese industry stand. Made by Yamaha of Hamamatsu, it has a large, flat, expanded polystyrene diaphragm of asymmetrical shape measuring, for example, in one model, 82cm × 57cm. This is fixed rigidly at the periphery to an aluminium frame and driven by a conventional voice coil (6.6cm diameter) and magnet system (1.4 tesla flux density). Yamaha are perhaps more widely known as makers of pianos, and they say, in fact, that they got the idea for the diaphragm from the sounding board of a grand piano. Sound is produced not by straightforward piston action as in a cone loudspeaker but by flexural motions of the diaphragm similar to those of the sounding board of a musical instrument. Thus each part of the diaphragm vibrates separately and the radiation tends to be less directional than in a cone loudspeaker. The pressure/frequency response curve is extremely ragged because of the multiplicity of resonant structures, but the makers argue that colouration is a fact of life and anyway, this is how musical instruments produce their sound. (The device is called the 'Natural Sound' loudspeaker.) The purpose of the irregular periphery of the diaphragm is to prevent the formation of standing wave patterns, which would of course give undue emphasis to particular frequencies. To improve the efficiency at high frequencies the back of the diaphragm is moulded to form a number of radial ribs but Yamaha say that reproduction is not satisfactory in the treble and that equalization and an additional high-frequency loudspeaker should be used. Bass resonance of the largest model is 55Hz while continuous power handling capacity is 25 watts (100W instantaneous).

Another unusual loudspeaker, called the Projecteur de Son and shown by l'Automatic, has a moving-coil drive unit mounted in a cylindrical plastics enclosure (diameter 12cm, length 13cm for one model) which contains two cavities "inductively" coupled by a port to form a double resonator. This acoustic system is designed to damp the bass resonance and control the cone movements in such a way that the speaker will handle high power without distortion. Response (for the model mentioned) between 120Hz and 8kHz is ± 5dB.

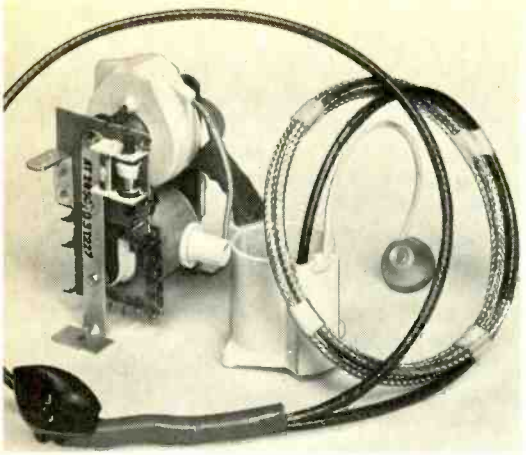
Showing shape and construction of Yamaha loudspeaker.





Miniature inductor, shown by Orega of Paris, compared in size with a match-head.

Power Transistors. One of the heaviest-duty transistors at the exhibition was undoubtedly the Westinghouse type 177 which will operate from supplies up to 140V, carry collector current up to 50A and dissipate up to 300 watts. The f_T is as high as 25MHz. SESCO (Société Européenne des Semiconducteurs) had a range for collector currents up to 30A, collector-base voltages up to 500V and dissipations up to 200W. Obtaining power amplification at v.h.f. and u.h.f. is, of course, more difficult, but R.C.A. were showing an overlay transistor with strip-line connections, type TA7344, which will provide a power output of 16W with a gain of 6dB at 400MHz and a power of 20W with a gain of 10dB at 225MHz. It operates from a 28V supply, is hermetically sealed in a



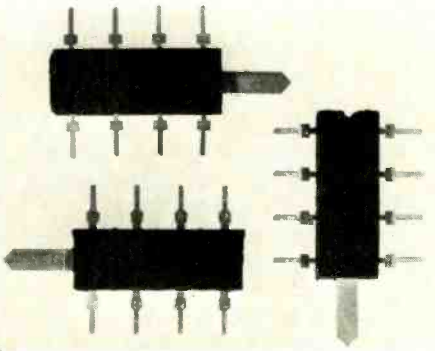
Line output transformer and e.h.t. generator for colour television receivers, shown by La Radiotechnique-Compelec of Paris.

ceramic-metal package, and will work over the temperature range −50°C to +125°C. Motorola had a range of r.f. power transistors constructed on an interdigitated principle that gives more uniform distribution of current through the devices. For this reason, it is stated, they cannot easily be damaged in operation even with mis-matched loads. One type will give a power output of 40W with a gain of 7.5dB at 175MHz and another 20W with a gain of 4.5dB at 400MHz.

Return-beam vidicon, called the Rebicon, in which the sensitive layer (23×23mm) is a photoconductor but the electron beam returns from it, modulated, as in an image orthicon, was shown by RCA. The signal is produced from the return beam by an electron multiplier. Limiting resolution is 4,000 lines.

Microwave devices. By the use of double diffusion epitaxial technology SGS-Fairchild have produced a range of n-p-n transistors, BFW73 to BFW79, which offer useful performance as microwaves. As amplifiers the devices are said to be capable of providing gains of 3dB at 4GHz and 6.5dB at 3GHz. A typical noise figure is 6dB at 1GHz. As oscillators the transistors can be used to generate frequencies up to 3.5MHz, a value which is normally only obtainable by frequency multiplication using a series of transistors and varactor diodes. Among other applications these transistors look promising as replacements for the klystrons (which, of course, are bulky and of limited life) used as pump oscillators in microwave parametric amplifiers. Another type of semiconductor replacement for the klystron in this application is the avalanche diode, and Sylvania were showing one, mounted in a tuning structure, which will generate a minimum of 10mW of r.f. power at any frequency in the X-band (8.2 to 12.4GHz). Called SYA-3200, it requires a d.c. bias in the region of 50-90V (current 10-25mA) and can be continuously tuned over a range of ±100MHz. This firm also had, as did Texas Instruments France, examples of Schottky barrier diodes for operation at microwave frequencies. The Sylvania ones were beam-leaded devices available as single diodes, pairs or quads (for use in balanced modulators). Texas microwave transistors included an L-band amplifier giving a gain of 8.5dB and noise factor of 6dB at 2GHz and an S-band oscillator allowing an output of 75mW at 4GHz to be obtained.

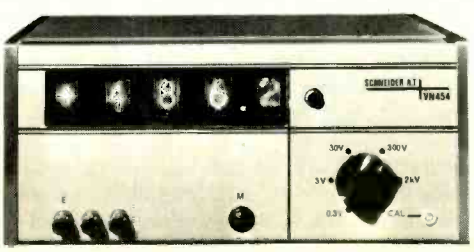
Colour TV tubes. One of the major criticisms of colour television sets has been the lack of brightness from shadow-mask tubes—particularly noticeable on black-and-white programmes. Sylvania have been tackling this problem by bringing into use phosphors of greater efficiency. In particular the red fluorescent material is a europium activitated yttrium vanadate phosphor treated with activators, while the green brightness improvement is obtained from not only a change in chemical composition but an alteration in particle size and distribution across the screen. The result, in a tube demonstrated at the exhibition, is a brightness on white claimed to be 23% greater than that of the nearest competitive tube (25-69% brighter than various other makes). Another feature of this tube is a method of shadow-mask mounting which compensates for the expansion, caused by electron heating, that tends to degrade colour purity during operation. In fact the mask moves forward as it gets hot. An alternative method of compensation, used by Standard Elektrik Lorenz, is to fix the shadow-mask symmetrically at four points (instead of the normal three) using bi-metal elements so as to obtain a uniform expansion starting at the centre.



General Electric i.c. audio amplifier giving 1W into a loudspeaker (scale in cm).

A further criticism sometimes levelled at television tubes is that the screen aspect ratio (usually 5:4) does not correspond to the 4:3 aspect ratio of the transmitted picture. Telefunken were showing a new colour tube, the A56-11X, in which this discrepancy has been corrected, the lengths of the sides of the tube face being 44.7cm and 33.7cm. Also the faceplate is flatter than normal. A completely flat faceplate is used in the glass bulb of the French grid type colour display tube, since the fluorescent screen is now deposited on the back of the faceplate instead of on a separate glass plate mounted within the bulb. A specimen envelope was shown by Sovirel of Paris but the complete tube was not on view.

Digital voltmeter with five ranges (0.3V to 2kV) and reading accuracy of ±5×10⁻⁴ shown by Schneider of Ivry, France.



Instrument for measuring distortion on telegraph circuits, including a signal generator for signal speeds of 50-2400 bands (Laboratoire Electro-Acoustique of Paris).

Reactive circuit devices. A small component called the Isoductor, functioning rather like a lumped-element version of a microwave circulator, can be inserted into v.h.f./u.h.f. signal circuits as a non-reciprocal attenuator, providing low forward loss (about 1dB) but high reverse loss (e.g. above 20dB). It can thus be used to make transistor or varactor circuits insensitive to load variations. Shown by Melabs, it is available in three models, covering between them the range 100-600MHz. Physically it is a 2cm diameter cylinder with three 120°-spaced connections—the circulator "ports". Power flows from Port 1 to Port 2 with low loss but power reflected from any varying load fed from Port 2 circulates to Port 3 and is dissipated in a resistive load connected to it. The ports "look" inductive and have to be tuned externally by capacitors.

Miniature inductors measuring 2.8×4.0×7.0mm shown by OREGA can be adjusted by a magnetic core to provide a control range of ±20% of nominal value. Inductances range from 25μH to 100μH and temperature coefficient is said to be very low. Pins are provided for mounting on printed circuits.

A "Monolithic" crystal filter shown by Collins Radio is a compact device combining properties of the crystal filter and the mechanical filter. It consists of a thin plate of quartz with pairs of electrodes arranged along it. Each pair of electrodes (one on top, one underneath) constitute a crystal resonator, while the quartz areas separating the pairs provide mechanical coupling between the resonators. Connections are made to the resonator at each end of the plate. The electrical analogue of the system is a row of *LC* resonant circuits coupled by inductors. Filters of this type, in transistor-type or flat packages, are available with centre frequencies of 3.5MHz to 20MHz and with bandwidths of 0.005% to 0.2% of centre frequency.

News of the Month

PAL-SECAM Rapprochement

The long-standing rivalry between the PAL and SECAM colour television systems has now been resolved, at least in a commercial sense, by a Franco-German receiver manufacturing agreement between Compagnie Francaise de Television, which holds patents on SECAM, and A.E.G.-Telefunken, which owns the PAL patents. At the same time there has been a major reorganization of those sections of the French industry concerned with colour television in general and SECAM in particular.

By the C.F.T.-Telefunken agreement, the French set manufacturers have been given a licence to make and sell PAL receivers and the German set manufacturers have been given a licence to make and sell SECAM receivers. Thereby the royalties normally charged by both sides are cancelled. This affects both single-system receivers and also combined PAL/SECAM sets, of which there is a growing number in Europe.

It is being said, notably by C.F.T., that this agreement was precipitated by the fact that C.F.T. owns a patent, not actually used in SECAM, which is somehow connected with the phase-error correction principle at the heart of the PAL system. In the past Telefunken have strongly denied this contention. *Wireless World* has asked C.F.T. for details of the critical patent, but the company has declined to give further information. At any rate it emerges from the agreement, according to C.F.T., that C.F.T. will now no longer "engage in proceedings against the manufacturers of PAL receivers".

As for the reorganization in the French colour television industry, C.F.T., which was set up in 1958 originally to develop and exploit SECAM but started to expand into development and manufacture of hardware (e.g. the grid colour tube), has now become a company devoted solely to the commercial exploitation of patents. Its new president is M. Jean Cahen-Salvador, a member of the powerful Conseil d'Etat which advises the French Government. All R & D and manufacturing work had been hired off to established French firms, principally to a new organization formed by the merging of television interests of C.S.F. (Compagnie Générale de Télégraphie Sans Fil) and C.F.T.H.-H.B. (Compagnie Francaise Thomson-Houston-Hotchkiss-Brandt). As for the grid colour tube* hitherto handled by C.F.T., this has now been taken over by a new company, France-Couleur, set up by a private financier and entrepreneur, M. Sylvain Floirat. Opinions differ on the development status of this tube, but some French sources say that France-Couleur is going to build a factory to start manufacture as soon as possible. (Incidentally the Floirat group have a 25% interest in the new C.F.T., the rest being owned jointly by C.S.F. (25%), the French government (25%) and Compagnie de Saint Gobain, the glass manufacturers, who owned 50% of the original C.F.T.)

Finally there has been established a non-profit-making organization called Intersecam, the purpose of which is to protect and promote the SECAM colour television system throughout the rest of the world. This means, in fact, trying to persuade those countries which have not settled on a colour television system to adopt SECAM. In this work the organization will be assisted by the O.R.T.F. (the French broadcasting organization) and the French industry. President of Intersecam is M. Paul-Roger Sallebert.

* "French Rival to Shadow-Mask Colour Tube" *Wireless World*, May 1967, p. 236.

Prince Philip Advises Young Engineers

The idea that membership of the professional institutions should be denied to engineers and technicians who do not aspire to a defined strata level in the academic training structure, was criticized by the Duke of Edinburgh speaking at a meeting last month attended by 600-odd young engineers.

Replying to a question during an open discussion which followed his talk, the Duke indicated that as he saw it, Institution membership should include all who were "attached" to that particular "subject", and he could see no reason why technicians should be forced to join a separate institution.

In his opening address the Duke urged engineers to get themselves into the decision-making side of industry; in management, or in politics, and not just be content to remain as "boffins" all their lives. He suspected that too often in the past major projects have failed because of a decision-making gap, rather than because we were technically inferior. Company executives should be trained engineers, able to discuss technical matters with prospective customers. Customers should not be told to refer their enquiries to the "technical boys". On a national level, decisions made by the political process, our decision-making machinery, were far too important to be ignored by scientists and engineers.

Arranged by the Council of Engineering Institutions, the meeting was held at the Institution of Electrical Engineers, and a tailpiece concerns the solitary contribution to the discussion from an I.E.E. delegate, which perhaps illustrates the way in which our social behaviour influences our claims to engineering prowess. This young man wondered what was wrong with the engineer image. He was an engineer, but he said he always told his friends that he was a scientist, because if they were told he was an engineer, they would get the impression that he went around repairing television receivers!

The Computer Merger

In a recent statement to the House of Commons the Minister of Technology said "I am pleased to be able to inform the House that, with the backing of the Government, the commercial and scientific computer businesses of I.C.T. and English Electric Computers are to be brought together into one company to be called International Computers Ltd (I.C.L.). I.C.L. will be by far the largest company outside the U.S.A. specializing in commercial and scientific computers. Plessey, a major manufacturer of telecommunications equipment, will participate in the new group and will also form a joint development company with I.C.L. to study and develop the convergence between computers and communications."

The new company is going to be faced with a number of headaches, not the least of which is to ensure that the new computer system to be produced by them is compatible with both the I.C.T. 1900 series and English Electric's System 4 range. Representatives of the two companies say that this is a software problem and although a "knotty one", far from being economically insurmountable.

The Government will be participating in the financing of the new company to the extent of £17M over a period of five years. Of this amount the Ministry of Technology will be providing £13.5M over the next four years towards I.C.L's research and developments costs. The remaining £3.5M is to be subscribed for ordinary shares of £1 each, which will be issued to the Government at par; 2s per share will be payable on issue and balance in 1972. The current market value of these shares substantially exceeds the amount subscribed for them. As a result of this arrangement the Government will initially hold 10.5% of the ordinary shares and other shares will be held; 53.5% by former I.C.T. shareholders, 18% by English Electric and 18% by Plessey.

Technology Co-operation Agreement

An agreement has been signed between the U.K. and Czechoslovakia which will allow the exchange of specialists and information, and facilities for study and research between the

two countries. In addition exchange of other forms of industrial co-operation may be agreed upon. This follows agreements that have been signed with Rumania, Hungary, Poland and the U.S.S.R.

As a result of the Russian agreement representatives of the Scientific Instrument Manufacturers' Association (S.I.M.A.) and industry have flown to Russia for talks with government officials and technologists. At the same time the largest exhibition of British instruments ever held outside the U.K. is taking place in Sokolniki Park, Moscow. This exhibition has been mounted by S.I.M.A. in collaboration with the Board of Trade at the request of the U.S.S.R. Chamber of Commerce.

World Engineering Federation Formed

In order to encourage co-operation between the engineering organizations of the world it was decided at a meeting in Paris of representatives of the engineering profession from all parts of the globe that the World Federation of Engineering Organizations should be formed. In all, 120 representatives from 60 nations and four regional federations were present at the meeting in UNESCO House. The decision to form the organization was unanimous. This constitutive assembly was then immediately followed by the first general assembly of the new federation and decisions were taken to carry out the programme of work on the qualification and development of professional engineers and of their supporting technical staff. Arrangements were also made to draw up a world-wide code of professional conduct for engineers.

Dr. Eric Choisy, of Switzerland, who had taken the chair at the constitutive assembly, was elected president of the Federation. Dr. G. F. Gainsborough, secretary of the I.E.E., was appointed secretary general. The next meeting of the Federation is due to be held in Beirut in October 1969.

Firms wishing to exhibit their goods outside Western Europe are now eligible for **substantial financial assistance** from the Board of Trade. The Board will in future contribute up to 50% of the cost of translating sales literature for distribution at the exhibition, they will pay up to 50% towards the return fares of two representatives manning each firm's stand and up to 50% of the cost of returning unsold goods from the exhibition. Up until now these facilities have been available only to exhibitors taking part in international trade fairs under the Board of Trade's joint venture scheme or in British Pavilions organized by the Department.

A **marine radar beacon** that is used to positively identify obstructions, lighthouses, drilling rigs and the like has undergone its first sea trial. Designed and built by Ether Engineering the beacon has been called URSA Minor (Unattended Racon Semiconductor Apparatus) and is claimed to be the first to use semiconductors entirely. In operation the equipment receives output pulses from any standard marine radar in the 9.3-9.5GHz band and will then transmit in reply a coded pulse which will appear on a p.p.i. display as a series of dots and dashes. This means without modifications to existing ship-board radar systems an operator can identify obstructions in his vicinity.

The Electrical and Electronic Industries Benevolent Association is the amended title of the organization formed in 1905 to help non-manual workers in the electrical industry. During 1967 the association paid over £83,000 to people in need—workers, former workers or dependants—and towards the costs of retired beneficiaries living in the association's own establishment at Broome Park, Surrey. Among the contributors to last year's income, which totalled nearly £130,000, were British Radio Valve Manufacturers' Association, Electronic Valve and Semiconductor Manufacturers' Association, Radio Industries Club, Radio and Television Retailers' Association, B.B.C., A.T.V. and a number of "light current" manufacturers.

A **self-testing and repairing digital computer** is to be installed in the jet propulsion laboratory of the California Institute of Technology in Pasadena, U.S.A. An error detecting code is applied to all instructions and data within the computer. Should an error be detected part of the programme is repeated and if the error persists the power supply to the faulty section is removed and applied to a spare serviceable section. The process is controlled by a triplicated repair control module operating on a majority vote basis. In the event of a split decision being made (2:1) the faulty repair control module is disconnected and a new one substituted.

D. B. G. James, author of the **"Simple F.E.T. Pre-amplifier"** article published last month, is on the staff of Swansea College of Technology not the University College, Swansea, as stated. Incidentally, the C94 f.e.t. referred to in this article is manufactured by Semitron Ltd., Crickdale, Near Swindon.

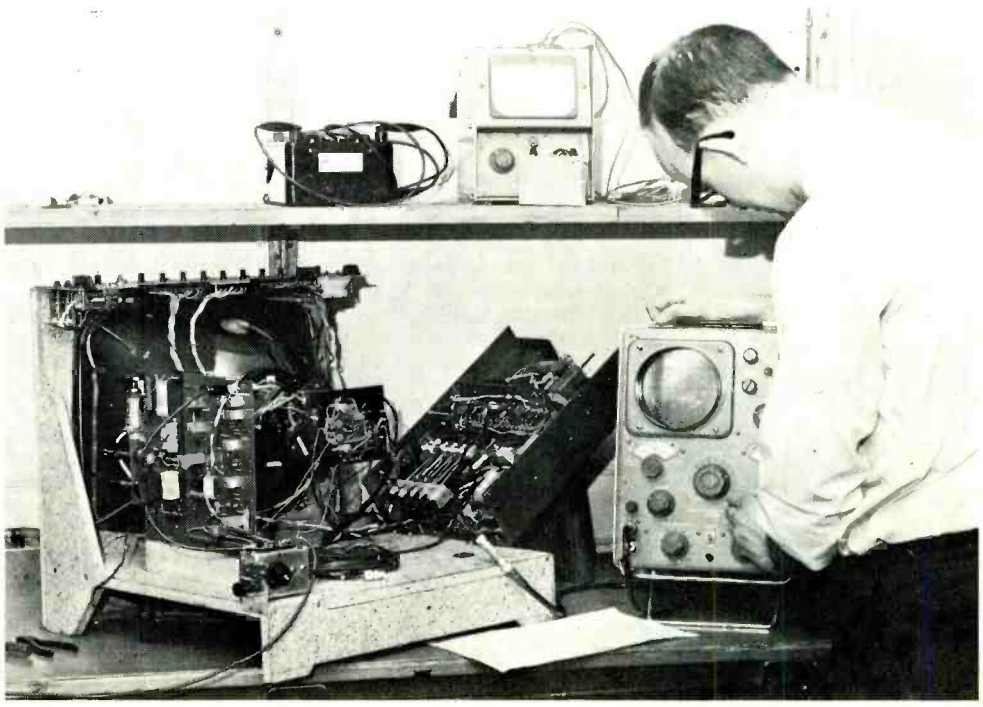
Wireless World colour television receiver

Constructional details of a colour television receiver will be given in a series of articles starting in next month's issue of *Wireless World*. The photograph shows the set, with some units removed, during its development.

A colour receiver is a complex piece of electronic apparatus and its proper initial adjustment requires the use of quite a lot of test apparatus; even with this, skill is needed. It must be emphasized, therefore, that its construction should be attempted only by those who are thoroughly familiar with all aspects of black-and-white apparatus.

In order to simplify the equipment as much as possible no provision is made for the reception of 405-line transmissions. The complications which arise when this is included are not so much electrical as mechanical, since the provision of a large number of mechanically linked switches in many different units raises almost insuperable problems when standard components must be used.

A 19-inch colour tube is used, but the 23-inch can be employed with little electrical alteration, and the receiver is of hybrid design; that is, both valves and transistors are included. All the low-power circuits have transistors, but the high-power circuits and all circuits feeding the c.r.t. use valves.



Personalities

Sir Francis McLean, C.B.E., B.Sc., F.I.E.E., director of engineering in the B.B.C. for the past five years, retires in May after 31 years with the Corporation. He graduated at Birmingham University and was with Standard Telephones & Cables from 1925 until joining the B.B.C. in 1937. He headed various groups in the Engineering Division before being appointed deputy chief engineer in 1952. In 1960 he became deputy director of engineering. Sir Francis was created a knight bachelor in the 1967 New Year honours.

T. S. Crabtree, managing director of Arrow Electric Switches Ltd., has been appointed a vice-president of the parent company Arrow-Hart & Hegeman Electric Co., of Connecticut, U.S.A. Born in Colne, Lancs., he is the first non-American vice-president to be appointed by the 72-year-old parent company, which formed its British subsidiary in 1932. It was in 1932 that Mr. Crabtree joined Arrow as their works manager. He has been managing director since 1951.

J. H. Head, deputy managing director of Racal Instruments Ltd, has become managing director of Racal-Andec which is the new name given to Andec which joined the Racal group in 1962. Mr. Head joined Racal Instruments as director and general manager on its formation in 1959. He was at one time

J. H. Head

with Sydney S. Bird Ltd, and from 1951/59 general manager of Advance Components.

D. T. N. Williamson, the designer of what has become known as the Williamson amplifier originally described in *Wireless World* in 1947, is among 32 recently elected Fellows of the Royal Society. The citation reads "distinguished for his work on sound reproduction, and for his extensive achievements in the design and numerical control of machine tools". Mr. Williamson, who has been technical director of Molins Machine Company since 1961, joined the M. O. Valve Company in 1943 after studying at Edinburgh University and from 1946 to 1961 was with Ferranti, Edinburgh, working mainly on precision measurement and control.

Also among the 32 recently elected Fellows of the Royal Society are **Eric Eastwood,** C.B.E., Ph.D., M.Sc., F.I.E.E., director of research of the English Electric Group, whose "contributions to the technology and applications of radar" are mentioned in the citation; **Antony Hewish,** lecturer in physics at the Cavendish Laboratory, Cambridge, "distinguished for his contributions to radio astronomy, especially by using the scintillation of radio sources to obtain information both about the interplanetary plasma and the structure of the radio sources themselves"; **Donald E. Broadbent,** Sc.D., director of the Medical Research Council's Applied Psychology Research Unit Cambridge, "distinguished for his researches in experimental psychology, especially on problems of perception"; and **David P. Craig,** professor of physical chemistry at the Research School of Chemistry, in the Australian National University, Canberra, Australia, "distinguished for his theoretical contributions to the interpretation of electronic spectra and to solid state chemistry".

A. Brian Close, Grad.I.E.R.E., has joined Radionic Products Ltd, manufacturers of electronic and radio teaching aids, as technical manager. Mr. Close, who is 25, spent the first seven years of his career with S.T.C. He then taught for a year in a technical college. He was until recently a development engineer with M.E.L. Equipment Company. Radionic also announce the appointment of **Michael J. Howell,** B.Sc., Assoc. I.E.E., as marketing manager. A graduate of Leeds University, where he studied electrical and electronic engineering, he was at one time on the production staff of Texas Instruments but more recently with Ferranti, Edinburgh, working on guidance systems. He is 25.

Ralph E. G. Keon, A.M.I.E.R.E., recently joined AIM Electronics Ltd, of Cambridge, as European marketing manager. Mr. Keon, who studied on the Continent, worked for eleven years in the valve industry—first with S.T.C. then M.O. Valve and subsequently Elliott

R. E. G. Keon

Brothers on microwave valves—was overseas sales manager of Airmec Instruments from 1962 until he joined AIM.

W. J. Bray, M.Sc. (Eng), D.I.C., F.I.E.E., director of research at the General Post Office, has had the Fellowship of the City & Guilds of London Institute conferred on him "for eminence in the field of radio communication, particularly in the design of microwave and radio systems, including communication satellite ground stations". Mr. Bray, who joined the Post Office Engineering Department in 1934, has spent most of his career in the Research Station at Dollis Hill. Since 1960 he has concentrated on space communications systems but previously was concerned mainly with ionospheric and tropospheric scatter. He has been director of research since 1966.

John C. Gladman, B.Sc. (Hons.), aged 48, has become manager of English Electric's Industrial Computer Division at Kidsgrove (North Staffs.), where he will be responsible for the design, development and manufacture of computer equipment for industrial control and automation systems, as well as associated peripheral equipment and "software". He studied at Manchester University in 1938/39, and after a period of war-time service with the Royal Corps of Signals, gained an honours degree in electrical engineering in 1948. He then joined Metropolitan-Vickers and on the formation of the A.E.I. Electronic Apparatus Division was appointed asst. manager and later manager of the computer engineering department. Mr. Gladman joined E.E. Computers Ltd, in 1967.

K. D. F. Chisholm, A.M.I.E.R.E., has been appointed chief engineer of English Electric's Industrial Computer Division. He joined E.E. Computers in 1955 as senior development engineer working on the DEUCE computer and at the beginning of 1967 became deputy chief engineer of the Central Processor Department. He is 43.

A. H. Sage, B.Sc. (Eng.), who joined English Electric as a graduate apprentice in 1950, with a degree in electrical engineering from Bristol University, is appointed deputy general manager (commercial) of English Electric's Industrial Control and Automation organization.

The 1968/69 president of the Electronic Engineering Association, who will for the first time also automatically assume the active position of chairman of council, is **Commander H. Pasley-Tyler,** a director and group general manager of Elliott Automation Ltd. He joined Elliott Brothers (London) Ltd., in 1950 on retiring from the Navy in which he had served for 25 years. Commander Pasley-Tyler, who is 58, specialized as a signal officer after training at Dartmouth Naval College and was for some time after the war in command of a training establishment. He later went to Washington as a member of the British Naval Mission. The retiring president is **Sir John Toothill,** C.B.E., D.Sc., general manager of Ferranti's Scottish group of factories, and the retiring chairman is **Group Captain E. Fennessy,** C.B.E., director of Plessey Electronics Group.

John Gosman Scott, B.Sc., has rejoined Ferranti Ltd., Edinburgh, as sales manager of the Information Equipment Group. Mr. Scott, who is 40 and graduated in physics at St. Andrews University, originally joined Ferranti on coming down from the University in 1951. In 1960 he went to Hughes International (U.K.) as technical manager in charge of semiconductor manufacture. For the past two years he has been with Electrosil, of Sunderland, as technical director.

OBITUARY

Jack White, distributor sales manager of SGS-Fairchild Ltd, died recently at the age of 53. He joined the company in 1965 after spending four years with Texas Instruments at Bedford, prior to which he was for five years with Mullard's semiconductor division.

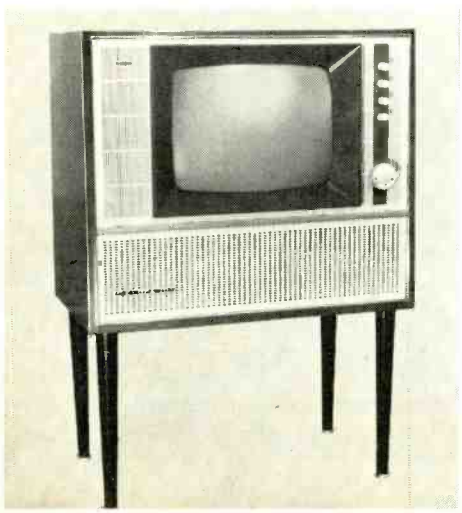
Russian Colour Sets in Production

Four models using shadow-mask tubes for SECAM III transmissions

Colour television programmes on a limited scale are now being broadcast in the U.S.S.R., using the SECAM III system, and 625-line compatible colour receivers are being produced in several factories. At a recent international conference on colour television in Paris details of four models available to the Russian public were given by Professor S. Novakovsky, of the Ministry of Radio Production. All use shadow-mask colour tubes manufactured in a recently established Soviet plant, have 12-way channel selectors, use flywheel sync, operate from 127V or 220V supplies and are designed for a reliability of 1500 hours m.t.b.f. Circuitry follows normal SECAM practice, which means of course that the receivers contain a delay line and electronic switching arrangement to change the sequentially transmitted chromaticity components of the signal into simultaneous form. Since in SECAM III transmissions these colour components are carried by frequency modulation of a subcarrier (6.5MHz) the decoding section of the receivers also contains frequency discriminators, one for R−Y and the other for B−Y. Three of the sets have hybrid circuitry while the fourth, a smaller, cheaper model, uses valves only.

Roubin-401 has a rectangular tube of 59cm diagonal and 90° deflection angle. The hybrid circuit contains 24 valves, 15 transistors and 45 diodes. Two loudspeakers are provided. The transistors are utilized mainly in the chrominance and sound channels, except for their respective output stages. Sensitivity (50μV in both vision and sound channels) is said to be sufficient for satisfactory reception in fringe areas. Automatic screen "degaussing" and vertical geometrical distortion correction are included The delay line and associated circuitry are constructed as a separate module allowing lines of different types to be used. In the luminance channel there is a rising frequency characteristic above 4.9MHz, which is normal practice in Russian television receivers. Besides the usual brightness and contrast controls there is a colour saturation control, which varies the peak-to-peak amplitude of the R−Y and B−Y chrominance signals. The set consumes 400 watts and weighs 70kg.

Record—101, low-price 40cm set.



Radouga-5 has the same 59cm rectangular colour tube as the Roubin-401 but its circuit is more transistorized: 14 valves, 46 transistors and 53 diodes. As a result the power consumption is lower (280W). Sections entirely transistorized are the vision and sound i.f. amplifiers, the a.f. sound amplifier, the vertical scanning circuits and the luminance channel (except for the output stage). The chrominance section contains 15 transistors, with 3 valves for the three colour-difference signal output stages. This set is also lighter—60kg.

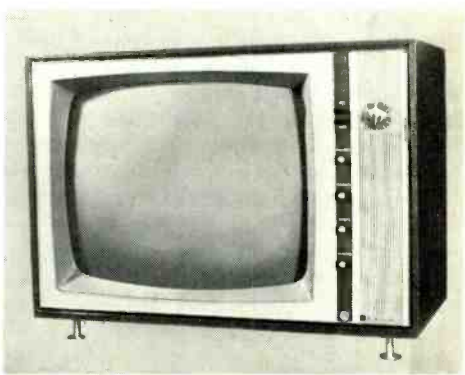
Radouga-4, a smaller receiver, has a tube of 40cm diagonal and 70° deflection angle. The circuitry and valve/transistor ratio are similar to those of Radouga-5, except of course for the scanning arrangements for the narrower-angle tube. Because of this smaller deflection angle, no geometrical distortion correction circuitry has been included, and this has reduced the power consumption to 260W. Weight is 40kg. Sensitivity of the two Radougas is 150μV.

Record-101, using a 40cm diagonal 70° tube, has been specially designed as a low-price receiver, and for this reason has an all-valve circuit. As a result the set is relatively big for its screen size, and its power consumption is higher (360W). The frequency characteristic of the whole vision channel is determined by a filter inserted before the vision i.f. amplifier, and as a result the characteristic of this i.f. amplifier does not have to be adjusted, so that tuning procedures are simplified in manufacture. In the luminance channel the frequency characteristic falls off rapidly above 3.6MHz. In the chrominance section each frequency discriminator has controls to set the zero-frequency position and adjust the frequency band between the two peaks of the characteristic: this allows good linearity to be obtained and simplifies adjustment during manufacture. Wherever possible cheap readily-available valves have been used to keep the price down. Sensitivity is relatively low at 200μV.

It will be noted that these receivers use the shadow-mask type of colour tube. This is understandable since the problems of manufacturing this kind of tube are now well understood and much experience has been gained with it all over the world. At the same time Professor Novakovsky mentioned that the U.S.S.R. has acquired a licence to make the new French grid tube† developed by C.F.T. (Compagnie Francaise de Television) and is about to set up a factory to produce it in quantity. This is part of the general Franco/Soviet agreements on technological exchange. In view of what is known about the state of development of this tube in France, however, it seems unlikely that the tube will appear in Russian colour receivers for some years.

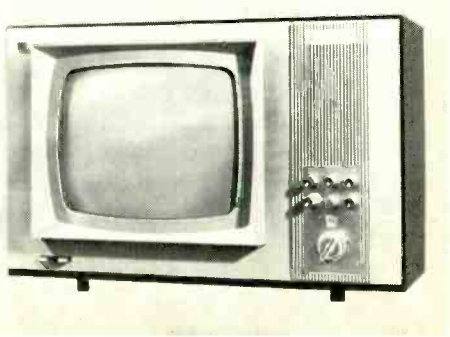
It was clear from Professor Novakovsky's remarks that the techniques and problems of manufacture, testing and after-sales maintenance of colour receivers are much the same in the U.S.S.R. as in capitalist countries. The main difficulty, in a country where there is very little machinery for advertising and sales promotion, seems to be the purely commercial one of geting people to buy the product. In Professor Novakovsky's own words: "The manufacture of large numbers of colour television receivers raises the problem of selling them." It seems to be exactly the opposite problem to the one we have in Britain.

†Outlined in "French Rival to Shadow-mask Tube" W.W. May 1967, p.236. See p.110 this issue.



Roubin—401, with 59cm screen.

Radouga—4, with 59cm screen.



New B.B.C. Monitoring Loudspeaker

3. Three designs, using different combinations of units

*by H. D. Harwood** B.Sc.

As mentioned last month, three designs of loudspeaker were possible with the units available. Design A was similar to the type LS5/1A construction and employed the plastic cone 305mm unit and two of the 58mm units; type B used the 305mm unit for the bass, the 200mm unit for the middle frequencies and a single 58mm improved unit for the high frequencies; type C was similar to type B but used the 110mm unit for the middle-frequency range. As it was not possible to determine from a study of the units which would give the best reproduction it was decided to build a prototype of each and carry out final listening tests.

Type A Loudspeaker. The design of the type LS5/1A will not be described in detail; it is sufficient to mention here that the low-frequency unit is employed up to about 1.7 kHz, and above this frequency two high-frequency units operate in parallel up to approximately 3.5 kHz. Above this the output from one is attenuated, leaving one only to cover the remaining part of the spectrum. The response/frequency characteristic of the 305mm plastic cone unit is smoother than that of the 380mm cone used in the LS5/1A and the design of the crossover network is therefore somewhat simpler; a 100mm slit, described last month, was fitted over the front of the 305mm unit. The response/frequency characteristics achieved are shown in Fig. 21 for the horizontal plane. The axial response is smooth but it will be observed that in spite of the 100mm slit the response/frequency characteristic at 60° in Fig. 21 is not uniform and is rather like that of the LS5/1A in this respect.

Type B Loudspeaker. In the type B design the 305mm plastic-cone bass unit is employed up to a frequency of 400 Hz. Above this frequency the 200mm middle-frequency unit operates up to 3.5 kHz where a change is made to the 58mm improved unit. As already mentioned, the bass resonance frequency of the middle-frequency unit is about 50 Hz and it is necessary to enclose the rear to prevent it acting as a vent at low frequencies. In order to make use of the sensitivity of the middle- and high-frequency units the high-flux-density version of the low-frequency unit is employed. In this design the relative voltages applied to the units are adjusted by means of an auto-transformer placed ahead of the crossover networks; by this method the relative levels can be adjusted without having to change components in the crossover network as was the case with the LS5/1A. It also has the advantage that the nominal impedance of the loudspeaker can be adjusted to any convenient value to suit amplifiers commercially available. Fig. 22 shows the response/frequency characteristics in the horizontal plane and Figs. 23 and 24 those in the vertical plane above and below the axis. It will be observed that the curves in Fig. 22 are smooth and close together.

Type C Loudspeaker. This design is essentially similar to that of type B but employs the 110mm diameter unit for the middle-frequency range. The lower crossover frequency in this case is about 450 Hz, the upper crossover frequency remaining at 3.5 kHz. As the middle-frequency unit has a bass resonance of about 400 Hz the mechanical impedance at low frequencies is high and it is not necessary to enclose the rear. Owing to the lower sensitivity of this middle-frequency unit there is no advantage in employing the high-flux-density low-frequency unit and the lower-flux-density type is therefore used. As with the type B design, an auto-transformer is inserted ahead of the crossover network.

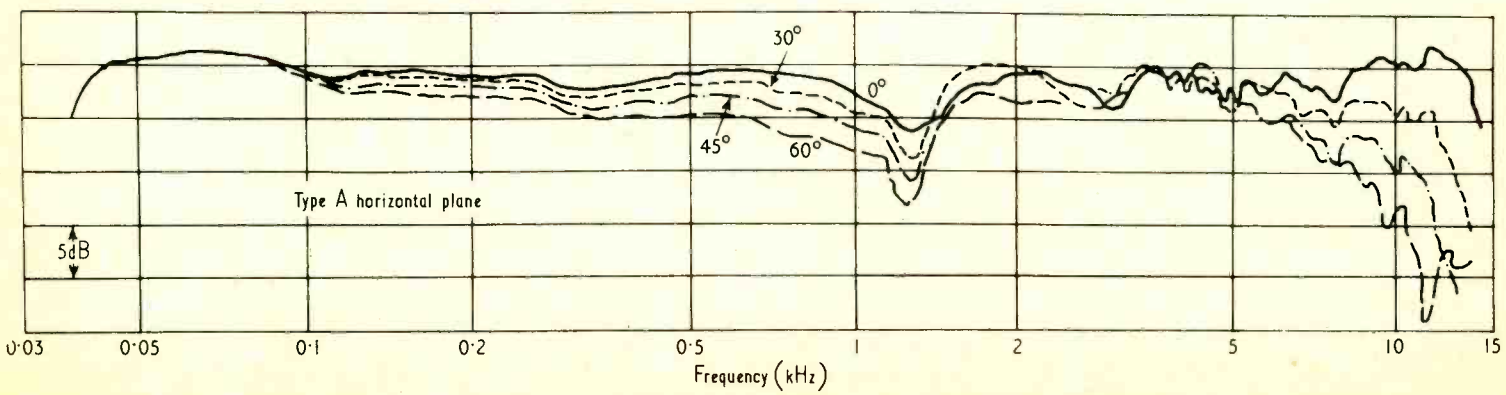
The response/frequency characteristics in the horizontal plane are shown in Fig. 25. It will be seen that the curves in Fig. 25 are smooth and except at the highest frequencies very nearly coincident.

Listening Tests

The three prototype loudspeakers were given a listening test and compared with a type LS5/1A and a still earlier experimental model known as the R.M.L. which was included because some observers considered it to be superior to the LS5/1A. The tests, which were carried out by experienced members of B.B.C. operational and programme staff, included speech from both dead and reverberant surroundings and recorded and live orchestral items, the latter from the B.B.C.'s Maida Vale 1 studio. For the live music test the loudspeakers were checked in turn in two rooms both of which communicate directly with the studio, and direct comparisons with the live programme were thus possible. The quality of reproduction of all three prototypes was judged an improvement on that from both the LS5/1A and the

*B.B.C. Research Department.

Fig. 21. Response/frequency characteristics of type A loudspeaker in horizontal plane.



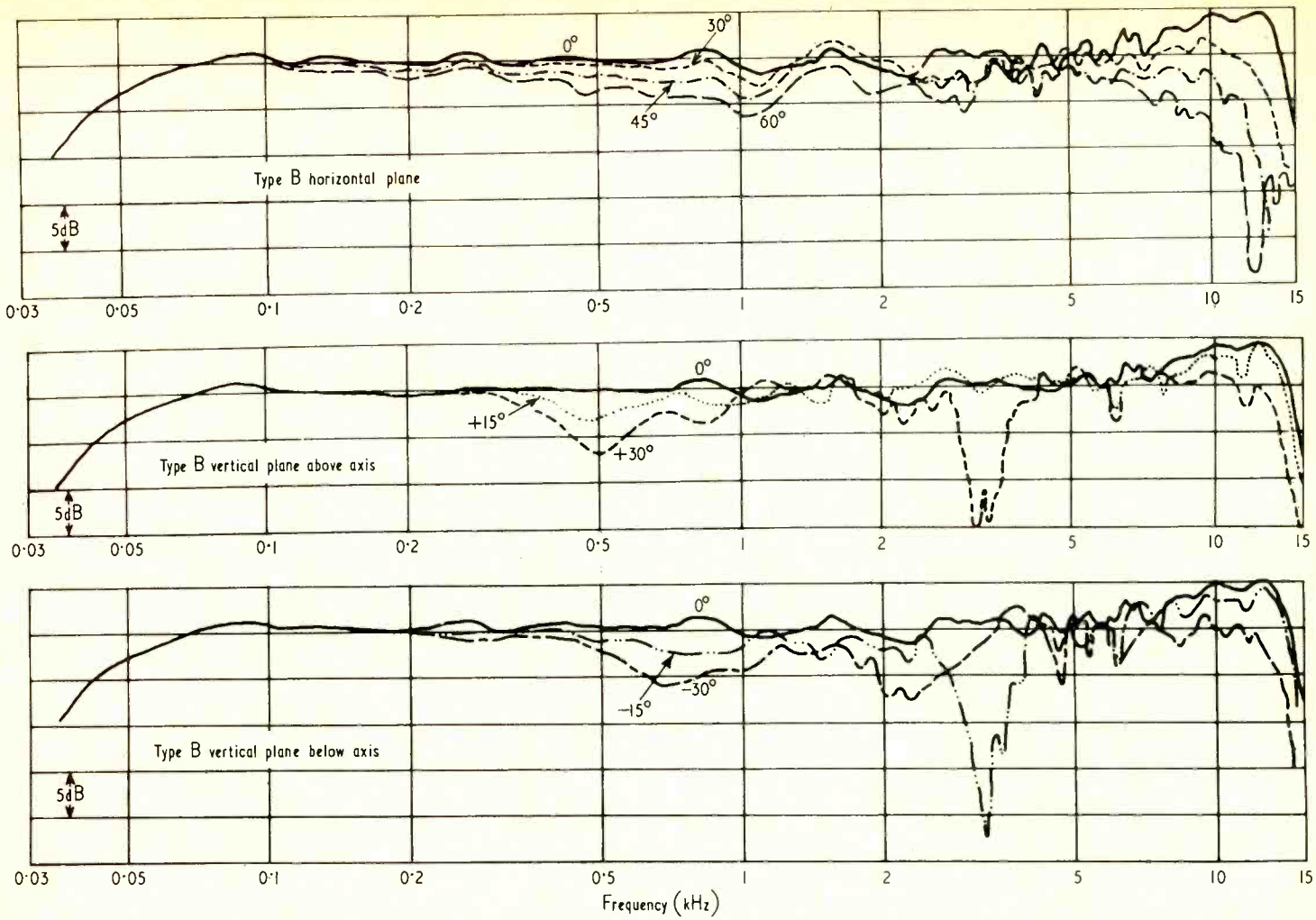


Fig. 22. (top), Fig. 23. (middle) and Fig. 24. (bottom). Response/frequency characteristics of type B loudspeaker in horizontal plane, vertical plane above axis and vertical plane below axis.

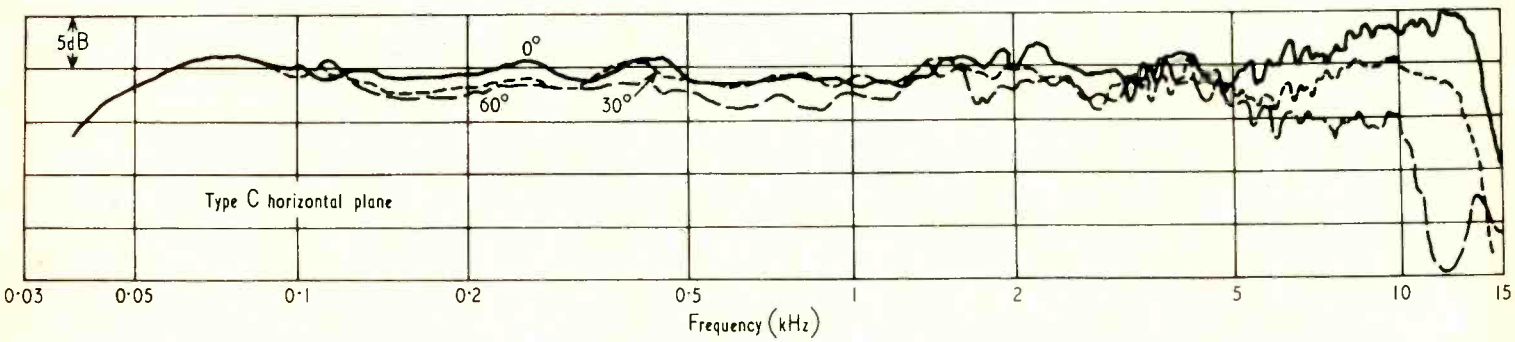


Fig. 25. Response/frequency characteristics of type C loudspeaker in horizontal plane.

R.M.L. It was further agreed by all that the sound quality from the type B loudspeaker was outstanding, being better than that from types A and C but that from the type C was very slightly coloured by the remains of the resonances around the 1.5 kHz region mentioned last month. The wide angle of radiation of type B in the horizontal plane was also favourably commented on.

In view of this verdict the remaining measurements were confined to the type B model. Two variations of this design have been constructed; one, designated LS5/5, is floor based with a rectangular cabinet mounted on a plinth; the other, designed for hanging, is lozenge shaped and is coded LS5/6. In the LS5/6 the vertical positions of the units are reversed with respect to those of the LS5/5, the bass unit being mounted uppermost, as in the LS5/2A. This is done in order to keep the bass unit near to the main reflecting surface in the room, in this case the ceiling.

Repeatability in Production

Some experience of the repeatability of the low-frequency unit has been obtained and was described in reference No. 1 in the March issue. There has been considerable production experience with the 58mm high-frequency unit. The 200mm unit was, however, hand made specially for this prototype and there was no experience of its repeatability in production. To speed up acceptance tests a number of pre-production models of the LS5/5 loudspeaker were built and advantage was taken of this to determine the spread in frequency characteristics likely to be obtained in practice.

Fig. 26 shows the spread in the unequalized axial frequency characteristic of six middle-frequency units measured in the cabinet without the rear enclosure; in the figure the curves were arbitrarily lined up at 750 Hz. It will be seen that the spread is very small over the operating frequency range of 400 Hz to 3.5 kHz.

Fig. 27 shows the spread in axial frequency characteristics of six complete loud-

speakers. It should be noted that the trend of the curves is more uniform and the spread is appreciably smaller than that to be expected in practice from moving-coil microphones and even from many electrostatic microphones. In the past, the monitoring loudspeakers have been the least predictable link in the studio chain, but with the introduction of these new loudspeakers this should no longer be so.

Directivity

The variation in mean spherical radiated power as a function of frequency was measured by the use of octave bands of noise. It is shown in Fig. 28. The corresponding directivity index* is given in Fig. 29; the variations of both quantities with frequency are less than those of the LS5/1A and LS5/2A and very much less than those found with any other loudspeaker which has been tested.

*The directivity index of a loudspeaker is the logarithm to base 10 of the ratio of the sound power which would be radiated if the free-space axial sound pressure were constant over 4π steradians to the actual sound power radiated.

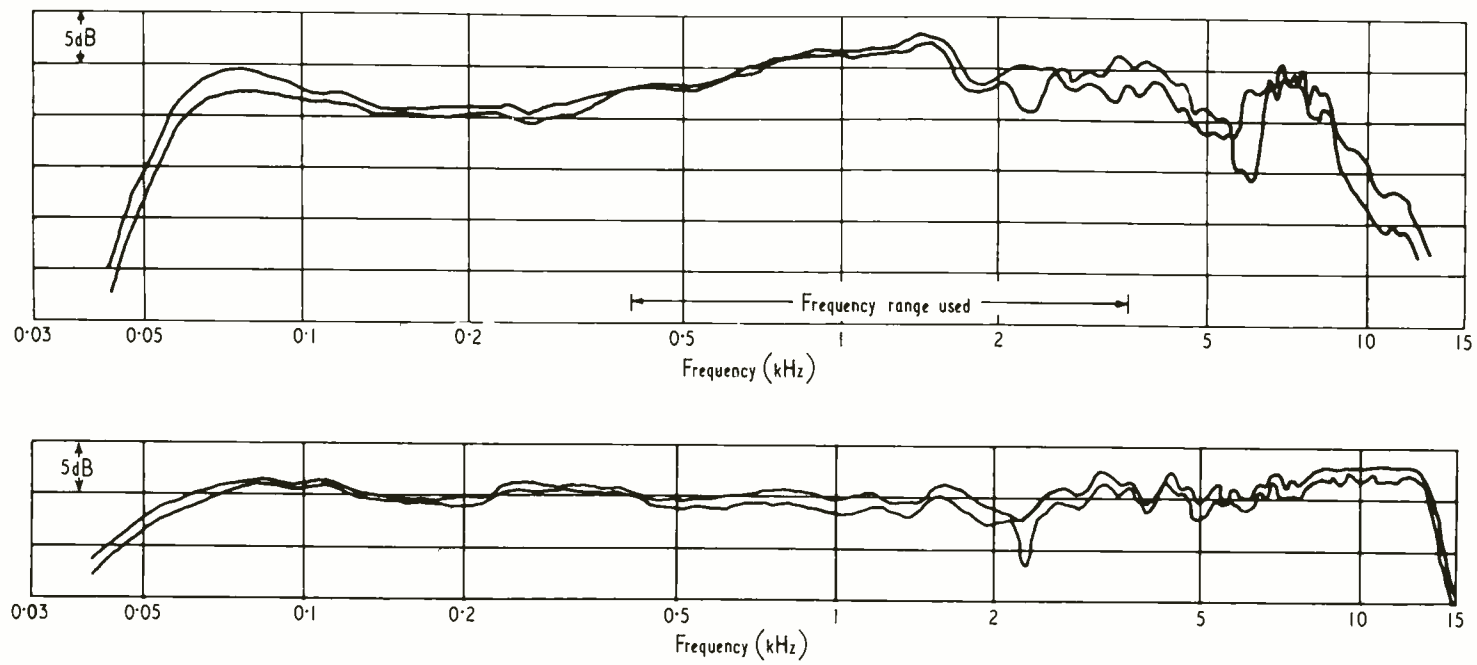
Impedance and Distortion Characteristics

Fig. 30 gives the circuit diagram of the cross-over network. The inductors in all cases have Radiometal cores and operate well below the saturation level. Fig. 31 shows the modulus of the impedance of the loudspeaker measured on the 25-ohm tapping of the auto-transformer. In explanation of this curve it should be mentioned that, although the circuit of Fig. 30 appears to be conventional, in fact the L to C ratios employed are not such as to give simple low pass, band pass and high pass filters. These ratios are chosen to give non-uniform pass band characteristics in such a way as to equalize those of the loudspeaker units, e.g. Fig. 15 (b), and so yield a uniform axial frequency response. It is noteworthy that the equalization can be performed by this simple means and without introducing any further components; it does, however, result in the irregular impedance characteristics of Fig. 31. Adjustment for differing sensitivities of units in production is of course made by changing the appropriate tap on the auto-transformer.

Early tests on the 305mm unit indicated that it would deliver a higher level of sound without overloading than would the 380mm unit employed for the LS5/1A loudspeaker. Fig. 32 shows the curves of harmonic distortion measured on the axis of the complete LS5/5 loudspeaker at 1.5m for a sound level of 1 N/m^2 and Fig. 33 gives the corresponding curves for intermodulation tests; these curves include the effect of the variable impedance load on the power amplifier, and were obtained by special apparatus[1] designed for this purpose.

To those unaccustomed to such curves attention is drawn to three points. The first is that the curves, particularly of the higher harmonics, are at least an order more irregular than is that of the fundamental. The second, which is related, is that although the mean level of the curves is fairly clear the average level of distortion cannot be obtained by measurements at spot frequencies. For example, at 83 Hz the level of 8th harmonic is

Fig. 26. Spread in axial response/frequency characteristics in six 200 mm units in large cabinet.



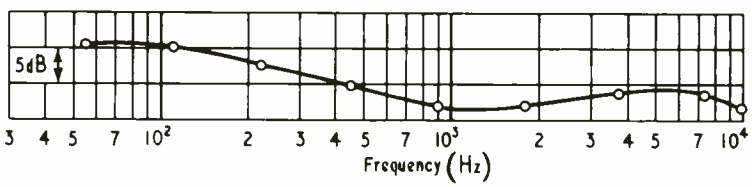


Fig. 27. (Above) Spread in axial response/frequency characteristics of six LS5/5 prototypes.

Fig. 28. (Left) Mean spherical response of LS5/5 loudspeaker measured in octave bands.

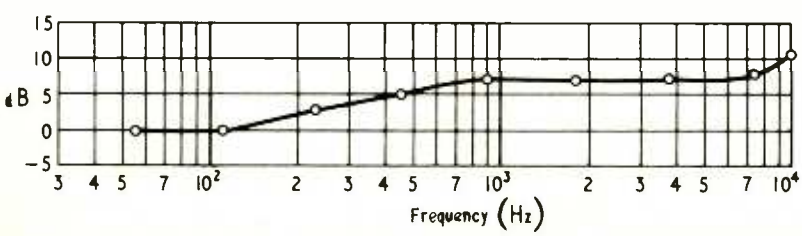


Fig. 29. (Left) Directivity index of LS5/5 loudspeaker measured in octave bands.

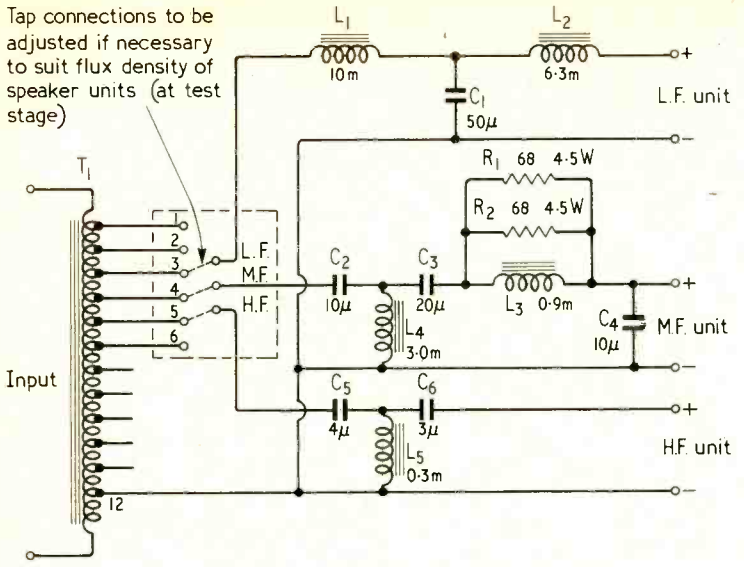


Fig. 30. (Left) Circuit diagram of crossover network of LS5/5 and LS5/6 loudspeakers. All component values are ±2%.

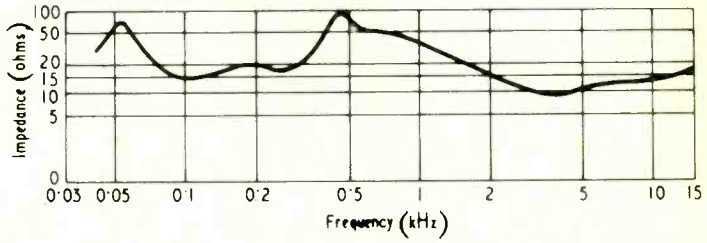
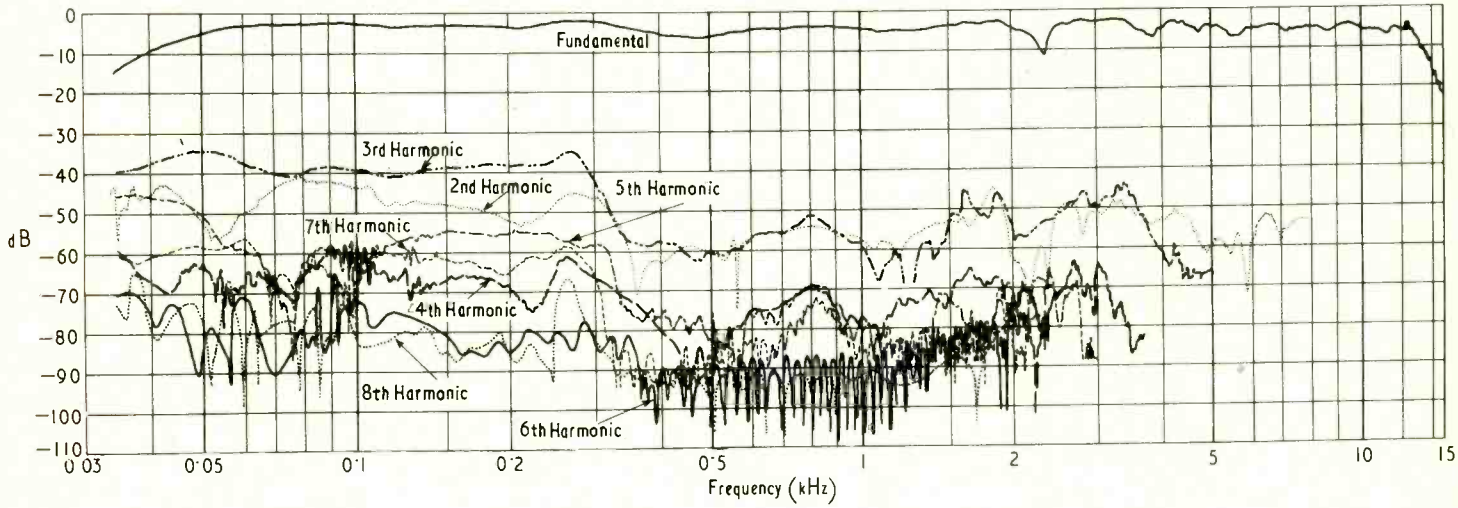


Fig. 31. (Above) Modulus of impedance of LS5/5 and LS5/6 loudspeakers.

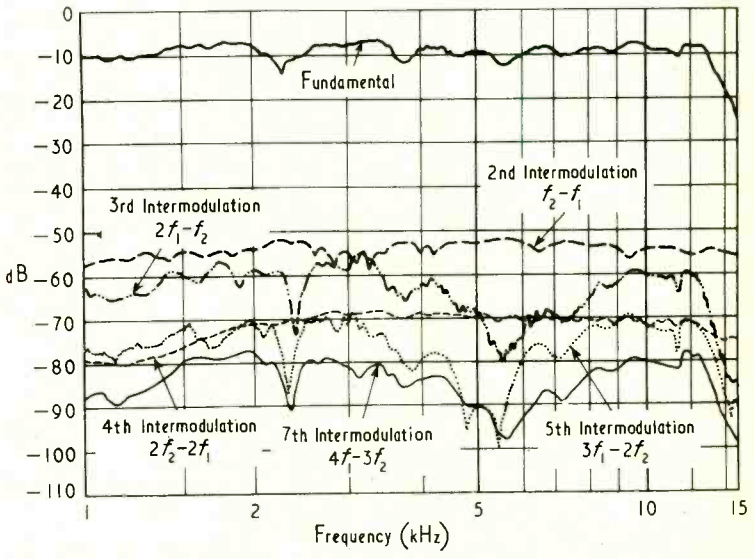
Fig. 32. (Below) Harmonic distortion of LS5/5 loudspeaker measured at 1 N/m² at 1.5m.



8 dB above that of the 6th while 2 Hz farther up the scale the position is reversed to the extent that the 6th is 28 dB above the 8th harmonic, a relative change of 36 dB in 2 Hz! Finally, the levels of distortion shown are inaudible.

The level of the sixth intermodulation product was too low to measure. It will be seen that the distortion levels are quite low even at the lowest frequency at which each unit is used, thus indicating that they are being operated well within their limits. The distortion curves shown in Fig. 14 of reference No. 1 were taken on the type LS3/1 loudspeaker at the same sound pressure and comparison with Figs. 32 and 33 shows that the distortion levels of the new loudspeaker are appreciably lower than those of the old design in spite of the fact that this used a larger (380mm) low-frequency unit.

Fig. 33. (Right) Intermodulation distortion of LS5/5 loudspeaker measured at 1 N/m² at 1.5 m.



Power Amplifier

A commercially produced transistor power amplifier is used, capable of supplying 25 watts into a 25 ohm load. Associated with it is a pre-amplifier, designed by the B.B.C. Designs Department, which provides the usual balanced bridging input impedance and also the bass pre-emphasis circuits, mentioned last month, which give a rise of 4 dB at 40 Hz for the LS5/5 and 7 dB at 40 Hz for the LS5/6.

Dimensions

The LS5/5 loudspeaker cabinet is approximately 350mm wide by 430mm deep by 660mm high, giving an external volume of 0.1m³. It is mounted on a plinth, 520mm high, which houses the power amplifier. The LS5/6 cabinet is of irregular shape but has the same volume as that of the LS5/5.

The weight of the LS5/5 loudspeaker together with the power amplifier is 47kg, that of the LS5/6 without amplifier is 35kg.

Acknowledgements. The author wishes to express his thanks to the Director of Engineering of the British Broadcasting Corporation for permission to publish this article.

Reference

1. "Apparatus for measurement of non-linear distortion as a continuous function of frequency" by H. D. Harwood. B.B.C. Engineering Monograph No. 49, July 1963.

The Human Computer

An examination of life processes in terms of communication theory

by J. R. Brinkley, F.I.E.R.E.

Modern genetic theory postulates that genetic information is passed from parent to child in the form of coded molecules. By similar precept it is reasonable to assume that environmental information received via the senses and the sensors for subsequent processing also has a molecular basis.

These precepts about human (and animal) information pose for the specialist in communication theory, and in particular for the communication systems analyst, certain challenging questions. The questions follow from the further assumption that the individual may be regarded as a computer or information processor, processing information with the object of survival, that is individual survival, group survival and overall species survival.

The first question is: what kind of information process is the individual carrying out?

The process must in detail be almost unimaginably complex, handling as it does millions of millions of "bits" of genetic and environmental information. The fact that vast quantities of information are processed does not necessarily mean, however, that the computer system is complex in principle.

I should like to suggest that the individual may be represented by the simple system diagram of Fig. 1.

The individual, represented by the circle, has two inputs and two outputs. G_{in} represents genetic input, the information received by the child, at the time of conception, from its parents. G_{out} is the information passed on in cell form to the subsequent generation. Genetic information in this definition includes growth and repair information, system operating information and instinctive behaviour patterns. It includes all information not learned by nor taught to the individual.

Environmental information may be defined on a similar basis as information received via the senses and body sensors and not inherited from parents.

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The analyst is now asked to accept that the individual has these two sources of information and no others. This does not preclude the acquisition of mystical or religious information but requires only that it should arrive via one of the two

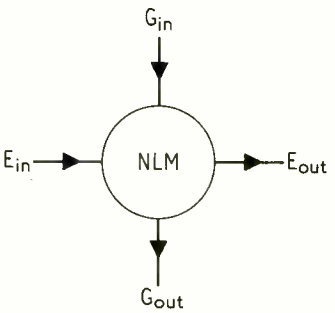


Fig. 1. The individual represented in terms of its information processing functions. G = genetic information, E = environmental information, NLM = non-linear mixer.

prescribed paths. The next question he has to answer is, what kind of process is performed inside the circle upon the two kinds of information? The answer would appear to be that the process is one which fits the general classification of non-linear and that the individual may be classified in communication terms as a non-linear information mixer.

In communication systems there are two general classifications of information mixer, the linear and the non-linear. Linear mixing is distortionless mixing as in a mirror or a high fidelity amplifier. The outputs are the simple addition of the inputs and no new products occur. It is, characteristically, a sterile process.

Non-linear mixing on the other hand is distorted mixing of the kind which takes place in a one-way conductor such as a diode or in an over-loaded transistor circuit or in a distorting amplifier. This kind of mixing is multiplicative and it is characterized by the appearance of new information products not present in the original inputs. It is important to note that these new products have a precisely defined harmonic relationship to the original parental frequencies which caused them to be generated.

Of the two kinds of mixer, the individual clearly belongs to the non-linear class. His outputs are not simple replicas of the inputs. If they were, no new information could result and the process would be sterile in the information sense. The individual may thus be described as a non-linear mixer of genetic and environmental information and as such may be expected to behave in the manner characteristic of non-linear mixers.

What are these characteristics? First the individual's behaviour will depend not just on the two sets of information

presented to him, but also on the characteristic and the degree of the non-linearity encountered at the interface between the two types of information where the mix takes place*. This non-linearity will not necessarily have a constant value and it may be characteristically different in different persons.

Second, for maximum output of new information (and the production of new information to solve the new problems that are continually arising must be a prime objective of the system) the characteristic behaviour of non-linear mixers suggests that the genetic and environmental information inputs should be equal. An excess of one type of information over the other (which may frequently exist) will be wasteful and will produce no *new* information. The implication of this characteristic should perhaps cause educationalists to reconsider their ways. For the sociologist, heredity and environment should be seen as of precisely equal importance to progress. The social, political and economic implications of this deduction may be formidable.

Third, the new information produced by the mixing process will have outward looking characteristics. It will tend to produce divergent rather than convergent behaviour. As an example of what is meant by divergence, when two musical notes are mixed in a non-linear mixer the new tone products do not lie between the two parent tones but above and below them. The pattern of distribution of these new products is shown in Fig. 2. Thus the non-linear mixing of the two sets of informa-

Fig. 2. Non-linear mixing of two units of information: (a) the two units of information before non-linear mixing; (b) after non-linear mixing, showing new divergent products at equally spaced intervals.

tion conveniently generates a supply of divergent new information which can be explored for the purposes of solving new problems. Put in another way, non-linearity will programme the individual to explore the outer limits (e.g. scale new heights) rather than the inner limits of his genetic and environmental inputs. Such an outward looking system will have important survival value since a purely inward looking programme would tend continuously to narrow the field of search, a trend which would have a dangerous bias towards over-specialization and which could fail to detect shifts in environmental situations.

Fourth, the new information will not be thrown up in a random manner differing in a random way from its parent information. It will be generated in a systematic way obeying harmonic laws and spaced at intervals equal to the difference between the two sets of input information. The individual would appear to be programmed not only to explore outer limits but to explore them in a systematic rather than a random fashion. This does not exclude the possibility of random factors or "noise" playing a significant part in the process but it would suggest that systematic exploration is its main characteristic.

It will not be difficult to accept that new environmental output in Fig. 1 results from the environmental input being modulated, i.e. non-linearly influenced by the genetic input from G_{in}. It will immediately be asked, however, whether G_{out} is influenced by E_{in}. This is of course the hundred years old Darwin-Lamarck-Lysenkoe *et al* controversy, namely, does our day-to-day experience influence the genetic information passed to our immediate offspring?

The communication analyst may perhaps make a contribution to this difficulty by saying what he would expect an effective survival-oriented processor to do. He would certainly not expect detailed environmental experience to be passed on genetically to the next generation, since much of it would be irrelevant and all of it would be some thirty years out of date. On the other hand, it would not be unreasonable to expect a measure of "appraisal" information to be passed on as to whether the many parts of the parent's programme had been found to be either efficient or defective. Such information would have to be "weighed" against the corresponding information presented by the other partner and the preceding hierarchies. It would certainly seem wrong to draw genetic information from all previous generations *except* the last. The matter would seem to the communications analyst to be one for critical analysis rather than for polarized controversy.

A further interesting suggestion may be made, namely that the strange effects of halucinogen drugs (e.g. LSD) could be accounted for quite simply in terms of the non-linear mixing concept of Fig. 1. If the effect of these drugs is simply to reduce the individual's non-linearity then under their influence his environmental inputs would no longer be "distorted" by his genetic inputs. Sounds and colours could then be expected to become unusually clear and vivid. There would be no genetically generated inter-modulation products to distort or "fuzz" the perception. This is apparently a characteristic of one stage of such drug taking experience. The mixer might also be expected to become temporarily unstable due to the presence of the drug and the perception of dimensions could be expected to become distorted and variable because the normal transfer characteristics of the mixer would be upset.

The effect of moral detachment from and irresponsibility towards one's environment could also be accounted for by the "uncoupling" (linearization) of the individual's normally non-linear coupling between genetic and environmental information. Lastly, the weird hallucinations experienced could simply be due to a breakdown of the mixer resulting in a random and meaningless confusion of genetic and environmental information. This "doping" of the mixer interface by LSD could well carry the risk of permanent deterioration of the individual's ability to process information.

The source of creative ability

Fascinatingly enough, the system diagram of Fig. 1 also offers a rational answer to the long standing mystery regarding the source of creative ability and its concentrated form, creative genius. Creativity may be defined as the generation of successful new information and if the system diagram of Fig. 1 is accepted then new information generation can only take place within the circle. On the face of it, it must be due to non-linear mixing of the information inputs. When it is remembered that the action of a highly non-linear mechanism tends to be stiff, awkward and somewhat unstable rather than smooth, regular and predictable it will become apparent that the commonly observed association of non-conformist behaviour and creative ability may well be due to the high degree of non-linearity present in individuals capable of major creative output. It is of course true to say that non-conformity or non-linearity by itself will not ensure successful innovation since it will only give rise to possibilities and not necessarily to correct solutions.

The laws of non-linear mixing may also be used as the basis for analysing the process of sexual conception, which may be represented as an information mixing process as in Fig. 3.

At the time of conception the male parent presents one set of information and the female a corresponding set. Once again the mixing process would appear to be a non-linear one. If it were

*The question of precisely where the mixing interface is located, its nature and how it operates holds a fascination of its own but need not be considered here.

linear the child would receive twice as much information as required. No new information would be produced and evolution could not take place. If, however, the process is non-linear, then any two corresponding parental units of information representing a unit of detail required by the child will produce a divergent set of new products in the same way as the two musical notes of Fig. 2. Thus the inherent characteristics of non-linear mixing will in effect programme each new generation with a tendency to diverge genetically in a systematic rather than a random way. This surely is the correct answer to the enigma of the natural divergence of species, the enigma with which Fleeming Jenkins taunted Darwin, without solving the problem himself.

It is also interesting to note that the non-linear mixing concept of Fig. 3 may also be used to explain the phenomenon of genetic dominance. In a non-linear mixer a strong signal will

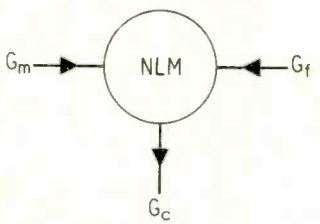


Fig. 3. Sexual conception. G_m = male genetic information, G_f = female genetic information, G_c = information generating new child, NLM = non-linear mixer.

weaken but not eliminate a weak signal. The effect is known in communication theory as capture effect in a hard limiter and demodulation in a soft limiter. This opens the way to the idea that genetic dominance is not random but systematic and in any event a more involved and elegant process than currently envisaged.

Non-linear mixing at conception will tend to suppress weaker information and noise. This phenomenon can explain how the life force is able to defeat the second law of thermo-dynamics by suppressing the weaker signals and noise in the parental mix. The action is analogous to the regenerative non-linear repeaters which enable communication signals to be "cleaned up" at intervals and re-transmitted over indefinitely long distances. Without such non-linear processing the species would continuously accummulate noise. It would "age" progressively and eventually die out submerged in acquired noise.

It is interesting to note that non-linear mixing at conception will give each child a substantial quota of new information not

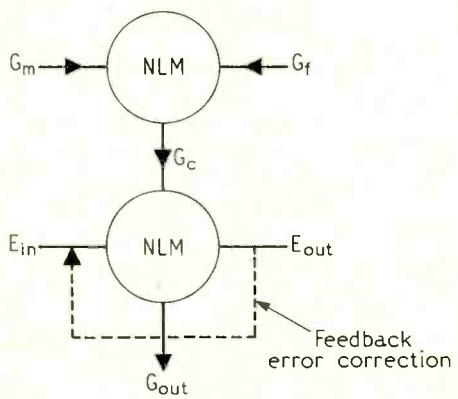


Fig. 4. System diagram for human behaviour. G_m = maternal information, G_f = paternal information, G_c = genetic output to child, E_{in} = environmental information input, E_{out} = environmental information output, G_{out} = genetic information output.

present in either parental chain. By the same token, since the child may be assumed to have approximately the same amount of information as any one parent, a substantial quota of parental information must also be "retired".

A more complete system diagram for human behaviour is shown in Fig. 4. In this diagram the two non-linear mixing processes are conjoined and a feedback error-correcting path is added to show the error-correcting process inherent in human survival behaviour. This, I suggest, is the basic communication system diagram from which human behaviour analysis should proceed.

Molecules of the life process

Up to this point I have attempted to describe the individual and the phenomenon of conception as information processes. Using the same approach it is interesting to consider the characteristics required of molecules if they are to act as the basic information carriers in such processes. Much brilliant work has been carried out in recent years with the DNA and RNA molecules to show how these molecules store genetic information. The molecules of the life process, must however, do much more than store information to make a living information system possible. As information processors they must in fact be versatile in the extreme.

In particular they must be able to receive information, both genetic and environmental, for storage and subsequent processing. They must re-transmit information substantially free from noise and presumably at the correct playback speed. The latter requirement is remarkable in itself since it should be remembered that while some of the genetic information "played back" by the individual was recorded one generation ago, the remainder goes back in stages millions of years to the origins of living matter.

The molecules must also be able to take part in a regeneration process to ensure that life information does not become progressively more noisy with time and they must be able to participate in an innovation process of the kind already described. Most remarkable of all, perhaps, they must be able to identify "wanted" as opposed to "unwanted" information and subsequently perform an information organization function, the end result of which is the successful creation and operation of a human being.

Perhaps the most challenging characteristic of these molecules to the communication engineer is, however, that the signals they process are comparatively low speed signals, complex waveforms no doubt, but requiring low frequency rather than high frequency oscillators for their synthesis and low frequency resonators for selection and noise exclusion. For example, the highest frequency received by the ear is 20 kHz. The voice does not transmit usefully much above 5 kHz. The eye achieves its great information capacity by paralleling great numbers of comparatively slow speed input channels.

Now molecules are made up of collections of atoms, and atoms in turn are made up of atomic particles, protons, neutrons and electrons. Experiments show that the frequencies associated with molecular and atomic vibrations are extremely high. These frequencies are many millions of times too high to be used directly in the synthesis and processing of the low frequency signals required for the life process. Yet the communication engineer is bound to ask, where do the low frequencies first appear and how are they generated? The problem is not eased by the fact that by his normal standards low frequency generators and resonators are physically large. Thus a 10 kHz radio aerial may be 50,000 ft long. A 256-hertz organ pipe is 1.1 ft long. Quartz resonators and *LC* circuits, though smaller, are still substantial in size. The search for low frequency resonators to match in size his integrated micro-circuits is as yet unsuccessful. Yet nature

apparently knows how to process low frequencies using single molecules. Restating this point briefly, the individual atoms give rise, so far as is known, only to very high frequency oscillations, much too high for the life information process, yet when they are put together in molecular form the necessary precision low frequency characteristics suddenly appear. There would seem to be only two explanations of this apparent mystery. Either the new low frequencies are synthesized from the very high atomic frequencies or they have some other basis for which there is at present no explanation. Under such circumstances the possibility of a synthesis process should be examined.

Following this line, the first thing to note is that life is never produced by any single element. Significantly it needs a minimum of four kinds of atom in combination. Moreover, it is always the same four kinds of atom which are used. The four vital constituents are hydrogen, carbon, nitrogen and oxygen†.

Now each of these four elements has its own electron shell structure. For example, the electrons in the outer shells are in the number sequence 1, 2, 3 and 4. Each atom will also have its own characteristic frequencies of radiation. Moreover, the atoms are bound together under strain which if it is to vary will vary in a non-linear manner. The living molecule may therefore be considered as a non-linear combination of the H, N, C and O atoms each with their own frequencies. The non-linear combination of multiple frequencies of this kind is in turn well known to the communication engineer as the basis of frequency synthesis.

Moreover, four oscillators in non-linear combination are known to have prodigious possibilities in terms of new frequency generation and will readily produce low frequencies down to and including if necessary zero frequency. Those of us who have designed receivers or transmitters with three oscillators will know only too well of their propensity to produce low frequency whistles. Receivers with four oscillators are eschewed because of the unavoidable proliferation of unwanted new frequencies.

Characteristics of atomic frequencies

Thus the possibility suggests itself that the life frequencies may be synthesized from atomic frequencies of H, C, N and O and a close examination of these atoms for suitable frequency characteristics is indicated.

The appropriate characteristics of the atomic frequencies required in such a system can be listed as follows:

(a) The body's processes are vitally concerned with or influenced by temperature. The atomic frequencies involved would be expected to vary from a mean frequency at blood heat over a range of perhaps a few kilohertz when ambient temperature varies from, say, −30°C to +50°C, the temperature extremes in which life can be supported.

(b) Similarly, the ambient pressure range under which life can survive should also produce precise atomic frequency variations ("beats") in the low kilohertz range.

Both these characteristics call for atomic frequency stability of an extremely high order but not for "infinite" short term stability. The atom, in other words, would have to be minutely and accurately responsive in terms of frequency to its environmental temperature and pressure.

(c) For the systematic production of low frequencies it would seem preferable for the frequencies associated with the elements H, C, N and O to be in some simple mathematical relationship. The most suitable arrangement would perhaps be equal frequency spacing. More correctly it would be minute divergence from a simple mathematical relationship which would generate the vital low frequency signals.

These suggestions may seem novel and perhaps strange to those not familiar with frequency synthesis processes. Yet either the low frequency signals of the life process are synthesized from atomic frequencies in this manner or in some like manner or their generation is an unexplained phenomenon.

If, on the other hand, it can be shown that the system is based on atomic oscillation and resonance then its extreme miniaturization and its long term stability could be readily explained.

To sum up

In conclusion, the main ideas being proposed by the writer are as follows:

1. Man has two separate and distinct sources of information, genetic and environmental, and no others.
2. The "system" diagrams of the life process are as shown in Figs. 1, 2, 3 and 4.
3. His survival process is based on mixing the information inputs and the key to the process is that the mixing is non-linear.
4. Non-linear mixing imparts characteristic patterns to all human behaviour.
5. It is non-linear mixing which generates all new information and imparts the hitherto unexplained outward-looking characteristics to the process.
6. Sexual reproduction is a further example of non-linear information mixing, and in this role non-linearity is a key mechanism in the human and animal evolutionary process.
7. Genetic and environmental information are of exactly equal importance to the generation of new information and hence to human progress.
8. If it is accepted that life information is carried by molecules, then the atoms H, C, N and O must be examined more closely to see how their molecular combinations provide for this phenomenon. In particular their ability to handle low frequency signals must be explained.

In a more general summing up, a new theory of human behaviour and the life process is proposed, which is based upon the non-linear mixing of the information streams involved. The theory provides an explanation, for the first time so far as I am aware, of how new information is generated. This could be of great importance since a recognition of the mechanism involved should enable the process to be fostered.

The new theory suggests, again I believe for the first time, that genetic and environmental information are of precisely equal importance to the progress of the human race. In this respect it will be ironic if the age-old debate which has occupied man's mind and energies for centuries and which has been the cause of bitter controversy and bloodshed, the argument of heritage versus education and training, can be resolved by a simple deduction based on communication theory. It is even more ironic, yet surely not altogether surprising, that the deduction appears to call for a perfect compromise.

More speculative, but perhaps equally important, is the proposition that the now widely accepted theory that molecules act as the carriers of living information suggests the need for a modification or a development of atomic theory. The modification is required to explain how atoms and molecules are able to generate and process with great precision and efficiency the low frequency signals which make up the life process. A possible modification of atomic theory to account for such processing has been put forward.

This contribution is a preliminary one from a more extensive work on the subject in course of preparation.

†Small traces of a large number of other elements are also used presumably to give variety to the mix but the basic constituents of life are the four elements named.

Radar Pulse Compression

The relationship between pulse length, bandwidth and range resolution.

by Brian A. Wyndham, M.I.E.R.E.

QUITE early in the history of radar, it was appreciated that if one wished to increase range resolution it would be necessary to reduce pulse length. It can be shown that for a matched filter

$$\frac{S}{N_{max}} = \frac{2E}{N_o}$$

where S = max. instantaneous output signal power
N = output noise power
E = received signal energy
N_o = noise spectral density (watts/cycle/second)

By definition, a matched filter is one which maximizes the output peak-signal to mean-noise power ratio. The relationship given above shows that the ability to detect signals in the presence of noise is a function of the received pulse energy and not on the shape or form of the signal.

For the simple pulse radar, the matched filter takes the form of a filter having a bandwidth approximately equal to (Pulse Length)$^{-1}$. The shorter the pulse is, the wider the bandwidth of the filter and, as a result, more noise appears at the output of the filter.

Because the shorter pulse has to compete with this extra noise in order to be detected, its peak power must be larger to overcome it. However, the pulse energy (Peak Power × Pulse Length) remains unchanged if the required signal-to-noise ratio is the same. Since the maximum useful range of a radar is determined by a certain minimum signal-to-noise ratio, it follows that a short-pulse radar having the same maximum range as a longer-pulse radar, also requires to radiate a higher peak pulse power. This being the case, the ultimate practical limit is set by the peak power-handling capability of the transmitter output valve. In large radars, this is usually of the order of a few megawatts. Once the maximum range and the range resolution are specified then the peak power demanded of the transmitter can be determined. This may or may not be feasible according to the state of the technology.

The relationship between pulse length, bandwidth and range resolution allows us to infer that better range resolution is available if the bandwidth of the pulse is increased. The problem then is to increase the bandwidth of a relatively long pulse and in some way extract the extra range resolution information. Patents relating to such a system were awarded in both Britain and Germany in the 1940s, but the practical solution was found in the United States in the following decade.

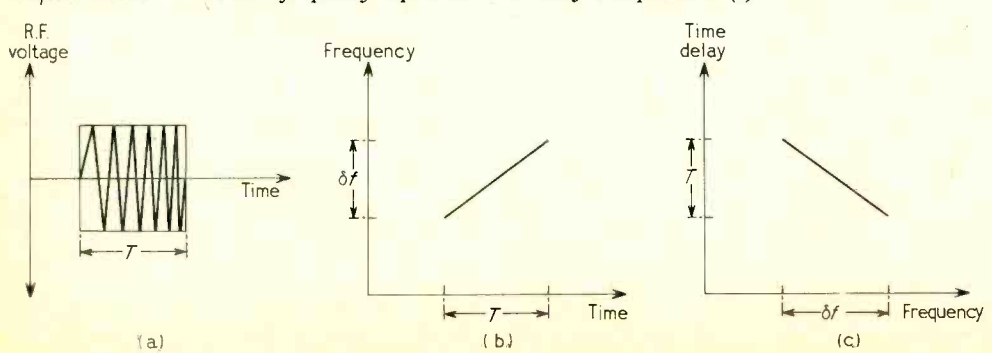
The solution to the first part of the problem, that of increasing the bandwidth of a long pulse, is relatively easy to solve. One has only to sweep the frequency of the carrier over the required bandwidth during the duration of the pulse. The simple way of doing this is directly to modulate the frequency of the transmitter oscillator with a sawtooth waveform so as to generate a linear frequency sweep, either upwards or downwards. This is called active generation as opposed to passive generation, which presumes a knowledge of pulse compression techniques for its understanding and will be mentioned again later.

The second part of the problem, that of extracting the extra information from the increased bandwidth, is more difficult and is best understood by reference to Fig. 1 in which (a) and (b) show, diagrammatically, a pulse whose carrier frequency changes linearly during its period. Fig. 1(c) shows the frequency/time characteristic of a specially constructed circuit or device whose function is to introduce a time delay which is frequency dependent, in other words a dispersive network. This network is shown to introduce longer delays to low frequencies than it does to high frequencies. If, therefore, a signal having the characteristics of Fig. 1(b) is fed to a network having characteristics like Fig. 1(c), the earlier and lower frequencies are kept waiting, so to speak, for the later and higher frequencies to catch up. If both signal and network functions are similar but in opposite directions (i.e., matched) all the frequency components of the input signal add in phase at the output of the network. It would appear, therefore, that all the frequency components of the input pulse of duration T, appear simultaneously at the output, implying an extremely short pulse. Actually, nothing can happen so instantaneously as the infinitely short pulse suggested by this simple concept, and for a complete picture one must examine the spectrum of the input pulse and calculate the effect of the network on it. Since the purpose of this article is to describe simply what pulse compression is and how it works it is not intended to delve deeply into the mathematics.

Supposing that the amplitude/frequency characteristic of the input pulse is rectangular (i.e., all frequencies within the pulse are of equal amplitude) then the pulse shape at the output of the network is given by the inverse Fourier Transform as shown in Fig. 2(a) and (b).

The envelope of this pulse shape tends to the form $(\sin \pi T\delta f)/(\pi T\delta f)$ as $T\delta f$ (pulse length × frequency sweep) increases. The diagram shows that the pulse length at the output is $2/\delta f$ between the first zeros, and such a pulse is shorter than the input pulse and pulse compression is achieved. In practice, the process of compression will take place in

Fig. 1. A pulse whose carrier frequency increases linearly is sketched in (a) while the relation between pulse duration and frequency is shown at (b). The characteristic of a special circuit element which introduces a frequency-dependent time delay is depicted at (c).



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either the r.f. or i.f. circuitry of the receiver, the input signals being the target echoes. The final detector of the receiver will then produce a video pulse having the envelope shape of the compressed pulse, as shown in Fig. 2 (c). For comparison, the shape of the original uncompressed pulse is also shown, and it is seen that the peak amplitude of the pulse has increased. Note also that the main pulse is accompanied by smaller ones, called range sidelobes.

The compression ratio can be expressed simply as ($T\delta f$) and the peak pulse power increases by the same factor, or since one usually examines the pulse voltage, a factor of $\sqrt{T\delta f}$.

Having now produced a compressed pulse at the receiver output, it can be seen that two such pulses can be much closer together than the original longer pulses before they merge into one another. If, however, one of the pulses is of smaller amplitude, it may become confused with one of the range sidelobes flanking the main pulse. In practice, therefore, a shaping filter is incorporated to reduce the size of the sidelobes without affecting the main pulse too much. This shaping process is analogous to the technique of tapering the energy distribution across an aerial aperture in order to reduce sidelobe levels. For pulse compression, it is the energy distribution across the frequency spectrum which is tapered by means of a shaping filter. Just as the aerial beam-width is increased by energy tapering, so also is the compressed pulse-width, but this is worth while in order that small targets can be seen close to larger ones. Fig. 3 shows how two targets, one large and one small, can be separated by pulse compression, whereas the original uncompressed pulses would have caused overlapping and confused signals.

Dispersive Networks

It will be appreciated that the nucleus of any pulse compression system lies in the dispersive element, this representing the matched filter referred to earlier.

For simplicity, it can be assumed that the frequency/time characteristic of the transmitted pulse is linear (i.e., linear f.m., sometimes called "Chirp"), while the amplitude remains constant. Dispersive delay lines matched to such a characteristic may take many forms.

Lumped constant networks comprising multisection *LCR* transmission lines were among the first to be used successfully.[1] Generally, these operate at tens of megaherz and can be made to work with compression ratios ($T\delta f$), of up to 100 or so, a factor which determines the number of sections in the network. Parasitic elements and the greater losses incurred, tend to set an upper practical limit.[2]

Ultrasonic devices, operating at the receiver intermediate frequencies, have been exploited successfully, and dispersive systems have also been constructed for use in the 10-kHz to 100-kHz range, a region not of particular interest to the radar engineer.

Two types of disperser have been developed

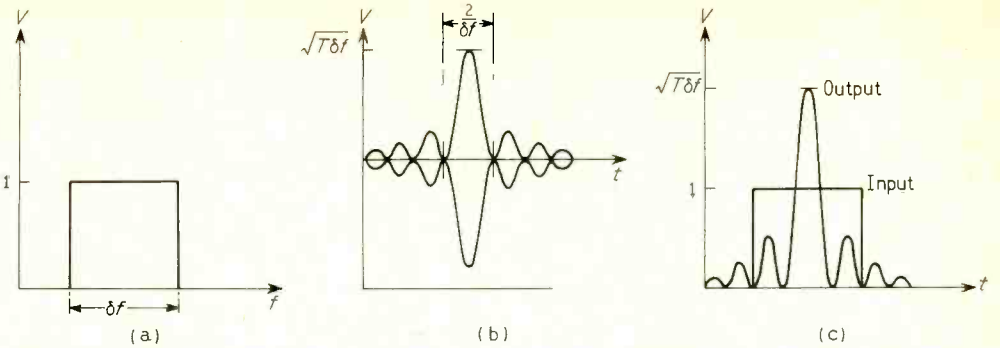


Fig. 2. These diagrams show the input pulse spectrum at (a), the envelope of the output pulse at (b) and the shape of the output detected pulse at (c).

under this heading. One of these uses a grating arrangement of transducers on quartz.[3] By using a wedge-shape quartz crystal and placing the arrays of contacts on opposite faces, an ultrasonic wave is caused to propagate between one face and the other. One array is fed with the frequency-swept i.f. pulse, the ultrasonic wave being received by the other set of contacts and passed on to the remainder of the receiver. The dispersive effect arises because the component frequencies are guided into that portion of the wedge whose thickness, and therefore the delay, is appropriate to the frequency. Frequencies requiring a longer delay are guided across the thicker portion of the wedge.

The other type of ultrasonic disperser is simpler in construction and comprises a long strip of metal. An ultrasonic wave is launched into the strip through a transducer placed at one end and received at the other with a second transducer. The cross-section of the strip may be either circular or rectangular, the effective velocity of propagation of waves in such a structure being a function of the frequency.[4]

High- and low-pass filters possess dispersive properties near their cut-off frequencies. The former type introduces less delay for the lower frequencies while the reverse is the case for the latter. A particularly interesting application of this effect may be exploited at microwave frequencies, rather than at intermediate frequencies. In this case, waveguide is used, but of somewhat smaller dimensions than normal for the frequency of the signals. Waveguides are used to support the transmission of microwave signals over a band determined by their cross-sectional dimensions. The upper frequency limit is fixed by the point at which higher-order modes may be propagated, corresponding to a wavelength equal to the broader dimension of rectangular waveguide. The lower-frequency limit, or cut-off frequency, occurs when the broad dimension is equal to a half wavelength. Normally, waveguides are used with signal frequencies well within these limits, and the propagation velocity varies but little over the useful band. It is in the region near to cut-off that the velocity changes rapidly with frequency and by using a waveguide size smaller than normal for a particular band of frequencies, a simple dispersive line is obtained. One such system employs 91.5 metres of No. 11A waveguide, short-circuited to give an effective length of 183 metres, and compresses a pulse of 1.05 microseconds to one of 8 nanoseconds centred at 2,725 MHz. This permits a resolution of 10 ft and is therefore capable of separating the wings, propellers and tail plane of a single aircraft.[5]

Many other devices have been tried out and it is not possible, nor necessary, to refer to them all in an article of this nature which is intended only to give a broad outline of the potentialities.

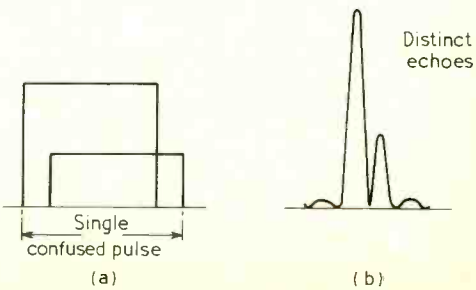
The transmitted pulse may sweep up or down in frequency, but if the sweep slope is not matched to the disperser, then it may only be necessary to invert the signal by choosing the local-oscillator frequency, which may be lower or higher than the signal frequency. If the local oscillator is higher, then the i.f. signal sweep will have the reverse slope.

Passive Generation

Reference was made earlier to passive generation. It has been assumed until now that the transmitter carrier frequency has been swept by direct modulation of the oscillator. An alternative arrangement may be used in which a short pulse is applied to a dispersive line, whose output will be a longer frequency-swept pulse. This latter may be amplified to a higher power level and radiated as the transmitted pulse. On reception of the target echo, sideband inversion must be used to allow the same disperser or a similar one to be used to restore the short pulse. In case the reader feels this to be a pointless exercise, having started with a short pulse in the first place, it should be remembered that the reason for using pulse compression is to exploit the peak power capabilities of the transmitter, and more energy can be packed into the pulse if it is of longer duration at the transmitter output.

For passive generation it is essential that the disperser is linear. Sideband inversion is necessary at some point between the generation of the frequency-swept pulse and its reception and re-application to the disperser. If the

Fig. 3. Without pulse compression two radar targets produce a single confused pulse (a), but with compression two distinct echoes (b) can be seen.



disperser were not linear, the inverted signal would be unmatched since any non-linearity effect is also inverted. The waveguide disperser cannot therefore be applied to passive generation, since the rate at which the group delay increases rises rapidly as the cut-off frequency is approached. This non-linearity of the waveguide system does, of course, present a problem in the design of a suitable active-sweep system, but this can be overcome.[5]

Sub-Clutter Visibility

Up to now, only one aspect of pulse compression has been mentioned: that of improved range discrimination. There is another bonus which in some cases is more important, and this is the improved sub-clutter visibility.

Unlike an aircraft, rain is an extended target system which may be large enough to fill the entire beam width and deep enough in range to fill the equivalent pulse length. The radar pulse can be assumed to occupy a volume or resolution cell bounded laterally by the beam edges and longitudinally by the leading and trailing edges advancing in range at the velocity of propagation. A small isolated target in the path of this pulse will return an echo of basically identical characteristics, but extensive rain, consisting of large numbers of small scatterers returns an echo whose energy content is related to the volume occupied by the pulse. It is to be expected, then, that a short pulse will return less energy from the rain than the longer one. With pulse compression, a similar situation arises since the overall effect is that of a short-pulse system. The rain, which to the radar consists of large numbers of small closely spaced targets, is not resolved into individual targets even by pulse compression techniques and the signals retain their noiselike characteristics. Unlike the isolated target, the mean level of a rain echo is not increased by the factor $\sqrt{T\delta f}$, so that the effective signal-to-clutter ratio is increased. This is shown in Fig. 4. The photographs were obtained by applying pulse compression to alternate pulses of a radar and the upper traces show the results on an A scope with, and the lower without, pulse compression. The uncompressed pulse length was 5 μsec and the compression ratio was 25:1.

In conclusion, one should compare the performance of a pulse-compression radar with a simple radar having the same final pulse width.

Owing to the presence of range sidelobes, better range resolution is obtained with the simple radar. The use of a shaping filter in the pulse-compression receiver reduces the signal-to-noise ratio as well as deteriorating the range accuracy. The wideband nature of the transmitted pulse, which must be swept in frequency in an accurately controlled manner, forbids the use of a fixed-frequency magnetron, and a high power klystron must be used instead. Furthermore, the complexity of a pulse-compression radar places it at a disadvantage compared with the conventional short-pulse radar. However, where ultimate range performance is required with improved resolution, accuracy and good sub-clutter visibility, pulse compression is a most useful technique.

I would like to thank my colleagues at R.R.E. for their assistance in providing material for this article and to Mr. K. F. Slater for his helpful suggestion during its preparation.

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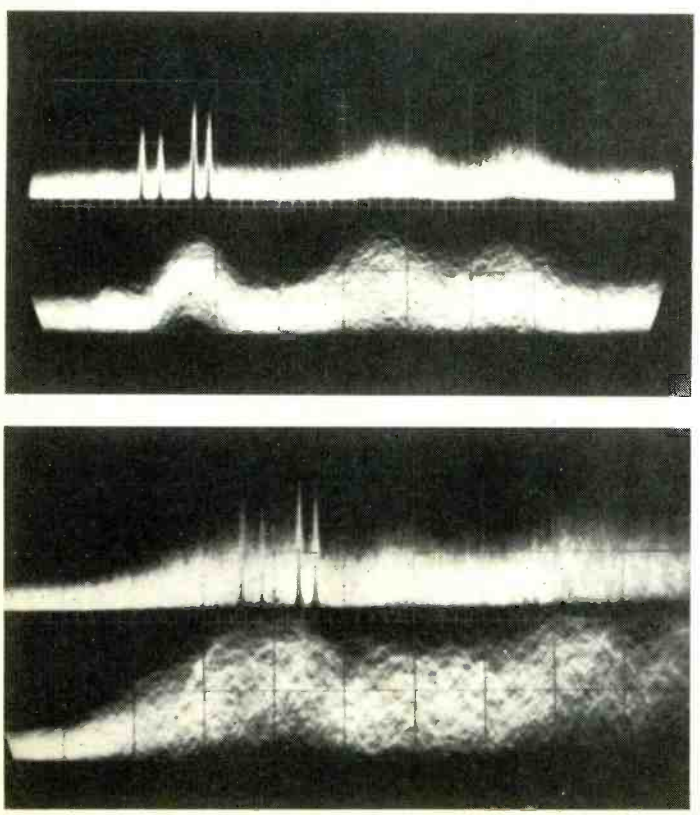


Fig. 4. With and without pulse compression; the upper pair are of a snowstorm approaching a group of targets and the lower pair taken 10 minutes later, are with the storm over the same area as the target. (Crown copyright).

Holographic Store

A high-density storage system which employs alkali-halide crystals as the storage medium and holography as the means of storing and retrieving data was described by Gabor U. Kalman of Carson Laboratories, Connecticut, at a recent I.E.E.E. convention in New York. Apparently alkali-halide crystals can be made photo-sensitive in a high-temperature diffusion process that creates local photon absorbing irregularities in the crystal which are called colour centres. In a potassium bromide crystal (KBr), for example, a representative colour centre would be formed by replacing a Br ion with an electron in the lattice structure enabling this portion of the crystal to absorb a photon at red wavelength. In doing this the crystal becomes transparent and, thereby, records information. The potential of this technique may be realized when it is stated that it is possible to create 10^{18} colour centres in a typical crystal. If the crystal is now illuminated from an ultraviolet source it returns to its original state and the process may be repeated. The main disadvantage encountered so far, results from the relatively low sensitivity of the crystal to light, however, this can be overcome by using high-power light sources such as lasers.

To read in information a thick treated crystal is placed in the interference pattern or holograph, produced by a reference and information laser beam. The hologram will be recorded three-dimensionally in the crystal by changes in the colour centres. A large number of independently recoverable holograms can be stored in the same volume of the crystal by rotating the crystal between successive exposures. Over 100 holograms have been stored in a single crystal in this manner.

To retrieve information from the crystal the hologram can be read out from a narrow angular range centred round the incident angle of the reference beam. A thick crystal stored hologram can be reconstructed, in a typical case, a few minutes of arc on either side of the reference angle.

In practical experiments a 2 × 2 inch crystal has been used to store hundreds of documents by dividing the crystal up in a mosaic fashion. The technique has also been used with colour holography and a full colour image has been stored and retrieved from a crystal using the methods outlined.

Public Address Show 1968

Wide range of modern p.a. systems and ancillary equipment shown at the A.P.A.E. exhibition

Held as usual at the King's Head Hotel, Harrow-on-the-Hill, Middlesex, for three days, March 12-14, the 20th International Public Address Exhibition, organized by the Association of Public Address Engineers, attracted entries from several European countries, Japan and the United States, as well as from most leading makers of p.a. equipment in the U.K.

In the larger rack and panel type installation, Shure Electronics demonstrated an audio level controller which they call "Level-Loc". It is basically a low-noise unity gain pre-amplifier with input and output matching functions, with the additional capability of reducing its gain as the input signal increases. This maintains the output signal reasonably constant and permits the speaker greater freedom of movement when using the microphone. It also removes the effect of "popping p's" from speech, although under demonstration conditions, the long recovery time-constant robbed the listener of the following word or two. Under very low signal conditions, the gain is nearly unity, but with a large applied signal a reduction approaching 100 times may be obtained, without introducing significant distortion. The degree of reduction is determined by the input signal itself. A distance selector switch, calibrated to show the distance from the microphone at which gain reduction becomes effective, determines the input level at which reduction commences. High and low input and output impedances are provided.

The trend towards smaller physical size of p.a. equipments, coupled with their smaller appetities for operating power without cost to the available output, has resulted in a big increase in systems shown under the general heading of portable p.a. intended for outdoor or indoor use and not requiring special transport. In most cases they could be run from a car electrical system and they ranged from equipment which requires a small tripod support, through the shoulder-strap carrying type to the megaphone type. Worthy of mention is the smallest of these, the Japanese TOA CA-500, shown by Audio & Design. This little 12V amplifier is capable of delivering a 10-W rated output while measuring only about 3 × 2 × 6 inches and weighing 2.2 lb. It can be run either from an external 10-16V source or from an optional snap-on battery pack which takes eight U2 cells. A matching hand microphone and loudspeaker are available. A portable system shown by Fi-Cord International comprised a microphone, amplifier and loudspeaker in a container carried like a briefcase.

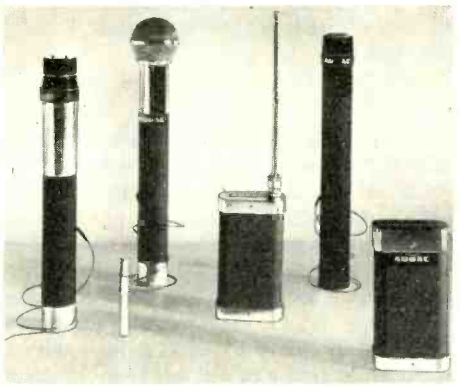
There were signs that the public address engineer would increasingly be expected to carry more ancillary equipment to cover field events. On the one hand, there was a range of low voltage fluorescent lighting equipment shown by C.T.H. Electronics, and on the other a display of sports timing devices and digital clocks by Hird-Brown who specialize in this type of equipment and who were exhibiting for the first time this year. Special timers were shown for sporting events including a battery operated timer to actuate stop-watches automatically and print-out timers operated by photo-cells.

A new application for p.a. equipment was seen in the form of under-water communication equipment by Partech International. This equipment allows direct conversation to take place between a diver and his base boat. Sound from the boat unit transducer, which is submerged over the side, can be picked up at distances up to 400 ft. by a receiver unit worn by the diver. A transmitter element carried by the diver permits two-way communication. The underwater transducers used in the equipment were developed by Goodmans Loudspeakers.

The familiar Acos sound level meter shown by Cosmocord can now be extended in range by the addition of an external amplifier module which enables sound pressure levels of 35—120 dB to be investigated. Also available is a self-contained calibrator unit which enables the sound level meter to be calibrated, with accuracy over the temperature range — 10 to +60°C. Calibration level is 87 dB. The calibrator unit is designed to screw on to the meter, thus providing a fully enclosed cavity connection. The background music theme of last year's show was continued by the appearance of a number of new continuous tape cassette machines typified by the Philips music player LGC 2000, shown by Peto Scott.

Full use was made of the advantages offered by transistor circuitry to develop compact units, and integrated amplifiers were much in evidence with the mixer, pre-amplifier, power output and speaker selection stages housed in a single case. In this category were the C.T.H. Electronics MA25, MA50 and MA100 models, the Vortexion CP50, Ultra Electronics TA10, and a 100-W model by S.N.S. Communications.

In an exhibition which was totally concerned, one way or another, with sound reinforcement, it came as a surprise to find one exhibitor, Amplivox, proclaiming the benefits of wearing a pair of earplugs which formed part of their show. These they called "ear defenders", and the makers claim that while they reduce the general noise level to 1/1,000 part of its original intensity, the wearer is not prevented from conversing or from hearing warning signals.



A selection of integrated radio microphone transmitters shown by Audac.

Shure M62 "Level-Loc" audio level controller.

Hird-Brown high speed electronic timer.

Philips model LGC 2000 cassette loaded music player.

Relay-semiconductor Control Circuits

How semiconductors are used in conjunction with electromechanical relays or even as substitutes for them

by T. D. Towers, M.B.E., M.A.*

Broadly, a relay is an electrical switch whose load contacts are actuated by an armature controlled by a coil electromagnet, with the control voltage applied across the coil. Relays are available for both d.c. or a.c. operation. Coil control voltages usually range between about 1 V and 250 V, with a preference for 6, 12, 24, 48, 110 and 240 V, although there are relays that operate as low as 25 mV. Drive coils may have resistances from a few ohms up to 50 kΩ, and inductances from a few mH up to 50 H. The resistance and inductance tend to be related with a coil L/R time constant between 1 and 10 ms. Operating powers usually range from a few mW to 20 W. The actual mechanism may take many forms from the simple P.O. type of relay where the switch points are actuated by a separate armature to the modern reed relay where the armature itself is in the switch contact.

For non-inductive loads, light current relay contacts commonly handle up to 5 A up to about 30 V. Above 30 V, particularly with d.c. switching, the contact ratings must be reduced. For inductive loads, ratings are always much less than for non inductive. Empirical derating rules you can use are: (a) for contacts rated at a current I_M for 30 V non-inductive switching, reduce the rating for higher voltages, V, to I_M (1-V/500), and (b) for inductive loads, take only a quarter of the non-inductive ratings.

Relay Contact Protection

When the switch in an inductive circuit is opened, the magnetic field in the coil collapses and a voltage is generated equal to Ldi/dt, where L is the inductance and di/dt the time rate of change of current decay. Across the switch contacts this voltage transient is added to the load rail voltage. If not suppressed, it tends to lead to pitting and unreliable operation.

Standard electronic textbooks will give you details of C and R networks often used to reduce switching transients across opening contacts. Semiconductors too can be used for spike suppression. In Fig. 1(a) a germanium or silicon diode is fitted across the load, with polarity as indicated . . . "pointing to positive". When the high positive voltage spike starts to appear across the load on switch off, the diode forward-biases as soon as the spike voltage exceeds the positive rail voltage and thereafter clips the spike. The reverse voltage rating of the diode is unimportant, so long as it is greater than the rail voltage. As to the current rating, my own generous rule is to select a diode with a peak current rating of not less than 25 times the relay "on" current. Sometimes a varistor (voltage dependent resistor) such as one of the S.T.C. CZ series or the Mullard E299DD series is used instead of the diode. The varistor should have a 20 °C resistance greater than 10 times the load resistance at the relay drive voltage.

To protect the relay coil control switch contacts, a diode can equally be used as shown in Fig. 1(b), just as for the load contacts. Note again the diode "points to positive". The main disadvantage of this form of diode suppressor is that it tends to lengthen the release time of the relay.

A further refinement is a transistor circuit of the type shown in Fig. 1(c) across the actuating switch of a 12 V relay. With no suppression circuit across the switch, reverse spikes of about 600 V occurred. A 0.25 μF capacitor across the points reduced these to about 300 V, while the transistor circuit shown cut them down to about 25 V. In this arrangement, when the points are opened, the capacitor (discharged while the points were closed) holds the BFY50 silicon n-p-n transistor hard on until it has charged up sufficiently through the transistor base-emitter diode and the 1 kΩ resistor to cut the transistor off completely. This is equivalent to the points opening slowly so that di/dt is small and the Ldi/dt voltage spike is also small.

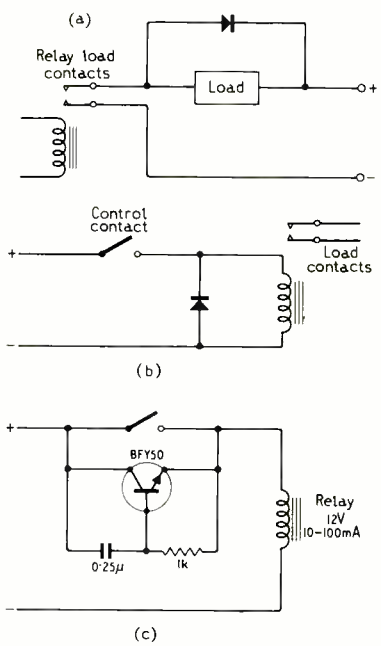


Fig. 1. Relay switching transient suppression circuits: (a) Load contacts—diode across load. (b) Diode protecting drive coil control switch. (c) Transistor spike suppressor.

Relay-driver Linear Amplifiers

Transistor linear amplifiers are in common use to operate a high-current relay from a low current signal source. Fig. 2(a) shows the basic arrangement. When switch S is open, no base current is available to the transistor, Tr, and it is cut off. As a result, no current passes through the relay coil. When S is closed, the current supply from the control voltage V_{BB} via the resistor R_B drives the transistor hard on, so that it becomes a virtual short-circuit connecting the lower end of the relay coil to the negative rail. This causes the relay to pull in. One refinement often used is to make S a change-over switch (as shown dotted) so that it connects the base of the transistor to the negative rail in the off position. This is usually done if the equipment is likely to work in high ambient temperatures, where the leakage currents with the base open circuit are liable to become excessive, particularly with germanium transistors.

More sensitive control of the relay is achieved by adding additional transistor amplifier stages. Fig. 2(b) shows an arrangement in which, when no input signal is applied, the 2N1304 Tr_1 is cut off and the BFY50 Tr_2 is switched hard on, pulling the relay in. When a positive voltage of about 0.5 V with a current demand of about 40 μA is applied to the input, the 2N1304 saturates and the BFY50 cuts off, allowing the relay to fall out. The driver transistor is made a germanium one whose bottoming voltage ("on" collector-to-emitter voltage) is considerably lower than the forward base-

*Newmarket Transistors Limited

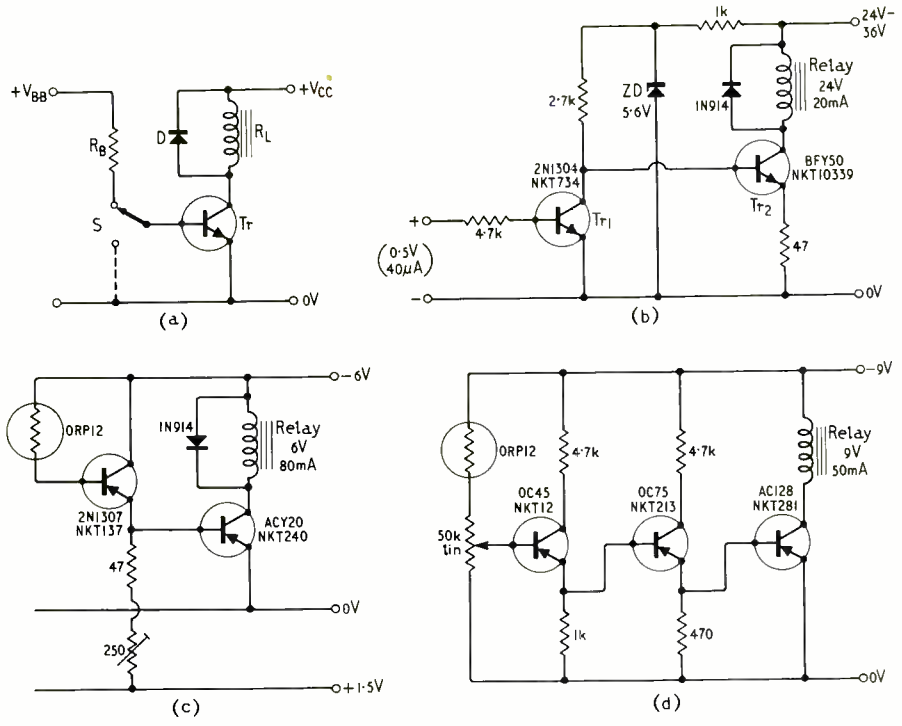


Fig. 2. Relay driver linear amplifiers: (a) Single stage. (b) Two-stage inverting. (c) Two-stage non-inverting (d) Three stage non-inverting.

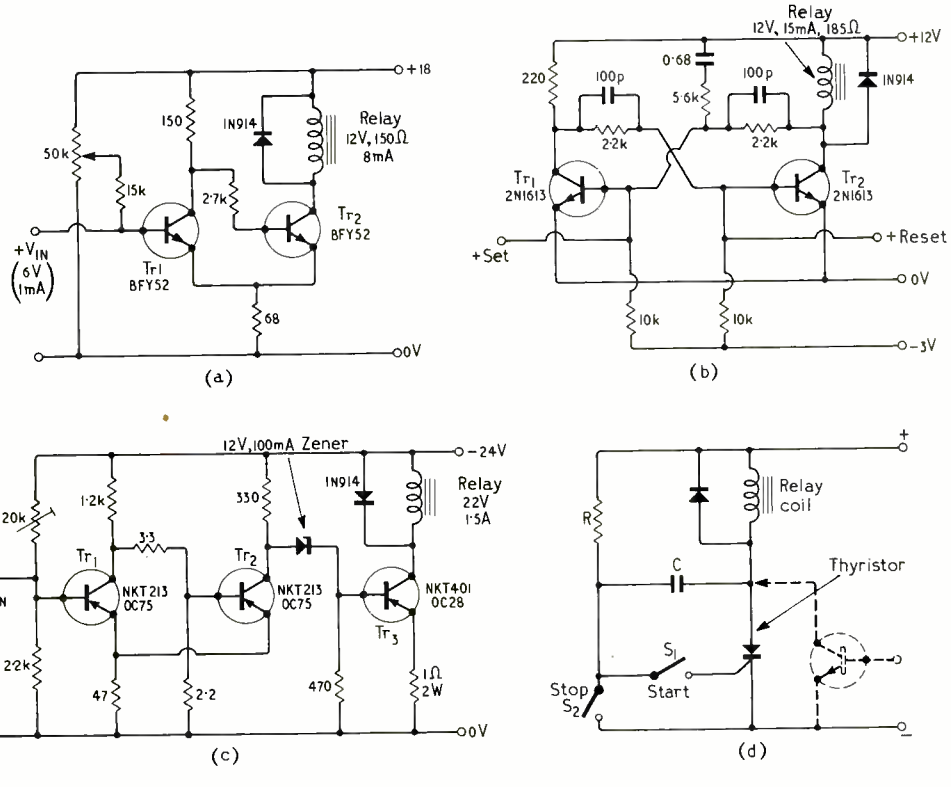


Fig. 3. Relay-driver regenerative amplifiers: (a) Single-stage Schmitt trigger. (b) Single-stage bistable. (c) Multistage Schmitt with preamplifier. (d) SCR control of relay.

emitter operating voltage of the BFY50 silicon transistor.

Fig. 2(c) shows another two-stage linear transistor amplifier operating a relay, but this time the circuit is non-inverting. When the ORP12 cadmium sulphide light cell is not illuminated, it has a very high resistance and practically no base current is supplied to the 2N1307. The output ACY20 transistor is held cut off, and the relay is not pulled in. When the ORP12 is illuminated, base current is supplied to the 2N1307, which in turn drives on the ACY20 and operates the relay. The purpose of the variable resistance network from the base of the ACY20 to +1.5 V is to adjust the threshold voltage for the particular ORP12 being used. It also ensures that under high-temperature conditions the ACY20 does not pass sufficient leakage current when cut off to operate the relay spuriously.

A single-power-supply, three-stage, linear d.c. relay-driving amplifier is shown in Fig. 2(d). The relay comes on when the ORP12 is illuminated. The 50 kΩ linear potentiometer permits adjustment of the relay operating threshold. Although the circuit diagram shows the circuit operated by an ORP12 light cell, equally well it could be controlled by a mechanical switch in series with a resistance in the light cell position and passing only microamps. In the non-operating state, all the transistors are turned off and the current consumption is negligible, so that the circuit is well suited to dry battery operation.

Relay-driver Regenerative Amplifiers

The linear relay-driver amplifiers described above suffer from the failing that the threshold signal which pulls the relay in can vary with temperature, and also can hold the relay for some time hovering between on and off, i.e. "chattering". It is therefore, common to use a regenerative amplifier to drive the relay. Then the operation is a positive snap action with the relay either on or off.

Fig. 3(a) shows a Schmitt trigger with the relay coil as the load of the right hand transistor, Tr_2. So long as the input level is less than 6 V, the left hand transistor is cut off and the right hand transistor is turned full on, with the relay pulled in. When the input signal exceeds about 6 V, Tr_1 is driven rapidly into conduction and Tr_2 cut off, so that the relay falls out with certainty. The 50 k potentiometer is used for precise setting of the threshold operating point.

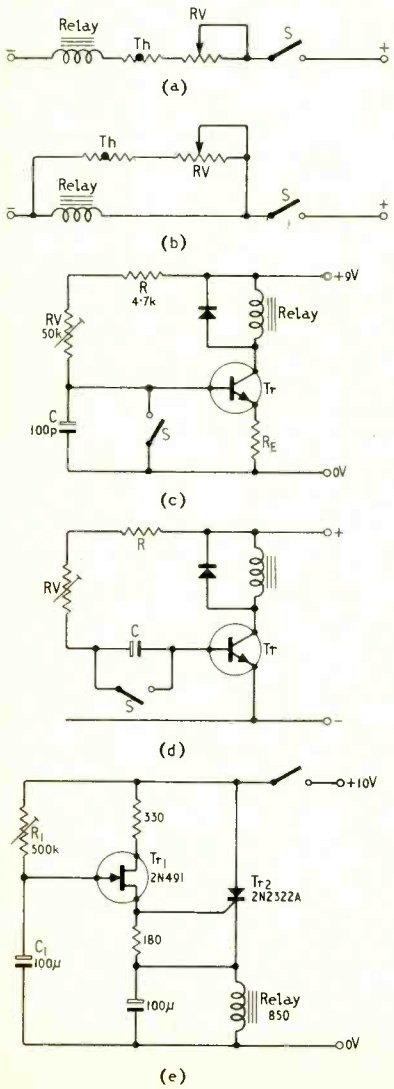
Another regenerative amplifier system that is used is illustrated in Fig. 3(b), where the relay coil forms the load of one side of an Eccles Jordan bistable multivibrator. The Eccles Jordan is a fairly conventional design, except for the *CR* network connected from the 12 V rail to the base of Tr_1. This is included to ensure that, when the power supply is first switched on, Tr_1 is driven hard on and Tr_2 cut off, with the result that the relay is not pulled in. A positive signal on the "reset" terminal to the base of Tr_2 drives the relay sharply on, and a positive signal on the "set" terminal to the base of Tr_1 cuts it off.

For higher power relays, it is usually necessary to add a buffer power stage between the regenerative circuit and the relay. Fig. 3(c) illustrates a typical arrangement. Here the Schmitt trigger (Tr_1, Tr_2) is coupled to the output power transistor, Tr_3, via a 12 V Zener diode. When a negative control signal of sufficient amplitude is applied to the input, Tr_1 turns on and Tr_2 off. Current then passes through the 330 ohm Tr_2 collector load resistor and the Zener diode into the base of Tr_3 and drives the power transistor hard on, thus operating the relay. As the bottoming voltage of the NKT401 at 1.5 A is less than 0.5 V and the free-air dissipation of this power transistor is not less than 1 W, the transistor can be operated without a heat sink. However, if it is to work at high ambient temperatures inside equipment, it should be mounted on a two inch square of 16 s.w.g. aluminium.

Another form of regenerative relay driver commonly uses a thyristor or s.c.r., for which a basic circuit is shown in Fig. 3(d).

Initially S_1 and S_2 are both open, and, as no trigger potential is supplied to the gate of the thyristor, it is cut off and no current passes through the relay coil. If now S_1 is closed, a positive voltage is applied to the gate via resistor R and turns the thyristor on. In its "on" condition, the thyristor is a virtual short circuit and current flows to operate the relay coil. If now S_1 is opened, the thyristor will continue to conduct, but C charges up virtually to rail potential. Subsequently closing S_2 applies a negative pulse to the anode of the thyristor and cuts it off. For cutting off the thyristor, an alternative to S_2 is to connect a transistor from its anode to cathode as shown dotted in Fig. 3(d). If a positive switch-off voltage is applied to the base of this transistor, the device bottoms and reduces the voltage across the thyristor below its hold voltage with the result that it switches off. The relay falls out then when the transistor base control voltage is removed.

Fig. 4. Relay time-delay circuits: (a) Thermistor-controlled slow-on/fast-off. (b) Thermistor fast-on/slow-off. (c) Transistor-controlled slow-on/fast-off. (d) Transistor fast-on/slow-off. (e) Very slow-on u.j.t. relay control circuit (40 sec ±1 sec, from −25°C to +75°C).



Relay Time-delay Circuits

Semiconductors are in common use for providing time-delay periods in the operation of electromagnetic relays. One simple way to delay the "on" switching time of a relay is to place a thermistor (negative temperature coefficient resistor) in series with the coil as shown in Fig. 4(a). When the switch S is closed, the thermistor has initially a high resistance, but, as it heats up, its resistance reduces until the current through the coil is sufficient to pull the relay in. The variable resistance RV may be included to enable some variation of the delay time. The series thermistor should have a resistance at room temperature of about three to five times the relay resistance. The Mullard VA series of thermistors is suited to this application. For example, the VA 1070 with a cold resistance of about 400 ohms dropping to 25 ohms at 300 mA can be used with conventional 12 V, 80 mA relays.

The arrangement of Fig. 4(a) gives slow turn on and fast turn off. For fast turn on and slow turn off, a shunt thermistor can be used as in Fig. 4(b). Again the thermistor should have a cold resistance three to five times the relay coil resistance.

A transistor circuit to give slow-on, fast-off relay operation is shown in Fig. 4(c). Switch S is normally closed, earthing the base of the transistor and cutting it off, so that the relay is not pulled in. When S is opened, capacitor C begins to charge up with a time constant approximately $C(R+RV)$ via the resistance string from the h.t. rail, until the potential on the base of the transistor is sufficient to turn it on. Thus the relay turn on is delayed. Now when switch S is closed again, the capacitor C discharges instantly and the transistor Tr is turned off extremely sharply.

Fig. 4(d) shows a rearrangement of the elements of Fig. 4(c) to give a circuit with a fast-on and slow-off time. Switch S is normally open and the capacitor blocks off any current to the transistor base, so that no collector current flows to operate the relay. When S is closed, the capacitor discharges and base current through the resistance string from h.t. turns the transistor full on so that the relay pulls in sharply. When S is re-opened, the capacitor continues to supply base current until it is charged up via the resistor network thus giving a slow turn-off action.

Many more refined variants of these arrangements are possible, such as the very slow turn-on circuit given in Fig. 4(e). Normally switch S is open and all the capacitors are discharged. When S is closed, C_1 charges up through R_1 with a long time constant until the potential on the emitter of the unijunction transistor, Tr_1, rises above its firing potential. At this the unijunction becomes low resistance and applies a firing pulse to the gate of the thyristor Tr_2. The thyristor then turns on and switches operating current into the relay coil. When S is opened again, the thyristor supply voltage is removed, so it ceases to conduct and the relay falls out. This circuit has been used to provide a 40 second operating delay (±1 second) in a relay over the range of −25°C to +75°C.

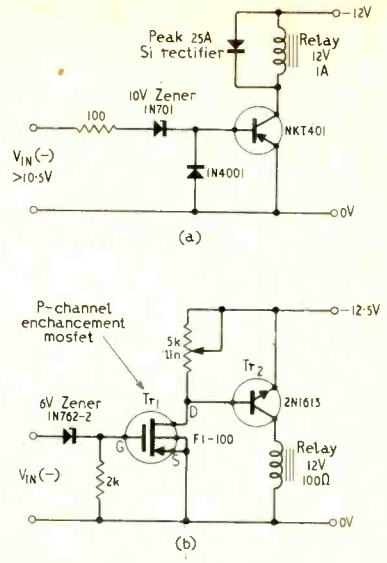


Fig. 5. Close-differential-operation relay drivers: (a) Single-stage transistor/Zener. (b) Two-stage f.e.t./transistor.

Close-differential Operation Relay Drivers

Many of the relay driver circuits given earlier have the limitation that the control signal operation point is uncertain and may have considerable backlash, i.e. the relay may not fall out until the control voltage is well below the pull in voltage. One way to get close-differential-operation, i.e. with the fall-out signal level close to the pull-in level, is to design the Schmitt trigger circuits used in Figs. 3(a) and (c) to have very small hysteresis or backlash. The easiest way to do this is to replace the common emitter resistor of Schmitt with a Zener diode of the same voltage as the common emitters reach when the relay is pulled in.

An interesting circuit giving close-differential operation is given in Fig. 5(a). Here, as the input signal is increased negatively, no base current flows in the transistor until V_{in} is greater than the 10 V breakdown voltage of the 1N701 Zener diode plus the base-emitter forward voltage drop required for the NKT401 to come on (which is about 0.3 – 0.5 V). Thus, when V_{in} reaches about 11 V the power transistor turns full on and its collector current operates the 12 V, 1.5 A relay. The 1N4001 silicon diode across the base-emitter of the NKT401 prevents overdriving the output transistor. Up to 0.6 V on the transistor base, the diode does not conduct significantly, but above that level it begins to do so and shunts excess current away from the base of the transistor. Because of the sharp breakdown characteristics of the Zener diode the fall-out signal voltage of this circuit is within a few hundred mV of the pull-in voltage.

Fig. 5(b) illustrates the use of a p-channel enhancement-mode m.o.s.f.e.t. with a threshold voltage of about 5 V to give close-differential operation of a relay. When V_{in} is greater than 6 V, the Zener diode conducts through the 2 kΩ resistor to the positive rail, but so long as the input voltage is less than 11 V, the voltage drop across the resistor is less than 5 V and the m.o.s.f.e.t. does not

conduct. So long as the m.o.s.f.e.t. is not conducting the 2N1613 transistor is cut off and the relay is not operated. When the input voltage is greater than 11 V, the m.o.s.f.e.t. gate voltage rises above 5 V and it conducts. The current in the 5 kΩ variable drain resistance then takes the base voltage of the 2N1613 transistor positive and turns the relay on. For V_{in} smaller than 11 V, the relay is non-operative, and for V_{in} greater then 12 V the pull in action is certain. By cascading a second f.e.t. after the first, it has been possible to reduce the difference between turn-on and turn-off to 0.1 V.

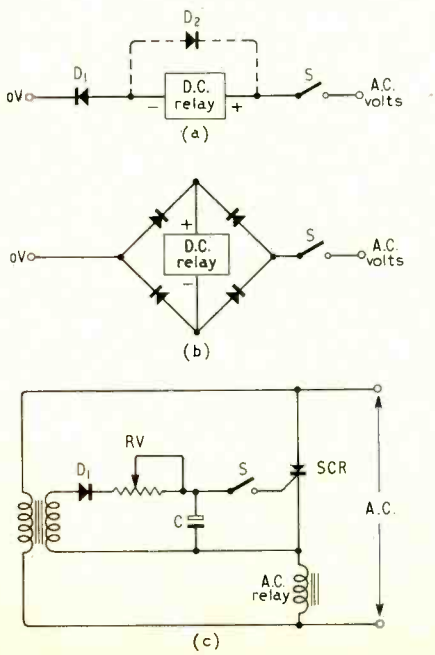
A.C. Relay Drive Circuits

You can adapt any d.c. relay to work from a.c. by combining it with rectifier diodes. In Fig. 6(a) the series diode D_1 permits only positive current to pass through the relay and cuts off on negative half cycles. It should have a current carrying capacity several times the operating current of the relay. The clamp diode D_2 shown is optional and is the surge suppression diode discussed earlier. In this case it not only protects the switch contacts, but also prevents excessive reverse voltage being applied to the series diode D_1 on switch off.

Another arrangement of diodes used for a.c. driving of a d.c. relay is shown in Fig. 6(b). Here four diodes are used in a full-wave bridge.

Where it is desired to operate a true a.c. relay other than by a mechanical switch, it is common nowadays to use a thyristor in some circuit such as Fig. 6(c). When switch S_1 is open, the s.c.r. has no trigger potential applied to its gate, and it is non-conducting. Meanwhile current passing through the transformer T is rectified by diode D and builds up a smoothed d.c. voltage at the top of capacitor C. If now S_1 is closed a positive potential is applied to the gate of the s.c.r. and turns it on. So long as S_1 is held closed, the s.c.r. remains conducting. When S_1 is opened, the s.c.r. cuts off when the a.c. line volts next change from positive to negative, and the relay drops out, and stays inoperative.

Fig. 6. A.C. relay drive circuits: (a) Operating d.c. relay on a.c. with single diode. (b) Operating d.c. relay on a.c. with diode bridge. (c) Thyristor drive of a.c. relay.



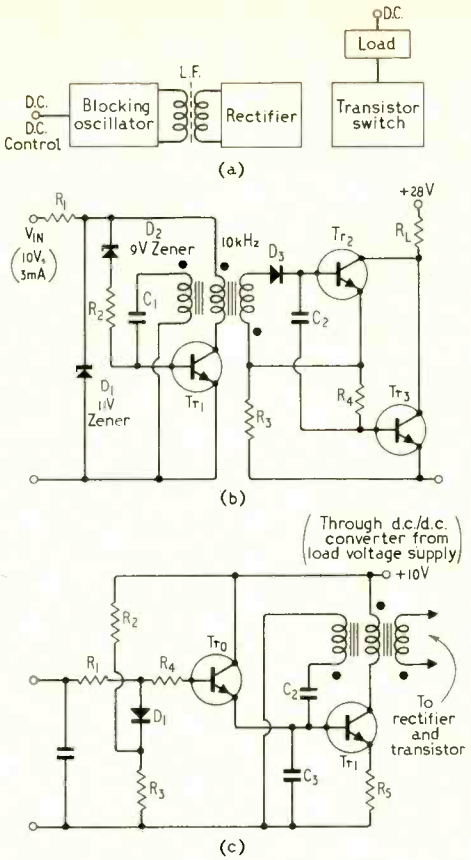


Fig. 7. "Static" (non-mechanical) relay substitutes: (a) Basic blocking oscillator control. (b) Simple practical circuit. (c) Highly sensitive overload-protected static relay input circuit.

Static Relays

A static relay differs from a static switch in that there must be isolation between the control and load circuits, and on/off snap action must occur. So far, the design of static relays using only transistor circuits has required the inclusion of an oscillator. Fig. 7(a) is typical. In this, a blocking oscillator is arranged so that it oscillates on the application of a d.c. control signal. The output from an isolated tertiary winding on the blocking oscillator transformer is then rectified and used to turn on a transistor switch.

Fig. 7(b) shows one version of the static relay where an input of 3 mA at 10 V causes the blocking oscillator, Tr_1 to fire at about 10 kc/s. The secondary output is rectified by D_3 and smoothed by C_2 and turns Tr_2 and Tr_3 on to switch current through the load resistor R_L from the 28 V load supply. The 9 V Zener diode D_2 together with the forward base-emitter voltage drop of the silicon transistor, Tr_1 ensures that the relay does not come into operation until the 10 V d.c. is applied to the input. The Zener D_1 ensures that input overloads are bypassed.

In the circuits of Fig. 7(b), the collector voltage for the blocking oscillator transistor, Tr_1, must be supplied from the signal source. If the collector voltage for Tr_1 could be supplied separately and an extra stage of amplification introduced, a much more sensitive relay would result. Such a circuit is shown in Fig. 7(c). Here an extra stage of transistor amplification, Tr_0, is introduced before the blocking oscillator. Overload protection is now not by Zener diode but by a forward-biased silicon diode D_1 backed off by a potentiometer R_2, R_3 across the 10 V rail. This 10 V d.c. rail supply to the blocking oscillator is provided by a d.c./d.c. converter from the 28 V load supply voltage. The circuit of Fig. 7(c) can be designed to operate on a 0.7 V input signal.

If you are intersted in more detail of the design of static semiconductor relays you should consult "Static Relays for Electronic Circuits" by R. F. Blake, Chapman and Hall Ltd., London. Anyone interested in examining electromagnetic relay characteristics and circuits should consult standard reference works such as "Telephony" by J. Atkinson, Pitman, London and "Connectors, Relays and Switches" by G. W. A. Dummer and N. E. Hyde, Pitman, London. He will also find much useful information in such books as "Electronic Apparatus for Biological Research" by P. E. K. Donaldson, Butterworth, London.

May Conferences and Exhibitions

Further details are obtainable from the addresses in parentheses

LONDON

May 13-18 — Olympia
Instruments, Electronics and Automation Show
(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)

May 25 — Hotel Russell
Professional Audio Exhibition & Symposium
(Assoc. of Professional Recording Studios, 47 Wattendon Rd., Kenley, Surrey)

HARWELL

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

OVERSEAS

May 6 & 7 — Washington
Human Factors in Electronics
(H.P. Birmingham, Code 5630B, Naval Research Lab., Washington, D.C. 20390)

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)

I.E.A. Exhibition

Olympia, London, May 13-18, 10 a.m. to 6 p.m. Admission 5s.

	Stand Number
AB Bofors	G 60
A.B. Electronic Components	G 57
AB Engineering Co.	E 634
AB Nordquist & Berg	G 60
AEG (Great Britain)	N 167
AEI Automation	G 49
AIM Electronics	G 354
A.K. Fans	G 23
A.P. Electronics	G 60
A.P.T. Electronic Industries	G 315
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Budd Instruments	N 410
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Collins Radio Co.	G 345
Colvern	N 425
Comark Electronics	N 471
Computer Controls	E 520
Computer Memory Systems	N 182A
Computer Technology	E 530
Computing Techniques	E 652
Comsip-Kilpatrick	G 58
Condensateurs Fribourg S.A.	E 528
Conklin Instrument Corp.	E 267A
Contraves Industrial Products	E 266A
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Core Memories	E 550
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Dale Electronics	N 460
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Eurotherm	N 408
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Ever Ready Co.	E 505
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Facit-Odhner Electronics	G 356
Fairchild Instrumentation	E 629
Fairey Surveys	E 639
Farnell Instruments	E 262
Farris Engineering	G 64
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Fernseh G.m.b.H.	E 247
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Fielden Electronics	G 47
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Fluid Equipment Co.	N 481
Fluke Manufacturing Co. Inc.	N 178
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Foster Instrument Co.	E 515
Foster, W. & J.	N 441
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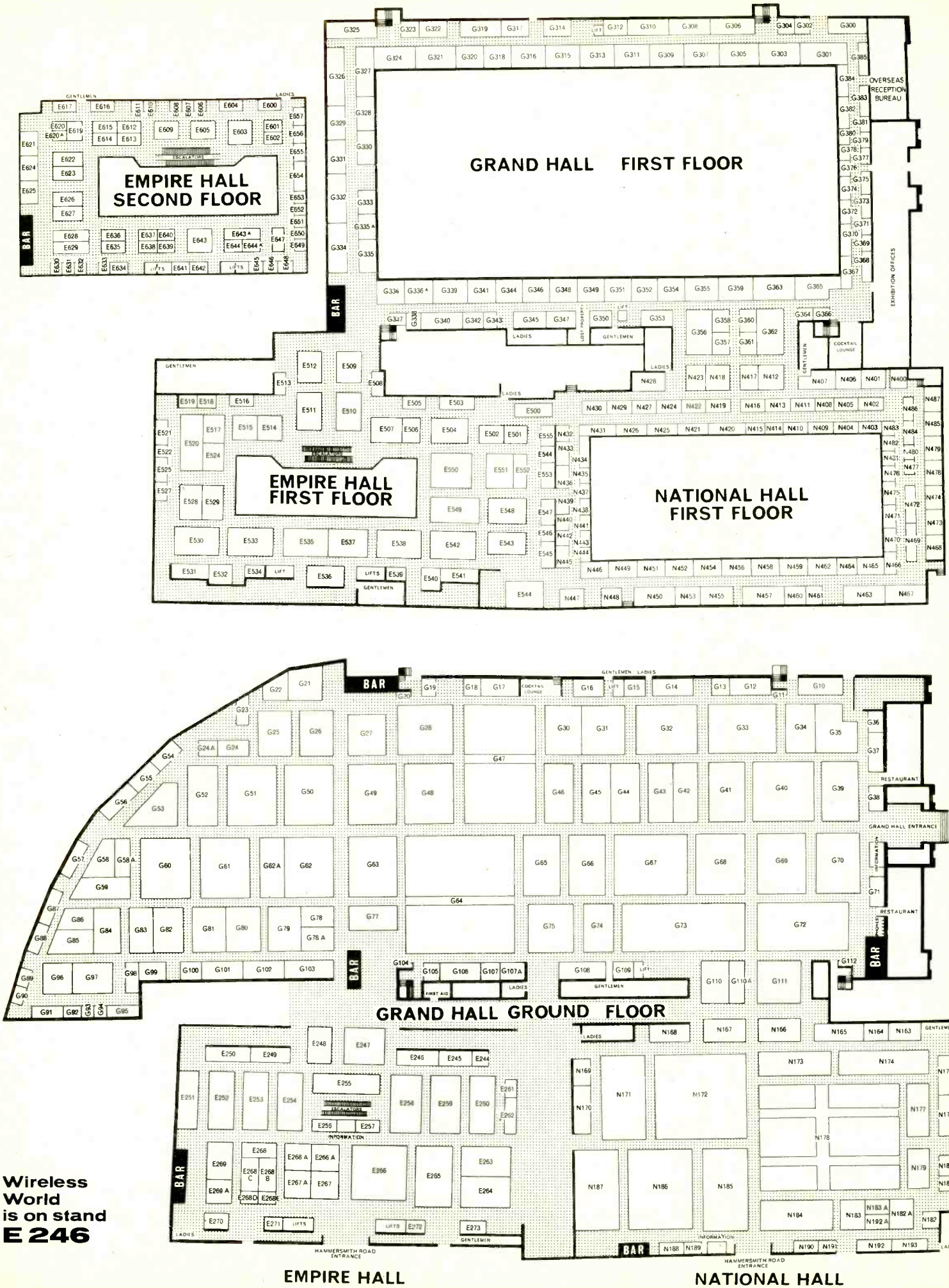

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Letters to the Editor

The Editor does not necessarily endorse opinions expressed by his correspondents

How Important is Detection?

The one disadvantage of Dr. Macario's otherwise admirable "homodyne detector" described in the April issue, is that it fails at the very time when it is most needed; that is, when the carrier level is very low. The synchrodyne, on the other hand, provides a locally regenerated carrier of constant level, but, as Dr. Macario observes, it is subject to phase errors which may cause distortion.

There would seem to be some scope for improvement by means of a system which behaves as a homodyne (in Dr. Macario's sense) when the carrier level is adequate but as a synchrodyne when the level drops. This would minimize noise breakthrough and distortion. My grounds for believing this are as follows. If the oscillator in a synchrodyne were exactly in phase with the incoming carrier then the synchronizing signal could be removed without upsetting the system. No practical oscillator has the required stability, of course, but two important points follow. First, the more stable the local oscillation the less synchronizing signal is needed. Secondly, if the synchronizing signal is removed, the local oscillation does not immediately slip out of phase. A perfectly stable oscillator has, by definition, an infinite "memory" for phase. A practical oscillator has some degree of phase memory, depending on how nearly correct its tuning is. It follows that if a synchronized oscillator is placed after the limiting amplifier in Dr. Macario's circuit it will tend to fill in the gaps of carrier during deep troughs of modulation or fading. The Schmitt trigger will always operate at approximately the correct instants.

Two refinements to this proposal suggest themselves. First, since the oscillator is not required for most of the time, and is a potential cause of phase errors, it would be useful to arrange that when the incoming carrier is strong the tuned circuit is heavily damped. Secondly, since the oscillator's only function in this circuit is to provide phase memory (unlike the synchrodyne, where it has to suppress the modulation as well) it could in principle be replaced by a passive high-Q tuned circuit. The absence of a continuous oscillation would then avoid the tuning-in whistle of the synchrodyne. It is obviously impracticable to make a passive circuit with a sufficiently high Q to cope with relatively long periods of loss of carrier during fading, or even during deep low-frequency modulation troughs: some form of positive feedback (Q multiplying) circuit is required. Common sense suggests that the arrangement most likely to succeed is a circuit which oscillates freely in the absence of an incoming carrier but is progressively damped as the carrier amplitude increases.

With such a system, the receiver operator could forget about synchronization when reception was good, but if fading or distortion manifested itself he could try to improve matters by adjusting the fine tuning control. The degree of improvement obtained in practice would depend on the short-term stability of the high-Q circuit and on the relative phase shifts undergone by carrier and sidebands in the transmission path.

G. WAREHAM

London, W.C.2.

The author replies

Mr. Wareham's ideas are very interesting. We have carried out some experiments with an oscillator synchronized to the incoming signal in the manner suggested, and as Mr. Wareham points out, if the coupling is strong the circuit behaves almost exactly as the circuit described; if the coupling is weak one soon loses lock and moreover if the oscillator is very stable it is extremely difficult to pull it very far, so that one has the dual problem of needing very accurate tuning and a stable local oscillator in the receiver.

By carrier fade I am presuming this is the case of fade relative to the sidebands and consequent overmodulation. This case and that of the total signal fading into the noise were discussed in a short note elsewhere[1], and in the case of overmodulation one can run the synchronizing oscillator at twice the i.f. and it may be shown that, in theory at least[2], this leads to correction of the over modulation effect. However with a strong lock any noise during the signal crossover points tends to cause oscillator jitter and cancel any correction. This again points to the need for a very high Q (stable) oscillator and accurate receiver tuning facility.

We have recently developed some frequency-following carrier selection filters with bandwidths of a few tens of cycles (at 470 kHz) which will enable us to just select the carrier and remember it through a modulation trough, and so avoid having another oscillator in the receiver.

The circuit described in the article is of course broad band and whereas it detects the presence of carrier fade it can do nothing about it. To do something about it one must add more circuits ahead of, or following, the system. Many alternatives suggest themselves, but each will be equally complicated, though equally interesting.

R. C. V. MACARIO

University College of Swansea.

[1] "Homodyne Reception", *Electronics Weekly*, November 15th, 1967.

[2] F. G. Apthorpe (letter) *Electronic Engineering*, July 1947, p.238.

Stereophonic Broadcasts

Mr. David Bailey's somewhat caustic letter about stereophonic broadcasts and the minority interests of serious music listeners, seems to me rather off target. The valid point, surely, is not that the serious music stereophonic broadcasts be curtailed, but that the hours of stereophonic transmission be extended, and include all kinds of source material. After all, the special multiplexing equipment is in service and the present transmissions are compatible on monophonic receivers, so there would seem to be no insuperable difficulty in extending transmission time. This would enable Mr. Bailey's complaint to be met in a constructive way.

While on the subject, I believe that Holme Moss and Sutton Coldfield will soon be transmitting stereophonic programmes, but there will still remain very large areas of the country served with monophonic transmissions only. Presumably the stereophonic service will not be extended in coverage (and probably not in time either) unless there is a public demand that makes itself known to the B.B.C. and the Postmaster-General. May I therefore appeal to other readers to write about extending the service and, when stereo transmissions are introduced, be vociferous in their welcome?

COLIN A. RONAN

Newmarket, Suffolk.

"Invention" of the Transistor

Now that the celebration of the "invention" of the transistor is under way, perhaps it might be fitting to celebrate the 50th anniversary in 1980.

On October 22nd, 1925 and October 8th, 1926, Dr. Julius Edgar Lilienfeld applied for patents concerning a solid-state method for controlling electric currents. The patent was granted on January 28th, 1930 and is U.S. Patent No. 1,745,175. The patent clearly describes what today would be called an n-p-n transistor. Dr. Lilienfeld developed his device and was granted two more patents: No. 1,877,140 on Sept. 13th, 1932 describing an n-p-p-n transistor, and No. 1,900,018 on March 7th, 1933, describing another n-p-n device. He also described the use of a reversed-biased p-n junction as a variable capacitor!

A. J. WATTS

J. H. ORCHARD-WEBB

Exeter.

Letter from America

Radio and electronics shows seem to follow the same kind of pattern on both sides of the Atlantic. For the first few years everyone co-operates and all the sales managers, engineers—even the accountants are happy. Then what happens? First firm A decides that the money spent is not really justified so they pull out. Then firm B begins to have doubts and they reduce the size of their stand to something a bit larger then a 'phone booth and put their money in a lavish exhibition-cum-cocktail party at a neighbouring hotel. The following year they are joined by many other firms who finally decided to move out to opulent hotel suites where they presumably discuss deliveries and dispense technical information over martinis and chicken sandwiches. And so those interested not only have to walk around the stands at the main exhibition but have to make the rounds of the local hotels too!

Although the I.E.E.E. Show held recently in New York's Coliseum was probably larger than last year's, with some 900 exhibitors and 1300 stands, there were signs of dissension. For instance, nearly 100 exhibitors who were there in 1967 did not return. These included several major semiconductor companies. Motorola and IRC led the way last year and it is thought that many other firms will break away and possibly join the extra-mural affairs at hotels like the Plaza, Warwick and Americana next year. However, if semiconductor firms could be said to display a certain lack of interest in the Show, the same could not be said of the instrument firms who occupied the whole of one floor (the exhibition spread over four floors). Some very elaborate equipment was on show including a new solid state phase angle voltmeter with wideband coverage from Gertsch, and a new Recipromatic Counter by General Radio. This instrument has no range controls and it measures the period and automatically computes the reciprocal and displays the frequency on a six-digit read-out. Digital read-out meters were well in evidence and a typical example was the Trymetrics Model 4243 which is a four-digit multimeter with a range up to 999.9 volts and an accuracy of 0.01%. Triolab had a similar instrument with a range of 1mV to 1kV in four ranges plus current and resistance ranges. The input impedance is 10 megohms and accuracy was stated to be 0.1% of reading plus one digit. It is fitted with rechargeable batteries and priced at $895. Instrulab were showing a temperature indicator with digital read-out that should find many applications. Tektronix had a new oscilloscope plug-in amplifier using f.e.t. input stages and Telonic were demonstrating an unusual sweep generator which had an output of 8 watts! Four models are available covering the ranges from 20 to 1000 MHz.

One floor was given over to production equipment and here were automatic soldering conveyors, computer-programmed coil winders and so on. Much space was devoted to printed circuits and one of the most interesting exhibits was a circuit engraver by Graphic Electronics. This machine will make a small quantity of p.c. boards for the cost of the board material only and it runs completely unattended. It works like this: the hand-drawn copy is placed on a scanning cylinder, the machine scans the image, simultaneously cutting a standard epoxy or fibreglass copper-clad blank which is attached to another revolving cylinder. The engraving stylus is tungsten and no chemicals are used. When all the boards are completed, the machine switches itself off. The cost of this machine—called the Directron, is $3,750 which is not unreasonable considering the time it could save. BTU Engineering had a thick-film furnace which could deliver 12,000 circuits an hour! This sort of output has increased the demand for reliable automatic test equipment and there are now several firms specializing in this field. As an example, Teradyne have a computer operated automatic test system which comprises a digital computer teletypewriter and measurement system for i.cs at $65,000. Such a machine can carry out very complex tests extremely quickly—in fact they can test quite complicated circuits in a few milliseconds.

In another part of the Show were sections for microwave equipment, components, materials, complex systems and semiconductors. Mallory introduced a stereo i.c. pre-amplifier — their first venture into this field. RCA had a new unit measuring $\frac{3}{4}$ inch by just over $\frac{1}{4}$ inch with 14 leads. This contained a wideband i.f. amplifier, f.m. detector, and a.f. amplifier and is intended for television or f.m. receivers. The tiny package consists of 14 transistors, 5 diodes, 3 Zeners and 20 resistors! In 1965 total sales of i.cs were $79 million and this year they are expected to reach $325M with a forecast of $500M by 1970. To put these figures into some kind of perspective—the total American sales of all electronics last year was approximately $22 billion and the growth rate is about 6%.

One of the most interesting features of the I.E.E.E. Show is the big programme of lectures. This year there were nearly 300 papers, on a wide variety of subjects, delivered during 60 sessions. Some were so popular that overflow meetings were held in adjoining rooms with C.C.T.V.—naturally!

As already mentioned, the total number of exhibitors was around 900. Of these, 21 were Japanese, 15 Canadian, 12 German and only 6 British. Should more British firms be represented? I would say a definite 'yes' but, of course, the products must be backed by efficient distribution and service; *especially service*.

More on X-ray radiation from colour TV; The Public Health Service recently looked at some 1124 sets and only 66 showed a radiation greater than the accepted standard of 0.5 millirontgen per hour at a distance of 5cm from the set. The main causes of the excessive radiation were shunt regulator valves, rectifiers and the picture tube itself. It was stated that all sets emitting X-rays above the standard level could be corrected by reducing the tube voltage or replacing valves. There is still no agreement on the 'safe standard' and on methods of measurement but optimists hope this will be cleared up at the meetings between the National Council on Radiation Protection & Measurements and the Electronic Industries Association.

Solid state, or varactor tuners have been used in Germany for some time now but problems in channel separation have prevented their adoption here in America. Both Fisher and ADC use varactor tuning on f.m. receivers introduced last year and no doubt similar receivers will appear very soon. Meanwhile, progress has been made with television tuners and several firms will be able to market them within a few weeks. Oak have a model with continuous u.h.f./v.h.f. coverage and Standard Kollsman are working on a similar unit. Varactor diodes are now available with high capacitance swings and it is possible to utilize them in ordinary medium waveband receivers. So the familiar ganged capacitor will soon disappear—but no doubt we will have other problems!

An enormous amount of money is spent on space research by agencies like NASA and —as might be expected—engineers often come up with inventions that find applications in other fields. One of the most interesting of recent 'spin-offs,' as they are called, is due to a Goddard Space Centre scientist, Edward Thomas. This invention is a reversible fuse or circuit breaker that might well replace conventional type fuses. It consists of a special epoxy resin impregnated with silver-plated copper particles and at operating temperature the particles are in close contact and resistance is about 0.1 ohm. At higher temperatures the expanding epoxy separates the metal particles and the resistance increases sharply to something like a megohm.

G. W. TILLETT

World of Amateur Radio

Beginners' Licence Coming The P.M.G. announced on March 11th, that a new "Beginners' Licence" is to be introduced in the autumn. The details have not yet been settled but its stated purpose is to encourage interest in amateur radio in people, especially young people, who have not yet reached the standards of qualification needed for a Class A or Class B licence. The new licence will, presumably, be valid for a short period only (possibly 12 months), after which time the holder will be required to qualify for a Class A or Class B licence. A Novice licence has been available in the United States for several years but it is by no means certain that it has proved very successful. It is doubtful whether the introduction of a "Beginners' Licence" will be welcomed by many U.K. amateurs of long standing, few, if any, of whom have been invited to express an opinion on the idea. It is generally felt that the Class B licence, which permits telephony operation above 427MHz, goes far enough to meet the wishes of those who, although technically competent, are not able to pass a Morse test at 12 w.p.m. This view is further strengthened by another announcement by the Postmaster General that holders of the Class B Licence will shortly be authorized to operate in the 144-MHz band. Regular users of this very popular band will watch this development—erosion it has been called—with interest.

Reason for Scarcity

It has always been difficult for European radio amateurs to understand why certain parts of the United States are harder to contact than others. Especially is the "scarcity" apparent in the case of those who aspire to qualify for the Worked All States (WAS) Certificate issued by the American Radio Relay League. A recent census of amateur radio licences in the United States reveals that Wyoming (539), Delaware (619), North Dakota (755), Nevada (789) and South Dakota (789) have the lowest number of licensed amateurs per state with the District of Columbia recording 734. In contrast California (Sixth District), with 39813 licensed amateurs, outnumbers even the combined strength of New York (24438) and New Jersey (13049) which, together, form the U.S. Second District. The eight Southern States, which form the Fourth District, are placed third with a total of 36978 of which number, Florida alone accounts for 10165. Other five-figure totals are recorded in Massachusetts (11276), Pennsylvania (15067), Texas (15166), Ohio (16274), Michigan (10195) and Illinois (15444). At the time of the census, (published in the Autumn 1967 edition of "The Radio Amateur Call Book") there were 284,439 licensed amateurs in the U.S.A. and 137,038 in the rest of the world.

Transarctic Expedition.—The experimental station call sign G7AE is being used by a group of well-known British amateurs who have been authorized by the British Post Office to maintain contact with Sir Vivian Fuchs' British Transarctic Survey Expedition base station MPE. Telegraphy operation takes place on 13999 kHz on Saturdays and Sundays from 09.30 GMT.

New World Record on 13 cm.—Radio communication by amateurs over a record distance of 274km (209 miles) on a wavelength of 13cm (2300MHz) was achieved by the Swiss station HB9RG and the West German station DJ4AU on January 21st. Communication was established on telephony (s.s.b.) and telegraphy. The previous record distance for the 13-cm band was 170 miles established by two U.S. amateurs in 1963.

Mobile Rallies—Clash of Dates.—Due to an unfortunate clash of dates two of the best-known and most popular Mobile Rallies of the summer season are to be held on the same day—Sunday, June 30th—one at Longleat Park, near Frome, Somerset, and the other at the U.S. Air Force Base at R.A.F. Mildenhall, Suffolk. The former event is being organized by the Bristol Group of the R.S.G.B. and the latter by the Amateur Radio Mobile Society.

U.K.-France reciprocal licensing agreement has been concluded permitting the radio amateurs of one country to operate in the territory of the other. Application forms for a French reciprocal licence in the series F0, are available, on receipt of a stamped and addressed envelope, from the General Manager, Radio Society of Great Britain, 28 Little Russell Street, London, W.C.1. Mr. Gerald Lander, G3OOH, of Peacehaven, Sussex, and now licensed to operate as F0FR, was the first U.K. amateur to obtain a French reciprocal licence.

South Yemen.—Aden and the rest of the South Arabian Federation was granted Independence as the People's Republic of South Yemen on November 30th, 1967, and became the 123rd Member of the United Nations on December 14th, 1967. Radio amateurs in the new Republic are now operating under the prefix 7O. Included in the new Republic are Kamaren (formerly VS9K) and Perim (formerly VS9P) as well as Socotra (formerly VS9S), now part of the Sultanate of Qishn, and Kuria Muria (formerly MP4M) now part of the Sultanate of Muscat and Oman.

Botswana has a new Prefix.—Radio amateurs in Botswana, formerly Bechuanaland, will, in future use a prefix in the block 8OA to 8OZ instead of the prefix ZS9. The change has been authorized by the International Telecommunication Union at the request of the Botswana Government.

V.H.F./U.H.F. Convention.—The 14th Annual International V.H.F./U.H.F. Convention organized by the Radio Society of Great Britain is to be held, for the second year in succession, at The Winning Post Hotel, Whitton, Twickenham, Middlesex, on Saturday, April 27th. Manufacturers are providing an exhibition in the morning, followed in the afternoon by a lecture session and a new feature called "shop window" when trade exhibitors will discuss their products. The Convention will conclude with the customary banquet and raffle. The all-in price has been fixed at 30s. or 25s. 6d. for the dinner only. The organizing secretary is Mr. Frank Green, G3GMY, 48 Borough Way, Potters Bar, Herts. Ladies will be welcomed at the banquet.

GB Call Signs.—United Kingdom radio amateurs who wish to set up special stations at exhibitions, mobile rallies and the like or who wish to operate as an expedition may obtain a special licence in the GB series upon application to the G.P.O. Every effort will be made to issue a call-sign to suit the event. Applicants for a GB licence should state a preferred letter group and give an alternative. Simultaneous operation on two or more frequency bands is permitted when specially requested.

VERON Radio Camp.—Visitors to the Netherlands during Whitsun (May 31st—June 3rd) will be warmly welcomed at the annual radio camp organized by the Dutch national amateur radio society. A special station (PA6AA) will be on the air continuously on all bands and modes. Details from W. H. Kerstens, PA0UHS, Nachtegaalspad 2, Arnhem, Holland.

Australis Oscar.—Further to our report in the December 1967 issue we now understand that the satellite is likely to be launched in June. More accurate details cannot be given as such information carries the "classified" tag until after the launch. Special report forms are still available from W. Browning (G2AOX), 47 Brampton Grove, Hendon, N.W.4, on receipt of an S.A.E.

JOHN CLARRICOATS G6CL

New Products

Differential Operational Amplifier

Amplifier series 183 by Analog Devices of Kingston-upon-Thames are chopperless differential operational amplifiers designed to solve problems where low drift, very low noise, low thermal intertia, predictable low term stability and low cost are primary considerations. Because no single operational amplifier can meet all the widely divergent specification requirements without becoming expensive, the 183 is not recommended for applications involving signal manipulation from sources with more than 100kΩ imbalance, or in applications involving fast slew rates and fast settling time.

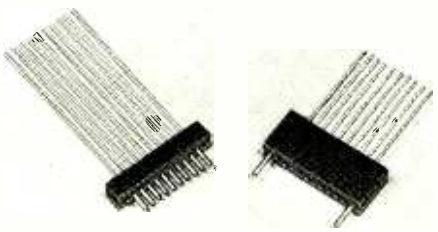
Special transistors and thermal design techniques are used to reduce the effects of thermal gradients, and long term drift due to resistor ageing is overcome by the use of high stability metal film resistors. Stabilities of better than 100μV/year are obtainable, and warm-up drift is less than 20μV. The 183 series can be connected to give gain without change of sign and used in this mode

the amplifiers will have an impedance of 1,000MΩ. Principal features are: open loop voltage gain 2 × 10; output 20V p-p at 5mA; initial voltage offset 0.5mV(max) at 25°C; input impedance 2MΩ and common mode impedance 1,000MΩ. Common mode rejection is 100,000 and common mode voltage range is ± 10V(min). Analog Devices Ltd., 38-40 Fife Road, Kingston-upon-Thames, Surrey.

WW 314 for further details

Microminiature Connector

Available in strip configuration with 1 to 40 pin and socket contacts on 0.025-in centres, a new connector by Cannon (which they call the "Nano") has been designed for applications where



extremely close centres are necessary. It is claimed to be the smallest connector of its type in the world.

Straight-through construction of contact area to termination point eliminates unnecessary electrical interfaces and the contact alignment design assures positive mating of the pin and socket contacts. These are of the twisted-pin type used throughout the Cannon microminiature range. Corrosion-resistant metal alloys are employed in the contact construction and the connectors are available with standard pigtails for easy termination to printed circuit boards, modules or flat conductors. Rated at 1A, the contacts can be preharnessed at the Cannon factory to customers' specifications. Cannon Electric (Great Britain) Ltd., Lister Road, Winchester Road, Basingstoke, Hants.

WW 311 for further details

D.C. Bench Units

Designed around the two basic criteria that the performance should be sufficient for a multitude of engineering applications and that this performance should be achieved at the lowest practical price, Liberty Controls stabilized bench supplies type A1025 and A2025 have a fully variable output with overload protection and cost £32 and £39 respectively.

The units have identical specifications except in respect of output current. Maximum output current of the A1025 is 1A and that of the A2025 is 2A. Output voltage is variable from 0-25V and output resistance is less than 0.015Ω. Output impedance below 300kHz is less than 0.4Ω. Ripple and noise is less than 2mV peak-to-peak

and stabilization ratio is 2,000:1. Input voltages are single phase 210-250V or 100-125V, 45-55Hz. Dimensions 12 × 8 × 8in; weight 13lb. Two modular variants of the units less meters are available, type AC1025, £27, and type AC2025, £33. These have the same electrical specification as type A but the physical design is modified. Liberty Controls Ltd, Cadwell Lane, Hitchen, Herts.

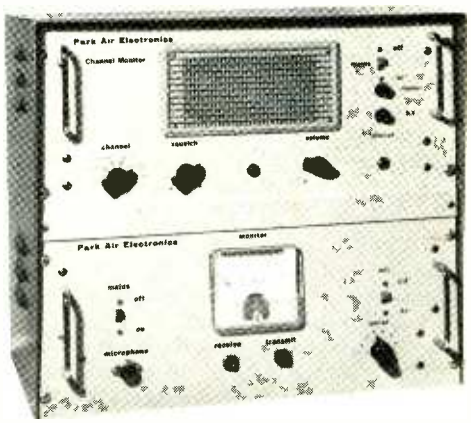
WW 318 for further details

Aero Band Equipment

Two items announced by Park Air Electronics are, a higher power version of their 50X v.h.f. a.m. aeronautical band transmitter and a new portable mobile receiver for the v.h.f. aeronautical band.

Type 100X transmitter has an r.f. output of 20W and is complete with power supply and modulator. It has a frequency coverage of 118-156MHz and is intended as a compact transmitter for use by airport authorities in conjunction with existing receivers, or with the Park Air model 60A receiver system. The assembly is available in either cabinet form or for 19-in rack mounting.

Type 40A receiver is a crystal-controlled portable receiver for the v.h.f. aeronautical band designed for simple operation by unskilled personnel. All silicon solid state circuitry is used and it is claimed that input signals of 1μV or less can be resolved. Audio power delivered to the built-in loudspeaker is 0.5W. The 40A incorporates its own internal power supply, but provision is made for the connection of an a.c. mains auxiliary power unit if required. A telescopic aerial is included and provision is made for using an external aerial. Of die-cast aluminium construction, the receiver is complete with carrying handle and measures



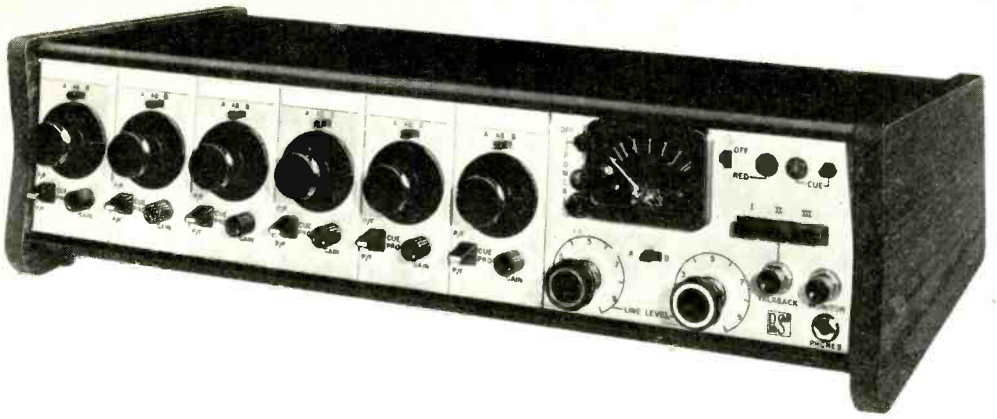
27.5 × 17.5 cm. Weight including batteries is 2.3kg. Park Air Electronics Ltd., Red Lion Square, Stamford, Lincs.

WW 312 for further details

Modular Sound Mixers

Specific requirements of smaller broadcasting organizations and recording studios, are met in a new six-channel modular mixer offered by Peto Scott. The mixer may also find use in other applications, particularly in education establishments, where it is desirable to use multiple microphone channels to select individual voice sources in order to overcome the problem of extraneous unwanted noise in classrooms.

By adopting a modular unit method of construction, it is possible to assemble the mixer to provide a required number of channels for a wide variety of installations, either in a free-standing desk top enclosure or for assembly into existing consoles. A rack mounting version is also available. Features include, up to 20 pre-amplifier input channels, variable pre-set gain, two independent group output channels, peak programme meter, full pre-fade and monitoring facilities, loudspeaker muting,



forward and reverse cueing and talkback to three studios. All modules use transistors throughout.

The provisional specification shows an overall frequency response of 40Hz to 15kHz ±3dB and 100Hz to 8kHz ±1dB. It is emphasized, however, that the upper limits of the frequency response curve can easily be tailored to suit particular circumstances. For example: recording studios may require the h.f. response to be extended to 20kHz or even higher, whereas broadcasting organizations may require the high frequencies to be attenuated in some circumstances. It is the flexibility of the design which the makers consider is of importance to the user, particularly where *ad hoc* studio control facilities are often required at short notice.

Overall distortion is <0.5% at +6dB output, and overall gain 100dB nominal. Input to the preamplifier modules is 600Ω or 150Ω, and two completely independent output channels from the line amplifier module can be 600Ω or 150Ω each. Mains supply voltage is 115 or 230 V 50Hz. Peto Scott Ltd, Addlestone Road, Weybridge, Surrey.

WW 324 for further details

D.C. Comparator Bridge

Made in Canada by Guildline Instruments Ltd., and distributed in the U.K. by Claude Lyons, type 9920 d.c. comparator bridge is particularly suitable for comparison of resistors of 1,000Ω and below, and for the scaling of low resistances, under which each resistor functions at its own power level. For example: a 1Ω standard resistor carrying 100mA and dissipating 0.01W may be directly compared to a 0.001Ω shunt carrying 100A and dissipating 10W, to an accuracy of 1 part per ten million. Accuracy is dependent only on the linearity of a transformer turns ratio, and calibration is permanent. The design completely eliminates the effects of thermal e.m.fs, lead resistance and switch contact resistance. No critical resistors are used. Internal power supplies provide currents of one and two amperes respectively, and an external power supply delivering up to 100A is provided. Claude Lyons Ltd., Instruments Division, Hoddesdon, Hertfordshire.

WW 303 for further details

Wide Range Sound Spectrograph

Kay Electric of New Jersey say they have adapted the proven techniques of previously produced spectrographs and introduced them in the new model 7029A which is claimed to have the wide range of 5 to 16,000Hz. It is a solid state

unit offering a choice of sonogram time scale to enable short duration sound or signals to be expanded and longer signals or phrases to be compressed. Printed circuitry is employed with plug-in modules allowing all systems to be housed in a single compact cabinet. Plug-in units can be used to provide a wide variety of analyses. The standard filter can be interchanged with plug-in filters to provide a wide range of widths for more demanding analyses. Tape recorders having a good mechanical "pause" feature can be synchronized by a start-stop control on the spectrograph. Kay Electric Co., Maple Avenue, Pine Brook, New Jersey, U.S.A.

WW 307 for further details

A.C. Digital Voltmeter

Digital presentation of the true r.m.s. value of any input without respect to the waveform is the claim made by Fluke International for their model 9500A automatic a.c. voltmeter. The new instrument accepts voltages from 0.001 to 1,100V r.m.s. in five ranges, and accuracy is said to be ±0.05% from 50Hz to 10kHz. Range selection can be automatic or manual. A crest factor of 10 virtually eliminates effects from voltage spikes or pulse trains, and a low capacitance, high resistance input minimizes loading effects. Frequency response is 20Hz to 700kHz. Calibration is automatic when the instrument is turned on. On-line calibration is either automatic or manual, selected by a front panel control. Complete remote control is possible if required. Fluke International Corporation, P.O. Box 102, Watford, Herts.

WW 322 for further details

Magnetron Power Supplies

Power supply equipment designed to operate 2,450MHz continuous wave magnetrons is available from Hirst Electric in two basic forms, a "P" series for general industrial applications, and an "M" series for lower power applications such as microwave ovens etc. Both types have the magnetron heater transformer supplied as a separate unit to allow for positioning in close proximity to the magnetron and they are thyristor controlled.

Phase angle in the e.h.t. primary circuit is advanced gradually so that the applied voltage to the e.h.t. transformer is "ramped up", thus avoiding non-synchronously applied mains inrush current. The magnetron is not shock excited by the sudden application of full e.h.t., which is conducive to longer life.

The "M" series is supplied in module form, allowing the equipment manufacturer choice of layout, and consists of control chassis, e.h.t. transformer, e.h.t. rectifier and series impedance resistor. The control chassis is fitted with an 18-way plug and socket for wiring to interconnection diagrams supplied. The "P" series is supplied complete in a case with front panel instrumentation. Hirst Electric Industries Ltd., Gatwick Road, Crawley, Sussex.

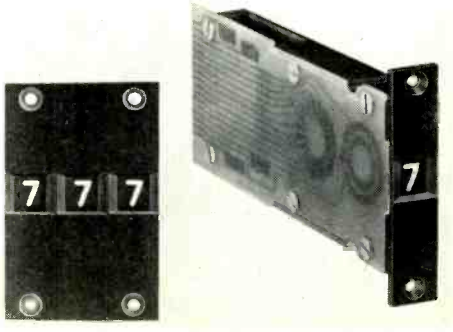
WW 313 for further details

Module Counter System

An advanced single-wheel counter module system, consisting of three basic modules: the series 7049 counter unit, series 7050 predetermining counter unit and series 7051 switch unit, comes from Veeder-Root. Used either singly or in combination, these decade module units can provide practically any counting configuration requirement. They can be supplied in back-of-panel or panel mounting arrangements, and being of standard width, can provide tailor-made set-ups. If required, specially made-up unit combinations can be supplied to specific applications.

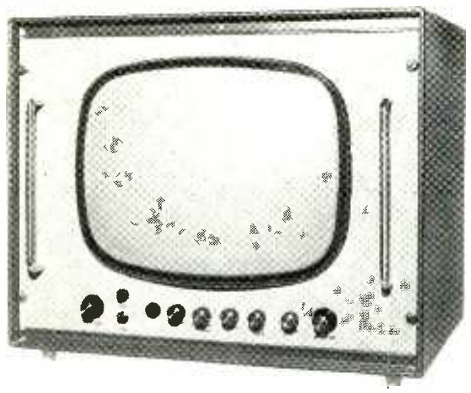
Large read-out figures, gold-plated printed circuit, positive non-overthrow, magnetic circuit, and silver contacts are some of the features, with 2,400 c.p.m. speed for the counter modules. The 7049 counter unit measures approximately 4.35in. deep × 2.38in. high × 0.5in. wide, the 7051 single-pole 10-position switch unit has similar height and width but is 2.8in. deep and the 7050 predetermining counter is 4.35in. deep × 3.8in. high × 0.5in. wide. All units operate on 12, 24, and 48V d.c. Veeder-Root Ltd, New Addington, Surrey.

WW 319 for further details



Video Monitors

Plug-in sub-chassis construction is a feature of a new range of valve type television monitors announced by J.D. Jackson Electronics. Designated M14/V1, M16/V1, M17/V1, M19/V1 and M23/V1, each size of monitor uses three standard chassis which enables a service replacement scheme



to be operated. The M14/V1 (illustrated) measures $19\frac{3}{4} \times 16\frac{1}{4} \times 14\frac{3}{4}$in. and this model in common with the M16/V1 and M17/V1 is available in a rack mounting version.

Designed for 525/625 lines, 50/60 field scanning standards, the video monitors have a bandwidth of 8MHz and an input impedance of 75Ω or higher. Signal-to-noise ratio is 40dB. The plug-in sub-chassis comprise (1) line and field timebases, (2) video amplifier, and (3) power supply unit. Operation is from 115 or 230V 50-60Hz a.c. mains supply. J.D. Jackson Electronics, Egglestone Works, Lombard Street, Newark-on-Trent, Notts.

WW 308 for further details.

Power Transistors

Two low-cost germanium power transistors announced by Motorola are suitable for television deflection circuits and industrial power supply designs. They are types MP3730 and MP3731, priced at 9s 6d and 12s 6d respectively for quantities of 100.

Both devices are capable of 56 W and will operate in temperatures up to 110°C. The 320V type MP3731 is capable of providing efficient operation in 1kW output invertor designs with frequency regulation changes no greater than 20% over a 6:1 input voltage variation. The devices are packaged in TO3 cases. Motorola Semiconductors Ltd, York House, Empire Way, Wembley, Middx.

WW 320 for further details

Audio Mixer

Designed specially for location recording with quality tape recorders, a new four-channel portable mixer model 2880 by Sela, of Stockholm, is now available from their U.K. agent, Carston Electronics. The mixer can be powered from mains or battery, and the four balanced transformer microphone inputs are able to accept outputs over

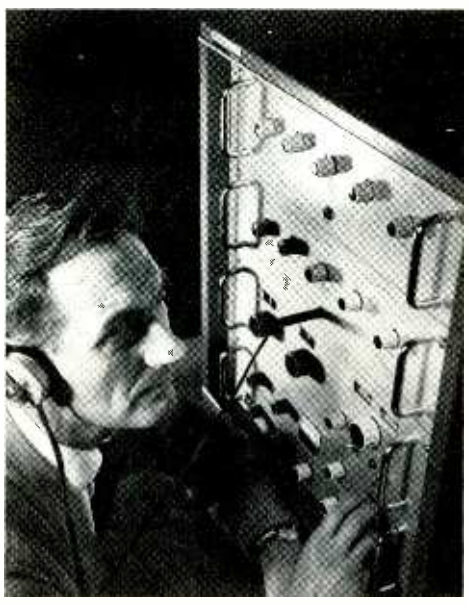
a wide range of levels from moving-coil or capacitor microphones with impedances from 50 to 200Ω. A five position 0 to −25dB attenuator provides control over input levels from 10 mV maximum in the −25dB position. Input impedance measured at 1.5kHz is 3.8kΩ and noise level is better than −125dB at 170Ω. Frequency response is within 0.5dB from 40Hz to 16kHz and 5dB down at 20kHz. Distortion is less than 0.1% at normal level and better than 0.2% at maximum output. Features include ±10dB bass equalization at 100Hz and ±10dB treble equalization at 10kHz. Designed to be carried by hand, the Sela mixer weighs 12lb and costs £225. Carston Electronics Ltd, Electra House, Wiggenhall Road, Watford, Herts.

WW 327 for further details.

Professional Communications Receiver

Marconi announce a completely new h.f. communications receiver for international point-to-point links which, they believe, has unbeatable performance and reliability for its size and cost. Named Hydrus, the receiver is a compact and versatile equipment designed for operation in a wide range of transmission modes. Extensive use is made of f.e.ts, in the solid state circuitry chosen because of their advantage over conventional transistors of reduced damping effect on timed circuits, by reason of their high input and output impedance.

Although there are many versions of the receiver available, a dual diversity Hydrus, with



independent sideband facilities handling two separate channels, will cost approximately £3,500. Other standard versions cost less. The receiver covers the 1.5 to 30MHz band in four ranges. Tuning is by decade switches followed by a continuously variable final tuning control. A sophisticated a.f.c. system locks on to signals drifting up to ± 250Hz. A.g.c. circuits operate over a 90dB variation of signal strength, controlling the output to within 6dB.

Component stability is said to provide for long periods of unattended operation on "main line" telephony and telegraphy circuits. Fast re-tune by decade switching in 0.1MHz steps, facilitates rapid operating and an interpolating variable oscillator, covering 100kHz between these decade steps, is calibrated directly with the signal frequency on the front panel. The set comprises three basic units; a receiver unit, a synthesizer and a telegraphy/telephony unit.

These units are mounted in 19 in. wide cabinets, $5\frac{1}{4}$ in. high, for fitting into a bench mounted cabinet for single receiver installations, or into free standing cabinets for more extensive set-ups. For servicing purposes the units can be drawn out on extension runners. Operating power requirements are 100-125V and 200-250V, 45-65Hz single phase a.c. ± 6%. Over 300 different versions of the receiver can be supplied. The Marconi Co. Ltd., Chelmsford, Essex.

WW 315 for further details

Measuring Instrument

A highly sensitive centre reading instrument combining the functions of voltmeter, ammeter and null detector, the M.L. nanoammeter and microvoltmeter permits accurate readings as low as 5×10^{-6}V and 5×10^{-9}A (0.005μA). Twelve ranges of voltage from 100–0–100μV to 30–0–30V, and twelve ranges of current from 100–0–100nA to 30–0–30mA are selected by a multi-way switch on the front panel. Generous overload conditions exist on all ranges and a floating input is provided, with a common mode rejection of better than 100 dB. The instrument can be used on a.c. supplies of 100-125V and 200-250V. M.L. Industrial Products Ltd., Electronics Division, 292 Leigh Road, Trading Estate, Slough, Bucks.

WW 306 for further details

Transistors for Aerial Amplifiers

Three new silicon planar n-p-n transistors specially developed for use in television and f.m. receiver aerial amplifiers have been announced by Mullard. Types BFW16, BFW17 and BFW30, they can also be used in applications which have severe intermodulation requirements such as wideband amplifiers for telephony or wideband amplifiers for oscilloscopes. Common features are a high gain with a high f_T (1.6GHz for the BFW30) and a very low intermodulation factor. Mullard Ltd., Torrington Place, London W.C.1.

WW 310 for further details

Rebuilt Colour C.R.T.

The successful rebuilding of a 25-in domestic colour TV tube by Vacuonics is believed to be the first operation of its kind by an independent firm in the U.K. It is envisaged that rebuilt tubes of this type will cost about half that of a new one and, because the tube is the most expensive single item in a colour receiver, it should represent a considerable saving in cost to the customer. Because the materials required for the process were unobtainable in Europe the necessary components were supplied by Griffiths Electronics Inc., Linden, New Jersey, U.S.A., through their agents in this country the C.E.A. Group of Birmingham. Vacuonics Ltd., Newtown Street, Old Hill, Staffs.

WW 317 for further details

Digital Voltmeter

This integrating digital voltmeter (500 Mk II) incorporates an integrated-circuit amplifier, has a basic accuracy of 0.2% of f.s.d. and a zero drift typically better than two least significant digits per eight hours in normal environments. The instrument, which employs a f.e.t. input stage in the input chopper-stabilized amplifier, can tolerate inputs of up to 1 kV on all ranges without damage; common-mode rejection is better than 120 dB. Output readings are displayed on decade number tubes and decimal-point indicator lamps. A 10% over-range facility extends the scale length

to 1100 on all ranges. Four ranges are incorporated from ±1 V to ±1000 V d.c., the input resistance is > 10 MΩ (> 1 MΩ on the 1 V range). An internal calibration standard has an accuracy of ±0.001%/year. The price is £120. Weir Electronics Ltd, Durban Road, Bognor Regis, Sussex.

WW 325 for further details

High-dissipation Isolated-can Transistors

In the quest for high-dissipation in small packages, transistor manufacturers generally attach the active element to the device casing. "Live can" devices of this sort have proved an embarrassment to users over the years because they can cause accidental circuit shorts. Newmarket Transistors Ltd, Exning Road, Newmarket, Suffolk, have developed a technique by which they eliminate the fine-wire connections to the transistor emitter and collector, which have previously limited the permissible power dissipation, and have left the base connection isolated from the device case. The resultant device has no electrical connection to the transistor element other than through the connection leads. One example of this is the Newmarket ACY 17–21 (NKT237–241) series of germanium, p-n-p, TO5, 1-A, low-frequency transistors.

WW 323 for further details

Lightweight Magnetrons

A lightweight, X-band, pulsed magnetron is available from Mullard for use in small marine radar installations. It weighs 456 g and has a smooth outline, eliminating moisture traps. The magnetron (type YJ 1240) will deliver a peak output power of 900 W, its low anode voltage, 2 kV, means that it can be used in solid-state equipments without much difficulty. Operating frequency is 9.345–9.405 GHz and the rate of rise of the pulse voltage is 100 kV/μ s. Mullard Ltd, Mullard House, Torrington Place, London W.C.1.

WW 301 for further details

Also from Mullard an X-band magnetron intended for airborne long range radar for operation at altitudes of up to 25,000 ft is the type YJ 1250. Weighing 1.9 kg it can be used with pulses of up to 6μ s duration at a peak output power of 90 kW. It has a permissible anode voltage of 15 kV and a long life cathode that will give a minimum of 5000 operating hours.

WW 302 for further details

Miniature Potentiometer

A low cost, single-turn potentiometer intended for industrial applications has been introduced by Bourns (Trimpot) Ltd, Hodford House, 17/27 High Street, Hounslow, Middlesex. The potentiometer, model 3365, is 0.5 inches in diameter by 0.225 inches long and is available in two printed-circuit mounting styles. Rated at 0.5 W at 40 °C the potentiometers are available from 10 Ω to 50k Ω and are capable of operating in the temperature range −55 °C to +105 °C. The standard resistance tolerance is ±5% with a resolution of 0.09 to 0.88% and a temperature coefficient of 70 parts per million per °C. Price for quantities around the 200 mark are 19s 5d per piece.

WW 304 for further details

Laboratory Capacitors

Two precision capacitance boxes with very low residual capacitance and a high accuracy setting capability are available from J. J. Lloyd Instruments, Brook Avenue, Warsash, Southampton. The first instrument, known as type PVC 1 is a triple-range, air-spaced capacitor with a minimum

setting of 5 pF inclusive of strays. The capacitor dial has a slow-motion drive and each range is calibrated directly in pF inclusive of residuals. A double scale is incorporated to indicate either absolute capacitance when the instrument is used in the floating two-terminal mode or for three-terminal use with one terminal connected to the screen. The capacitance ranges covered are 5–50, 15–105, and 30–200 pF and the accuracy at 20 °C is ±0.5% or ±0.5 pF; d.c. working voltage is 700 V. The second capacitor box, type PVC 2, has a single-range air-spaced capacitor directly calibrated in pF and fitted with a slow-motion dial. It also has a single decade of aged silver-mica capacitors to extend the range up to 1100pF (minimum setting 15 pF). The accuracy is again ±0.5% or ±0.5 pF; d.c. working voltage is 500 V.

WW 321 for further details

Differential Data Amplifier

An encapsulated differential data amplifier suitable for use with load cells, resistive strain-gauge bridges and thermocouples that can be soldered directly on to printed-circuit card is available from Analog Devices, 38–40 Fife Road, Kingston-on-Thames, Surrey. The amplifier (model 601) is fully screened and guarded—the guard shield being driven by an operational amplifier to give common-mode rejection of 40 × 10⁶. The gain is variable from 20 to 2000 with an accuracy of 0.01% and a stability of better than 0.02% per month; temperature coefficient is 0.003%/°C. A d.c. linearity of better than 0.2% is claimed. Frequency response is within 1% up to 1 kHz and is 3 dB down at 30 kHz; harmonic distortion is less than 0.05% for all frequencies up to 2 kHz. The output settles to 0.1% in 100μ s for a full-scale input step. Wideband noise from d.c. to 50 kHz is 4μ V r.m.s. referred to the input plus 1 mV referred to the output.

WW 309 for further details

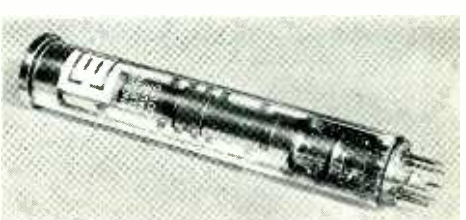
Heat Absorbers

Soldering accessories now available from Henri Picard & Frere include heavily-insulated heat absorbers for protecting delicate components during soldering. Two sizes are available. One type, 34L, is 2.75 inches long and is made of plated steel with copper jaws. The other, type 34S, is only 1.25 inches long, and is made entirely of a highly-conductive copper alloy.

WW 326 for further details

Electrostatically Focused Vidicons

A new range of vidicons which incorporates a gun structure for electrostatically focusing the electron beam is available from English Electric Valve Co. Ltd. These electrostatically-focused vidicons are for application where small camera size and low power consumption are important. Because there is no magnetic focusing field the strengths of the deflection fields can be as little as one quarter of those normally required. Low power (95-mA) heaters are also used. The construction of the vidicons is such as to allow deflection coils to be mounted directly on the glass bodies, further reducing camera size. The use of electrostatic focusing gives freedom from the "S" distortion and focus-induced image rotation normally associated with magnetic focusing, thus making this type vidicon suitable for multi-tube colour cameras. A uniform "beam landing" characteristic provides good signals from the whole picture area. An example of the tubes in this range is the 8134VB which has a high blue sensitivity intended to overcome the difficulties normally associated with tungsten filament lighting.



WW 305 for further details

Literature Received

E.E.A. Capacitor Guide is the first of a series of publications to be produced by the Central Technical Committee of the Electronic Engineering Association. The publications will be, as this one, in the form of guides on the use of electronic components, the aim being to improve the reliability of electronic equipment by assisting in the choice of components. Each guide will consist of a résumé of the salient features of a particular component family It will discuss physical construction emphasizing points that the designer should bear in mind while making a choice and it will give workshop notes on assembling the components into equipment. The Capacitor Guide classifies components by dielectric into the following groups: paper, plastic film, mica, ceramic and vitreous, and electrolytic—including "solid" aluminium and tantalum capacitors. Copies of the publication (price 15s) are available from the Information Office, Electronic Engineering Association, Berkeley Square House, Berkeley Square, London W.1.

Mullard have published the 1968 edition of their **Data Book;** this differs on three counts from previous issues. For the first time it embraces the complete ranges of the company's valves, c.r.ts, semiconductors and components for entertainments applications. The main sections have been made easily distinguishable by using different coloured pages for each of them. Also for the first time, it has been decided to make the book available to electronics enthusiasts outside the trade, through the dealers at a retail price of 3s 6d. Equivalents and replacement types are given for valves, c.r.ts and semiconductors.

W.W. 340 for further details

A 120-page booklet giving full data on all the **E.E.V. vacuum capacitors** currently being produced is available from the English Electric Valve Co., Chelmsford, Essex.

W.W. 341 for further details

We have received a leaflet entitled "Systemised Products" from **Vero Electronics Ltd.,** Industrial Estate, Chandler's Ford, Eastleigh, Hants., that describes the various forms of equipment practice available from them. Also included is a summary of other products in the Vero range.

W.W. 343 for further details

The 1968 **condensed catalogue** from Westinghouse Semiconductors, 1-3 Regent Street, London S.W.1, gives abridged data on transistors from low current plastic encapsulated devices to a 250 A power type. Data is also given on s.c.rs, rectifiers and rectifier assemblies.

W.W. 344 for further details

Technical Bulletin No. 4 from Bakelite Xylonite Ltd., Manningtree, Essex, discusses a new **electrical grade of Bexphane E.** This is a balanced biaxially orientated polypropylene film developed as a capacitor dielectric. The bulletin summarizes the features and advantages of the film and gives details of electrical and physical properties and yield data.

W.W. 345 for further details

We have received a catalogue describing servo-control, induction, reluctance and hysteresis **synchronous motors** from Amphenol Ltd., Thanet Way, Whitstable. Each of the four types of motors is available with one of twenty standard gear trains from 0.67 to 1800 r.p.m.

W.W. 346 for further details

Palladium, lightest of the platinum-group metals, has a large number of applications from dentistry and jewellery through to electronics. Facts pertaining to palladium are contained in a 20-page booklet produced by International Nickel Ltd., Thames House, Millbank, London S.W.2.

W.W. 347 for further details

The **one-inch vidicon tubes** being manufactured by E.E.V. are described in a twelve-page brochure available from the English Electric Valve Co., Chelmsford, Essex. The vidicons are suitable for a wide range of applications in broadcasting, process control and military fields.

W.W. 342 for further details

A compound for applying to the threads of nuts and bolts ensuring that they can later be easily dismantled is described in the leaflet "Kern Antionic Compound" available from Special Product Distributors Ltd., 81 Piccadilly, London W.1. The compound resists corrosion and is effective in the temperature range $-212°$ to $+1642°C$.

W.W. 348 for further details

Details of a **25-A thyristor,** type 27TX, are given in Technical Publication 26-127 available from the Westinghouse Brake and Signal Company Ltd., 82 York Way, Kings Cross, London N.1.

W.W. 349 for further details

Magnetic pick-ups that produce an electrical output when brought into close proximity to moving ferrous objects are discussed in a leaflet from Trio Instruments Ltd., "Allington", Dartford Road, Farningham, Kent.

W.W. 350 for further details

The **Audio Equipment Catalogue** produced by R.C.A. consists of 155 pages describing the range of professional audio equipment produced by the company. Details are given of microphones, consoles, custom made audio equipment, amplifiers, power supplies, racks and accessories, turntables, tape recording equipment, loudspeakers and test equipment. Broadcast and Communications Products Division, Radio Corporation of America, Camden, New Jersey, 08102.

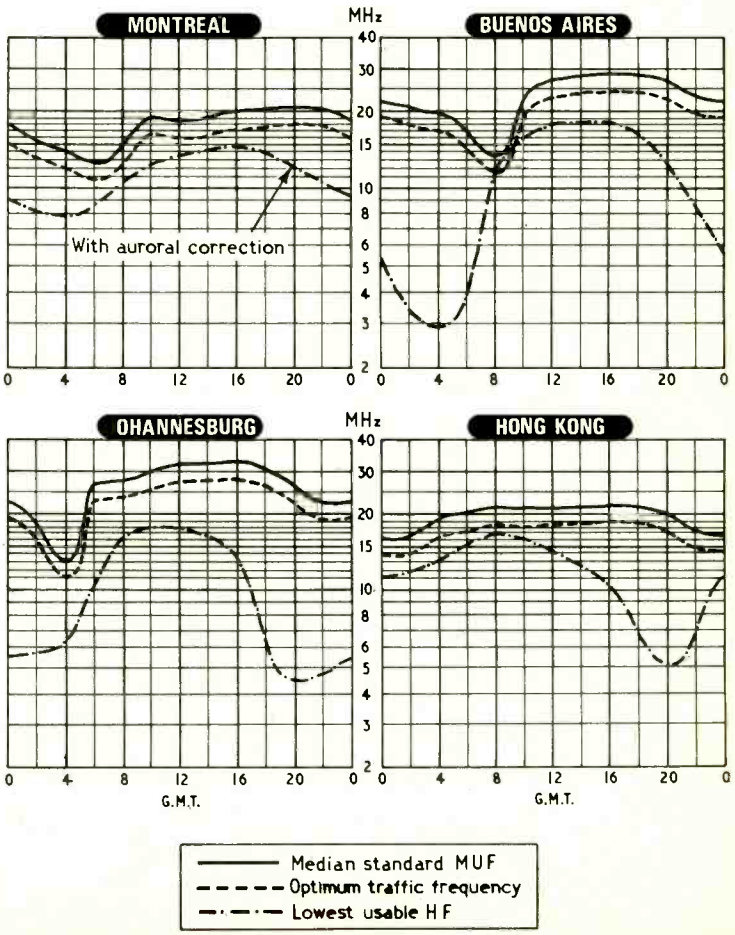
W.W. 353 for further details

H.F. Predictions—May

The prediction charts show median standard MUF, optimum traffic frequency (FOT) and the lowest usable frequency (LUF) for reception in the U.K. Unlike MUF, the LUF is closely dependent upon such factors as transmitter power, aerial gain and type of service. LUFs shown were drawn by Cable and Wireless, Ltd., for commercial telegraphy using power of several kilowatts and aerials of the rhombic type.

Seasonal changes are most striking on the Hong Kong route, the peaks of recent months are depressed giving an FOT below 20MHz which changes little throughout the 24 hours. Montreal route shows the same characteristic as it is also an East/West path in the same hemisphere. Daylight FOTs for the trans-equator paths to South Africa and South America continue at about 25MHz.

Predictions are based on an ionospheric index (IF2) of 133, an increase of one over the previous month.



May Meetings

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

LONDON

1st. I.E.E.—Annual general meeting of London Graduate & Student Section followed by "The design of high-quality audio amplifiers" by J. Dinsdale at 18.30 at Savoy Pl., W.C.2.

1st. B.K.S.T.S. & R.T.S.—"The work of Alan Blumlein", an appreciation by several speakers, at 19.30 at the Royal Overseas League, Park Pl., St. James's St., S.W.1.

7th. Soc. Relay Eng.—"International standards for wired television" at 14.30 at the I.T.A., 70 Brompton Road, S.W.3.

7th. I.E.E.—"Memory in the nervous system" by Prof. J. Z. Young at 17.30 at Savoy Pl., W.C.2.

8th. B.K.S.T.S.—"Stereo radio reception" by J. W. Wanden, at 19.30 at the Royal Overseas League, Park Pl., St. James's St., S.W.1.

13th. I.E.E. & I.E.R.E.—Colloquium on "Special-purpose digital machines" at 18.00 at Savoy Pl., W.C.2.

15th. I.E.E.—"Integrated p.c.m.—telephony bit by bit" by H. B. Law at 17.30 at Savoy Pl., W.C.2.

16th. I.E.E.—Discussion on "Frequency scanning aerials" at 17.30 at Savoy Pl., W.C.2.

20th. I.E.E.—"Novel techniques for beam steering and compensation of distortion in large reflector aerials" by A. W. Rudge and T. Pratt at 17.30 at Savoy Pl., W.C.2.

22nd. Inst. of Navigation.—"Surface guidance on airports" by G. Harrison at 17.00 at the Royal Institution of Naval Architects, 10 Upper Belgrave St., S.W.1.

23rd. S.E.R.T.—Discussion on "Education and training for maintenance" at 19.00 at London School of Hygiene and Tropical Medicine, Keppel Street, W.C.1.

GLASGOW

17th. S.E.R.T.—"Reminiscences of a service engineer" by R. T. Frost at 19.00 at Examinations Hall, Stow College, 43 Shamrock Street, C.4.

HORNCHURCH

8th. I.E.R.E.—"Solid state bulk effects" by C. P. Sandbank at 18.30 at the Havering Technical College, 42 Ardleigh Green Road.

MANCHESTER

7th. I.E.E.—"Some problems of the organisation of science in the modern world" by Lord Bowden at 18.15 at U.M.I.S.T.

MIDDLESBROUGH

1st. I.E.E.—"The place of the technologist in modern society" by Prof. M. W. Thring at 18.30 at Cleveland Scientific Inst.

NEWCASTLE-UPON-TYNE

1st. S.E.R.T.—"Microwaves in industry" by J. Bilbrough at 19.30 at Charles Trevelyan Technical College, Maple Terrace.

PLYMOUTH

1st. R.T.S.—"Recent developments in video tape recording" by R. E. Nether at 19.30 at the Studios of Westward Television Ltd.

PRESTON

2nd. S.E.R.T.—"Industrial electronics" at 20.00 at Harris College, Corporation Street.

TORQUAY

9th. I.E.E.—"The engineer and the law" by H. B. Morton at 14.30 at Electric Hall.

Real and Imaginary

By "Vector"

"Come and join us"

I see that in a recently published study of manpower in the electronics industry* some concern is expressed at the shortage of scientists in industrial research. According to the report, a large proportion of high quality graduates is drawn instead into academic and government institutions (although it doesn't specify what kind of institutions).

This situation isn't really surprising when you come to think about it. After all, a graduate scientist is a high-souled creature who throughout his university life has been conditioned to regard anything less than pure research as sordid. He knows vaguely that there *is* such a thing as industrial research but would consider the prospect of entering it with the same degree of enthusiasm which a Victorian Lord of the Manor would have exhibited for going into trade. He equates industry with unspeakable things like muck, oil and grease and, above all, harbours a horrid suspicion that, once in it, he would be expected to do something specific in the way of work (which is a wild surmise if ever I heard one). But there it is; that's the image and you can't really blame him for not wanting to join. Very few wild rabbits enter cages voluntarily.

The shortage is made even more acute by the status-symbol aura associated with the possession of a research department. If an electronics company hasn't got one it is generally considered not to have arrived, so naturally there comes a danger period in the life of every small but up-and-coming manufacturing concern when the situation goes critical.

The first symptom shows when the chairman gets a touch of the March Hares and is observed stomping up and down his sanctum cutting a fresh swathe in the carpet pile with each new stomp. It would convey nothing to describe his countenance as expressing grave dissatisfaction because all chairmen look like this all the time anyway. Let us say therefore that our chairman's expression is several orders of magnitude graver and more dissatisfied than is its wont. Which is scarcely surprising because, to put the matter in a TO5 can, he *is* gravely dissatisfied. He has suddenly discovered that something in life is missing but he wots not what.

Then, like St. Paul of old, he is smitten by a blinding light, paralysing him in his tracks. In lesser men it would be diagnosed as epilepsy but when it occurs in chairmen it is called inspirational genius. Instantly with crystal clarity he knows just what is wrong. It is his company. It hasn't got a research department. Unthinkable!

Characteristically, he trumpets for his general manager and demands the reason why. The G.M. replies nervously that electronic baby alarms, the company's main product, have never seemed to him to call for much in the way of research; he adds that in his experience as a father of 10 it doesn't need a research team to find out how to alarm a baby. He is thereupon sacked on the spot, not for his hazy grasp of the function of the company's product but for failing to wave a magic wand and materialise a gleaming glass palace out of thin air.

Once the fatal decision is made, the first step is to acquire an asylum of laboratories. The only point on which the planners called in to do the job will agree is that the laboratories must be sited in pleasant rural terrain, for it is well known that scientists are intensely sensitive to atmosphere and will only thrive in congenial surroundings. In due course an imposing edifice arises, architecturally part early nuclear and part late Bayswater Road. It is so deep in the heart of the countryside that no road exists within miles. The chairman regards the inaccessibility as an advantage; he has always wanted an excuse to buy a helicopter. The lack of an access road will not bother the scientists as their little hooves never quite touch the ground anyway.

Phase two of the operation is to stock the buildings with physicists and, as with jugged hare, the first thing to be done is to catch them. Frankly, this is no task for the amateur; better by far to leave it to a reputable physicist-trapper, for not every one which is caught is suitable and considerable expertise is necessary to know which to keep and which to throw away. The main features the professional will look for are the distinctive markings (known in the trade as 'hons') which an expert eye can categorise as first, second or third class. There are three main breeds of physicists to go for, namely the "Oxon", the "Cantab" and the quaintly-named "Redbrick". The first two varieties are highly prized by fanciers and have an additional scarcity value but the Redbrick is said by some to be more industrious.

Physicists in captivity are frequently intractable at the outset and are prone to pine for their natural habitat, the university, but provided that the laboratories are plentifully equipped with complicated and expensive toys they usually settle down, given time and patience. Do not fuss them; put them in their glass-walled cages at 9 a.m. and let them play or sleep until 5 p.m. when they should be put out for exercise.

The great moment comes when, after a short quiescent period (often as little as six or seven years), one of them produces something he or she has made. It will bear no resemblance whatever to the equipment which is urgently required by the Works but then, life is like that. If, for instance, the desired end-product is a Mark II baby alarm the nearest you are likely to get to it is an experimental electronic mousetrap. The idealist or the inexperienced may be forgiven for feeling that the whole exercise has been pretty futile.

Not so, however. The realist accepts the mousetrap gratefully and then casts around for a mousetrap manufacturer whose own laboratories have produced an experimental baby alarm. The two then come to an amicable cross-licensing agreement and in this fashion science and industry can be linked in happy wedlock.

If this should catch the eye of any emerging young scientists I hope enough has been said to show that research in industry can be every bit as jolly as on the campus; in fact, the chances are that you won't know the difference. You may even get the chance of roughing up an M.P. or two because, having got himself a research department, the chairman will naturally want to show it off to visiting V.I.Ps. It will be just like home.

By comparison

I am most grateful to Bob Eldridge of Vancouver, B.C., for his comments on my March contribution. He writes:

First let me say that I enjoy your column immensely, and it is evident that you enjoy writing it.

If what you say about telephoning in Britain is anything like the true state of affairs, then Britain really is in a very serious condition. Surely you must be exaggerating beyond all belief!

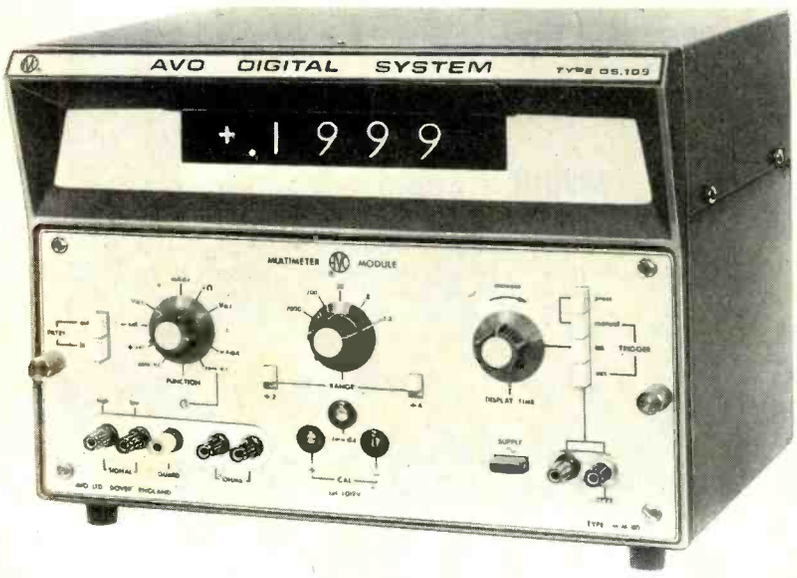
If I want to talk to co-workers I dial the last four digits of their telephone number. If I want to call someone not on our PABX I dial 9 to pick up the normal dial tone, then dial their number. Another part of our company, 15 miles away has a similar PABX. If I want to call someone on that one I dial 2, followed by their extension digits.

If I want to call another city I dial 112-514-870-2175 for example which takes me straight into an extension on a PABX there. If I want Montreal information I dial 112-514-555-1212 which takes me direct to the information operator there at no charge. I can do the same to Dallas (Texas), Miami (Florida) or any other major city in north America.

When the new electronic exchanges come along we will be able to . . ., but that is tomorrow. I am sure glad our today is less tedious than you say yours is.

*"Manpower: Studies No. 5. Electronics", Ministry of Labour, H.M.S.O.

When is an Avo meter not an Avometer?



When it's an Avo Digital System

That's new! Yes, and it has full multimeter and print-out facilities and other plug-in capabilities.

See it on IEA Stand G35

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THORN

AVΩ MEANS BASIC MEASUREMENTS ALL OVER THE WORLD

WW—005 FOR FURTHER DETAILS

Audix

VISIT OUR EXHIBITION AT THE **ROYAL HOTEL** WOBURN PLACE, LONDON, W.C.1 **APRIL 18th-21st** "AUDIO FAIR TIME"

TAILOR-MADE TO YOUR OWN REQUIREMENTS

SOUND SYSTEMS and ELECTRONICS

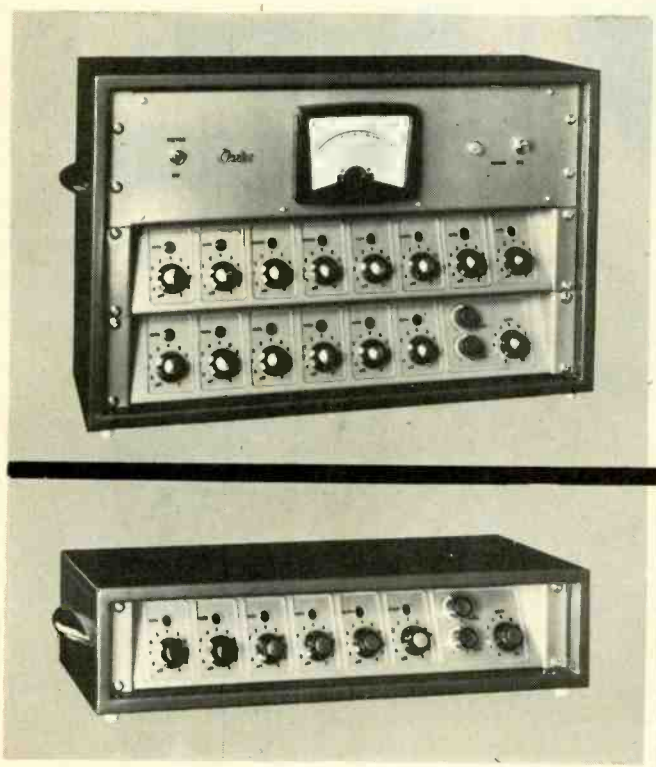
●HIGH PERFORMANCE ●COMPACT MODULAR CONSTRUCTION ●RACK OR CONSOLE MOUNTING

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.

MODULAR AUDIO AMPLIFIERS

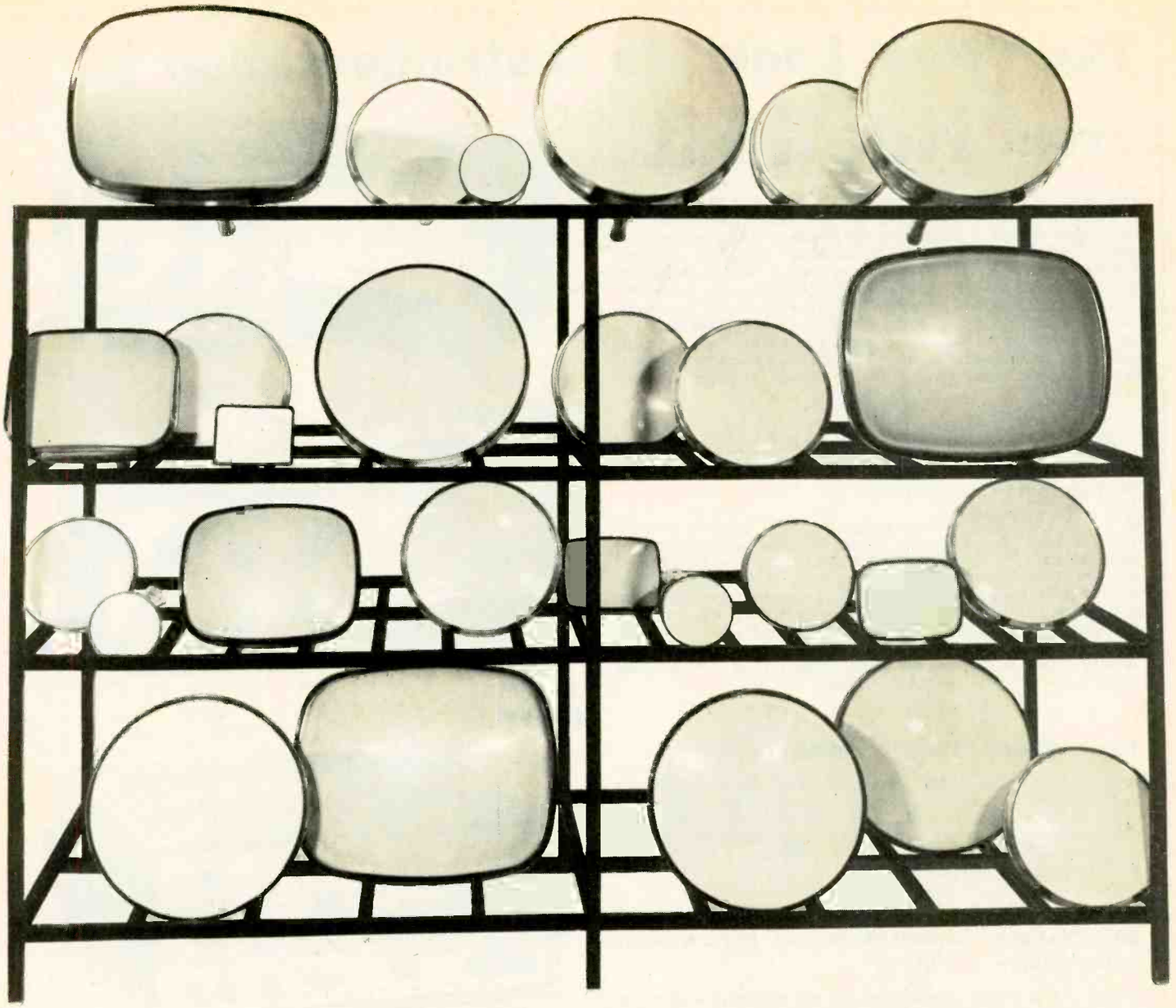
Audio Power Amplifiers having outputs of from 10 to 80 watts and to operate in conjunction with MXT/6 Mixing Assemblies. Silicon Translstorised throughout—stable—high performance—overload and output protection—distortion better than .5% 20 Hz to 15,000 Hz—output 15 ohm and 100 volt to line.



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.

Integrated Mixer/Amplifiers Models A25–30 watts, and A80–60 watts, having inputs for two Microphone Channels balanced at 30 ohm, Auxiliary inputs for Microphone, Gramophone and Tape, each channel independently controlled. Overall Master Gain Control. Treble and Bass tone controls giving ± 12db lift and cut.

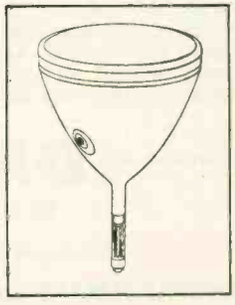
AUDIX SOUND SYSTEMS & ELECTRONICS STANSTED ESSEX Telephone: STANSTED 3132/3437



CRTs off the shelf

(Specials take a little longer)

EEV is probably the best source of specialised CRTs. The standard range is wide and deliveries 'off the shelf'. 'Specials' take a little (but not much!) longer. Use this service in CRTs. It's the most flexible on hand.



ENGLISH ELECTRIC VALVE COMPANY LIMITED

CHELMSFORD, ESSEX. TELEPHONE: 61777

AP300

WW—007 FOR FURTHER DETAILS

The "New Look" In Instrumentation is From Heathkit

The newest and most practical innovation in electronic instrumentation is the exciting new ultra-functional styling format from Heath. New instruments feature a unique cabinet frame consisting of the front and rear panels and side rails which completely supports the component chassis independently from the top and bottom cabinet shells. This allows complete freedom from assembly, check-out, and calibration. The sturdy side rails conceal retractable carrying handles. The die-cast front panel bezel styled in chrome and black, the black side rails, and the beige front panels and cabinet shells give the new instruments an appearance as up-to-date as their functional performance. See these new instruments and more in the new 1968 American Heathkit catalogue.

KIT IM-25
£48.10.0

Ready to use prices on request of all models.

New Solid - State High - Impedance Volt - Ohm Milliammeter . . . IM-25

● 9 A.C. and 9 D.C. voltage ranges from 150 millivolts to 1500 volts full scale ● 7 resistance ranges, 10 ohms centre scale with multipliers × 1, × 10, × 100, × 1k, × 10k, × 100k, and × 1 meg . . . measures from one ohm to 1000 megohms ● 11 current ranges from 15μA full scale to 1.5A full scale ● 11 megohm input impedance on D.C. ● 10 megohm input impedance on A.C. ● A.C. response to 100 kHz ● 6in. 200μA meter with zero-centre scales for positive and negative voltage measurements without switching ● Internal battery power or 120/240 volt A.C., 50-60 Hz ● Circuit board construction for extra-rugged durability.

KIT IM-16
£28.8.0

New Solid-State Volt-Ohm Meter, IM-16

● 8 A.C. and 8 D.C. ranges from 0.5 volts to 1500 volts full scale ● 7 ohm-meter ranges with 10 ohms at centre scale and multipliers of × 1, × 10, × 100, × 1k, × 10k, × 100k, and × 1 megohm ● 11 megohm input on D.C. ranges, 1 megohm on A.C. ranges ● Operates on either built-in battery power or 120/240 volt A.C., 50-60 Hz ● Circuit-board construction.

KIT IP-17
£37.4.0

New Variable Control Regulated High Voltage Power Supply . . . IP-17

● Furnishes 0 to 400 volts D.C. @ 100 mA maximum with better than 1% regulation for 0 to full load and ±10 volt line variation ● Furnishes 6 volt A.C. @ 4 amperes and 12 volt A.C. @ 2 amperes for tube filaments ● Provides 0 to −100 volts D.C. bias @ 1 milliampere maximum ● Features separate panel meters for continuous monitor for output current and voltage ● Terminals are isolated from chassis for safety ● High voltage and bias may be switched "off" while filament voltage is "on" ● Modern circuit board and wiring harness construction ● 120/240 volt A.C., 50-60 Hz operation.

KIT IP-27
£46.12.0

New Improved Version of the famous Heathkit Solid-State, Voltage-Regulated, Current-Limited Power Supply . . . IP-27

● New zener reference ● New improved circuitry is virtually immune to overload due to exotic transients ● 0.5 to 50 volts D.C. with better than ±15 millivolts regulation ● Four current ranges 50 mA, 150 mA, 500 mA and 1.5 amperes ● Adjustable current limiter: 30 to 100% on all ranges ● Panel meter shows output voltage or current ● "Pin-ball" lights, indicate "voltage" or "current" meter reading ● Up-to-date construction ● Unequalled performance in a laboratory power supply.

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DEPT. WW-5, GLOUCESTER, ENGLAND

Member of the Schlumburger Group including the Heath Company

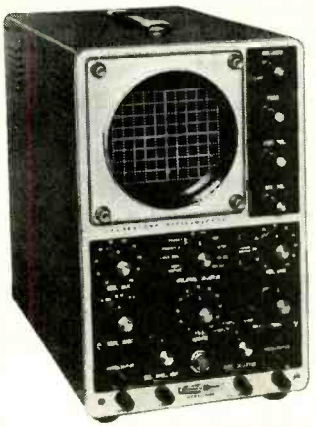
MANUFACTURERS OF THE WORLD'S LARGEST SELLING ELECTRONIC KITS

WW—008 FOR FURTHER DETAILS

Heathkit for Quality Test Instruments

(All models available in Ready-to-Use or Kit Form)

5in. WIDE-BAND GENERAL PURPOSE OSCILLOSCOPE IO-I2U



● "Y" sensitivity 10mV r.m.s. per cm. at 1 kc/s ● Bandwidth 3 c/s-4.5 Mc/s. ● Frequency compensated input attenuator X1, X10, X100. T/B, 10 c/s-500 kc/s. in 5 steps. ● Two extra switch selected pre-set sweep frequencies in T/B range. ● T/B output approx. 10 v. peak to peak. Built-in 1V calibrator. ● Facility for "Z" axis modulation. Electronically stabilised power supply. ● Power req. 200-250 v. A.C., 40-60 c/s., 80 watts. ● Fused. ● Front panel, silver and charcoal grey ● Cabinet, charcoal grey, size $8\frac{5}{8} \times 14 \times 17$in. deep. Net weight 23lb.

Kit £35.17.6 Ready-to-use £45.15.0

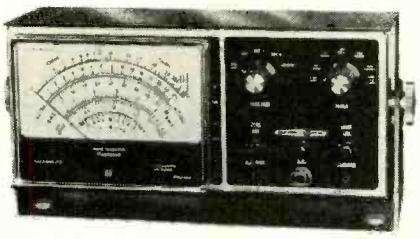
Attenuator and demodulator probes available as optional extras.

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

● The ideal 'scope for service man, laboratory technician, amateur radio enthusiast or hobbyist ● "Y" bandwidth 2 c/s-3 Mc/s ± 3dB ● Sensitivity 100 mV/cm ● Push-pull vertical and horizontal amplifiers ● Wide range time-base generator 20 c/s-200 kc/s in four ranges ● Automatic lock-in synchronisation ● Mu-metal c.r.t. shield Printed circuit board construction ● Power req. 200-250 v. 50-60c/s A.C. 40 watts ● Fused ● Front panel silver and charcoal grey. Size 5in. w. $\times 7\frac{3}{4}$in. h. $\times$ 12in. deep. Weight: $9\frac{3}{4}$lb.

Kit £23.18.0 Ready-to-use £31.18.0

6in. VALVE VOLTMETER, IM-13U

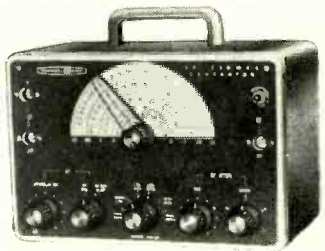


● Modern styling ● The ideal VVM for the Electronic Engineer ● 6in. Ernest Turner 200μA. meter with multi-coloured scales ● Unique gimbal bracket allows bench, shell or wall mounting ● Measures A.C. (r.m.s.) D.C. volts 0-1.5, 5, 15, 50, 150, 500, 1,500 ● Resistance range 0.1 to 1,000MΩ with int. battery ● Vernier action zero and ohms adjustment ● Roller-tinned printed circuit ● High input resistance (11MΩ) ● Size $5 \times 12\frac{11}{16} \times 4\frac{3}{4}$in. Complete with test prod and leads.

Kit £18.18.0 Ready-to-use £26.18.0

HV and RF probes available as extras.

GENERAL PURPOSE RF SIGNAL GENERATOR RF-1U

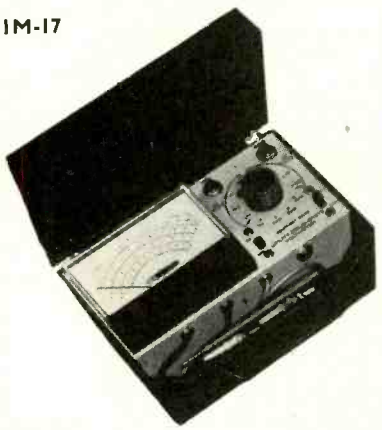


An outstanding generator for service test, lab. and hobbyist. Ideal for the alignment and trouble shooting of RF, IF and audio circuits ● Large easy-to-read dial ● Pre-aligned coil and bandswitch assembly RF output of at least millivolts ● 100 kc/s-100 Mc/s. fundamentals up to 200 Mc/s harmonics ● 400 cycle audio signal with 4 v. output ● Dimensions $9\frac{1}{2}$in. wide $\times 6\frac{1}{2}$in. high $\times$ 5in. deep.

Kit £13.18.0 Ready-to-use £20.8.0

Full specification sheet available on any HEATHKIT model

NEW PORTABLE SOLID-STATE VOLT-OHM-METER IM-17



● Solid-state circuit ● FET input, 4 silicon transistor, 1 diode ● 4 A.C. voltage ranges ● 4 D.C. voltage ranges ● 4 ohm ranges ● 11 megohm input on D.C. ● 1 Megohm input on A.C. ● $4\frac{1}{2}$in. 200μA meter ● Battery powered ● Rugged polypropylene case with self cover and handle ● Storage space for test leads ● PCB construction.

Kit £12.12.0

NEW, HANDY PORTABLE TRANSISTOR/DIODE CHECKER IT-27

Ideal test bench or service kit ● Checks shorts, leakage, open element, and current gain.

Kit £4.10.0

Other instruments in range include:

$4\frac{1}{2}$in. VALVE VOLTMETER V-7AU

7 A.C. 7 D.C. 7 ohms ranges ● $4\frac{1}{2}$in. 200μA meter measures r.m.s. and pk-to-pk ● 11 megohm input resistance.

Kit £13.18.6 Ready-to-use £19.18.6

$4\frac{1}{2}$in. MULTIMETER, MM-1U

● 50μA meter ● 22 voltage, current and resistance range ● 20,000 ohm/volt D.C. and 5,000 ohm/volt A.C. sensitivities ● Polarity reversing switch.

Kit £12.18.0 Ready-to-use £18.11.6

SINE/SQ. GENERATOR, IG-82U

Covers 20 c/s to 1 Mc/s in 5 bands ● Simultaneous Sine and sq. wave outputs ● Separate attenuator controls.

Kit £25.15.0 Ready-to-use £37.15.0

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DEPT WW-5, GLOUCESTER, ENGLAND

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MANUFACTURERS OF THE WORLD'S LARGEST SELLING ELECTRONIC KITS

WW—009 FOR FURTHER DETAILS

Heathkit for value in Hi-Fi-Audio

Outstanding Fully Transistorised

12+12W STEREO AMPLIFIER, TSA-12

This luxury-quality amplifier utilises transformerless output circuitry using complementary transistors giving superior performance, lower phase shift, wider response and lower distortion. All power transistors are adequately heat-sinked for cool operation and long life. It delivers 12 watts R.M.S. per channel into 8 ohms over an extremely wide frequency range of 16 to 50,000 c/s. A six-position source switch easily handles your records, radio or auxiliary inputs—stereo or mono. The output of one channel relative to the other may be varied by the Balance control and there are Baxandall type tone controls for Bass and Treble boost and cut. Input level controls are mounted on the rear panel for gram and radio inputs. Its high-class performance is matched only by its sleek and attractive low silhouette styling, with its brushed gold-anodised-aluminium front panel and matching brown knobs with spun-gold insets.

Ready to use **£38.0.0** Kit **£30.10.0** Cabinet **£2.5.0** extra

Outstanding Fully Transistorised **AM-FM STEREO TUNER, AFM-2**

The purity of FM, the stirring realism of FM stereo, or the music, news and sports of AM . . . this quality tuner has them all at the turn of a switch. 18 transistors and 7 diodes for cool, instant performance, and long, dependable life. Freedom from distortion, crisp, clear reproduction . . . and all at a price far below comparable models! A built-in stereo decoder separates the stereo signal into two channels. A stereo indicator lamp lights when a stereo signal is received.

There is a phase control for minimum distortion with maximum stereo separation. A hinged lower front panel protects the secondary controls, adding to the neat, overall appearance, and greatly simplifying the operation of the unit. This is a high-quality precision instrument which will add sophistication and efficiency to your hi-fi system.

Ready to use price on request Total price kit **£32.13.0** Cabinet **£2.5.0** extra

Outstanding Fully Transistorised **20+20W STEREO AMPLIFIER, AA-22U**

This high-performance "International Class" amplifier has all the hallmarks of professional elegance.
Five stereo inputs (five on each channel) accommodate a stereo magnetic or ceramic pick-up, radio-tuner, tape recorder, and two other sources. There are output terminals for 4, 8 or 16 ohm loudspeakers. Separate output sockets are provided for tape recording from the amplifier. All controls are on the front panel, the secondary ones—to avoid the possibility of inadvertent adjustment—being elegantly concealed behind a slim hinged cover. The major controls include a 3-position mode switch (Mono-Stereo Rev.), a 5-position input source selector switch, volume, bass, and treble controls, and a push-push A.C. on-off switch. A brushed-golden anodised front panel and matching brown knobs with spun-golden insets complete the unit, putting this amplifier undoubtedly into the top class.

Ready to use **£59.15.0** Kit **£39.10.0** Cabinet **£2.5.0** extra

While stocks last, Low Cost Transistorised **STEREO AMPLIFIER, TS-23**

The TS-23 is a self-contained stereophonic amplifier designed for use with high-quality ceramic pickups. It provides a good frequency response (15 c/s to 18 kc/s) at lowest possible cost. A 6-position source selector switch easily handles your record, radio or tape inputs . . . stereo or mono. Separate controls provide bass boost, treble cut, amplifier balance and volume. 16 transistors 4 diode circuitry gives cool, instant operation . . . no warm-up time. The output of 3 watts per channel is adequate for small and medium-sized rooms. Compact, slim-line styling with attractive gold/brown Perspex front panel! Choice of 2-way installation . . . in a cabinet or freestanding (cabinet available optional extra) on a bookshelf.

Ready to use price on request Kit **£17.15.0**
Cabinet **£2.5.0** extra

Outstanding Fully Transistorised **FM STEREO TUNER, TFM-1S**

This de-luxe 14 transistor stereo tuner receives both mono and stereo signals . . . automatic stereo indicator lamp lights whenever a stereo signal is received. The switched A.F.C. (automatic frequency control) ensures that the station remains "locked-in" . . . high sensitivity 4-stage IF amplifier for best programme value at all signal strengths, all four stages act as limiters on strong signals ensuring noise-free reception. The unit includes a phase control to ensure maximum stereo separation. Accidental system setting changes are minimised. Only the tuning knob and on/off switch are in open view on the front panel. The hinged lower front panel protects the secondary controls. The whole unit is sleek and attractive, and like the other HEATHKIT models in this range incorporate an anodised "brushed-golden" aluminium front panel and matching brown knobs with open golden insets.

Ready to use price on request Total price kit **£25.2.6**
Cabinet **£2.5.0** extra

DAYSTROM LTD. DEPT. WW-5, GLOUCESTER, ENGLAND

WW—010 FOR FURTHER DETAILS

HEATHKIT Home Entertainment products

All models are available in ready-to-use or kit form

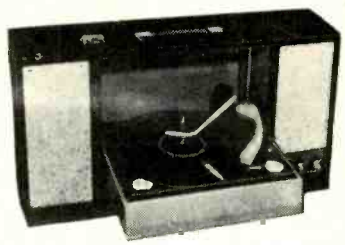
Latest Portable Stereo Tape Recorder STR-1

No other British model offers this specification for this price. Not only a tape recorder but a complete stereo sound system in one compact unit ¼-track stereo or mono record and playback at 7½, 3¾ and 1⅞ i.p.s. Latest 18 transistor circuit. Recording level indicator ● Well known British deck with digital counter. Stereophonic mic. and aux. inputs ● Speaker/headphone outputs ● Built-in audio amplifiers give 4 watts output (rms) per channel. Two high efficiency 8in. × 5in. loudspeakers. Versatile recording facilities. So-easy to build. Attractive black Rexine cabinet with pastel grey matching panels.

Kit £45.18.0 Ready to use £55.10.0

Latest Portable Stereo Record Player SRP-1

This stereo, fully transistorised, mains operated player offers new standards of reproduction. Automatic playing of 16, 33, 45 and 78 r.p.m. records. All transistor—cool instant operation. Dual LP/78 stylus. Plays mono or stereo records. Suitcase portability. Detachable speaker enclosure for best stereo effect. Two 8in. × 5in. special loudspeakers. For 220-250V. a.c. mains operation. Overall cabinet size 15⅝ × 3⅞ × 10¼in. Choice of handsome two-tone blue and grey or red and grey fabric coverings. Compact, economical stereo and mono record playing for the whole Family — plays anything from the Beatles to Bartok. All solid-state circuitry gives room filling volume.



Kit £27.15.0 incl. P.T. **Ready to use price on request**

Complete your motoring pleasure with a

LUXURY CLASS CAR RADIO, CR-1

A small, compact, high output unit. Superb long and medium wave entertainment whenever you drive. For 12v. positive or 12v. negative car earth system. ● 8 latest semi-conductors (6 transistors, 2 diode circuit) ● Powerful output (4 watts) will drive two speakers. ● Styled to harmonise with most car colour schemes. ● Supplied in two units, pre-assembled and aligned RF unit kit. £1/13/6 inc. P.T. IF/AF amplifier kit £11/3/6

Total price kit (excl. LS) . . . . £12.17.0 inc. P.T.
L/speakers and accessories available as extras.

LOUD SPEAKER SYSTEMS

A wide range of speaker systems available from model SSU-1 kit..... **£11 17 6**
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for example:—

AVON Mini SYSTEM

Excellent performance from a smallest possible size. Ideal for housing in a bookcase or other small spaces. Features: Special 6½ bass and 3⅜ mid/High frequency units ● Inductor/capacitor cross over net work. Very strongly constructed with 12 mm. plywood. Fully finished walnut veneered cabinet. Supplied in two parts, both required. Cabinet kit £8/18/-. L. Speakers and crossover network £4/18/-.

Total price kit £13.16.0

BERKELEY slim line SYSTEM

The system you have all heard and read about.

● Beautiful walnut veneered, fully finished cabinet ● Two specially designed 12in. and 4in. speakers. ● New compact "slim line" size. ● 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 harmonise with modern or traditional decor. Takes up less than 1 sq. ft. of floor space.

Kit £19.10.0 Ready to use £24

Portable Radios to Entertain you wherever you are

UXR-1—Portable

Strong, robust construction with reliable performance. 6 transistor, 1 diode circuit provides the power and range you can't get from miniatures. Covers long and medium wavebands. Cabinet finished in beautiful real leather or in the attractive colours Navy Blue, Coral Pink, Lime Green (please state second choice).

Kit £11.19.0—colour case
Kit £12.18.0—real leather

UXR-2—Portable

A De-luxe 7 transistor, 3 diode circuit offers big-set sound. Battery saving circuitry—batteries last for months. Push buttons for Long and Medium wave coverage and tone control. Easy-tune slide-rule dial. Double-tuned I.F. stage. Output for phone or tape recorder. Choice of real brown or black leather case and handle.

Kit £14.18.0

LOW-COST AUDIO AMPLIFIERS

5 watt Mono Amplifier, MA-5

● Built-in pre-amplifier. ● Two switch-selected inputs. ● Separate bass, treble and volume controls. ● 5 watt r.m.s. output. ● Less than 0.5% distortion at 5 watts, ref 1 kc/s. ● Printed circuit board construction. ● Easy-to-build. Outputs for 3 or 15 ohm speakers.

Kit £11.9.6 Ready to use £15.15.0

3+3 watts Stereo Amplifier, S-33H

A Versatile Inexpensive Stereo/Mono Amplifier. ● Three stereo inputs . . . ceramic/crystal pick-up, radio tuner and auxiliary. ● 3.5 watts per channel. ● Separate bass, treble, volume and balance controls. ● Easy printed circuit construction. ● Attractive, elegant styling. Outputs for 3 or 15 ohm speakers.

Kit £15.17.6 Ready to use £21.7.6

Visit the HEATHKIT CENTRES

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LONDON:
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Demonstrations by arrangement

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The new standard Filmet range meets all the requirements of DEF 5115-1 Style RFG7 . . . and at a price that certainly isn't standard for the kind of stability it offers. But this you'll find out for yourself. When you ring, or write.

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Pye Telecommunications Limited designed, tested and produced the Pocketfone, Britain's first truly-portable u.h.f. radiotelephone system. Performance, reliability and impressive signal penetration in built-up areas have been proved under arduous service conditions by police and security services in Britain and overseas. The Pye Pocketfone has a myriad applications in government, industry and commerce. Export orders emphasise Britain's lead in this vital field of radio communication. Pye and Pye alone are organised and able to meet demands for any application – anywhere in the world.

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P19

This year, our two travellers are really going places.

Our travelling portables are a big success.

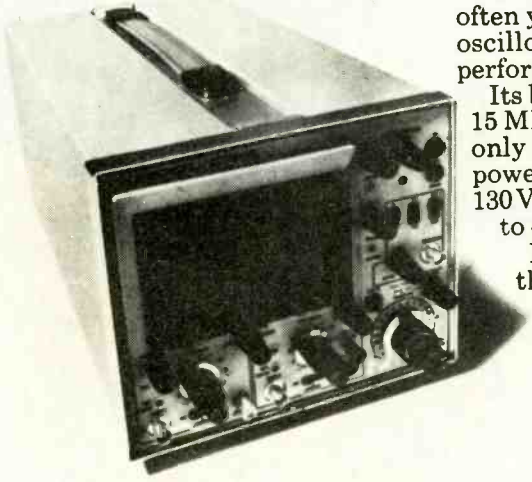
Since we announced LM 1619 and CD 1642 last year, they've been taken all over the world.

But we're not surprised. They can do so much. And they're so easy to take.

Look at LM 1619. It's a four-digit a.c./d.c. meter with fully floating input, its own internal Weston cell for calibration, and a frequency range from 40 Hz to10 KHz. Its accuracy is 0.2% on a.c. and 0.1% on d.c.

Yet it's rugged and compact, weighs only 11 lbs. and fits into a brief-case.

Or look at CD 1642. It's not often you'll see a portable oscilloscope with lab standard performance. With a trace this clear.



Its bandwidth is better than 15 MHz at 10 mV/cm. It weighs only 22 lbs. And plugs into any power supply from 100 to 130 V a.c. or from 200 to 260 V d.c., 44 to 440 Hz.

But you're not stuck with the mains. You can run CD 1642 from its own battery. Or from any 12-24 V d.c. supply—a car battery maybe.

There's no doubt about it. Both LM 1619 and CD 1642 are true portables. You can take them anywhere and they won't mind a bit.

So drop us a line. Let us tell you more.

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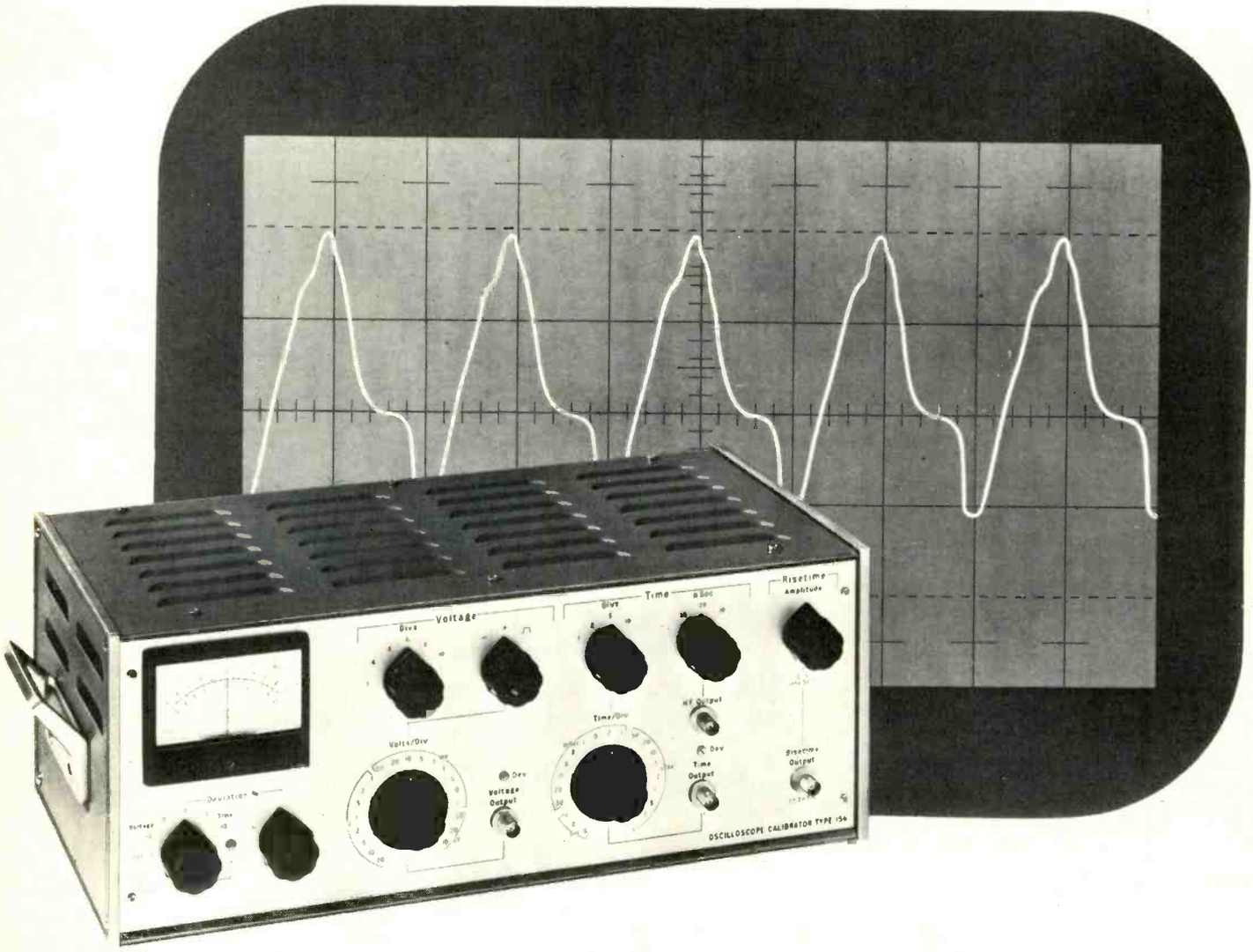
OSCILLOSCOPE USERS

here is the answer to your calibration problems!



A new instrument, the BRADLEY Oscilloscope Calibrator 156 provides all the facilities required for the calibration of modern precision oscilloscopes. Simple to use, it is designed to calibrate vertical amplitude and sweep speeds, and to check risetime. A unique feature is the direct reading of percentage deviation from true values.

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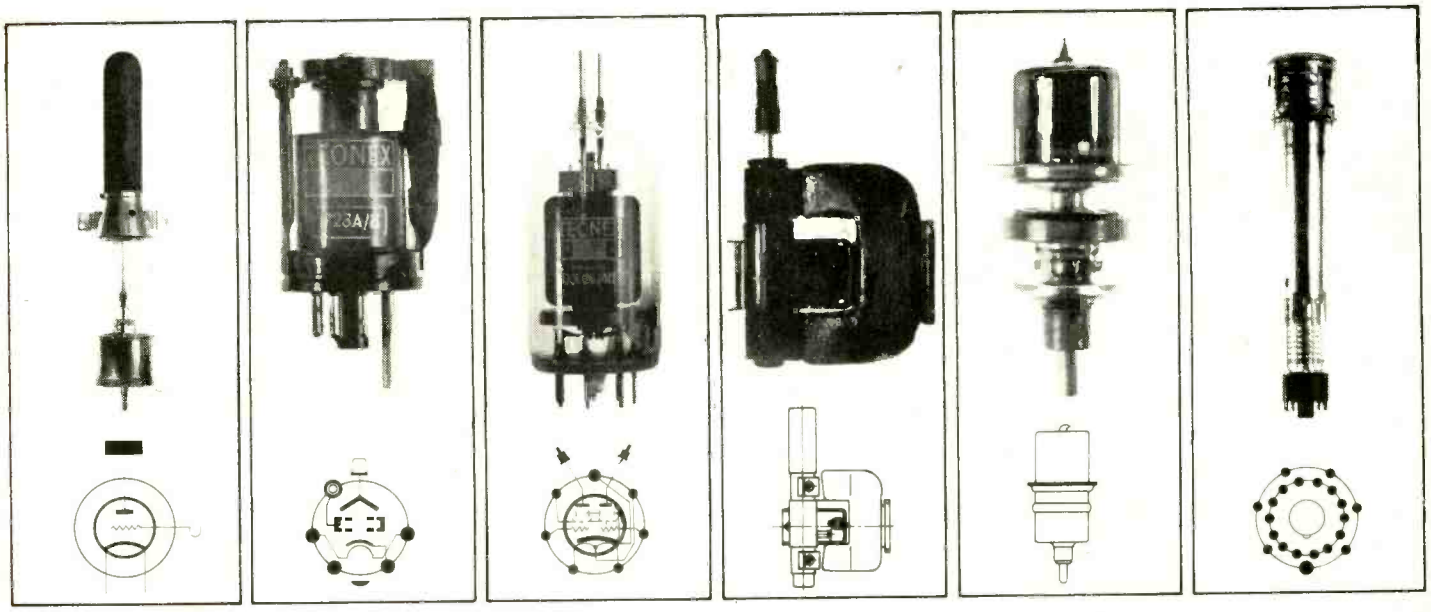

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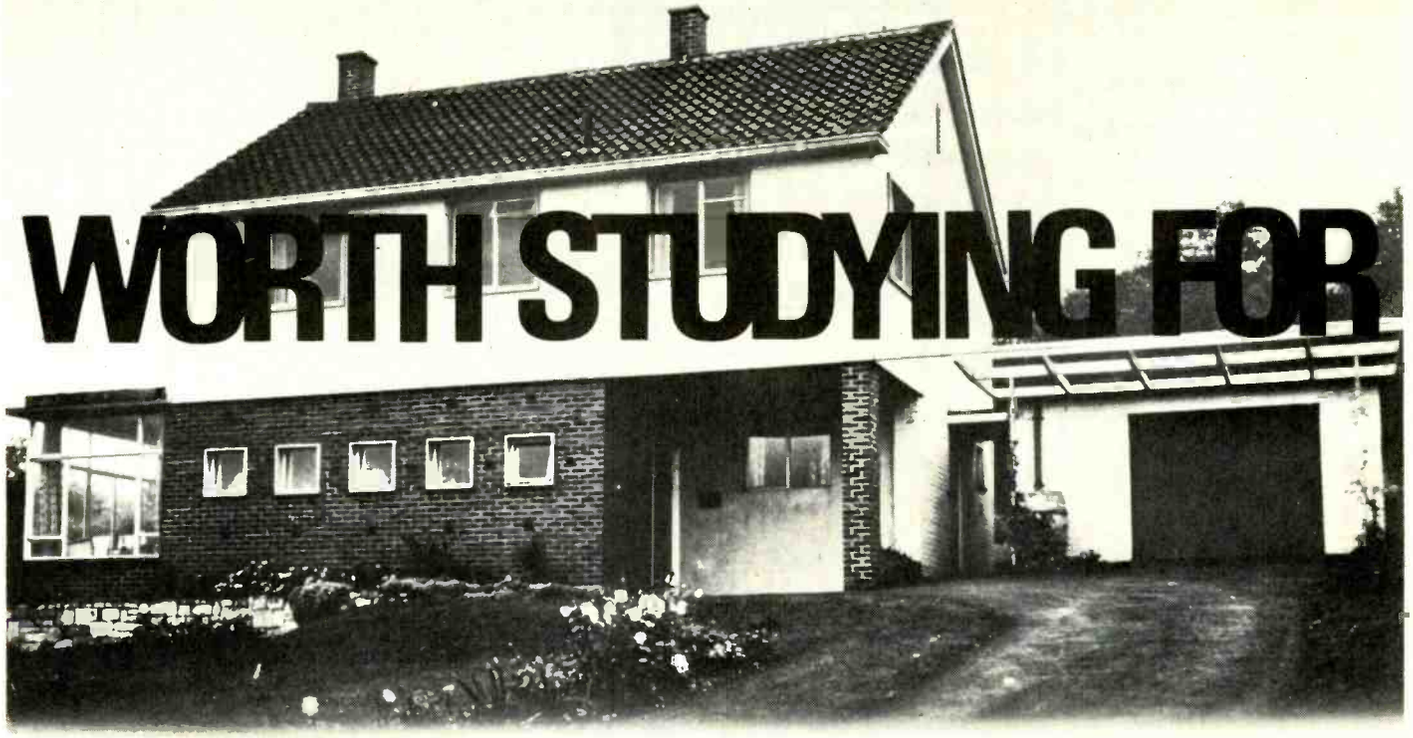

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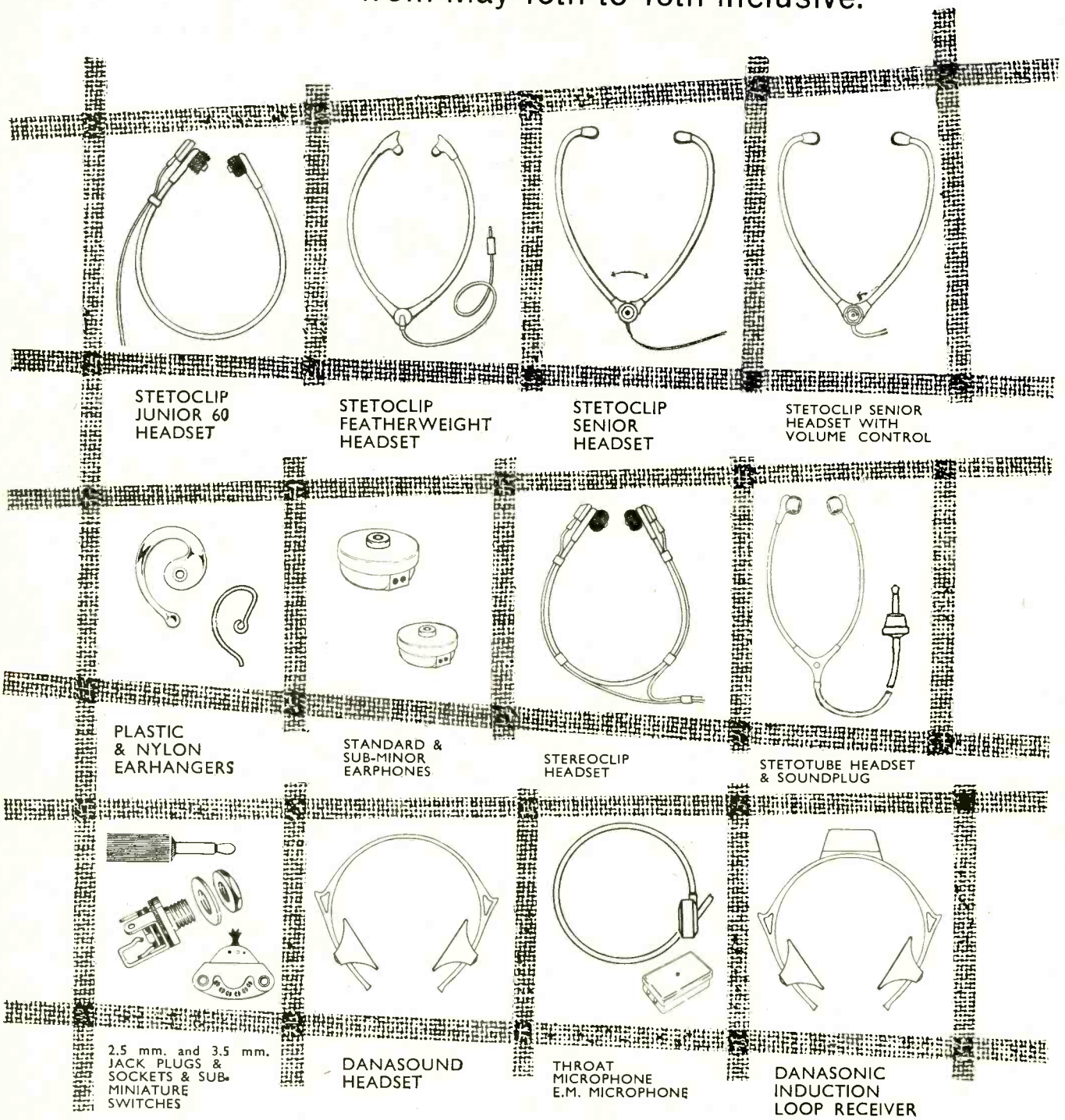

Danavox INTERNATIONAL

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Electro-Acoustic Components and Hearing Aids
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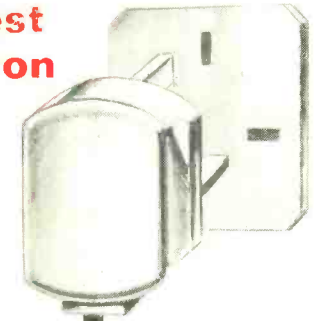
plug in the smallest soldering iron available



Fit any of the eighteen interchangeable bits to this Antex miniature soldering iron and you have the most versatile iron available for fine precision soldering of miniature and micro miniature assemblies. Fitted with a $\frac{3}{32}$" Ferraclad bit as standard, the optional bits offer a diverse range of shapes and sizes. The well balanced handle of the CN240 can be seen in electronics factories and production lines throughout the world. It plugs into any mains outlet. And the element at the end of the iron provides perfectly controlled heat, without any danger of overheating components. With a weight of only 1oz, plus its extremely supple flex, the CN240 is light and easy to handle. No transformer is required. The CN240 is only one of a large range of fine precision soldering tools and equipment by Antex. Introduce yourself to Antex by sending for a colour catalogue. Simply send the coupon.

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It's a rugged little device. The layered construction gives excellent stability and resistance to every form of shock and environmental stress.
We manufacture a preferred range, concentrated on the individual requirements of the British designer. There are other configurations available for more complicated designs: glass-encased, precision moulded, phenolic coated, and unencapsulated chips for hybrid integrated circuits.

The monolithic capacitor is already a pretty important contribution to the progress of modern electronics – our Monobloc Ceramicon design caters for projects of the future.
Contact us for the full details.
Technical Sales,
Erie Electronics Limited,*
South Denes,
Great Yarmouth, Norfolk.
Phone: 0493 4911
Telex: 97421

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

ERIE®

*Formerly Erie Resistor Limited.

WW—022 FOR FURTHER DETAILS

Why do they call plugs and sockets connectors?

And why do they call these UECL ones miniature, subminiature and microminiature when they could call them small, ever so small and ever so ever so small? And why do they make so many different kinds and call the pins contacts and have all sorts of numbers from 5 to 104? And why do some have solder cups or taper pins and polarising guides or screwlocks and some have hoods and some have shells? I'm sure I'll never understand. And what did daddy mean when he said they had positive locking because gran had to wait hours on the doorstep when it happened here.

Daddy keeps on saying you wouldn't understand and keeps on reading his brand new UECL catalogue which isn't fair because it tells him everything and he won't tell me. If you filled in the reader reply card you could get a new catalogue too and I bet you wouldn't be mean and you'd tell me.

UECL

Ultra Electronics (Components) Limited
419 Bridport Road, Greenford, Middlesex, England. Tel: 01-578 5721/7

WW—023 FOR FURTHER DETAILS

Tony ('Tactless Ton') Boxall 34
Wandsworth Technical College. Design draughtsman. Is considered a faster communicator of news than any known system and for knowing what goes on before it happens. Also follows a football team no one's ever heard of.

Ivan Hurst 25
B.Sc. (Eng.) London University. Design engineer. Self-styled lady-killer. Once drank a Chelsea pub dry (with a little help) but now feels 18 pints a sitting is sufficient to maintain his bon viveur reputation.

Laurie Bowles 37
Kingston College of Technology. Chief engineer. Keen badminton and tennis player—the sportsman of the team. Also very keen week-end grower of weeds in his Sussex garden.

Malcolm ('Scissors') Sizmur 32 B.Sc. (Eng.)
Newcastle University. Senior design engineer. Religion: Emitter follower. No hobbies. Says the financial fight to keep his home going occupies all his time. Grew beard to cut and sell to wigmakers to eke out income.

John Bailey
Marketing Manager and Member of Institute of Marketing. Age indeterminate, but high. Reputed to have delayed retirement to take up post. Known as 'father' of the group. Says he was in RAF. Group say it was RFC—and that he won an Iron Cross for shooting down more of ours than theirs.

Dynamco 71 14″ x 6½″ weighs 28½ lbs.

1st.Team.

These six men live, breathe and sleep oscilloscopes and in one year produced the 71 range.

How's that for teamwork!

Now what they've got to show for it is something that measures 14″ x 6½″ and weighs 28½lbs, plus ambitious plans for the future.

And a lot of satisfaction in a good job well done (together).

Dynamco got together the best men for the job in the country. Made them the first team in this field.

The 71's new plug-in concept enables the width of each module to be determined by the panel area needed for the controls, and by the volume needed for the components. Not by a fixed 'pocket-size'.

This means that simple modules plugged into the 71's display unit give you an instrument 12″ in width (30 cm) with a more comprehensive module combination attached, a width of no more than 14″ (35cm).

And the display:

A new short 5″ rectangular faceplate cathode ray tube operating at 10KV gives sharp, crisp displays.

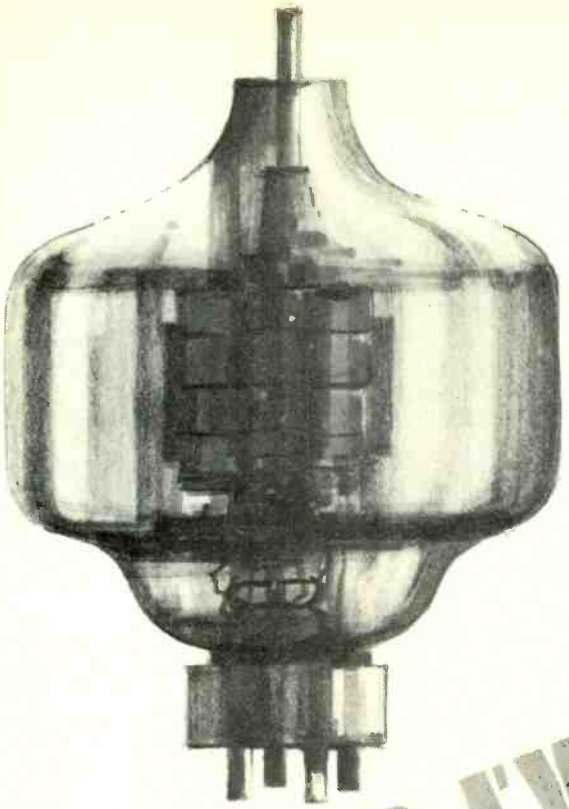
Brightness is consistent with band width to give strain-free viewing under high ambient light conditions.

Plug-in modules enable single or multi-trace displays to be obtained.

Alternative phosphors available. Camera fixing centres are standardised.

DYNAMCO

Dynamco Limited,
Dynamco House,
Chertsey, Surrey.
Telephone: 2636



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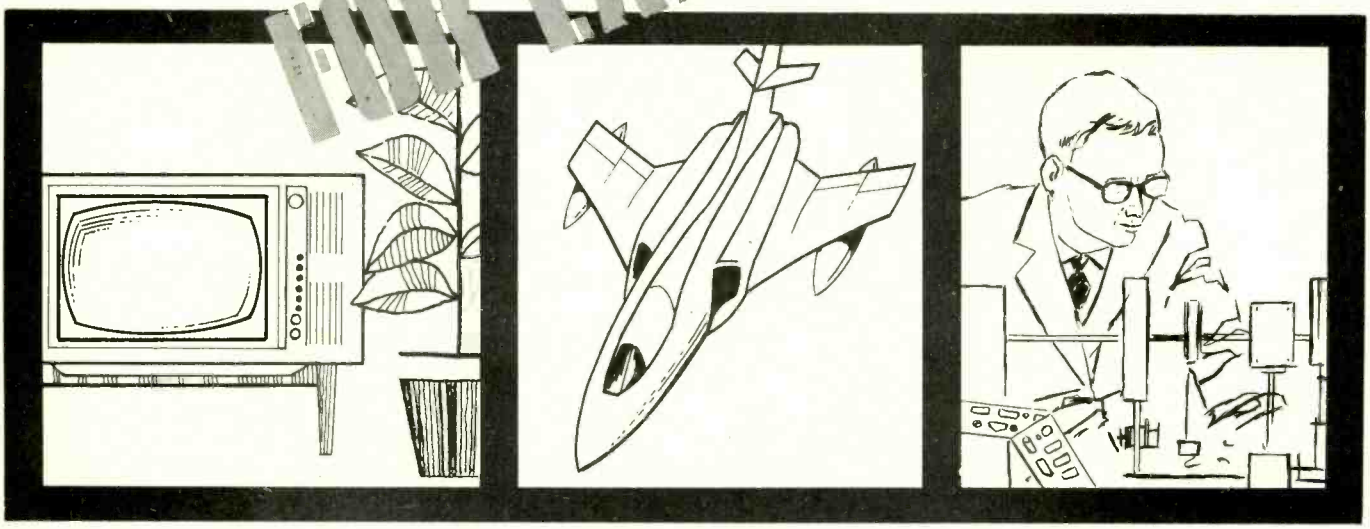

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Telephone: 01-485 8531 (10 lines). Telex: 2-2573. Cables: Hallectric, London, N.W.5.

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may give you an opportunity to visit us at Bayham Place
you will be very welcome

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Dial Euston 1639. Specify your meter . . . type, shape, size, F.S.D. It's almost certainly on our premises right now. It will almost certainly be on yours tomorrow (G.P.O. and/or B.R. willing). If by chance we haven't got *precisely* what you want, we'll tell you when you can have it. Or which stock alternative, plus or minus a few ohms, will do the job. Or how long by our stopwatch it will take us to modify a stock meter for you. You'll always get a straight answer from Anders . . . and 99 times out of 100 the answer will delight you.

Manufacture and distribution of electrical measuring instruments and electronic equipment. The largest stocks in the U.K. for off-the-shelf delivery. Prompt supply of non-standard instruments and ancillaries. Sole U.K. distribution of FRAHM vibrating reed frequency meters and tachometers.

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Ministry of Aviation Approved

WW—027 FOR FURTHER DETAILS

Has red tape been complicating your procurement of electronic components from the U.S.A.?

Let us help you cut through it!

Procurement of American-made electronic components used to be thought of as a complex, time-consuming procedure with a myriad of red tape details and problems. Not anymore — now you can join the growing list of companies that rely on the technical skills and services of Milo International, world-wide distributors of electronic components. Our team of experienced specialists will process your order with speed and efficiency from start to finish — immediate price and availability quotations, product information, application data, import certificates, export licenses, declarations, export packaging, delivery expediting, etc. And this all-inclusive service is provided for each order, **no matter how small or large.**

For whatever you may need in electronic components from the U.S.A., Milo International can satisfy your requirements with prompt delivery, at direct factory prices, from a huge in-stock inventory of thousands of components made by the leading American manufacturers including this partial listing:

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Pinnacle the largest single valve independent

THIS IS WHAT WE DO

Make available the widest range of valves for commercial and industrial use. Give a personalised service based on intelligence and speed.

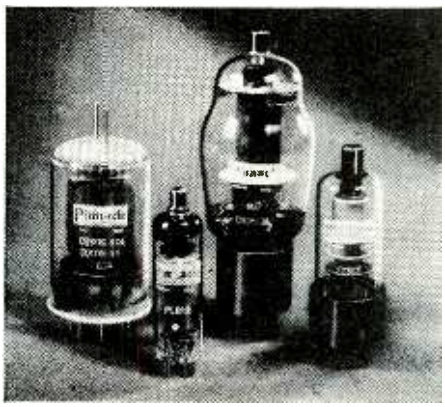
Ensure that we only Supply valves made by the world's foremost manufacturers.

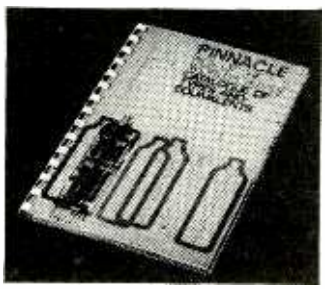
Provide valves selected for your special needs.

Help out rapidly with that "awkward" valve that nobody else seems to have heard of.

Specialise in European or American types which are not normally easily obtainable.

Rush you a small order, or quote for a bulk requirement—1's or 1,000's are all the same to us.





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Every valve in either widespread or specialised use in the fields of Entertainment, Industry, Education and Research will be found in our catalogue, together with its main equivalents, classification, and the Pinnacle "P" number under which it may be ordered.

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NEW FROM AMPLIVOX

'Astrolite' -the elegant design which sounds as good as it looks.

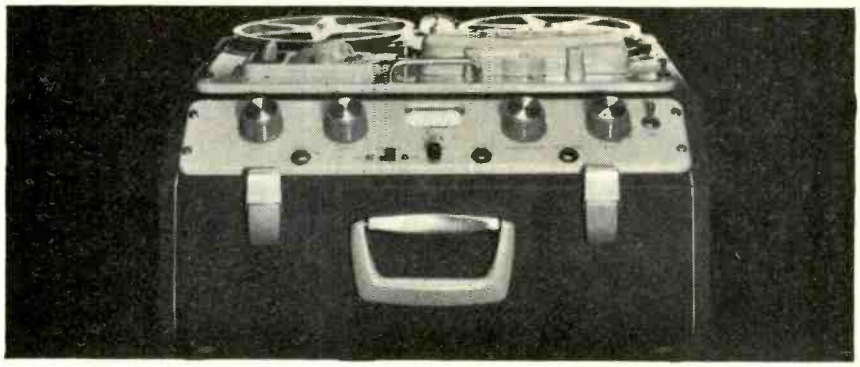
Here's Headset progress. 'Astrolite' combines all that's good in performance with reliability and a world beating design. Light in weight (6.5oz approx). New high level phones (1 mW gives comfortable listening level). Partial noise exclusion. Communications or high fidelity versions – magnetic, carbon or moving coil. 'Personal tension adjustment' gives fingertip control of microphone boom arm. Nylon and stainless steel unbreakability. Tropicalised. New design cable minimises crosstalk. Get details in full, today, from

AMPLIVOX LIMITED

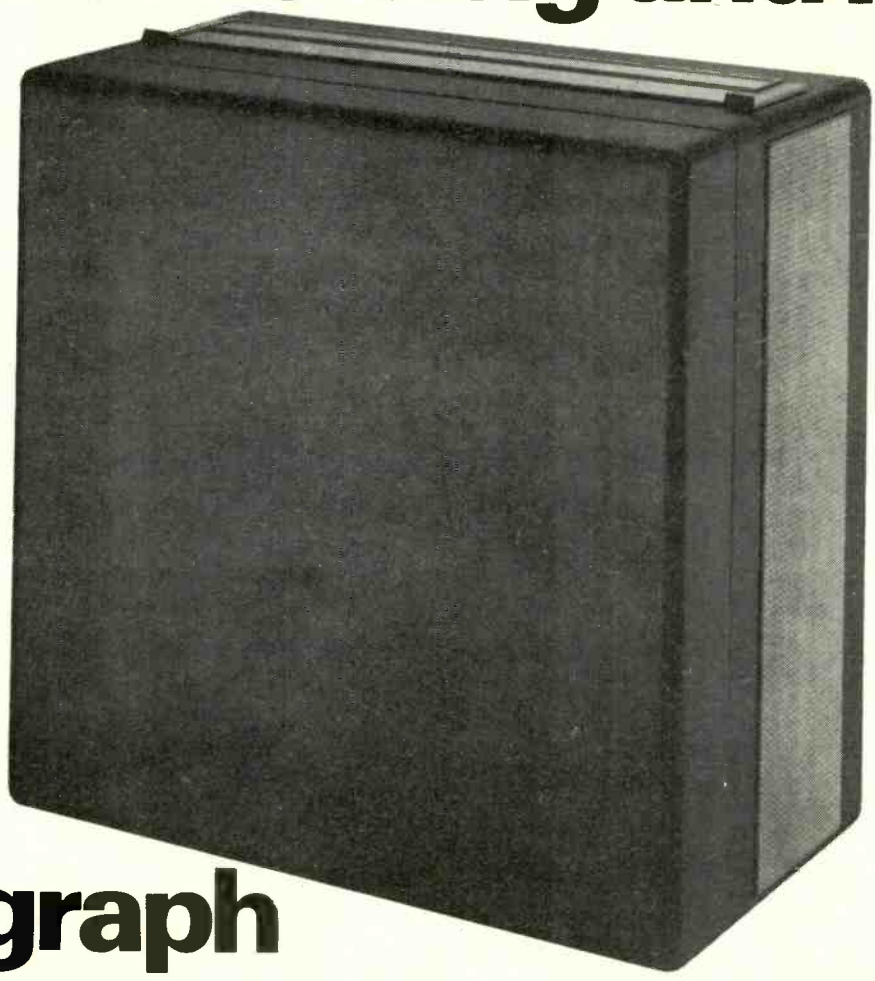
AMPLIVOX LIMITED INDUSTRIAL DIVISION,
Beresford Avenue, Wembley, Middlesex Tel 01-902 8991, Grams & Cables: Amplivox, Wembley.

WW—030 FOR FURTHER DETAILS

Ferrograph, 1949-1967



Now, another major event in tape-recording and Hi-Fi



Ferrograph New Generation Series 7

the tape recorder with the hearing-is-believing sound

Ferrograph quality
Ferrograph reliability
Ferrograph fidelity
plus a unique combination of 30 features

Ferrograph Tape Recorders were the first designed and made in Great Britain—in 1949. Since then they have set the standard of fidelity and unfailing reliability; over the years, Ferrograph have continually improved and added facilities from Series 1 to Series 6, but making no basic changes.

Continuous research and development have now produced a radically new family.

Now, Ferrograph present to you the New Generation, Series 7. Look at its superb new styling, look at its unique range of facilities. As soon as you can, *listen* to it, There is no finer instrument in its class!

To create it, engineers have tested and evaluated every new development. Market research has established what you, the user want by way of facilities —and *all* have been incorporated. Industrial designers have evolved a most appealing presentation and the whole new family is solid state.

Ferrograph New Generation Series 7

This basic Ferrograph instrument is available in Mono, and in Stereo with and without end amplifiers. Each version as a portable, or in elegant hardwood, all with concealed, flush-carrying handles and a new closure design. Every Series 7 instrument is a self-contained chassis-mounted unit, easily fitted into rack or cabinet, easily removed for servicing. Prices from £110.

30 features

Never before **have all these facilities been combined in one tape recorder. Some you know, many you have so far only wished for:**

1. *An entirely new design – with facilities resulting from a study of users' needs gathered over 17 years.*
2. *Modern styling of great functional dignity.*
3. *All silicon solid-state electronics with FET input stages and wide input overload margins.*
4. *Vertical or horizontal operation.*
5. *Unit construction: The 3 individual units i.e. tape deck, power unit and amplifier complex are mounted on a single frame easily removable from cabinet for service or installation in other cabinets or racks.*
6. *3 motors (no belts).*
7. *3 tape speeds.*
8. *Variable speed spooling control for easy indexing and editing.*
9. *Electrical deck operation allowing pre-setting for time-switch starting without need for machine to be previously powered.*
10. *Provision for instantaneous stop/start by electrical remote control.*
11. *Immediate access head block for editing and cleaning.*
12. *Single lever-knob deck operation with pause position.*
13. *Independent press-to-record button for safety and to permit click-free recordings and insertions.*
14. *Adjustable reel height control.*
15. *Damped tension arms for slur-free starting.*
16. *8¼" reel capacity.*
17. *Endless loop cassette facility.*
18. *Provision for signal operated switching units.*
19. *Internal loud speakers (2) – 1 each channel on stereo, 2 phased on mono.*
20. *4 digit, one-press re-set, gear-driven index counter.*

WW—032 FOR FURTHER DETAILS

21. *2 inputs per channel with independent mixing (ability to mix 4 inputs into one channel on stereo machine).*

22. *Signal level meter for each channel operative on playback as well as record.*

23. *Tape/Original switching through to output stages.*

24. *Re-record facility on stereo models for multi-play, echo effects etc., without external connections.*

25. *Meters switchable to read 100 kHz bias and erase supply with accessible preset adjustment.*

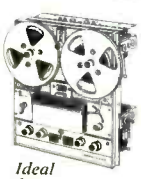
26. *Three outputs per channel i.e. (1) line out – level response. (2) line out – after tone controls. (3) power output – 8-15 ohms.*

27. *Power output 10W per channel.*

28. *Independent tone controls giving full lift and cut to both bass and treble each channel.*

29. *Retractable carrying handle permitting carrying by one or two persons.*

30. *Available in several alternative presentations.*



Ideal for rack mounting

Grey vinyl case

Elegant hardwood case

Please see next page for Ferrograph stockists

FERROGRAPH

the tape recorder with the hearing-is-believing sound

WW—033 FOR FURTHER DETAILS

Listen for yourself

To *know* the Ferrograph New Generation Series 7 you must look at it, listen to it, for yourself. You will find New Generation instruments soon in stock at many of the best tape-recording and Hi-Fi specialists in the country, including the following:

Ferrograph stockists

LONDON AREA

Chiswick
Masseys Centre of Sound
121/123 High St. W4

Holborn
Tape Recorder Centre
82 High Holborn WC1
Larg's of Holborn Ltd.
76/77 High Holborn WC1
Imhofs Ltd.
New Oxford St. WC1

Paddington
Teletape Ltd.
33-59 Edgware Rd. W2

Richmond
F. Cave
27 Hill St.

Streatham
Francis of Streatham
169/170 Streatham High Rd. SW16

Tooting
R.E.W. (Earlsfield) Ltd.
266 Upper Tooting Rd. SW17

Tottenham Court Rd.
Telesonic Ltd.
92 Tottenham Court Rd. W1

Aberdeen
C. Bruce Miller
51 George St.

Banstead
Raylec Ltd.
43 Buff Parade, High St.

Bath
C. Milsom & Son
Northgate

Birkenhead
James McKenzie Ltd.
Grange Rd. West

Birmingham
C.H. (High Fidelity) Ltd.
167/169 Bromsgrove St. 5
Griffin Radio Ltd.
94 Bristol St. 5
C. H. Young Ltd.
170 Corporation St. 2

Blackburn
Holdings of Blackburn Ltd.
39/41 Mincing Lane

Blackpool
F. W. Benfell Ltd.
17 Cheapside

Bognor Regis
Tansley & Cooke Ltd.
Sandymount Ave.

Brighton
Averys
77 St. James' St.
Lanes Radio
11 Gardiner St.
John King Films Ltd.
East Street

Bristol
Sound Selection
361-363 Gloucester Rd. 7
Audio Bristol Ltd.
Park Street Ave.
Bristol & West Recording Services Ltd.
6 Park Row 1

Bournemouth
Tape Recorder Co. (B'mouth) Ltd.
374 Old Christchurch Rd.

Cambridge
H. S. W. Speechley & Co.
25 High St. Linton

Cardiff
Sound Film Services
27 Charles St.

Cheltenham
University Audio
24 Winchcombe St.

Chester
Lloyd & Wylie Ltd.
42 Bridge St.

Chichester
G. A. Colbourne Ltd.
10 Southgate

Crewe
Charlesworth (Crewe) Ltd.
14 High Town

Derby
Victor Buckland Ltd.
41/49 London Rd.

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J. Nicolson
1 Haddington Place 7

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Edric Films Ltd.
34/36 Oak End Way

Glasgow
C. H. Steele
141 St. Georges Rd. C2

Goodmayes
Unique Radio
6 The Facade

Guildford
P.J. Equipment
3 Onslow St.

Ilford
Ilford Music Shop Ltd.
Pioneer Market Ilford Lane

Barking
Davis & Kays
21 London Rd.

Kirkcaldy
Caithness Brothers
270 High St.

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Becketts Film Services Ltd.
The Headrow 1
P.W.B. Audio Ltd.
33 Call Lane

Leicester
United Film Services
7 Kings St.

Liverpool
Beaver Radio Ltd.
60 Whitechapel

Manchester
Godleys Radio & T.V. Ltd.
8 Shudehill
Lancs Hi-Fi Ltd.
8 Deansgate 3
Kendal Milne Ltd.
Deansgate

Newcastle-on-Tyne
Turners Ltd.
Pink Lane

Nottingham
Audio Centre
Pelham St.

Oxford
Westwoods
45 George St.

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A. E. Ford Ltd.
84 Cornwall St.

Redcar
McKenna & Brown Ltd.
135 High St.

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Stephens
348 Gt. Cheetham St. East 7

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Sheffield Photo Co. Ltd.
6 Norfolk Row Fargate

Southampton
University Audio
4 Bargate St.

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Wayfarers Radio Ltd.
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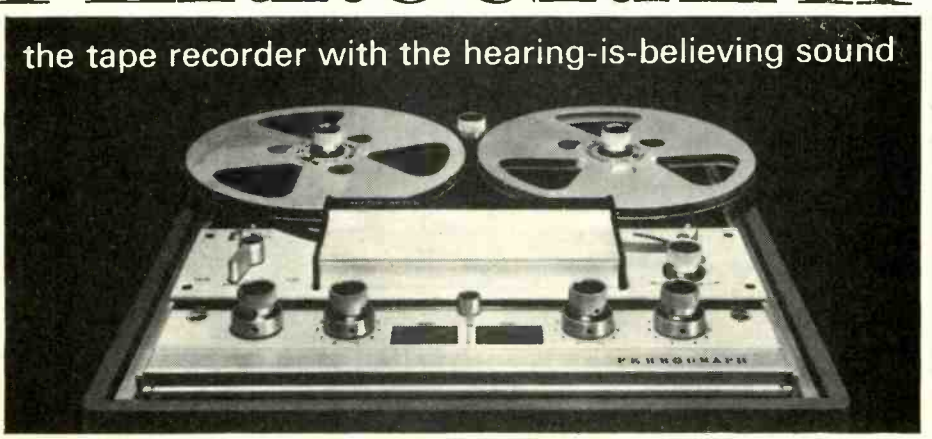

To The Ferrograph Co Ltd
Ferrograph House
84 Blackfriars Road London SE1
Please send me a free brochure on the Ferrograph New Generation Series 7

NAME .....

ADDRESS .....

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WW

WW—034 FOR FURTHER DETAILS

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IMMEDIATE DESPATCH

NEW

Solid State Process Timer type TDS

LATEST CIRCUIT PROVIDES PROLONGED ACCURACY

- 1% REPEAT ACCURACY
- OCTAL BASE PLUG-IN
- CIRCUIT CONTAINS BUILT-IN VOLTAGE STABILISER
- CONTACTS

Timed out 5 amp C/O
Instantaneous ·15 amp normally open
30 sec and 60 sec Linear dials
110 and 240 VAC operated
Approximately £10 dependent on quantity

SYS MINI-TIMER

SYNCHRONOUS MOTOR & CLUTCH

★ 10 MILLION OPERATIONS

★ Instantaneous & Timed out 3 AMP contacts.

★ Repeat Accuracy ±½%. 10 secs to 28 Hrs. May also be used as impulse start and automatic reset.

£11.0.0 approx. dependent on quantity.

NEW

TEMPERATURE CONTROLLER TYPE THP

- THERMISTOR OPERATED
- OCTALBASE PLUG IN
- COMPACT

Temperature ranges up to 240°C
Output contacts .4 amp
Accuracy 2% full scale
Complete with Thermistor
Approximately £15 dependent on quantity

AT-10 PNEUMATIC TIMER-delay relay

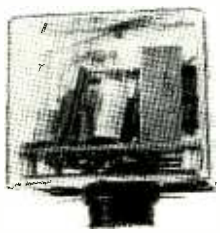
★ Fully adjustable up to 200 seconds. Fitted with 15 amp. S.P.D.T. switch.

★ One model provides delay after energise or delay after de-energise

approx. **£7.0.0**

dependent on quantity.

FLOATLESS LIQUID LEVEL CONTROL



★ 5 amp. OUTPUT CONTROL CONTACTS

★ Solid State

★ Octal-Base plug-in

The most compact unit available, measures only 2½" × 2½" × 3".

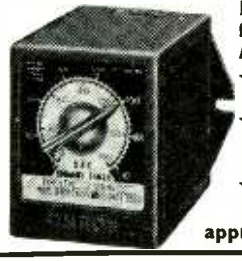
Approx. **£4.0.0.**

dependent on quantity.

SINGLE AND TREBLE STAINLESS ELECTRODES AVAILABLE.

STP Sub-Mini Process Timer

SYNCHRONOUS MOTOR & CLUTCH



Matchbox size frontal area.
Automatic re-set.

★ PLUG-IN OCTAL BASE

★ INSTANTANEOUS AND TIMED OUT 2 AMP CONTACTS

★ RANGES: 10 SECS. TO 36 MINS.

approx. **£5.0.0** each.

YL2 GPA

MAINS OPERATED PROXIMITY SWITCH

★ FOR BATCHING, CONVEYORS, MACHINE TOOL CONTROL, PACKAGING, SORTING, etc.

★ SENSES FERROUS OBJECTS

★ NEEDS NO MECHANICAL FORCE OR PRESSURE TO OPERATE

★ SOLID STATE SENSING HEAD INCLUDES CONSTANT VOLTAGE CIRCUIT

approx. **£12.10.0** dependent on quantity.

OTHER INDUCTIVE AND CAPACITY TYPES AVAILABLE

YL2 GPB

S5G

★ 1 MILLION OPS.
5 amp. c/o Sub-miniature Micro-switch.

2/6 each per 1,000

VAQ

★ 10 amp. c/o PUSH BUTTON Panel mounting. Buttons in six colours.

4/4 each per 1,000.

HEAVY DUTY PUSH-BUTTON SWITCHES

7 different panel mounting actuators including; knob, key, and lever, as well as push on/push off. Up to 4 switch blocks can be fitted. Dust and splash proof, D/P slow make and break, 5 amp rating. Full literature on request.

VV-15-1A

★ 15/10 AMPS. c/o

★ 100,000 ops.

1/11 each per 1,000
Single Throw 1/6 each

LIMIT SWITCH

WL 10 FNJ

★ 10 AMP 2 CIRCUIT

★ 5 INCH FLEXIBLE ACTUATOR AS ILLUSTRATED

AS LOW AS **53/9** EACH.

FIVE OTHER STANDARD TYPES AVAILABLE

V-10-1B

★ 1 MILLION OPERATIONS.

★ 10 amp. c/o.

★ COMPARE OUR SPEC. & OUR PRICES WITH OTHER SIMILAR TYPES.

Screw Terms. **3/1** each per 1,000

V-10-1A Solder Tags 2/3 each per 1,000
VV-15 IC2 187 Amp Tags 2/6 each per 1,000

NEW ! *Approx. 3/3 each per 1,000.*

CCR-5

Light force wire operated Micro-switch. Designed for even more economical coin operation mechanism.

U.L. APPROVED (Appr. No. 32667) - - - U.S. MILITARY SPECIFICATION

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OMRON PRECISION CONTROLS

OMRON LTD: 313 Edgware Road, London, W.2 Tel.: 01-723 2370 01-262-8584

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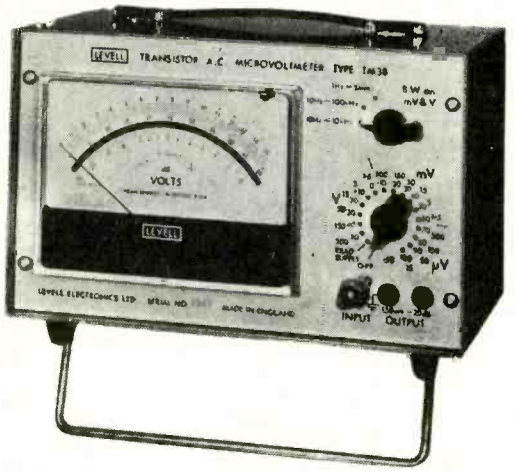
LEVELL VOLTMETERS measure μV's from 1Hz to 450MHz

TRANSISTOR A.C. MICROVOLTMETERS

Response from 1Hz to 3MHz with amplifier output available. Two versions differ only in meter size and bandwidth switch on type TM3B.



TYPE TM3A

£49

Complete with battery and input lead.

OPTIONAL EXTRAS
Leather case **£4/10/-.**
A.C Power Unit **£7/10/-.**

TYPE TM3B

£63

Complete with battery and input lead.

OPTIONAL EXTRAS
Leather Case **£5.**
A.C. Power Unit **£7/10/-.**

VOLTMETER RANGES

15μV, 50μV, 150μV . . . . 500V f.s.d. Accuracy ±1% ±1% f.s.d. ±1μV at 1kHz.

dB RANGES

−100dB to +50dB in 10dB steps. Scale −20dB to +6dB. 0dB = 1mW into 600Ω.

FREQUENCY RESPONSE

Above 500μV: ±3dB from 1Hz to 3MHz, ±0·3dB from 4Hz to 1MHz.
On 500μV: ±3dB from 2Hz to 2MHz.
On 150μV: ±3dB from 4Hz to 1MHz.
On 50μV: ±3dB from 7Hz to 500kHz.
On 15μV: ±3dB from 20Hz to 200kHz.

AMPLIFIER OUTPUT

150mV at f.s.d. on all ranges. Will drive a load of 200kΩ and 50pF without loss.

POWER SUPPLY

One type PP9 battery, life 1000 hours; or, A.C. mains when Power Unit is fitted.

★ ★ ★ ★ ★ ★ ★ ★ ★ ★

BROADBAND VOLTMETERS

As A.C. Microvoltmeters plus H.F. probe to extend response to 450MHz. Two versions differ only in meter size and L.F. bandwidth switch on type TM6B.

TYPE TM6A

£85

Complete with battery and input lead.
OPTIONAL EXTRAS

Leather Case **£4/10/-.**
A.C. Power Unit **£7/10/-.**

TYPE TM6B

£99

Complete with battery and input lead.

OPTIONAL EXTRAS

Leather Case **£5.**
A.C. Power Unit **£7/10/-.**

H.F. VOLTAGE RANGES

1mV, 3mV, 10mV . . . . 3V f.s.d. Square law scales. Accuracy ±4% of reading ±1% of f.s.d. at 30MHz.

H.F. dB RANGES

−50dB, −40dB, −30dB . . . . +20dB. Scale −10dB to +3dB. 0dB = 1mW into 50Ω.

H.F. RESPONSE

±0·7dB from 1MHz to 50MHz.
±3dB from 300kHz to 400MHz.
±6dB from 400MHz to 450MHz.

L.F. RANGES

As TM3A and TM3B except for the omission of 15μV and 150μV.

POWER SUPPLY

One type PP9 battery, life 1000 hours on L.F. ranges and 400 hours on H.F. ranges; or, A.C. mains when Levell Power Unit is fitted.

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PORTABLE INSTRUMENTS

Fully detailed leaflets are available on our complete range of portable instruments.

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STAND NO. E257. I.E.A. EXHIBITION, OLYMPIA

WW—038 FOR FURTHER DETAILS

PERFECTION— HERE WE COME

Start with one of the new "Series Four" Microphones, add our new Multi-Impedance Mixer, and feed into LUSTRAPHONE'S 50 watt (RMS) Silicon Transistor Amplifier. Finally, connect to the finest Loudspeaker you can find, and you will be a Stage Closer to Perfection. The Multi-Impedance Mixer, which can be used for both Mono and Stereo operation, employs plug-in modules for the utmost versatility. Advanced, but brilliantly simple, circuitry ensures that distortion, signal to noise ratio, and spurious breakthrough are of professional standards. Inputs of 50 Ohms, 200 Ohms and 2M Ohms are provided on *each* channel.
Like the LUSTRAPHONE Multi-Impedance Mixer, the LUSTRAPHONE 10 watt (RMS) and 50 watt (RMS) Silicon Transistor Amplifiers incorporate "State of the Art" circuitry resulting in unequalled performance and reliability.

Brief Specification of LUSTRAPHONE Silicon Transistor Amplifiers:

Power Output:	10 watt RMS or 50 watt RMS.
Frequency Response:	20 HZ to 20K Hz within 1db.
Total Harmonic Distortion:	0.5% at full rated power.
Signal to noise ratio:	74 db (Mixer).
Signal to noise ratio:	102 db (Power amplifier).

Send for free literature giving full details of LUSTRAPHONE "Series Four" Microphones, Multi-Impedance Mixers, and Silicon Transistor Amplifiers.

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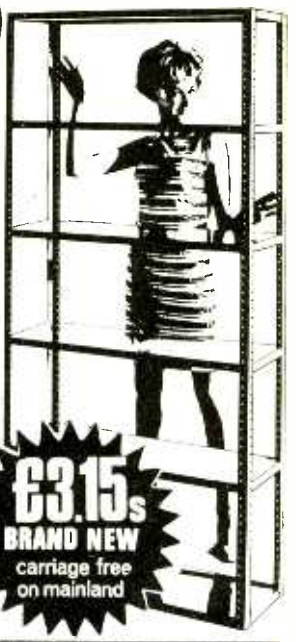

Immensely strong— completely adjustable, every inch. Delivered free, mainland, with spanner provided for erection in minutes. Buy it by the bay!

73" high x 34" wide x 12" deep unit with six shelves in heavy-gauge steel, stove enamelled grey or green! £3.15s.—Brand New! See the rest of the N.C. Brown range!

N.C. BROWN LTD.
pacesetters in storage equipment

Send your FREE BROCHURE ☐ or Send ☐ (how many) bays of steel shelving @ £3.15s in green ☐☐ grey (tick which)

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Address

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Tel: 69018. London. 25-27 Newton St., W.C.2
Tel: 01-405 7931

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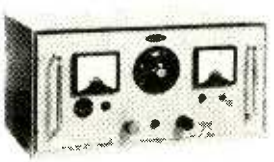
VARIABLE—HIGH CURRENT SMOOTHED POWER SUPPLIES WITH ACCUMULATOR PERFORMANCE DIRECT FROM A.C. MAINS



TYPES
250VRU/30/20
250VRU/60/10
250VRU/120/5
250VRU/240/2.5

PRICE: £131.5.0

TYPE 250VRU/30/20 provides outputs of 0-30 v. D.C. continuously variable, up to 20A. Overload capacity 200% for short periods Ripple Content, impedance and regulation equivalent to accumulator performance. Output protected.

INCORPORATES HEAVY DUTY SILICON RECTIFIERS. Complete with volt and amp meters, free standing, but suitable for 19in. racking.

USED BY MINISTRY OF TECHNOLOGY: Aircraft operators, for servicing 28 v. aircraft instruments, radio; within B.C.A.R.'s.

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Avoid the extra expense of super regulation you may never need.

PRICES: from **£31/4/-** up to **£88/4/-.**

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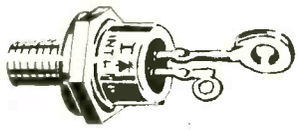

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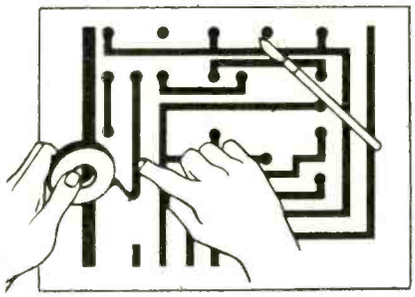

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Save drafting time and costs. Self-adhesive shapes and tapes. Terminal circles—fillets—tees—elbows—universal corners and mounting holes.

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for the protection of rectifiers and thyristors.

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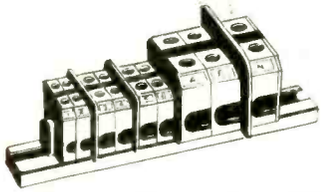

Rail Mounted Terminals and Terminal Blocks 0·5-250 Amps.

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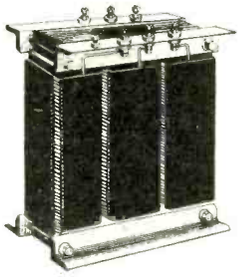

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0·25 kVA to 300 kVA

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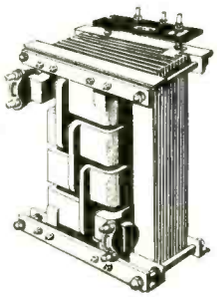

LOW VOLTAGE HIGH CURRENT TRANSFORMERS

with output currents of hundreds, thousands and tens of thousands of amps.
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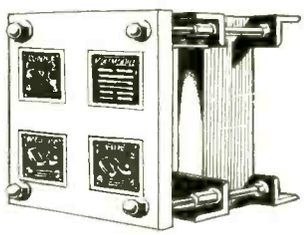

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200-400 Amps.

Zero to 100% Volts or 125% of Input Volts.

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For Magnets, Accelerators, Plating, Anodising, Spectroscopy, Plasma Arc, Toronto Arc, Electron Beams, Electrolysis, Welding, Quartz Lamps, Mercury Vapour Lamps. From 100 W to 200 kW.

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MALLORY

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THE NEW WHITELEY *Stentorian* INTEGRATED AMPLIFIER SYSTEM

A fully transistorized integrated amplifier designed for use with all types of pickup cartridges, it has facilities for tape and microphone inputs and the bass, treble, volume and balance controls are included. Input selection and mode of operation is by push-button switches. Available in its own specially designed teak veneered cabinet for shelf or bookcase mounting or in the new compact equipment cabinet illustrated. Come and see the full range of Whiteley Stentorian speakers and cabinets and discuss your particular hi-fi problems with our technical representatives.

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STAND No. 85

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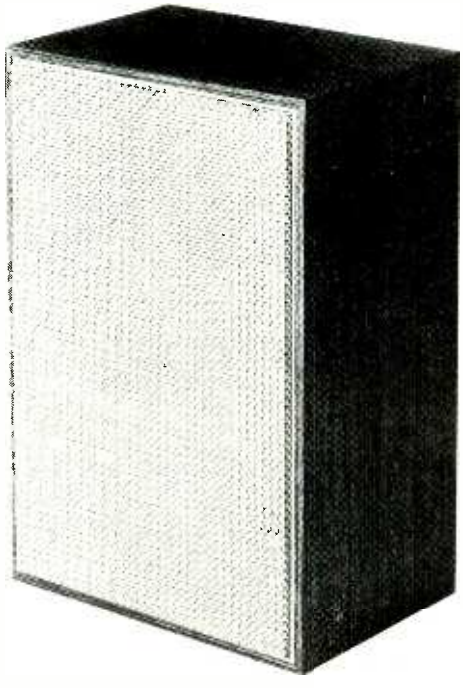
LOUDSPEAKER SYSTEMS



LC93

A 19" x 12½" x 8½" completely enclosed acoustically loaded cabinet housing a 9" graded Melamine paper cone with siliconized cambric suspension giving a frequency response of 60 Hz to 20 KHz.

LC94

A 29½" x 23¾" x 6⅛" acoustic Labyrinth enclosure fitted with acoustic resistance in the pipe, using the same highly efficient 9" speaker unit used in the LC93. Frequency response 45 Hz to 20KHz.

LC95

The LC95 loudspeaker system is an acoustically loaded Bass Reflex cabinet, measuring 31½" x 20¾" x 13½", fitted with two loudspeakers and a crossover network. The bass loudspeaker being used is a newly developed 12" unit having a Melamine treated paper cone with a cambric surround. The middle and high frequency unit is a new 8" loudspeaker having a Melamine treated paper ribbed cone and surround.

WHITELEY ELECTRICAL RADIO CO. LTD. MANSFIELD, NOTTS.

Telephone: Mansfield 24762 London Office: 109 Kingsway, W.C.2 Tel. HOLborn 3074

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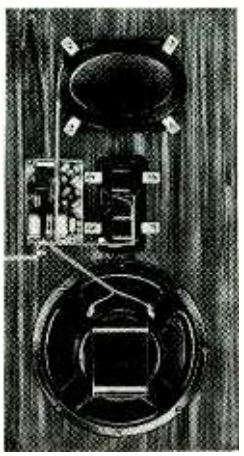
Peerless

HI-FI BAFFLE SPEAKER SYSTEMS FOR MONO AND STEREO

The new Peerless systems are engineered to the high quality standards that have made Peerless pre-eminent in high-fidelity design over the past years. Our experience, together with the most careful selection of materials and strictest manufacturing controls, assure performance of highest quality.

All the speaker systems are mounted and wired on a front board covered with plastic fabric grille and ready for cabinet mounting. Available in 4 ohm, 8 ohm or 16 ohm impedance.



4-30 PABS

4-30 PABS (also available as KIT, see below).

is a 3-way speaker system consisting of 4 speakers and crossover network
Max. Power Input: 30 Watts.
Frequency Range: 30-18000 c.p.s. in 50 litres (1.75 cb. ft.) cabinet.
Speakers Woofer D 120 W. special. Mid. Range O 570 MRC.
Tweeters 2 × MT 23 HFC.
Crossover Frequencies: 500 and 3500 c.p.s.
Dimensions (inside) for 50 litres cabinet: Approximately 24$\frac{5}{16}$in. × 13$\frac{3}{8}$in. × 9$\frac{1}{4}$in. (630 × 340 × 234 mm.).
Brown coloured plastic fabric grille.

2-8 PABS (also available as KIT, see below).

is a 2-way speaker system consisting of 2 speakers and crossover network.
Max. Power Input: 8 Watts.
Frequency Range: 50-18000 c.p.s. in 16 litres (0.57 cb. ft.) cabinet.
Speakers: Woofer B 65 W. Tweeter MT 25 HFC.
Crossover Frequency: 4000 c.p.s.
Dimensions (inside) for 16 litres cabinet: Approximately 15$\frac{9}{16}$in. × 9$\frac{3}{8}$in. × 6$\frac{1}{2}$ (395 × 245 × 165 mm.).
Specify grey or golden coloured plastic fabric grille.

2-10 PABS (not available as KIT)

is a 2-way speaker system consisting of 2 speakers and crossover network.
Max. Power Input: 10 Watts.
Frequency Range: 50-18000 c.p.s. in 6.5 litres (0.23 cb. ft.) cabinet.
Speakers: Woofer O 525 WL. Tweeter MT 20 HFC.
Crossover Frequency 3500 c.p.s.
Dimensions (inside) for 6$\frac{1}{2}$ litres cabinet: Approximately 9$\frac{9}{16}$in. × 6$\frac{1}{4}$in. × 6$\frac{9}{16}$in. (252 × 158 × 167 mm.).
Dark coloured plastic fabric grille.

3-15 PABS (also available as KIT, see below).

is a 3-way speaker system consisting of 3 speakers and crossover network.
Max. Power Input 15 Watts.
Frequency Range: 45-18000 c.p.s. in 30 litres (1.06 cb. ft.) cabinet.
Speakers: Woofer P 825 W. Mid Range GT 50 MRC. Tweeter MT 20 HFC.
Crossover Frequencies: 750 and 4000 c.p.s.
Dimensions (inside) for 30 litres cabinet: Approximately 20$\frac{3}{8}$in. × 8$\frac{5}{8}$in. × 10$\frac{1}{2}$in. (515 × 218 × 270 mm.).
Specify grey or golden coloured plastic fabric grille.

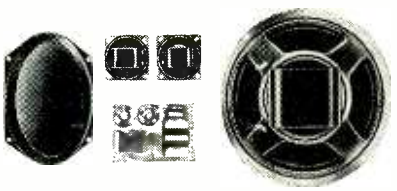
3-25 PABS (also available as KIT, see below).

is a 3-way speaker system consisting of 3 speakers and crossover network.
Max. Power Input: 25 Watts.
Frequency Range: 40-18,000 c.p.s. in 100 litres (3.5 cb. ft.) cabinet.
Speakers: Woofer CM 120 W. Mid Range G 50 MRC. Tweeter MT 20 HFC.
Crossover Frequencies: 750 and 4000 c.p.s.
Dimensions (inside) for 100 litres cabinet: Approximately 25in. × 15in. × 16$\frac{1}{2}$in. (635 × 380 × 412 mm.).
Specify grey or golden coloured plastic fabric grille.

Peerless

LOUDSPEAKER SYSTEMS IN KITS FOR MONO AND STEREO

If you want to spend a little extra time to establish your high-fidelity sound system and at the same time save money, you can get four of our PABS systems in KITS.
A KIT system consists of speakers, crossover network, drawing of cabinet as well as mounting instructions, but without baffle.
Available in 4 ohm, 8 ohm or 16 ohm impedance.



4-30 KIT

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HI-FI CABINET SPEAKERS FOR MONO AND STEREO

A trio of 2-way and 3-way compact speakers systems in oiled teak cabinets of bookshelf type, Danish design and technique at its very best.
Available in 4 ohm, 8 ohm or 18 ohm impedance.

2-10A MEDIUM SIZE SYSTEM

2-10 COMPACT SYSTEM

is a 2-way speaker system in cabinet with dark coloured plastic fabric grille. Combines one special woofer (5$\frac{1}{4}$in.), one closed-back tweeter (2in.) and a crossover network. Crossover Frequency: 3500 c.p.s. Frequency Range: 50-18000 c.p.s. Power Capacity: 10 Watts. Cabinet Size: 10$\frac{1}{4}$in. × 6$\frac{3}{16}$in. × 8$\frac{3}{8}$in. (260 × 156 × 213 mm.).

2-10A MEDIUM SIZE SYSTEM

is a 2-way speaker system in cabinet with brown coloured plastic fabric grille. Combines one special woofer (6$\frac{1}{2}$in. × 10$\frac{1}{2}$in. elliptical), one closed-back tweeter (2$\frac{1}{2}$in.) and a crossover network. Crossover Frequency: 3500 c.p.s. Frequency Range: 40-18000 c.p.s. Power Capacity: 10 Watts. Cabinet Size: 19$\frac{3}{4}$ × 9$\frac{7}{8}$in. × 10$\frac{5}{8}$in. (500 × 250 × 270 mm.).

4-30 MONITOR SYSTEM

is a 3-way speaker system in cabinet with brown coloured plastic fabric grille. Combines one special woofer (12in.), one special mid range (5in. × 7in. elliptical). two closed-back tweeters (2$\frac{1}{2}$in.) and a crossover network. Crossover Frequencies: 500 and 3500 c.p.s. Frequency Range: 30-18000 c.p.s. Power Capacity: 30 Watts. Cabinet Size: 25$\frac{9}{16}$in. × 14$\frac{3}{16}$in. × 11$\frac{7}{8}$in. (650 × 360 × 300 mm.).

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May WW 1968

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  Ideal for fast production soldering on the majority of modern electronic equipment.
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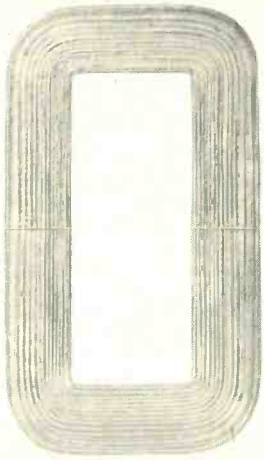
for grain oriented silicon iron transformer cores of 'C', 'E' or circular form



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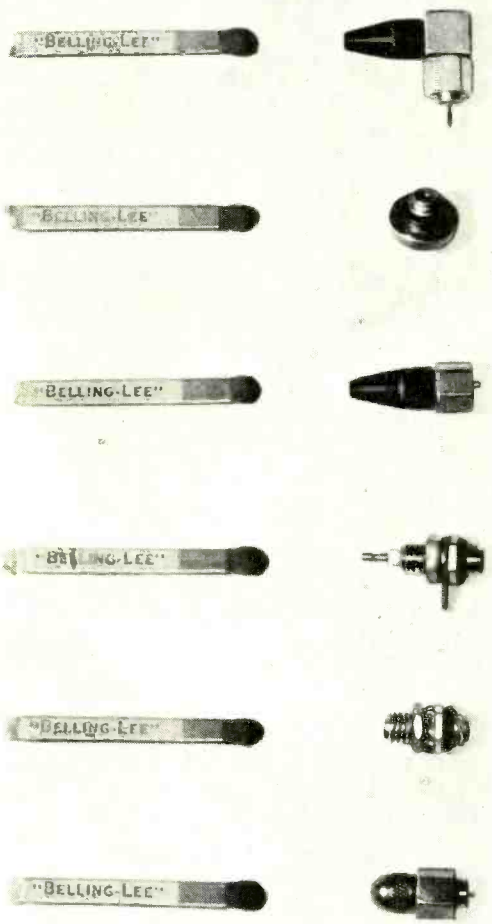

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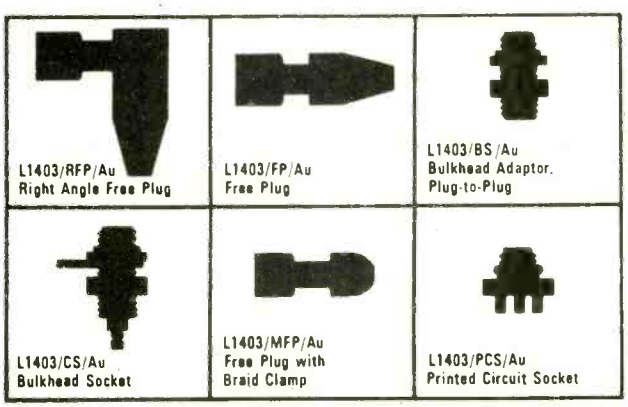

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Basic range: 6–60V @ 85°C, 1–470 µf.
Operating range: –55°C to 85°C

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* Very low stable leakage current.
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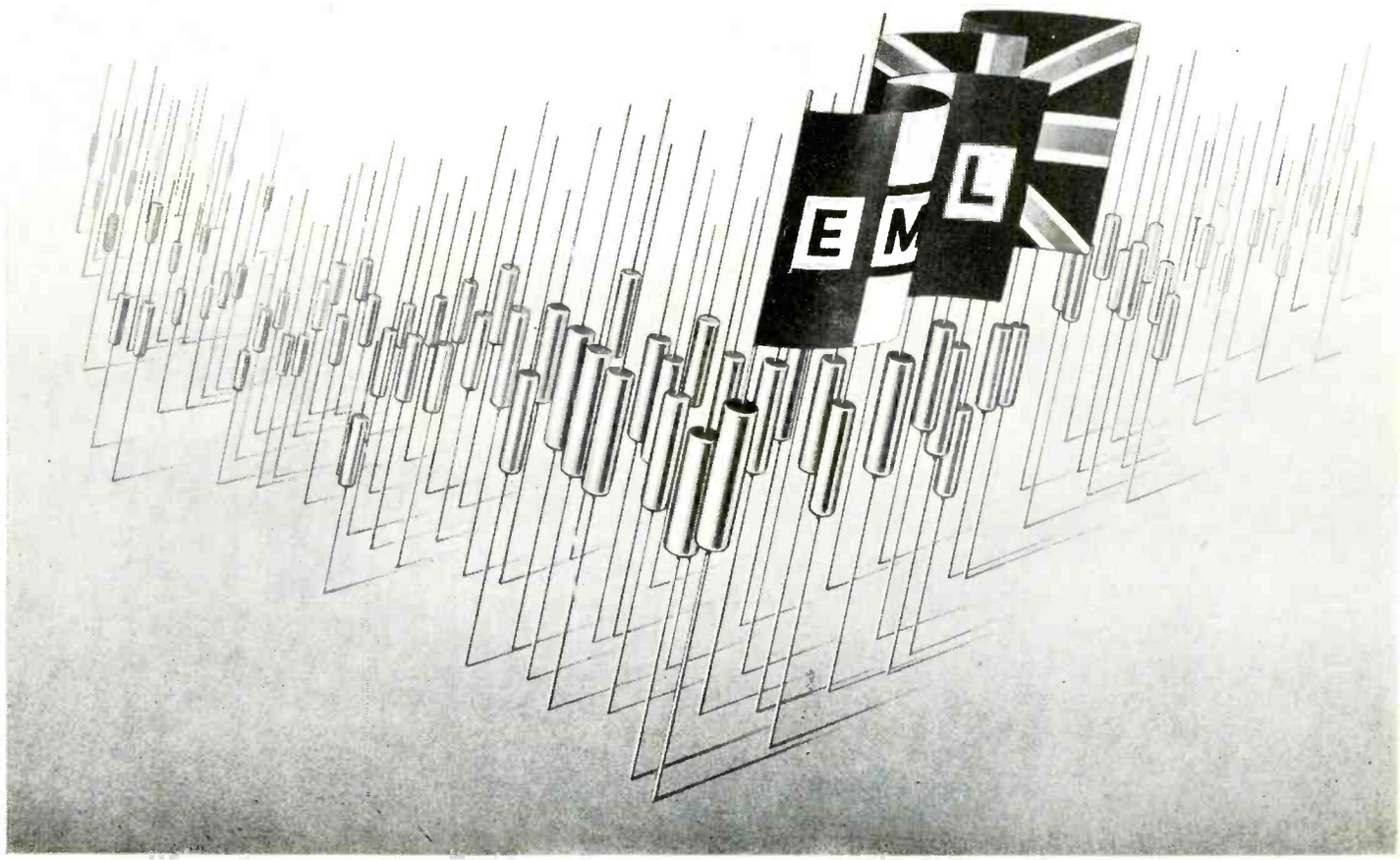

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SEE THE KEY TO PROGRESS BEING TURNED

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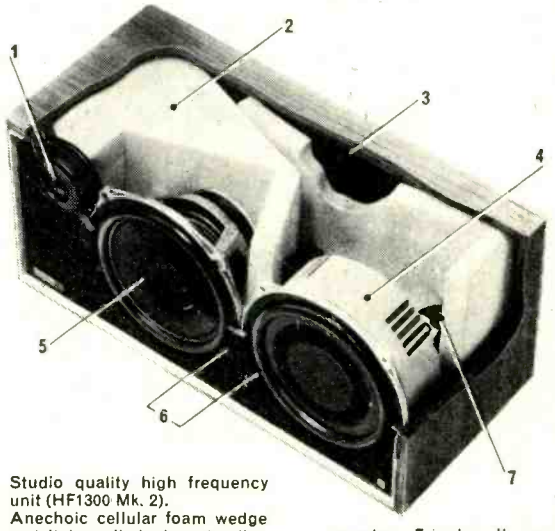
WW—074 FOR FURTHER DETAILS

Just what *is* this ABR, that makes such a vital difference to the 'DITTON 15'?



1. Studio quality high frequency unit (HF1300 Mk. 2).
2. Anechoic cellular foam wedge and lining eliminates standing waves.
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4. Auxiliary Bass Radiator (ABR) —plastic foam diaphragm giving high rigidity and low mass; double roll suspension allowing excursions up to ¼" with minimal distortion.
5. High compliance bass unit with massive Ferroba II magnet structure for optimum magnet damping and cone treated with viscous damping layer to suppress resonances.
6. Units mounted flush to eliminate diffraction effects and tunnel resonances; covered by acoustically transparent grille cloth for maximum presence.
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WW5/68

GD 997

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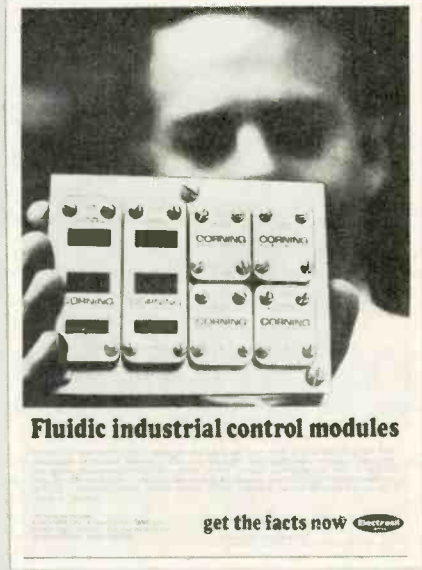

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- The latest in fluidics technology
- Interesting developments in Signetics integrated circuits
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- Augat IC breadboarding systems

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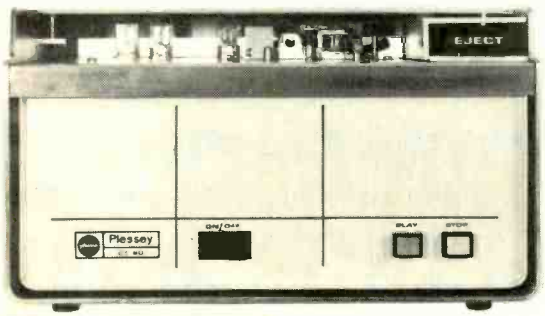
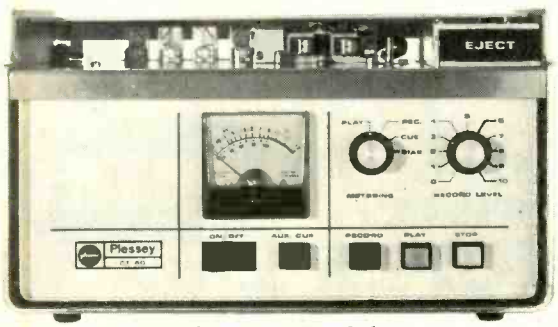
CT80
Cartridge recorders

from the world wide Plessey organisation meet the exacting demands of the broadcasting industry and other professional users–

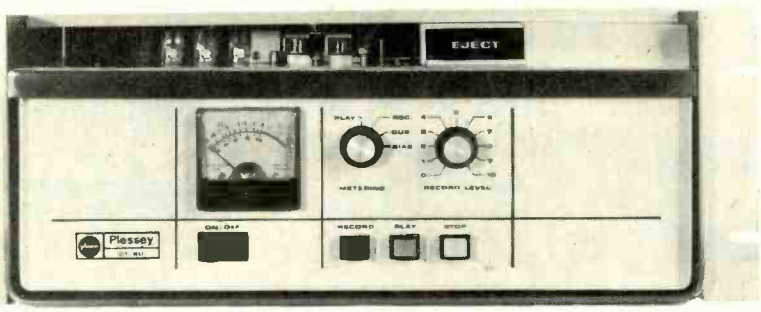


CT80P Replay Model
Desk top or recessed desk mounting

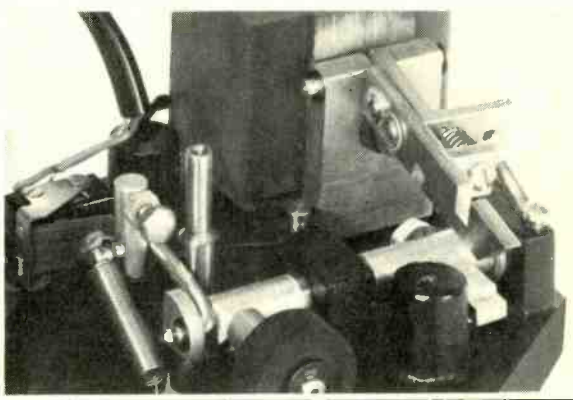


CT80R Record/Replay Model
Desk top or recessed desk mounting

Made to the world's highest professional standards, the CT80 range of endless-loop cartridge recorders offer the user peak performance and long term reliability. Radio and TV programming is **simplified** with the versatile CT80! Here are some of the important features:
Precision engineered models are available for continuous, heavy duty Replay or Record/Replay applications ☐ Loading standard NAB type A, B or C endless-loop cartridges is a split-second, one hand operation ☐ The unique capstan motor, actuating solenoid and puck wheel assembly, as illustrated, gives instant start with direct tape drive ☐ The CT80 Series is constructed in interchangeable, modular form to allow fast changeover of assemblies for maintenance purposes ☐ Individual plug-in epoxy circuit boards are fully silicon solid state with telecommunication grade components ☐ Complete head assemblies and motor/transport assemblies are available, pre-aligned and ready for use ☐ All operating, cueing and remote control facilities meet the needs of the professional user for simple, efficient and thoroughly reliable operation ☐ Further information is available now by contacting us or your local Plessey office direct.



CT80R Record/Replay Model
Standard 19" Rack mounting



PLESSEY

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AC83

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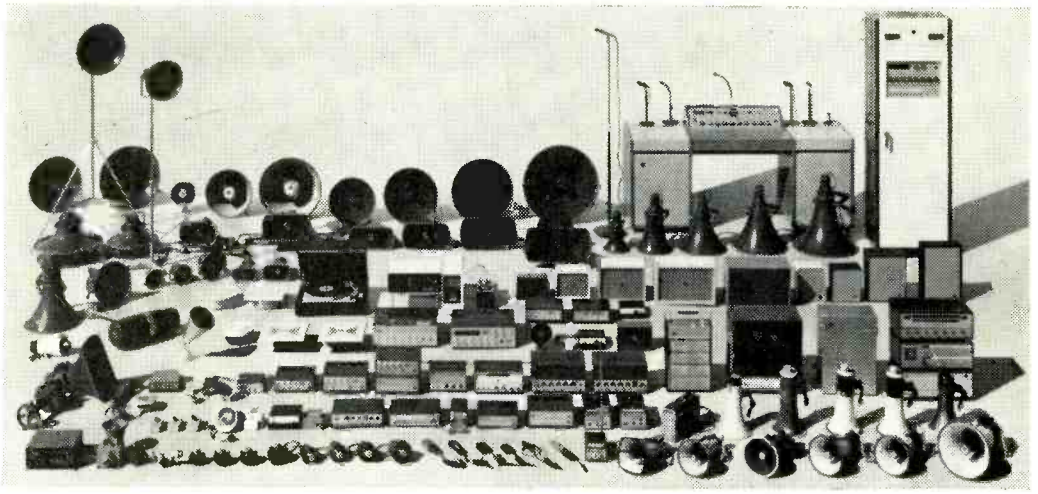

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LT55 6 WATT AMPLIFIER

A High Fidelity unit providing excellent results at modest output levels.

Frequency Response 30-20,000 cps—2dB.

Sensitivity 5 mv (max).

Harmonic Distortion 0.5% at 1,000 cps.

Output for 3-8-15 ohm Loudspeakers.

Recommended Retail price **8 GNS**

Size 9¼ × 2¾ × 5¼in.

Controls (5) Volume, Bass, Treble, Mains Switch, Input Selector Switch.

Input Sockets for 'Mike' Gram and Radio Tuner/Tape Recorder.

LTA15 15 WATT AMPLIFIER

High Fidelity Output switched inputs for Gram, 'Mike,' Tape, and Radio.

Frequency Response 10-40,000 cps —3dB.

Bass Control +18dB to —16dB at 40 cps.

Treble Control +17dB to —14dB at 14 Kcs.

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Recommended Retail price **16 GNS**

Size 9½ × 3¾ × 5¼in.

Output for 3-8-15 ohm Loudspeakers.

Please send a stamped addressed envelope for full descriptive details of above units, also TUNER/AMPLIFIERS STEREO and MONO.

LT66 12 WATT STEREO AMPLIFIER

A twin channel version of the LT55 providing up to 6 watts High Fidelity output on each channel.

Switched Input Facilities Socket (1) Tape or crystal PU (2) Radio Tuner (3) Ceramic PU Microphone.

Controls (6) Volume, Bass, Treble, Balance, Mains Switch, Input Selector Switch. Stereo/Mono Switch.

Facia Plate Rigid Perspex with black/silver background and matching black edged knobs with spun silver centres.

Recommended Retail price **15 GNS**

Size 12 × 3½ × 6in.

PTA30 HI-FI PUBLIC ADDRESS AMPLIFIER

A successor to our popular Conchord 30 watt unit.

Input Sensitivity 2 mv (max.)

★ Output 30 watts.

★ Output Terminals or Loudspeaker or combination of Speakers with total impedance between 3 ohms and 30 ohms.

★ Three individually controlled Jack Inputs for mixing purposes.

Recommended Retail price **20 GNS**

Size 12 × 3½ × 6in.

Housed in fully enclosed stove enamelled steel case.

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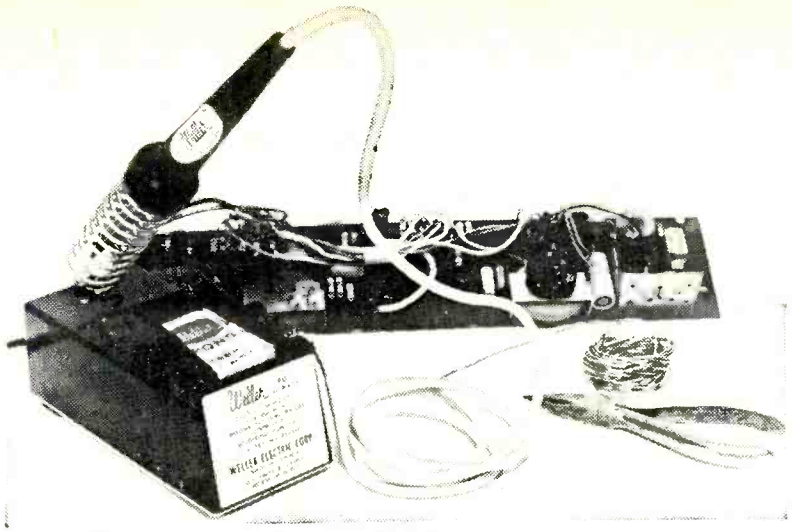

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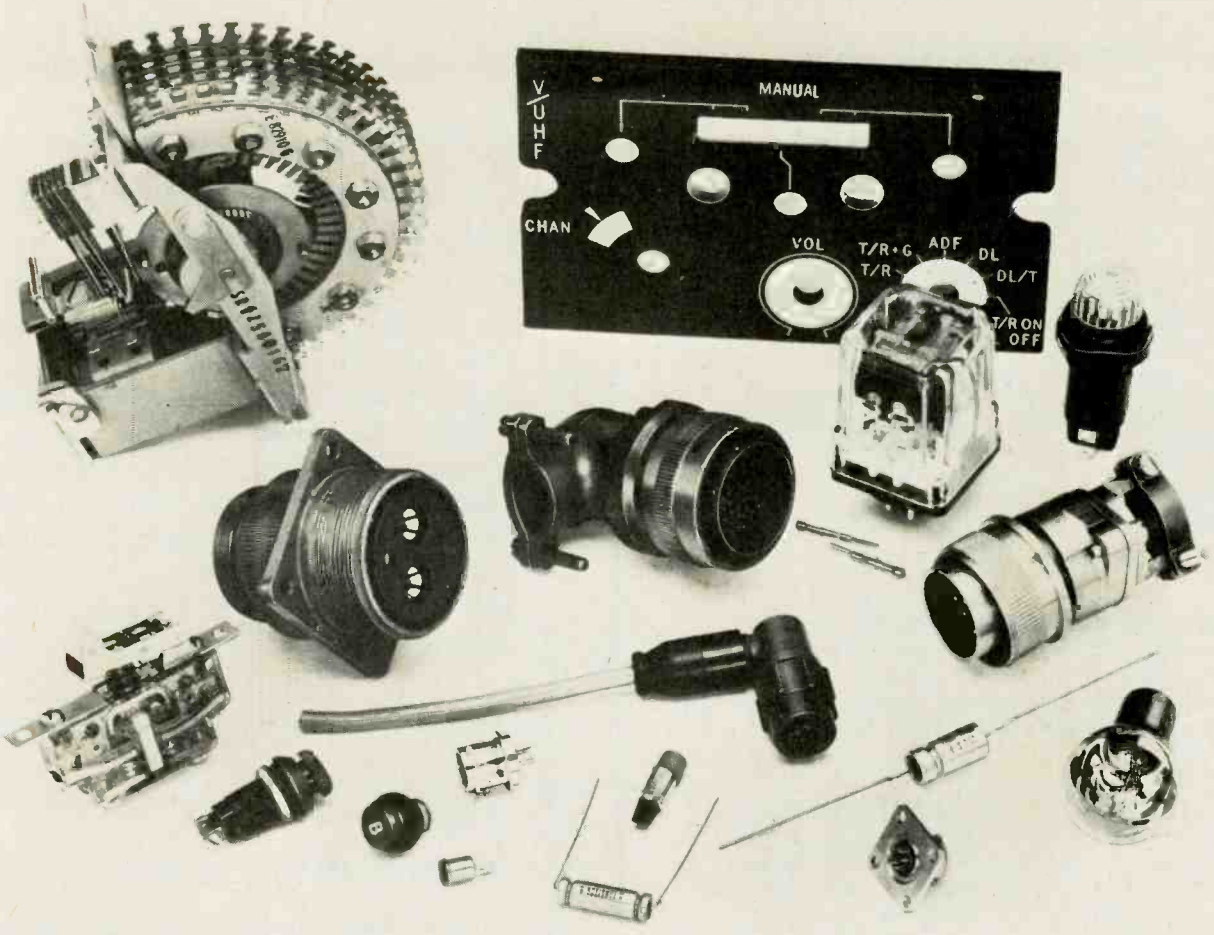

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WW—087 FOR FURTHER DETAILS

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These new devices offer features which can be exploited in an extremely wide field of applications. Their outstanding modulation and switching capabilities, coupled with completely solid state circuit design and small physical size make them ideally suited to such purposes as short distance speech and data links, remote relay controls, safety devices, burglar alarms, batch counters, level detectors, etc.

MGA100

TYPE MGA 100 General Purpose Gallium Arsenide Light Source
A filamentless, Gallium Arsenide infra-red emitter, only 5.54 mm. dia. and 8.1 mm. long. Features a robust cylindrical package coaxial with the beam, facilitating optical alignment and heat-sinking.

MAX RATINGS
Forward current I_F max. D.C.*.....400mA. *Forward peak current I_F max.* (pk)*.....6A
*Power dissipation**.....600mW. *Derating factor for T_{amb} greater than 25°C*....7.5mW/°C.
Reverse voltage V_R max.....1-0V.
**When mounted on an aluminium heat sink 1in.×$\frac{1}{4}$in.×$\frac{1}{4}$in.*
Supplied complete with suitable lenses, full Technical Data and Application Sheets, including Line of Sight Speech Link.

28′ 6 EACH *Post Free*

TYPE MSP3 Solid State Photo Receiving Device
An ultra-sensitive infra-red and visible light detector, this device is a complete silicon photo-electric receiver with a peak spectral response at 9500A. Size only 6.4 mm. dia. and 25.4 mm. long, yet absolutely complete, the device will generate sufficient power to drive an external relay. Chiefly intended for use in optical links based on Gallium Arsenide Light Sources, they are equally suitable for systems based on visible light. Features a robust cylindrical package coaxial with the incident light facilitating optical alignment and heat-sinking.

MAX RATINGS
Total dissipation (in free air, T_{amb}=25°C).....100mW. *Derating Factor*.....2mW/°C.
Output Current Intensity.....100mA. *Voltage*.....25V. *Operating Temperature*.....*from* −30° *to* +125°C.
Supplied complete with suitable lenses, full Technical Data and Application Sheets, including Line of Sight Speech Link.

MSP3

85′- EACH *Post Free*

31F2

28′ 6 EACH *Post Free*

Type 31F2 Micro-miniature Infra-Red Detector
Extremely small photo diodes of silicon NPN passivated planar construction and suitable for Punched Card Readers, Counters, Film Sound Track, etc.

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. . . and these new solid state devices . . .

RCA TRIACS Type 40432
Intended primarily for phase control of A.C. loads in light dimming, universal and induction motor control, heater control, etc., these gate controlled full-wave A.C. silicon switches, with integral trigger, switch from a blocking state to a conducting state for either polarity of applied voltage with positive or negative gate triggering.

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Wireless World

Electronics, Television, Radio, Audio

Fifty-eighth year of publication

May 1968 **Volume 74 Number 1391**

This month's cover. *In clinically clean conditions at S.T.C's North Woolwich factory a submarine repeater undergoes one of many rigorous inspections. These repeaters, now being laid on the new £22 million Lisbon-Cape Town project, are required to go on working faultlessly for periods exceeding 20 years and so have to be manufactured to ultra-high standards. Undersea cable and repeaters are now an important British export—S.T.C. has about 50% of the current world market.*

Contents

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Managing Director: Kenneth Tett
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Dorset House, Stamford Street, London, SE1

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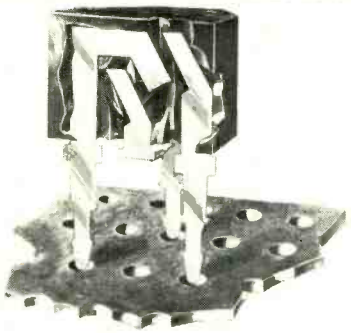
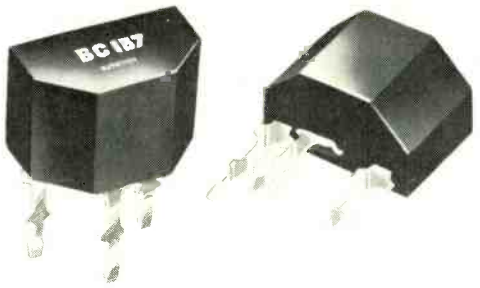
CONSUMER ELECTRONICS

Mullard





Lock-fit transistors stay where they're put

Putting transistor leads through boards, cropping them and hoping they'll stay put until soldered is out of date. Now just push a Lock-fit transistor in and it stays there. The leads are shaped to grip.

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By getting all the information before you select you can be really sure that you are going to make *savings* by choosing the particular component to meet your design parameters.

*AQL=Acceptable Quality Level.

Time well spent

There can't be many firms who've been in business as long as we have who have used the time to such advantage. Our past experience guides our future plans; provides us with an insight into the industry we serve; allows us to anticipate needs and deploy our resources over the most fruitful areas of research and development—and thereby provide modern, technically excellent products ready for the demands of tomorrow. We have co-operated in so many consumer electronics projects that it's quite likely we are working along similar lines to yours. So why not get in touch?

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WW 5

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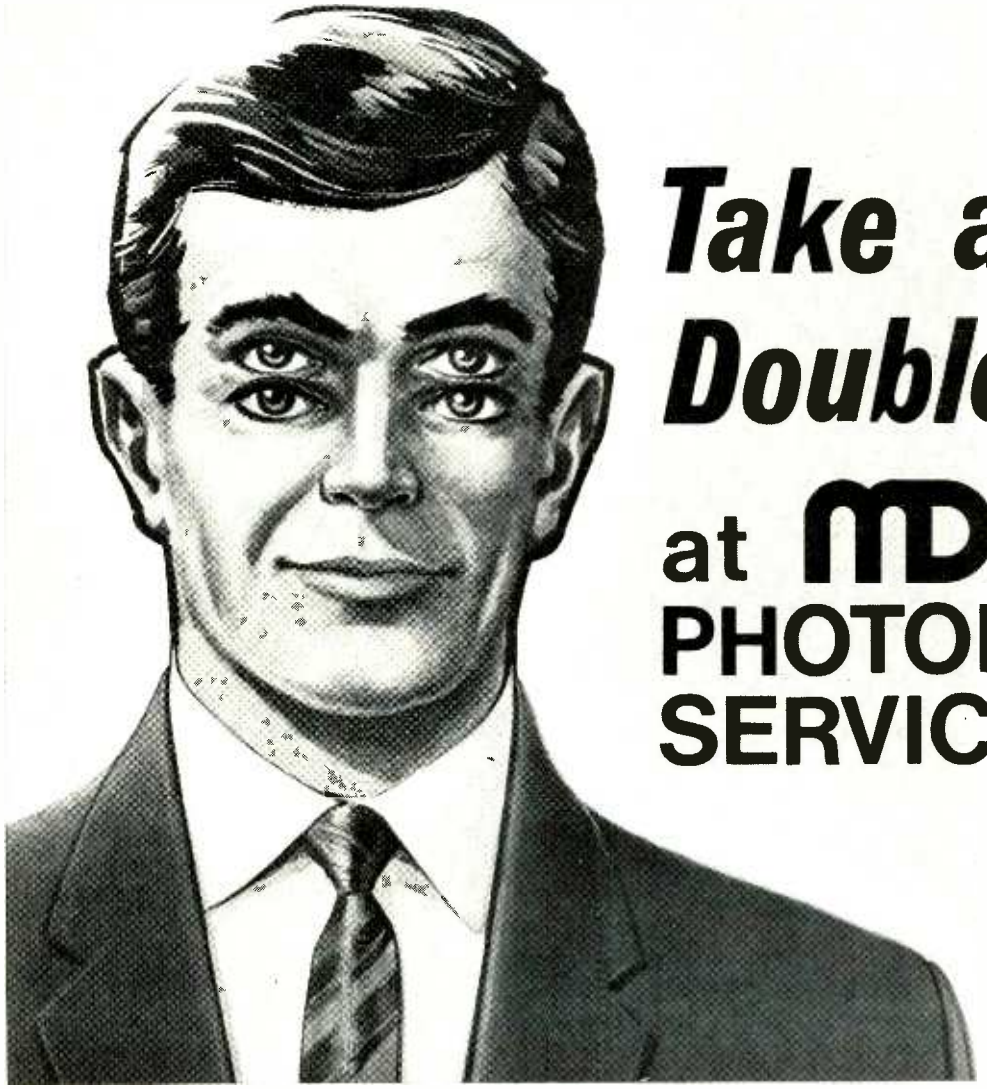

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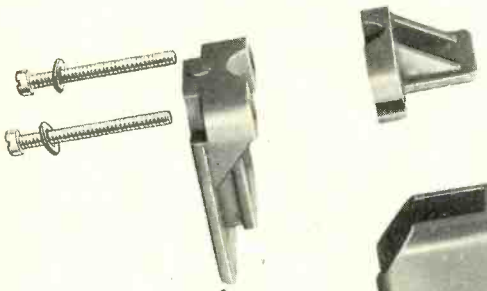

The undercover man!
That's the A.B.S. plastic cover – doing a professional protection job – to keep things clean till the dust dies down. Even a truncheon can't touch him!

The cable entry champ!
Thank him for the versatile cable get-away . . . straight out the top, or by the side exit! When he gets to grips with a problem he just won't let go.

This is the bullion specialist . . . with all the best connections! His contacts are gold plated, each has a 3 amp current rating with under 10 milli-ohm resistance and a minimum proof voltage of 1,500 volts peak!

'The bodyguard'
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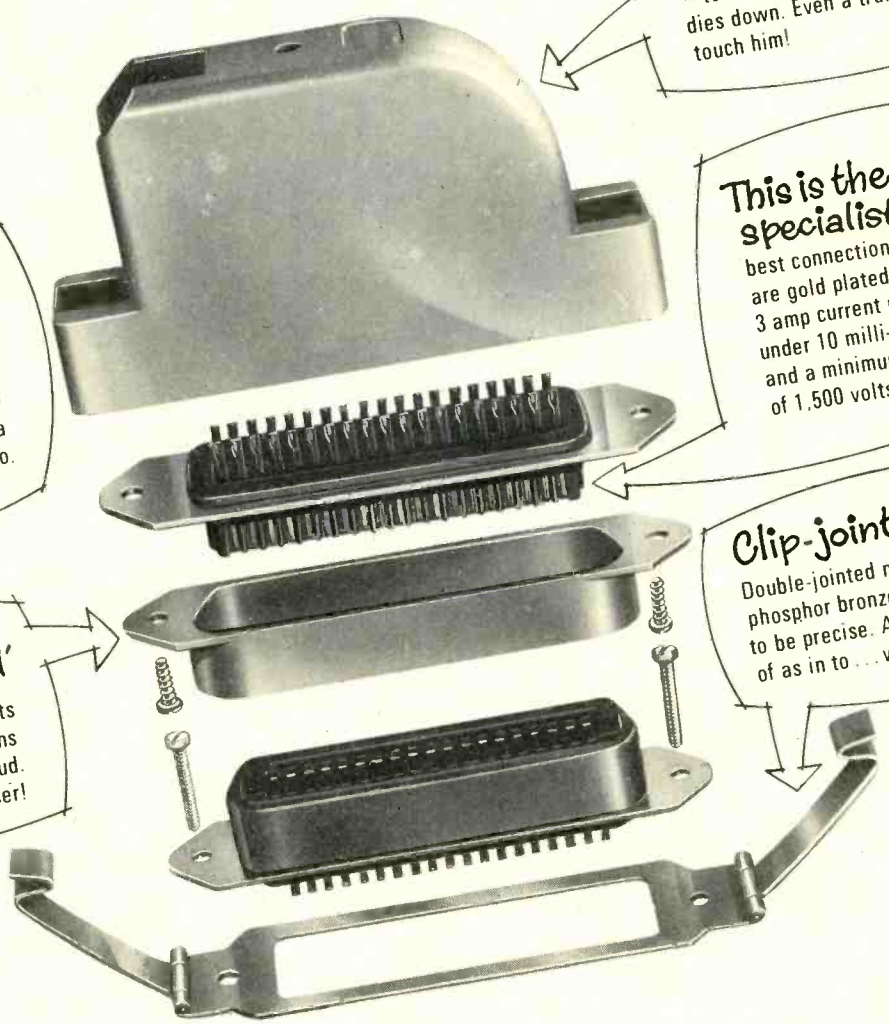
Clip-joint operator!
Double-jointed nickel plated phosphor bronze retaining clips, to be precise. As easy to get out of as in to . . . when you know how!



If you're daring enough to let the Redette boys have your name and address, they'd like to fill you in . . . on the details of the Redette range. Write or 'phone them now care of this address . . .

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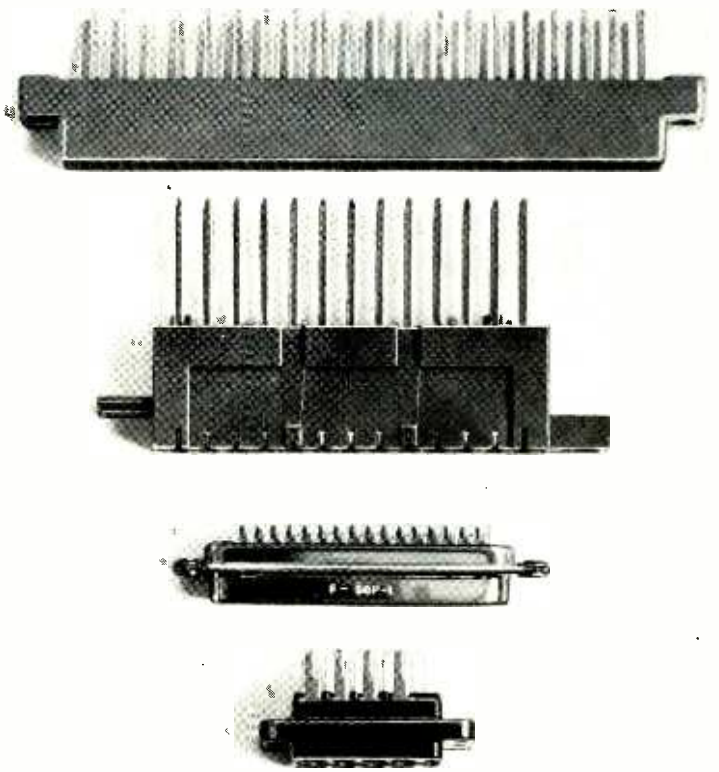
SASCO, P.O. Box No. 20, Gatwick Road, Crawley, Sussex. Tel: Crawley 28700 (also Chipping Sodbury 2641, Cumbernauld 25601 and Hitchin 2242) and agents for principal overseas countries.

We're the firm with all the best connections



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We've done our best to make it easy for you by devising some 5,000 connecting devices of one sort or another. And backing them with an endless amount of ingenuity.

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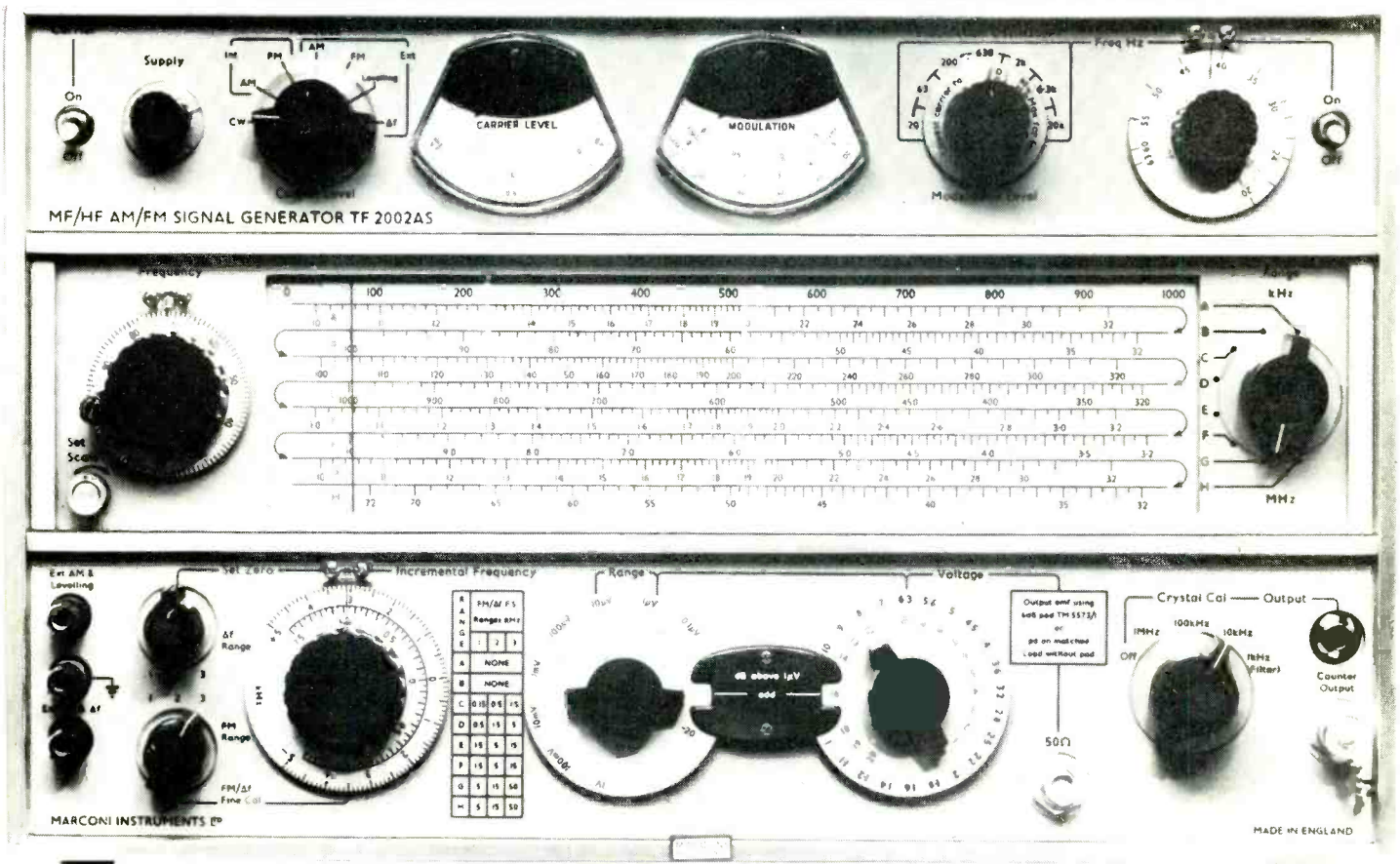

NEW MARCONI HF SIGNAL GENERATOR TF 2002 AS

All the advantages of TF 2002, the first fully solid state quality signal generator – versatility, freedom from inter-dependent controls – are retained in TF 2002AS. Now we have added F.M. and four other new features.
These – together with facilities such as a built-in variable frequency a.f. oscillator, four-range crystal calibrator with its own loudspeaker, and r.f. output down to 10 kHz with 0 to 100% a.m. – add up to an extremely powerful combination . . . and, incidentally, make TF 2002AS unique.

NEW FEATURES

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In addition to the normal a.m. the TF 2002AS has fully monitored, internal and external frequency modulation facilities.

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A control signal of ± 1 volt d.c. now gives ± 1.5 kHz shift at 100 kHz rising to ± 50 kHz at 10 MHz or above.

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Output Level:	0.1μV to 2 volts e.m.f.
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F.M.:	1.5 kHz deviation at 100 kHz.
	50 kHz deviation above 10 MHz.
Price:	£987.

Full environmental specification. Adopted for military use.
Please write for full technical details.

IEA exhibition stand N 172

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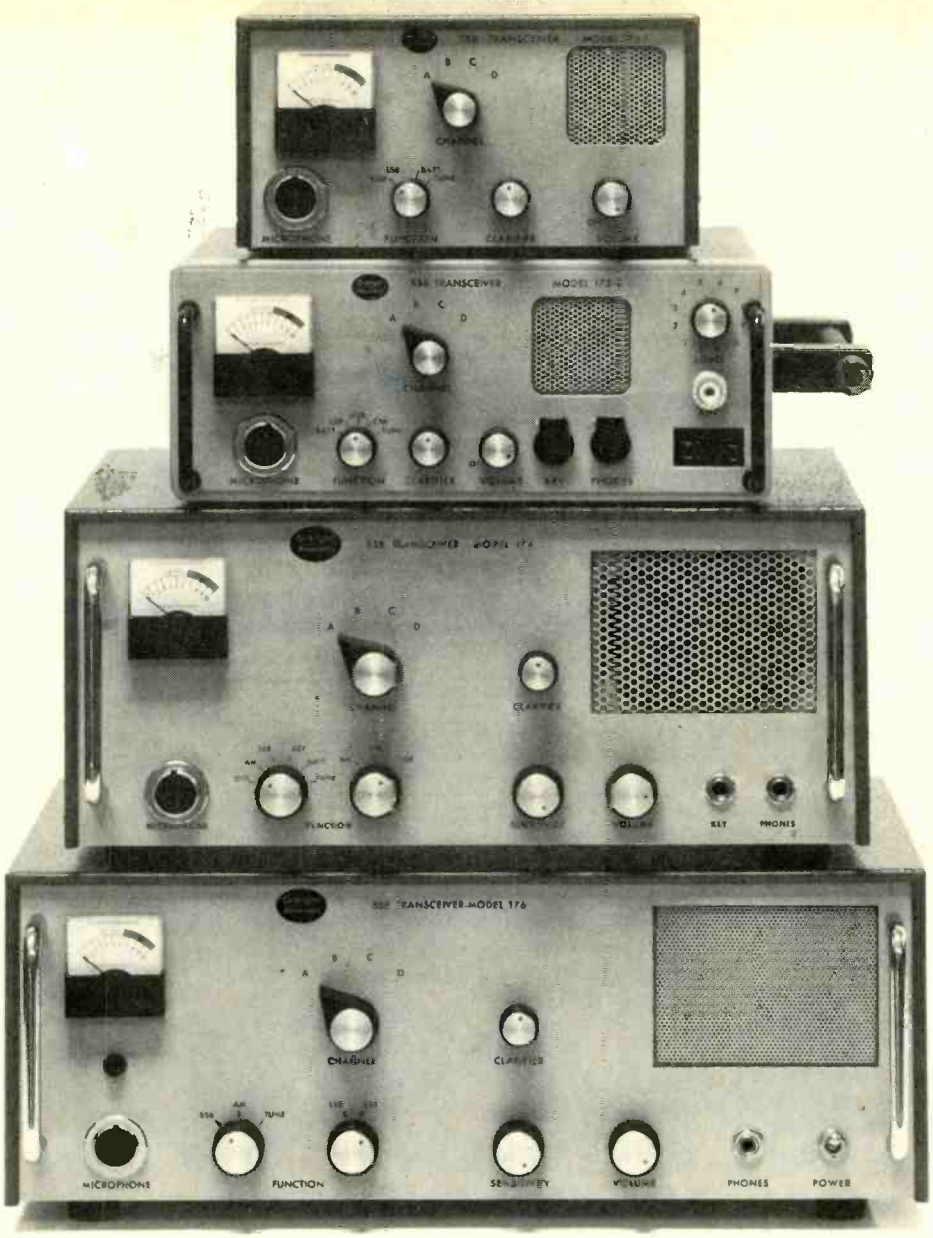
An English Electric Company

MARCONI INSTRUMENTS LIMITED
Longacres, St. Albans, Herts, England. Tel: St. Albans 59292. Telex: 23350
TA 7597



1 Model 175-1
10 watt SSB.
Mobile Set

2 Model 175-2
10 watt SSB.
Man Pack Set

Model 174-0
50 watt SSB.
Base or Mobile
Station 3

Model 176-0
100 watt SSB.
Base Station 4

Granger Associates introduce a new range of Teletransceivers

The world's leading suppliers of Wideband HF Antenna Systems now introduce a range of Single Sideband Teletransceivers utilizing the most modern solid state techniques.

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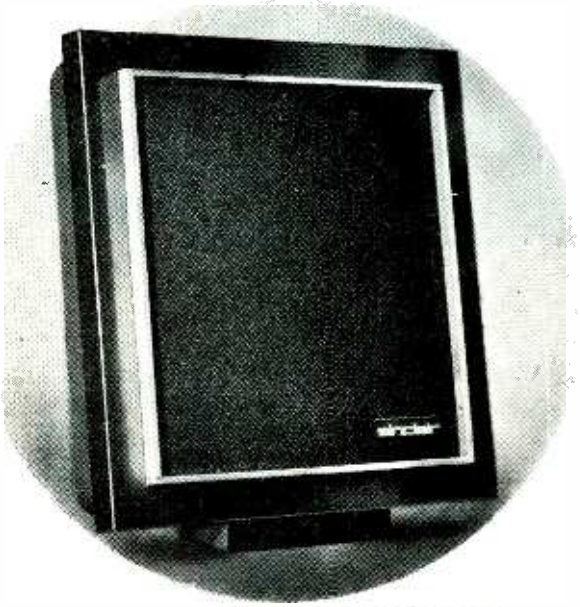
true-to-specification

SINCLAIR DESIGNS

Q.14



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- **SIZE**—9¾in. × 9¾in. × 4¾in. plus pedestal base.
- **IMPEDANCE**—15 ohms.
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- **FREQUENCY RESPONSE**—16 to 16,000 Hz with well sustained response below and above these levels.
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- **PRESSURE CHAMBER**—sealed, seamless formation made from special high-density low resonance materials.
- **FINISH**—Black matt, embellished with solid aluminium bars.
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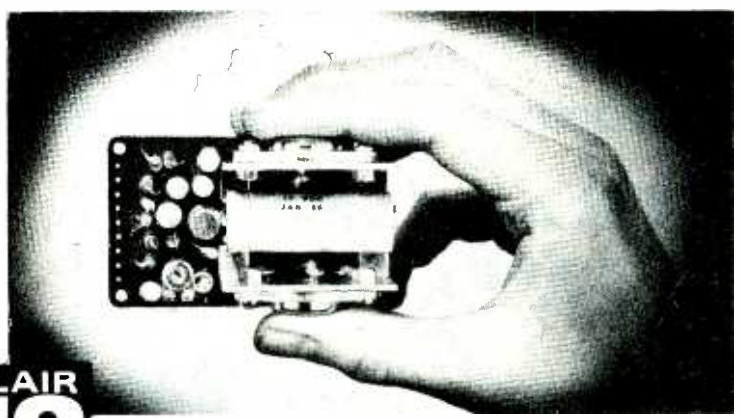
Try the Q.14 in your own home to-day. If you are not completely satisfied with this fully guaranteed loudspeaker, your money will be refunded in full including the cost of posting it back to Sinclair Radionics. Price (post free) **£7.19.6**

IDEAL IN MONO OR STEREO—Z.12 INSTALLATIONS



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COMBINED 12 WATT HI-FI AMP & PRE-AMP

- **12 WATTS R.M.S. CONTINUOUS SINE WAVE OUTPUT** (24 W. peak)
- **15 WATTS MUSIC POWER** (30 W. peak)
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- **FREQUENCY RESPONSE**—15-50,000 Hz ± 1dB.
- **PZ 4 STABILISED POWER PACK.** **99/6**
- **8 Transistors**
- **Signal to noise ratio** better than 60dB.
- **POWER REQUIREMENTS**—6 to 20V. D.C.
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Ready built, guaranteed and with Z.12 manual. **89/6**

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W.W.568

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or order straight away, working out total area of material required and referring to table below, which is for four-sided chassis in 16 s.w.g. aluminium.

48 sq. in.	5/–	176 sq. in.	10/4	304 sq. in.	15/8
80 sq. in.	6/4	208 sq. in.	11/8	336 sq. in.	17/–
112 sq. in.	7/9	240 sq. in.	13/–	368 sq. in.	18/4
144 sq. in.	9/–	272 sq. in.	14/4	and pro rata.	
P. & P. 3/–.		P. & P. 3/6.		P. & P. 4/6.	

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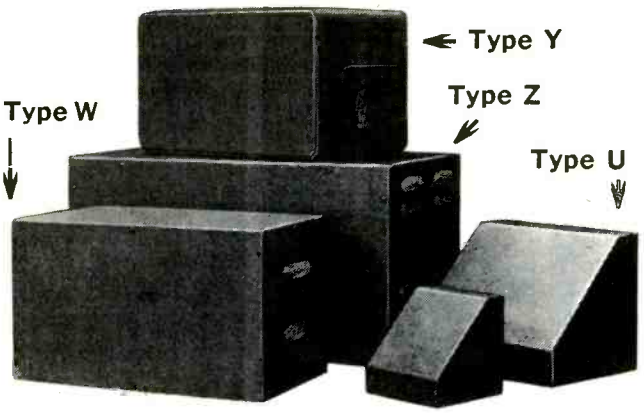
FLANGES ($\frac{1}{4}$in., $\frac{3}{8}$in.), **6d.** per bend.

STRENGTHENED CORNERS 1/- each corner.

PANELS: Any size up to 3ft. at 6/- sq. ft. 16 s.w.g. (18 s.w.g. 5/3). Plus post and packing.



CASES

ALUMINIUM, SILVER HAMMERED FINISH

Type	Size	Price
U	4 × 4 × 4*	11/–
U	$5\frac{1}{2}$ × $4\frac{1}{2}$ × $4\frac{1}{2}$	17/–
U	8 × 6 × 6	23/–
U	$9\frac{1}{4}$ × $7\frac{1}{2}$ × $3\frac{1}{2}$	24/–
U	15 × 9 × 9	49/–
W	8 × 6 × 6	23/–
W	12 × 7 × 7	37/6
W	15 × 9 × 8	48/6
Y	8 × 6 × 6*	29/–
Y	12 × 7 × 7	45/–
Y	13 × 7 × 9	50/6
Y	15 × 9 × 7	53/6
Z	17 × 10 × 9	72/6
Z	19 × 10 × $8\frac{1}{2}$	78/–

*Height
Plus post and packing.

Type U has removable bottom or back, Type W removable front, Type Y all-screwed construction, Type Z removable back and front.

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SIZES
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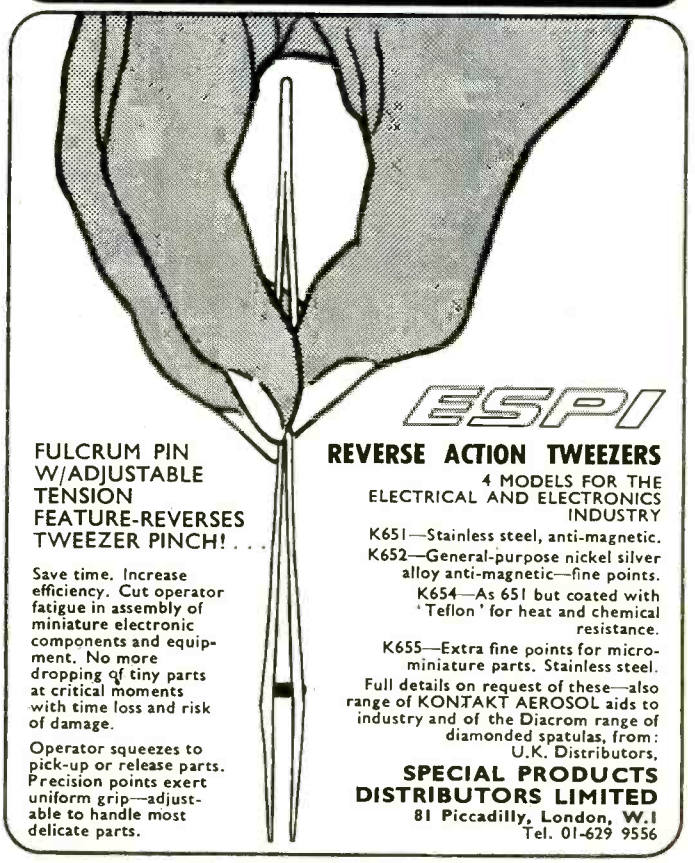
Tel: 01-460 9212 *Grams:* Transipack Bromley

WW—101 FOR FURTHER DETAILS

WHEN THE SQUEEZE IS ON THE PRESSURE IS OFF



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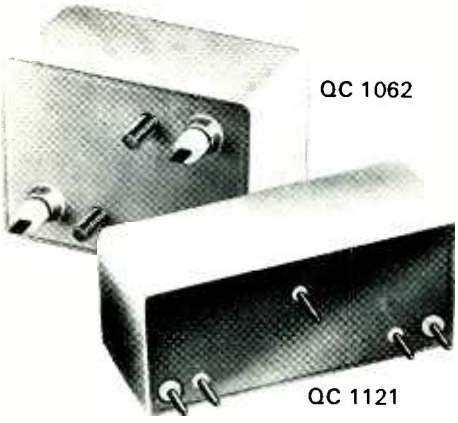
Save time. Increase efficiency. Cut operator fatigue in assembly of miniature electronic components and equipment. No more dropping of tiny parts at critical moments with time loss and risk of damage.

Operator squeezes to pick-up or release parts. Precision points exert uniform grip—adjustable to handle most delicate parts.

WW—102 FOR FURTHER DETAILS

quartz crystal filters 10·7 MHz

OVERALL SIZES:
QC 1062 1·42″ x 1·05″ x ·75″
QC 1121 1·496″ x ·708″ x ·59″



QC 1062	A	B	C	D	E	F	G
Channel Spacing	25kHz	25kHz	50kHz	50kHz	20kHz	25kHz	12·5kHz
Pass Band	±7·5kHz min.	±7·5kHz min.	±15kHz min.	±15kHz min.	±6kHz min.	±10kHz min.	±3·75kHz min.
Stop Band loss	90dB (10·4N) min.*	90dB (10·4N) min.*	90dB (10·4N) min.*	90dB (10·4N) min.*	90dB (10·4N) min.*	85dB (9·8N) min.*	90dB (10·4N) min.*
For frequencies beyond	±25kHz	±25kHz	±50kHz	±50kHz	±18kHz	±25kHz	±12·5kHz
Maintained to	±300kHz	±300kHz	±300kHz	±300kHz	±300kHz	±300kHz	±300kHz
Terminating Impedence	820ohms. in shunt with 25pF	1300ohms. in shunt with 25pF	2000ohms. in shunt with 25pF	2600ohms. in shunt with 25pF	1200ohms. in shunt with 25pF	2000ohms. in shunt with 25pF	560ohms. in shunt with 25pF

QC 1121	A	B	C	D
Channel Spacing	25kHz	50kHz	25kHz	12·5kHz
Pass Band	±7·5kHz min.	±15kHz min.	±7·5kHz min.	±3·75kHz min.
Stop Band loss	55dB (6·3N) min.*	55dB (6·3N) min.*	80dB (10·4N) min.*	55dB (6·3N) min.*
For frequencies beyond	±25kHz	±50kHz	±25kHz	±12·5kHz
Maintained to	±300kHz	±300kHz	±300kHz	±300kHz
Terminating Impedence	910ohms. in shunt with 25pF	910ohms. in shunt with 25pF	910ohms. in shunt with 25pF	560ohms. in shunt with 25pF

* Loss figures are relative to the maximum transmission level.

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A Subsidiary of the General Electric Co. Ltd. of England.

G.E.C.

WW—105 FOR FURTHER DETAILS

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CX2012

GD 974

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—for high fidelity

Write for Catalogue No: RCS 2002

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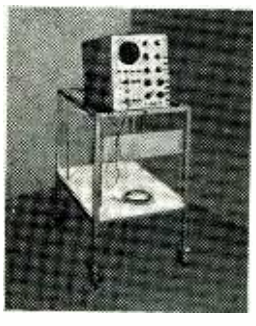

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The London Microphone range offers you quality microphones, good characteristics—and good looks, too, at remarkably little cost. All made in Britain.

NEW to the range: LM 200S Dynamic cardioid microphone. Balanced output. Like its counterpart, the LM 200, it eliminates unwanted background noise. Gives good recordings even under difficult conditions, but with this important *extra*—easily manipulated switch at point of recording.

	Low imp.	*High imp.*
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IMMEDIATE DESPATCH FULL SPARES AND SERVICE AVAILABLE

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As supplied to Min. of Defence and Crown Agents for overseas Govt.

LATEST DESIGN HEAVY DUTY 12/24 VOLT D.C.

Output: Adjustable up to **20 AMPS. CONTINUOUS** at 12/24 volts. **FULLY FUSED,** Neon indicator, 0-20 amp. meter. Size 16 × 12 × 20in high, in heavy gauge steel cabinet. Grey Hammer finish—Weight 50 lb. Input: 220/230/240 v. A.C. 50 cycles.

ONLY £32.10.0 Plus 40/- C. & P. G.B. (Inland)

30 Amp. LT. SUPPLY UNIT

UP TO 18 v. D.C. WITH SMOOTH STEPLESS VARIATION

Designed for CONTINUOUS use at max. loading

★ Fitted voltmeter and ammeter. ★ Instantaneous overload cut-out. Input: Mains A.C. Robust construction, 2 tone finish, steel case.

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Entirely suitable for plating plants, Laboratory supplies, etc.

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Specification: Output: 0-260 v. A.C. 0-240 v. D.C.

★ **Smooth stepless voltage variation from 0-Max.**
★ **Current consistent throughout the controlled range.**
★ **Ammeter and voltmeter fitted, and neon indicator.**
★ **Fully fused input and output.**

Strong steel case, with carrying handle and rubber feet. 11 × 7 × 14in. high. Made in England.

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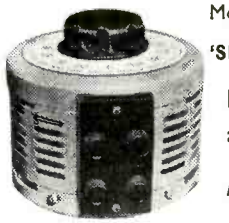
CURRENT PRODUCTION — BUY DIRECT FROM MANUFACTURER

VARIABLE VOLTAGE TRANSFORMERS



Modern styling for modern equipment

'SLIDE-TRANS' & 'SLIDUP' MODELS

Fully rated current consistent at all points along the winding

AVAILABLE ONLY FROM I.M.O.

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TRANSISTORISED MEGOHMETER

★ **PUSH BUTTON TO READ**

500 v. - 1,000 Megohms. Superb portable instrument. Supplied c/w batteries, probes and carrying case.

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NEW **LATEST PATTERN TUBULAR MAST**

Check these vital points:

★ Made from 6 × 1¾in. Sheradized steel sections, for durability and strength.
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Carr. 20/-. Returnable wood case 40/-.

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★ SENSES ANY OBJECT—INCLUDING THICK SMOKE

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★ **No attention**
★ **No Maintenance**
★ **No Moving Parts**
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Input: 190-250 v. A.C. **Output:** 240 v. A.C. **Accuracy:** ±1%. Capacity: 250 watts. Maintain "spot-on" test-gear readings at all times. **Weight:** 21 lb. Fitted signal lamp and switch. **Size:** 11 × 6½ × 6in. high.

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★ **COMPLETELY SEALED**
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230 volts A.C. Input 25-230 volts output.

5amp. model **£8/7/6**

10 amp. model **£13/15/-**

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OUTPUT: 0-260 v. 1½ amps.

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SPECIFICATION:

Alpha 0.7 to 0.997

Beta 5-300

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Capable of measuring GERMANIUM AND SILICON DIODES.

DESIGNED WITH RESISTANCE SCALE 200 ohms to 1 Megohm as an ADDED FEATURE. Housed in heavy duty plastic case, c/w internal battery.

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GERMANIUM BRIDGE RECTIFIER
Maximum rating 50 volts 5 amps. 4in. sq. cooling plates. Overall length 5in. BRAND NEW & BOXED. **22/6.** Postage 2/6.

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MARCONI TF-142E. This instrument measures the percentage of total harmonic distortion in the fundamental frequency range 100 to 8,000 c/s. The lowest scale engraving is 0.05%. Will handle 2 watts (continuous) and will give satisfactory readings with only 1 mW input. Mains operated. Output impedance 600 ohms. Very good condition. **£29.** Carr. 20/-.

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Fitted with 6SL7GT and 28D7 Valves. Brand new and boxed with manual. **12/6.** Postage 4/6.

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Detailed specification sent upon request. Offered in first class condition at **£350.** List price approximately £800.

WIRELESS SET No. 76
A compact CW only crystal controlled transmitter. Consists of a Pierce crystal oscillator (807) and a Power Amplifier (807). Both are cathode keyed by means of a relay. Six switched crystal channels are available in the frequency range of 2 to 12 Mc/s. (Crystals not included.) Aerial current is indicated on a panel meter and two spare valves are supplied. Operates from 12 v. car battery via internal rotary transformer. RF output 9 watts. Contained in steel case 12×12×8in. Weight 30 lbs. Ideal for 80 or 40 meters or cheap enough for breakdown. Condition as new. Circuit included. **£4/5/-.** Carr. 10/-.

HRO RECEIVER £30

The octal valve version. In mint condition. Complete with all nine general coverage coil sets covering 50 kc/s. to 30 Mc/s. Instruction Booklet and circuit, but less external power supply. Carriage 30/-. Complete manual available at 30/- extra.

PRICES NOW REDUCED CINTEL EQUIPMENT
ELECTROLYTIC CAPACITANCE AND INCREMENTAL INDUCTANCE BRIDGE No. 3660I
A modern instrument, all solid state, which accurately measures the capacity of electrolytic condensers from 0.1μF to 1,000μF under operating conditions. Leakage current and polarizing voltage are separately metered. Inductances from 100 mH to 100 H can also be measured with current up to 100 mA. A.C. mains operation. Unused with handbook. List price £220. Our Price **£70.**
WIDE RANGE CAPACITANCE BRIDGE. No. 1864.
A matching instrument to the above. All solid state. Mains operation. Measures from 0.002pF to 100μF. Unused with handbook. List Price £250. Our Price **£75.**

MARCONI TEST EQUIPMENT

PORTABLE FREQUENCY METER TYPE TF.1026 SERIES
TF.1026/4 2,000/4,000 Mc/s., TF.1026/5 1,800/2,200 Mc/s.,
TF.1026/6 3,800/4,200 Mc/s., TF.1026/7 1,700/2,100 Mc/s.,
TF.1026/9 2,425/2,525 Mc/s. **£40** each.

WIDE BAND MILLIVOLTMETER TYPE TF.1371
100μv to 300 mv in five ranges. 30 c/s. to 30 mc/s. **£45.**

VACUUM TUBE VOLTMETER TYPE TF.1300
A.C. measurement 0.05 to 100 v., 20 c/s. to 300 Mc/s. D.C. measurement 0.1 to 300 v. Each over 5 ranges. Will also measure ohms, 50Ω to 5mΩ in 2 ranges. **£45.**

SENSITIVE VALVE VOLTMETER TYPE TF.1100
100μv to 300 v. A.C. in 12 ranges. 10 c/s. to 10 Mc/s. Can also be used as a wide-band amplifier. **£50.**

DELAY GENERATOR TYPE TF.1415.
Provides sweep-delaying facilities when used in conjunction with the TF.1330 (series) or similar oscilloscope. Alternatively, it may be used independently as a general purpose delay generator. **£35.**

TF.867.A Standard Signal Generator	£200
TF.1066.B/2 U.H.F. F.M. Signal Generator	£200
TF.1067 Heterodyne Frequency Meter	£65
TF.1102 Amplitude Modulator	£40
TF.1221 Heterodyne Unit	£125
TF.1274 V.H.F. Bridge Oscillator	£40
TF.1275 V.H.F. Bridge Detector	£40
TF.1343A X-Band Signal Generator Set	£125
TF.1350/1 Power Unit for TF.1346/1	£40
TM 5683 Attenuator	£10
TM 6156 Attenuator	£10

Detailed technical specifications supplied upon request. Offered BRAND NEW at fraction of original cost.

Carriage and Postal Charges to N. Ireland and Eire extra.

CHARLES BRITAIN (Radio) LTD.
11 UPPER SAINT MARTIN'S LANE
LONDON, W.C.2. *01-836 0545*
Near Leicester Sq. Station. (Opposite Thorn House)
Shop hours 9-6 p.m. (9-1 Thursday). *Open all day Saturday.*

PCR-1 RECEIVERS
Covers 860-2080 metres, 190-570 metres, 5.6-18 Mc/s. 1 R.F. and 2 I.F. stages, 6 valves. Internal speaker, requires external Power supply. Circuit supplied. Fully tested prior to despatch. **£7/19/6,** Carr. 10/6. Fuller details upon request. Brand new external Power Supply Units, Vibrator Unit for operation from 12v. car battery, for caravans or boats **15/6** or A.C. Mains Units **£2.** Carr. 5/6.

AR.88 VIBRATOR POWER SUPPLY UNIT. Operates from 6-8 volt D.C. supply. Output 300 volts, 90 ma. Brand new, boxed, complete with leads. **15/-.** postage 7/6.

ADVANCE POWER UNIT TYPE DC4.
12 volts D.C. 4 amps output. A.C Mains operation 200-245 volts 50 c/s. Brand new. Boxed, **£20.** Carriage 10/6.

INDUSTRIAL METER, Iron clad. 0-300 volts A.C. 50 c/s. Moving iron, 6in. scale Fl. mtg. Brand new, boxed, **59/6,** postage 7/6.

RUTHERFORD PULSE GENERATORS
MODEL B7B. Produces trains of 50 volt pulses having repetition rates to 2 Mc/s., pulse delays and widths to 10,000μ secs., rise and fall times of 15μ millisecs. and a permissible duty factor of up to 30% at full amplitude.
MODEL B7D. Simultaneously produces two trains of 50 volt pulses (positive and negative polarity) having repetition rates from 20 c/s per sec. to 2 Mc/s per sec., pulse delays and widths to 10,000μ secs., rise and fall times which are separately and independently controllable at the front panel from 15 nanoseconds to approximately one (1) μ sec and a permissible duty factor of up to 30% at full amplitude. Offered as New at a fraction of original cost, complete with Manual. 220 volt A.C. operation. **£55** each.

T.C.C. METALPACK CONDENSERS.
0.1 mfd. 500 v. D.C. wkg. at 70°C. Brand new, polythene wrapped, **7/6** doz., or **£2** per 100.
T.C.C. METALMITE 350 v. D.C. wk. 0.1 mfd. (CP37N); 0.05 mfd. (CP35N); .01 mfd. (CP.32N) all at **5/6** doz. or **32/6** per 100.
SPRAGUE METAL CASED CONDENSERS 0.01 mfd. 1,000 v. D.C. wkg., **5/6** doz. or **32/6** per 100.

T.C.C. VISCONAL CONDENSERS.
8 mfd. 800 v. D.C. wkg. at 71°C. CP 152 v. Size 3 × 1¾ × 5in. high. BRAND NEW (boxed), **8/6** each. 6 mfd. 600 v. D.C. wkg. at 71°C. CP 127T. Size 3 × 1¼ × 5¼in. high. BRAND NEW. **5/6** each. **DUBILIER.** 4mfd. 600 v. wkg. CP 130T or similar 1¾ × 1¾ × 4¾in. high. BRAND NEW (boxed), **4/6** each. Postage 1/6.

WESTINGHOUSE PULSE TRANSFORMER CAT. NO. 4P43 L421741
Primary 5.5 kV. Secondary 22 kV. 0.5 to 2.5/sec. Pulse. Brand new and boxed **£5.** Postage 7/6.

THOMSON-VARLEY TYPE POTENTIAL DIVIDER
Non inductive. 4 decades—70,000 ohms resistance. Accuracy 0.01%. 350 v. maximum voltage. Brand new and boxed. **£30.** Carr. 10/-.

STANDARD TRANSFORMERS
Vacuum impregnated, interleaved. E.S. screen, universal mounting. Size 4 × 3¼ × 2¼in. ALL BRAND NEW. **24/-** each. Post 4/6.
Type 1. 250-0-250 v. 80 mA. 6.3 v. 3.5 a., 6.3 v. 1 a., tapped at 2 a.
Type 2. As above but 350-0-350 v. 80 mA.
Type 3. 30 v. 2 a., tapped at 12, 15, 20 and 24 v. to give 3 1-5-6-8-9-10 v., etc.
Type 5. 0-6-7-15 v. 4 a. Ideal for chargers.

MORSE REPERFORATOR. CREED TYPE 7W/3
200/240 volt D.C. motor. BRAND NEW, in original crate. **£15.** Carr. 30/-.

LOW CAPACITANCE BRIDGE
MARCONI TF. 1342. Range 0.002 pF. to 1,111 pF. Accuracy 0.2%. Three terminal transformer ratio arm bridge allows "in situ" measurements. Internal oscillator frequency 1,000 c/s. 12 × 17 × 8½in. Weight 15¾ lbs. A.C. mains 200 to 250 and 100 to 150 v. 40-100 c/s. With leads and handbook. **ABSOLUTELY BRAND NEW.** List Price £120. Our Price **£45.**

Lasky's Radio

SENSATIONAL PURCHASE OFFER!

CLOSED CIRCUIT TELEVISION

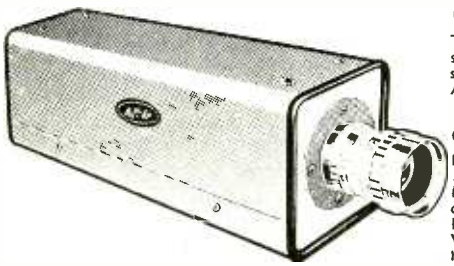
NEW AND PERFECT BRITISH MADE EQUIPMENT

AT LESS THAN HALF ORIGINAL COST!

The FIRST Bargain Package of its type AND ANOTHER GREAT FIRST FOR LASKY'S! An extremely flexible closed-circuit system made by Britain's largest manufacturer of electronic equipment. The basic system comprises two units—camera and control monitor. The units are fully transistorised with a wide use of printed circuitry making for compact size, simple installation and high reliability (both in and out of doors). High sensitivity and 625 line resolution ensure excellent picture quality under normal lighting conditions. Closed circuit television provides the penetrating, all-seeing eye that scans, inspects, controls and directs—that is today accepted as invaluable in almost every aspect of industry, commerce, transport and education. A wide range of accessories are available which further increase the system's

ALMOST LIMITLESS APPLICATIONS

SYSTEM SPECIFICATION **Scanning standards:** 625 line, 50 fields, 2: 1 interlace. **Horizontal resolution:** 600 lines. **Bandwidth** 8 Mc/s over complete system. **Linearity:** ±2% positional error. **Geometry:** ±2% of rectangle averaged over picture. **Auto Sensitivity:** over the range 60: 1 in light value—normal picture obtained with illumination of only 2ft. candles (50% subject reflectance) at lens aperture of f/2. Spectral **Response:** Panchromatic. **Ambient Temperature:** Max. temperature for all units —30 C. to +55 C. Power requirements 90/130 v. and 200/240 v. A.C., 50-60 c/s. **Consumption:** 45 watts including camera. **Camera Lenses:** Standard 16 mm. cine lenses with " C " mounts are normally used. **Accessories:** *See under Camera and Control Monitor.*



CAMERA

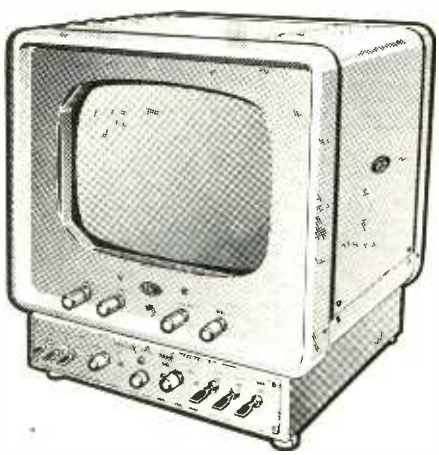
Totally enclosed dustproof unit only 3¾ × 4 × 10½ in., weighing 4 lb. Finished in two-tone blue/grey. Vidicon tube. Automatic sensitivity control enables the camera to maintain full picture quality over a brightness range of 60: 1. 625 line scanning standard 2: 1 interlaced, frame synchronised to mains supply. 600 lines horizontal picture definition with a bandwidth of 8 Mc/s. All supplies are obtained from the control monitor (consumption 5 watts).

CAMERA ACCESSORIES

Lenses: Superb quality 25 mm. (1 in.) f/1.8, " C " mount lenses made especially for this system are available, also a limited quantity of motorised zoom lenses.
Remotely Controlled Weatherproof Pan and Tilt Heads: Pan 340° at 6° per sec., Tilt 50° at 4° per sec. 230/250 v., 50 c/s operated.
Remotely Controlled Pan and Tilt for Indoor Use Only: Details as above.
Weatherproof Camera Housing: Windscreen Wiper, 75 w. heater, internal circulation fan, mounting bracket for camera housing (the latter items are extras for the Weatherproof Housing).

CONTROL MONITOR

14 in. screen, overall size 16 × 14 × 18 in. (excluding Remote Control Unit on which Monitor is shown), weight 30 lb. Panel controls provided: Mains on/off, Contrast, Brightness, Remote Focus. Preset controls (under side panels) include: Frequency lock, Monitor height, Frame linearity, Camera height, Camera width, Auto sensitivity, Camera linearity, Cable correction Video gain, Beam current, Y shift, Electrostatic focusing for camera and monitor. Additional input: Video 100 mV peak white positive into 50 ohms; Synch. 2 v. peak/peak negative. Output: 100 mV peak white positive; 2 v. peak/peak negative. Ambient temperature range 30° C. to +55° C.



ACCESSORIES

Remote Control Switching Unit (shown under Control Monitor): Controls auxiliary functions at the camera. i.e. pan/tilt zoom, windscreen wiper, etc. Size 18 × 14 × 3 in., weight 8 lb.
Distribution Unit: Used for selecting the required picture from those available on the control monitors and distributing it to the appropriate viewing monitor. Size 19½ × 13½ × 8¾ in., weight 30 lb.
Viewing Monitors: These are conventional domestic type receivers—19 in. and 23 in. models available.

Owing to the complexity and limited quantity of units available this equipment is available to CALLERS ONLY.

LASKY'S BASIC SYSTEM PRICE ONLY 125 Gns.

1—camera (complete with Vidicon) less lens, 1—Control Monitor, 25 yds. of cable. PRICES FOR LENSES AND ACCESSORIES ON APPLICATION.

PLEASE NOTE—THESE SYSTEMS ARE AVAILABLE ONLY FROM OUR HEAD OFFICE

3-15 CAVELL STREET, TOWER HAMLETS, LONDON, E.1 Tel. 01-790 4821/2

A demonstration system is available for your inspection by appointment.

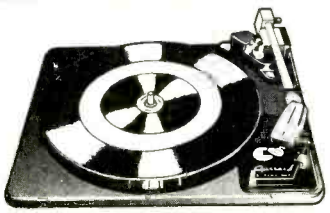
WW—116 FOR FURTHER DETAILS

Lasky's Radio

TAPE RECORDERS

NOTE *WE HAVE EXTENSIVE STOCKS OF ALMOST EVERY TYPE OF RECORDER*
AT PRE-BUDGET PRICES
SEND DETAILS OF YOUR REQUIREMENTS NOW!

RECORD PLAYERS



GARRARD AUTOCHANGERS

AP75	£22/11/6
AT60 Mk. II	£13/19/6
3000LM with stereo cart.	£9/19/6
A70	£13/19/6
Lab. A Mono/Stereo	£14/19/6
Lab. A. on plinth	£15/19/6
A50	£7/7/0
A1000	£7/7/0
A2000	£7/17/6

TRANSCRIPTION MOTORS

GARRARD 401	£27/19/0
GARRARD Lab. 80 Mk. II	£25/0/0

GARRARD BASES
WB1 ..... £3/16/3 WB2 .. £5/5/0

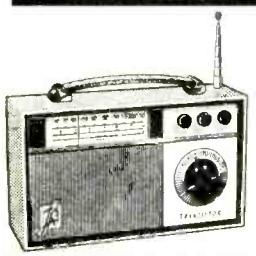
CLEARVIEW PERSPEX COVERS
WB1 ..... £3/17/0 WB2 ..... £5/7/11

Postage on all above 5/- extra.

SINGLE PLAYERS
Auto start and stop. Complete with pick-up arm.

GARRARD SP25 Mk. I	£10/19/6
GARRARD SP25 Mk. II Heavy t/table	£11/19/6
GARRARD SRP12	£4/7/6
GARRARD SRP10 mains model	£4/19/6
GARRARD SRP10 batt. model	£4/19/6

CONSTRUCTORS BARGAINS



THE SKYROVER DE LUXE

7 transistor plus 2 diode superhet, 6 waveband portable receiver covering the full Medium Waveband and Short Waveband 31-94M and also 4 separate switched band spread ranges, 13M 16M, 19M, and 25M, with Band Spread Tuning for accurate Station Selection. The coil pack and tuning heart is factory assembled, wired and tested. Superhet 470 Kc/s. Mullard Transistors. Uses 4 U2 batteries. 5in. Ceramic Magnet P.M. Speaker, 500 MW Output. Telescopic Aerial and Ferrite Rod Aerial. Tone Circuit in wood cabinet, size 11¼ × 6½ × 3in. covered with washable material, plastic trim and handle. Car aerial socket fitted.

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

H.P. Terms: 60/- dep.. 11 mths. at 12/9. Total H.P.P. £10/0/3.

Data 2/6. Refunded if you purchase parcel. Four U2 batts. 3/4 extra. All components avail. separately. A simple additional circuit provides coverage of the 1100/1950M. Long Waveband. All necessary components with construction data. **Only 10/- extra. Post Free. This conversion is suitable for receivers already constructed.**

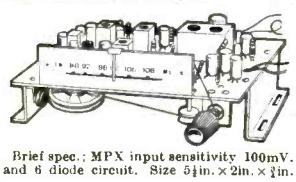
LASKY'S PRECISION PANEL METERS

Precision made in Japan by HIOKI. Each meter boxed and fully guaranteed with all fixing nuts and washers. Sizes are of front panel. Add 1/6 P. on each. Special quotation for quantities.

Type MK-38A 1½in. sq.	Type KR-52 3 × 2½in.	Type KR-52 3½ × 3in.	Type MK-45A 2in. sq.	Type MK 65A 3in. sq.
1mA DC .. 29/6	1mA DC .. 47/6	1mA DC .. 36/-	1mA DC .. 25/-	1mA DC 36/-
5mA DC .. 22/6	5mA DC .. 32/6	5mA DC .. 35/-	5mA DC .. 25/-	5mA DC .. 35/-
300V DC.. 22/6	300V DC.. 32/6	300V DC.. 35/-	300V DC.. 25/-	300V DC .. 35/-
50μA 36/-	50μA 56/-	50μA 59/6	500μA 25/-	500μA 39/6
500μA 27/6	100μA 47/6	100μA 49/6	1mA S mtr. 35/-	1mA S mtr. 37/6
1mA S mtr 29/6	500μA 37/6	500μA 42/6		
	1mA S mtr 39/6	1mA S mtr. 39/6		

TRANSISTOR FM TUNER CHASSIS

Fully tunable—range 88 to 108 Mc/s. Completely wired on printed circuit. 10.3 Mc/s. IF 6 transistors and 3 diodes. Slow motion tuning drive. Size 6¾ × 4 × 2¾in. Operates from any 9 v. D.C. source. Full data and circuit.



LASKY'S PRICE £6.10.0 Post 5/- extra.

MULTIPLEX ADAPTOR

Now you can enjoy stereo sound with the FM Tuner above. Brief spec.: MPX input sensitivity 100mV. Output 150mV. Self powered by a 9v. battery. 4 transistor and 6 diode circuit. Size 5¼in. × 2in. × ¾in. Also suitable for use with other FM tuners with MPX input.

LASKY'S PRICE 99/6 Post 5/6.

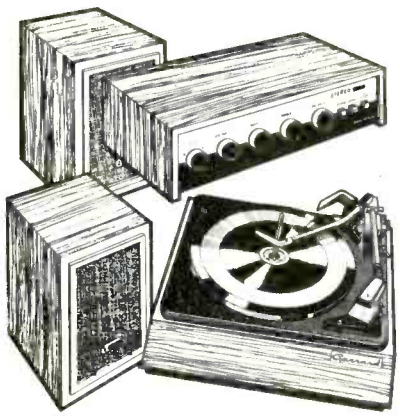
PACKAGE PRICE IF BOUGHT TOGETHER £11/11/-. Post 5/-.

DON'T MISS THIS!

HAVE YOU GOT YOUR LASKY'S CATALOGUE
FREE Second Great Reprint Issue Now Ready Containing over 1,500 items from our vast stocks. Just send your name, address and 1/- for post only.

COMPLETE SYSTEMS

SPECIAL HI-FI ECONOMY PACKAGE



At a time when value for money must rank especially high in importance we are introducing Package Deal complete Hi-Fi systems These are carefully matched for compatibility, sacrificing nothing in quality with the great advantage of the considerable cash savings that our Package Deal planning allows over a wide price range.

Philips GH925 stereo amplifier	£24 3 0
Garrard AT60 Mk. II, 4 speed autochanger	£16 7 7
Acos GP98 stereo ceramic cartridge	£2 12 11
Garrard WB.1 teak plinth	£3 16 0
2 Foster FCS 104 bookshelf loudspeaker systems	£19 19 0
TOTAL THIS PRICE	£66 18 6

Lasky's Package Price £61. 0. 0. U.K. Carriage 50/-
Package Price with 2 Philips GL 559 loudspeaker systems £64. 0. 0

AMPLIFIERS

TRIO TK-150E STEREO AMP.

Trio equipment is renowned the world over for quality—now this famous company break the price barrier with an absolutely new budget priced Hi-Fi unit. The TK-150E is an extremely compact 19 transistor and 8 diode stereo amplifier giving 40 watts music power. 13 W RMS power per channel. Inputs are provided for Magnetic pick-up (2.1mV.), Tuner (130mV.), and 2 Auxiliary Inputs (130mV. each) for use with another Tuner or Tape Recorder, sep. input for tape recorder (130mV.). Built-in tape monitoring circuit. Outputs for speakers, stereo headphones, tape play, 60W A.C. power outlet also provided. Controls include: Volume (L & R), bass, treble, input selector, power on/off, loudness, mode (stereo/mono), tape monitor/play (the last four are rocker switches). Frequency response 20-50,000 Hz (±1 dB). Signal to noise ratio: Mag. PU—better than 65dB, Tuner/Aux. 1 and 2—better than 75dB, tape play—better than 75dB. RIAA equalisation. Built-in power transistor protection circuit. Power requirements 200/250V. A.C., 50/60c/s. The superbly made and styled cabinet measures only 10¼ × 9¾ × 4¼in. Dark matt finish control panel with silver anodised trim and black/silver controls. Complete with detailed instruction manual and circuit data.

Lasky's Price 32 Gns. Carriage FREE in U.K.

MODEL KT-55 TRANSISTORISED STEREO AMP.

Made by well-known British manufacturer and incorporating the very latest transistor circuitry. Spec.: Output 5 watts per channel; 14 transistors (7 per channel) plus rectifier and varector in each channel; frequency response 25 c/s to 35 Kc/s at 3 watts (distortion better than 1%); input requirements P.U. 12 m/v., Radio 80 m/v, tape 80 m/v (radio and tape inputs are also suitable for higher output crystal cartridges); output Imp. 8-16Ω; bass, treble and balance controls with switching for Mono or Stereo and tape monitor; outlet socket for tape recorder. For 115/250 v. A.C. mains. All circuits are fully fuse protected. Very compact free standing teak cabinet, size 13¾ × 6¼ × 4¼in. with brushed aluminium front panel; all inputs and outlets are grouped at rear for easy access. Original List Price 25 gns.

Lasky's Bargain Price £16. 19. 6. Post & Pack. 10/-.

SPECIAL INTEREST ITEMS!

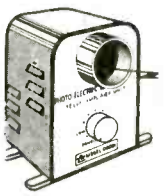
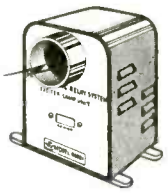


PHOTO ELECTRIC RELAY

MODEL Q4001

A new and inexpensive Photo Relay System—comprising "exciter" lamp and relay unit. Any interception of the light beam instantly triggers the relay which in turn will operate light, alarm bell or buzzer, electronic counter, heavy duty relay or electric motor. There are many interesting and useful applications for this system in the home, office, shop, factory, etc., i.e. people or object counting, alarm systems, door opening for garage or shop. Operates on 240V. A.C.; exciter lamp 12V. 20W. effective up to 15ft. in daylight or 50ft. at night or in low light. Very simple to install. In strong metal cases size (each) 6in. × 4¼in. × 3in. Complete with mounting brackets wire and full instructions.



Lasky's Price Only £7. 19. 6. Post 5/-.

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Open all day Saturday, early closing 1 p.m. Thursday

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WW—117 FOR FURTHER DETAILS

MULLARD

AAY11	2/-	BCZ11	10/-	OC82	4/6
AC107	14/6	BFY50	6/-	OC82D	4/3
AC127	6/-	BFY51	5/-	OC83	3/6
AC128	4/-	BFY52	6/-	OC84	4/-
AC176	6/-	BSX79	3/-	OC123	7/-
AD140	12/8	BTY79-400R	£4 6	OC139	12/-
AD149	11/-	BTY87-150R	23/-	OC140	12/-
AD161	7/6	BTY91-150R	35/-	OC169	6/-
AD162	7/6	BSX36-100	3/-	OC170	4/-
ACY17	5/-	BTY87-500R	47/-	OC171	6/-
ACY20	3/6	BYZ10	11/-	OC200	6/-
ACY21	4/-	BYZ12	7/6	OC201	10/-
ACY22	2/6	BYZ13	5/-	OC202	13/-
AFZ11	10/-	BZY93 C24	12/-	OC203	8/-
AFZ12	11/9	BY100	5/-	OC204	11/-
AF102	18/-	BYX20-200	8/-	OC205	10/6
AF114	4/9	GET102	5/4	OCP71	19/6
AF115	4/9	GET103	4/4	ORP12	9/-
AF116	4/9	GET111	10/-	ORP60	8/-
AF117	4/9	GET573	10/-	ORP63	9/-
AF118	9/-	OC19	5/-	ORP93	18/-
AF186	12/-	OC20	33/-	ORP90	19/6
AF239	12/-	OC22	13/-	OA5	3/-
ASY26	5/-	OC23	25/-	OA10	4/-
ASY28	5/-	OC24	19/-	OA47	1/6
AS221	4/-	OC25	7/-	OA70K	1/6
ASY29	6/6	OC26	12/-	OA73	1/6
BA115	2/6	OC28	12/-	OA79K	1/6
BC107	4/3	OC29	15/-	OA81K	1/6
BC108	4/3	OC35	9/6	OA85K	1/6
BC109	4/3	OC36	13/-	OA90K	1/6
BCY10	20/-	OC41	3/6	OA91K	1/6
BCY12	22/-	OC42	4/-	OA95K	1/6
BCY30	7/-	OC43	3/-	OA200	2/-
BCY31	9/-	OC44	3/-	OA202	2/-
BCY32	8/-	OC45	3/-	OA210	7/6
BCY33	6/-	OC71	3/-	SX631	7/-
BCY34	8/-	OC72	4/6	SX636	10/-
BCY38	19/-	OC73	3/-	SX638	12/-
BCY39	10/-	OC75	5/-	SZ20C	13/-
BCY40	16/-	OC76	3/-	6ISV	95/-
BCY71	15/-	OC81D	3/-	8VC1	19/9

2N3819FET	11/-
2N3826	6/-
1B40K10	19/-
1B100-M05	54/-

SINCLAIR

ADT140	12/6
ST141	5/-
ST140	3/-

FAIRCHILD

INTEGRATED CIRCUITS

Epoxy TO5 8 lead
μL 900 Buffer @ 11/-
μL 914 Dual Gate @ 11/-
μL923 J-K Flip Flop @ 14/-
4-page reprint on IC usage circuits data, etc. 2/6

J.E.D.E.C.

2N385A/2N388A ..	15/-
2N696 ..	9/-
2N706 ..	4/-
2N706A ..	6/6
2N711 ..	7/6
2N1132 ..	10/-
2N1302 ..	5/-
2N1303 ..	5/-
2N1304 ..	6/-
2N1305 ..	6/-
2N1306 ..	8/-
2N1307 ..	8/-
2N1308 ..	10/6
2N1309 ..	10/9
2N2147 ..	17/-
2N2160 ..	14/9
2N2646 ..	10/-
2N3436 ..	6/9

PLANAR BARGAIN

2N2926 Yellow 4 for 10/- New G.E.

Over 2,000 transistor and diode types ex stock.

Resistors: ¼ Watt 5% Miniature type, low noise—high stability. 10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68, 82 & decades to 820K. 1-25 pieces 4d. 25-99 3d. 100 pieces or over, 2½ each.
10% tolerance, ½ Watt, 1 Meg-8.2 Meg., same price.
Preset potentiometers, Standard or Sub-miniature types, 20% tolerance. Lin. vertical or horizontal.
100, 250, 500 ohm, 1k, 2.5k, 5k, 10k, 25k, 50k, 100k, 250k, 500k, 1 Meg, 2.5 Meg, 5 Meg. All at 1/6d. each. Discounts for quantities over 12 of 1 value.

WIRELESS WORLD DIGITAL COMPUTER

Send for our complete part list. Competitive prices for all components. Transistors, Diodes, Resistors, Capacitors, Neons, Veroboard, etc.

FAIRCHILD AF 11 20W SOLID STATE AMPLIFIER KIT

£8.8.0d Complete

Includes Printed circuit board, Semiconductors, Resistors, Capacitors, Heat sink and short circuit protection components. S.A.E. for details

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GUARANTEE: All the above-listed semi-conductor devices are Brand New, First Grade, and guaranteed. We will replace at no charge any device found to be faulty. Further: all devices carry the Manufacturer's name or Trade Mark, type number and batch number. We do not offer for sale devices often described as " new and tested " or bearing re-marked type numbers, these often have a short and unreliable life. L.S.T. COMPONENTS.

NO EXCUSES! NO DELAYS! FROM STOCK!

VARIABLE VOLTAGE TRANSFORMERS

50 AMPS

1 AMP.

INPUT 230 v. A.C. 50/60

BRAND NEW. Keenest prices in the country. All Types (and spares) from ½ to 50 amp. available from stock.

0–260 v. at 1 amp.	£5 10 0
0–260 v. at 2.5 amps. ..	£6 15 0
0–260 v. at 4 amps.	£9 0 0
0–260 v. at 5 amps.	£9 15 0
0–260 v. at 8 amps.	£14 10 0
0–260 v. at 10 amps. ...	£18 10 0
0–260 v. at 12 amps. ...	£21 0 0
0–260 v. at 15 amps. ...	£25 0 0
0–260 v. at 20 amps. ...	£37 0 0
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20 DIFFERENT TYPES AVAILABLE FOR IMMEDIATE DELIVERY.

Double Wound Variable Transformers

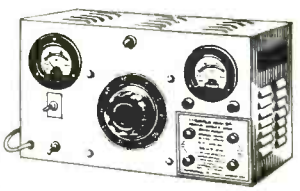
Fully isolated, low tension Secondary winding. Input 230 v. A.C. OUTPUT CONTINUOUSLY VARIABLE 0-36 v. A.C.

0-36 v. at 5 amp. £9.12.6— p. & p. 8/6

0-36 v. at 20 amp. £21.0.0— 15/- p. & c.

These fully shrouded Transformers, designed to our specifications, are ideally suited for Educational, Industrial and Laboratory use.

5 Amp. AC/DC VARIABLE VOLTAGE OUTPUT UNIT



Input 230 v. A.C. Output 0-260 v. A.C. Output 0-240 v. D.C. Fitted large scale ammeter and voltmeter. Neon indicator, fully fused. Strong attractive metal case 15in. × 8¾in. × 6in. Weight 24 lb. Infinitely variable, smooth stepless voltage variation over range.

Price **£30** P. & C. £2

7 Amp. A.C./D.C. Mk. II Variable Output Power Unit

Input 230 v. A.C. Output continuously VARIABLE from 0 to 260 v. A.C. OR 0 to 230 v. D.C. at 7 a. Robustly constructed in metal case, complete with safety fuse, neon indicator, voltmeter and ammeter. Size 17in. × 12in. × 7in. Weight 36 lb. Price £39/10/-. Carriage 40/-.

OPEN TYPES

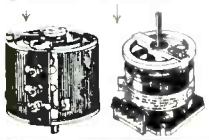
Designed for Panel Mounting. Input 230 v. A.C. 50/60 Output variable.

0-260 v.

½ amp	£3 10 0
1 amp.	£5 10 0
2½ amp.	£6 12 6

P. & P. 7/6

½ AMP. 1 AMP.



PORTABLE

Input 230 v. A.C. Output variable 0-260 v. A.C. at 1.5 amp. Fitted in beautifully finished steel case. Complete with voltmeter, pilot lamp, fuse, switch, carrying handle.

£9/5/-. P. & C. 10/-.

Also 2.5 amp. as above. **£11/7/6.** P. & C. 10/-.

CONSTANT VOLTAGE TRANSFORMER

Input 185-250 v. A.C. Output constant at 230 v.. AC. Capacity 250 watt. Attractive metal case. Fitted red signal lamp. Rubber feet. Weight 17lbs. Price **£11/10/-**, P. & P. 10/-.

L.T. TRANSFORMERS

All primaries 220-240 volts

Type No.	Sec. Taps	Price	Carr.
1	30, 32, 34, 36 v. at 5 amps. ..	£4/5/-	6/-
2	30, 40, 50 v. at 5 amps.	£6/5/-	6/6
3	10, 17, 18 v. at 10 amps.	£4/10/-	4/6
4	6, 12 v. at 20 amps.	£5/17/6	6/6
5	17, 18, 20 v. at 20 amps.	£6/12/6	6/6
6	6, 12, 20 v. at 20 amps.	£6/5/-	7/6
7	24 v. at 10 amps.	£4/15/-	5/6

INSULATION TESTERS (NEW)

Test to I.E.E. Spec. Rugged metal construction, suitable for bench or field work, constant speed clutch. Size L. 8in., W. 4in., H. 6in. Weight 6lb. 500 volts, 500 megohms. Price £22 carriage paid. 1,000 volts, 1,000 megohms, £28 carriage paid.

36 volt 30 amp. A.C. or D.C. Variable L.T. Supply Unit

INPUT 220/240 v. A.C. OUTPUT CONTINUOUSLY VARIABLE 0-36 v.

Fully isolated. Fitted in robust metal case with Voltmeter, Ammeter, Panel Indicator and chrome handles. Input and Output fully fused. Ideally suited for Lab. or Industrial use. £55 plus 40/- p. & c. Similar in appearance to above illustration.

SERVICE TRADING COMPANY

SERVICE TRADING CO

Postage and Carriage shown below are inland only. For Overseas please ask for quotation. We do not issue a catalogue or list.

LIGHT SENSITIVE SWITCHES

Kit and parts including ORP.12 Cadmium Sulphide Photocell. Relay Transistor and Circuit. Now supplied with new Siemens High Speed Relay for 6 or 12 volt operations. **Price 25/-,** plus 2/6 P. & P. **ORP 12 and Circuit 10/- post paid.**

20/240 A.C. MAINS MODEL

incorporates mains transformer rectifier and special relay with 3 × 5 amp. mains c/o contacts. Price inc. circuit **47/6,** plus 2/6 P. & P.

PHOTO ELECTRONIC COUNTER

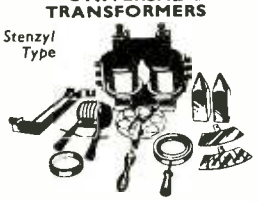
Can be set for counts of up to 500 per minute. 210-250 v. A.C. powered. Kit of Components, including photo cell, high speed non-resettable counter, transformer, relay, etc., together with clear circuit diagram, **£3/2/6,** plus 3/6 P. & P. With resettable counter, **£4/2/6,** P. & P. 3/6.

LIGHT SOURCE AND PHOTO CELL MOUNTING

Precision engineered light source with adjustable lens assembly and ventilated lamp housing to take MBC bulb. Separate photo cell mounting assembly for ORP.12 or similar cell with optic window. Both units are single hole fixing. Price per pair **£2/15/0** plus 3/6 P. & P.

UNIVERSAL DEMONSTRATION TRANSFORMERS

Stenzyl Type



A complete composite apparatus, comprising a robustly built Transformer and electro-magnet with removable coils and pole pieces, coil tapped for 230 v., 220 v., 110 v., 115 v., 6, 12, 36, 110 v. A.C. These coils are also used for D.C. experiments. Complete with all accessories as shown. **£19** plus 15/- carr. Leaflet on request.

A.C. CONTACTOR

2 make and 2 break (or 2 c/o) 15 amp. contacts. 230/240 v. A.C. operation. Brand new. **22/6** plus 1/- P. & P.

230/250 v. A.C. SOLENOID

Heavy duty type. Approx. 3lb. pull. **17/6** plus 2/6 P. & P.

12/24v. D.C. SOLENOID

Approx. 8 oz. push. **8/6** plus 1/6 P. & P.

CONDENSER

4,000 mfd. 25 v. **10/6** plus 1/6 P. & P.

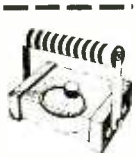
RESETTABLE HIGH SPEED COUNTERS

3 figure, 0/999 24 v. D.C. operation (illustrated). Similar, but may be pre-set to any number up to 999 reducing to zero. Either type **32/6,** P. & P. 2/6.
4 figure, 1,000 ohm coil, 36-48 v. D.C. operation, **£3/10/-.** P. & P. 1/6.

LATEST HIGH-SPEED MAGNETIC COUNTERS (NON-RESETTABLE)

4 figure, 10 impulses per second. Type 100A, 500 ohm coil. Type 100B, 2,300 ohm coil. Either **15/-** each, plus 1/6 P. & P.

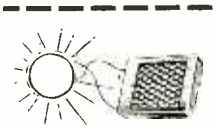
SUPER POWER ALLOY MAGNET



These fantastic ex WD magnets weighing only 4lbs. will lift well over 100 lbs. Fitted with swivelled handle and keeper. Size 4in. × 3¾in. × 1¾in. Packed in original makers' cases of two. Price **30/-** per pair, plus 7/6 P. & P.

TRANSISTORISED MORSE OSCILLATOR. Fitted 2½in. Moving Coil Speaker. Uses type PP3 or equiv. 9 v. battery. Complete with latest design Morse key. **22/6,** plus 1/6 P. & P.

34R SILICON SOLAR CELL



4 × .5 volt unit series connected, output up to 2 v. at 20 mA. in sunlight, 30 times the efficiency of selenium. As used in power Earth Satellites, **39/6.** P. & P. 1/6d.

"SOLAR CELL AND PHOTO-CELL EXPERIMENTERS' GUIDE"

Teaches the principles of light sensitive devices and their application. **26/-** post paid.

GENUINE NEW MULLARD 6AM SILICON DIODES. Not Rejects or Seconds.

BYZ13 200 PIV 7/-	BYZ12 400 PIV 8/-
BYZ11 600 PIV 9/-	BYZ10 800 PIV 10/-

NICKEL CADMIUM BATTERY

Sintered Cadmium Type 1.2 v. 7AH. Size: height 3½in., width 2⅝in. × 1 7/16in. Weight: approx. 13 ozs. Ex-R.A.F. Tested 12/6. P. & P. 2/6.

100 WATT POWER RHEOSTATS

(NEW) Ceramic construction, winding embedded in Vitreous Enamel, heavy duty brush assembly designed for continuous duty. **AVAILABLE FROM STOCK IN THE FOLLOWING 11 VALUES: 1 ohm 10a., 5 ohm 4.7a., 10 ohm 3a., 25 ohm 2a., 50 ohm 1.4a., 100 ohm 1a., 250 ohm 7a., 500 ohm 45a., 1,000 ohm 280mA., 1,500 ohm 230mA., 2,500 ohm .2a.** Diameter 3½in. Shaft length ¾in. dia. 3/16in., **27/6.** P. & P. 1/6.
50 WATT 1/5/10/25/50/100/250/500/1,000/1,500/2,500 ohm, **21/-,** P. & P. 1/6.
25 WATT 10/25/50/100/250/500/1,000/1,500/2,500 ohm, **14/6,** P. & P. 1/6.

VENNER ELECTRIC TIME SWITCH

200-250 v. A.C. 20 amp. contacts twice on, twice off, at any manually pre-set time. Spring reserve (in case of power cut) fully tested, **£3/9/6.** P. & P. 4/6. Or complete in weather-proof metal case (illustrated). **£3/19/6.** Plus 4/6 P. & P. Can be supplied with solar dial, on at dusk—off at dawn. Prices as above.

RADIO ALTIMETER

This precision Instrument, built to highest Ministry specification, is based on a 24 v. D.C. LOW INERTIA (Integrating) Motor. The Motor, fitted with gold brushes and drawing only 800 microamp at 24 v. D.C. drives two precision pots with platinum wipers through close tolerance gear-trains, including miniature slipping clutch, combined with two sub-miniature pots for calibrating the electrical bridge circuit. The 3in. calibrated dial, with a number aperture indicating one rev. per revolution of pointer with maximum of 5 revs., gives an effective scale length of approx. 30in. Offered at fraction of Manufacturer's price: **32/6,** plus 6/- P. & P.

SANWA MULTI RANGE METERS

Acknowledged throughout the world as the ultimate in test meters.
NEW MODEL U-50D MULTI-TESTER, 20,000 O.P.V. MIRROR SCALED WITH OVERLOAD PROTECTION. Ranges: D.C. volts: 100mV., 0.5 v., 5 v., 250 v., 1,000 v. A.C. volts. 2.5 v., 10 v., 50 v., 250 v., 1,000 v. D.C. current: 5μA. 0.5mA., 5 mA., 50 mA.,250mA. Size: 5⅛ × 3½ × 1¾in. **Complete with batteries and test prods. £7.5.0** Post paid.
Three other models available from stock. Descriptive leaflet on request.

220/240v. A.C. COOLING UNIT

2,300 r.p.m. 6in. blade size. Smooth powerful motor. All metal construction. Continuously rated. Individually tested. Offered at fraction of maker's price, **£2/15/-.** P. & P. 7/6.

THYRISTOR 400 piv, 5 amp., **14/6** post paid.
THYRISTOR 400 piv, 8 amp., **28/6** post paid.

SANGAMO WESTON

Dual range voltmeter. 0-5 and 0-100 v. D.C. FSD 1 mA. In carrying case with tests prods and leads. **32/6.** P. & P. 3/6.

AUTO TRANSFORMERS. Step up, step down. 110-200-220-240 v. Fully shrouded. New. 300 watt type, **£3** each. P. & P. 4/6. 500 watt type, **£4/2/6** each. P. & P. 6/6. 1,000 watt type, **£5/5/-** each. P. & P. 7/6.

PRECISION INTERVAL TIMER

From 0-30 seconds (repetitive). Jewelled balanced movement. Lever re-set. Operates 230 v. A.C. 5 am. c/o micro-switch. New Price **17/6** plus 2/6 P. & P.

20 amp. LEVER MICRO SWITCH

Brand new lever operated micro switch. 20 amp. A.C. c/o contacts. Price **4/6** each plus 1/6 P. & P. 5 for **£1** post paid.

SLIDER RESISTANCES

200 ohm 1.25 amp. **37/6.** P. & P. 3/6.
5 ohm 10 amp. **37/6.** P. & P. 3/6.

PRECISION FLATPOT

Manufactured by M.E.C. 50 k., 45 turn. Fly leads. all metal sealed construction. **10/6.** Plus 1/6 P. & P.

LATEST TYPE SELENIUM BRIDGE RECTIFIERS

30 volt 3 amp., **11/-,** plus 2/6 P. & P.
30 volt 5 amp., **16/-,** plus 2/6 P. & P.

MOVING COIL HEADPHONE AND MIKE

Soft rubber ear-pieces with M/C Mike fitted 5-way plug as on No. 19 set. New, in maker's packing, **16/6,** plus 3/6 C. & P.

A.C. AMMETERS 0-1, 0-5, 0-10, 0-15, 0-20 amp. F.R. 2½in. dia. All at **21/-** each.
A.C. VOLTMETERS 0-25 v., 0-50 v., 0-150 v. M.I 2½in. Flush round all at **21/-** each. P. & P. extra.
0-300 v. A.C. Rect. M-Coil 2½in. **29/-**
0-300 v. A.C. Rect. M-Coil 3½in. Type W23 ..... **55/-**

Latest type VARLEY MINIATURE RELAY in Transparent Case. 4 c/o 700 ohm, **15/-.** Base **4/-.** 2 c/o 700 ohm coil. Size ⅞ × ⅞ × 1⅜in. **12/6,** inc. base. **VARLEY** TYPE VP4 (similar to illus.), 5,800 ohm 4 c/o. New, **12/6,** less base.
Similar to above. Mfd. by GRUNER 4 c/o, 2,400 ohm coil. New, **10/-,** less base.

UNISELECTOR SWITCHES NEW 4 BANK 25 WAY

25 ohm coil, 24 v. D.C. operation. **£4/17/6,** plus 2/6. P. & P.

8-BANK 25-WAY FULL WIPER

24 v. D.C. operation, **£6/10/-,** Plus 4/- P. & P.

UNISELECTOR SWITCHES USED

75 ohm coil, 24 v. D.C., 6 bank 25 position, 5 non-bridging, 1 bridging wiper.
6 bank arranged to give 3 bank, 50 positions ex-equipment, **35/-** each. P. & P. 2/6.

MINIATURE UNISELECTOR SWITCH

3 banks of 11 positions, plus homing bank. 40 ohm coil. 24-36 v. D.C. operation. Carefully removed from equipment and tested. **22/6,** plus 2/6 P. & P.

AIR BLOWER

Highly efficient blower unit fitted with totally enclosed 200/250 v. A.C. 50 cycles. 1/20 h.p. motor, producing 2,800 r.p.m. outlet 2½ × 1½, used, but in first class condition and tested. Price **£3/15/-.** P. & P. 7/6.

230 VOLT A.C. GEARED MOTORS

Type D15G 5 r.p.m. 1.7lb. inch, £2/9/6, P. & P. 3/-
Type B16G 80 r.p.m. .26lb. inch, £2/2/-, P. & P. 3/-
Type D16G 13 r.p.m. 1.45lb. inch, £2/17/6. P. & P. 3/-.

GALVANOMETER

300-0-300 microamp. Calibrated 30-0-30. Mounted in sloping front case **£2/10/-.** P. & P. 3/6. **D.C. Voltmeter** 0-3 V and 0-15. V **£2** plus 3/6 P. & P. **D.C. Ammeter,** 0-.6 amp. and 0-3 amp. **£2,** 3/6 P. & P. The set of 3 matching instruments **£6,** P. & P. 6/6.

SOLAR OIL-FILLED CONDENSER.

240 mfd. for 230 V.A.C. or 600 volt D.C. Overall size 14in. x 9in. x 5½in. plus feet. Weight 46 lb. Guaranteed perfect. Manufacturer's packing. Price **£7/10/-.** Carriage 15/-.

DRY REED SWITCHES

New special offer of Dry Reed Switches, ¼ amp. contact, 1¼ × 1¼in., 4 for **10/-,** post paid.

NEW SOUNDPOWER OPERATED EX-ADMIRALTY HEAD AND BREAST SETS

Two such sets connected up will provide perfect intercom. No batteries required. Will operate up to ½ mile. Price **17/6** each, plus P. & P. 4/6, or **32/6** per pair. P. & P. 6/-.

S.T.C. SILICON POWER RECTIFIERS

RS300 Series. All types 1.5 amp. wire ended.
RS310, 100 v. P.I.V. **4/-.** RS350, 500 v. P.I.V. **8/-**
RS330, 300 v. P.I.V. **6/-.** RS360, 600 v. P.I.V. **9/-**
RS340, 400 v. P.I.V. **7/-.** RS380, 800 v. P.I.V. **10/-**
4 can be used to make 3 amp. bridge. Not Seconds. Brand New Stock. Post paid.

ALL MAIL ORDERS. ALSO CALLERS AT:
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SHOWROOMS NOW OPEN
Many Bargains for the caller.
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VALVES/SEMI-CONDUCTORS

BRAND NEW & GUARANTEED

OA2	8/-	6E5	8/-	30C18	14/-	ECC84	6/6	EZ40	8/6	PY81	6/-
OB2	6/-	6J4	9/-	30F5	14/-	ECC85	5/6	EZ41	8/6	PY82	6/-
1R5	8/-	6J6	3/6	30FL1	15/-	ECF80	7/-	EZ80	5/6	PY83	6/6
1S5	4/6	6K8	4/-	30L15	15/-	ECF82	7/6	EZ81	5/6	PY88	7/6
1T4	3/-	6L6	9/6	30P19	14/-	ECH35	11/-	GZ32	11/6	PY800	8/-
1U4	6/-	6Q7	8/3	30PL1	15/-	ECH42	11/-	GZ34	11/6	PY801	8/-
1U5	7/-	6SG7	6/-	30PL13	16/-	ECH81	6/3	MU14	8/-	U25	15/-
2D21	5/-	6SJ7	7/-	35L6	8/-	ECH83	8/6	PABC80	7/6	U26	15/-
3A5	10/-	6SL7	6/-	35Z4	8/6	ECL80	7/9	PCC84	6/6	U191	14/-
3Q4	7/-	6SN7	5/6	35W4	5/3	ECL82	7/-	PCC85	8/-	U281	8/-
3S4	5/-	6U7	7/-	50B5	6/6	ECL83	10/6	PCC88	11/6	U301	11/-
3V4	6/-	6V6	5/-	50C5	6/6	ECL86	9/-	PCC89	11/6	U801	17/-
5R4	9/-	6X4	4/3	80	7/-	EF37A	8/-	PCC189	12/6	UABC80	6/-
5U4	5/-	6X5	5/-	AZ31	10/-	EF40	10/-	PC86	11/-	UAF42	10/-
5V4	8/6	7B7	7/-	DAF91	4/6	EF41	9/6	PC88	11/-	UBC41	8/-
5Y3	5/9	7C6	6/6	DAF96	7/-	EF42	10/6	PC97	8/6	UBF80	7/-
5Z4	8/-	7Y4	8/6	DF91	3/-	EF80	5/-	PC900	9/6	UBF89	7/-
6/30L2	12/6	10C2	15/-	DF96	7/-	EF85	6/6	PCF80	7/3	UCC84	10/-
6AC7	4/-	10F1	9/-	DK91	6/-	EF86	7/-	PCF82	7/-	UCC85	7/-
6A67	6/-	10P13	15/-	DK92	8/9	EF89	6/3	PCF84	9/-	UCF80	9/6
6AK5	5/-	10P14	16/-	DK96	8/-	EF91	4/-	PCF86	9/-	UCH42	10/-
6AL5	3/-	12AT6	5/-	DL92	5/-	EF92	4/-	PCF800	15/-	UCH81	7/-
6AM6	4/-	12AT7	4/-	DL94	8/-	EF183	7/-	PCF801	10/-	UCL82	8/-
6AQ5	6/-	12AU7	5/-	DL96	8/-	EF184	7/-	PCF802	10/-	UCL83	10/-
6A86	6/-	12AX7	6/-	DY86	6/6	EL33	12/6	PCF805	14/-	UF41	10/-
6AT6	5/-	12BA6	6/9	E88CC	12/6	EL34	11/-	PCL82	7/6	UF80	7/-
6AU6	5/9	12BE6	6/3	EABC80	7/-	EL41	9/9	PCL83	9/6	UF85	7/6
6BA6	4/9	12BH7	6/6	E180F	15/-	EL42	11/-	PCL84	8/-	UF89	7/6
6BE6	5/3	12Q7	5/6	EAF42	9/6	EL81	9/-	PCL85	9/6	UL41	10/-
6BH6	8/-	128Q7	7/6	EB91	3/-	EL84	5/-	PCL86	9/-	UL84	7/-
6BJ6	8/-	19AQ5	6/-	EBC41	9/6	EL85	8/6	PFL200	12/6	UY41	7/6
6BR7	11/-	20F2	14/-	EBC81	7/-	EL91	4/-	PL36	10/6	UY85	6/6
6BZ6	7/-	20L1	13/-	EBF80	7/6	EL95	5/3	PL81	7/6	VR105/30	5/6
6C4	3/6	20P1	12/-	EBF83	9/-	EM80	7/6	PL82	7/-	VR150/30	5/-
6C6	4/-	20P3	12/-	EBF89	7/6	EM81	8/-	PL83	7/-	MANY	
6CD6	20/-	20P4	19/-	ECC40	11/6	EM84	7/6	PL84	6/9	OTHER	
6CH6	6/-	25L6	6/6	ECC81	4/-	EM87	7/6	PL500	14/6	TYPES IN	
6CL6	10/-	25Z4	8/-	ECC82	5/-	EY51	7/6	PY33	9/9	STOCK.	
6D6	3/-	30C15	13/6	ECC83	6/-	EY86	7/-	PY80	5/6		

TRANSISTORS

2N 753	4/6	B8Y26	4/6	OC73	5/-	XA104	4/6
2N 2160	14/11	B8Y28	4/6	OC74	5/6	XA124	4/6
2N 2926	5/-	B8Y65	4/6	OC75	4/6	XA125	4/6
AC107	4/6	B8Y95A	5/-	OC76	4/6	XB112	3/-
AC126	4/6	GET106	5/6	OC77	4/6	XC141	7/-
AC127	4/6	GET113	5/6	OC78	5/-	PHOTO	
AC128	4/6	GET873	5/6	OC81	4/-	TRANSIS-TORS	12/6
ACY19	5/-	GET874	4/6	OC81M	2/6		
ACY21	5/-	MAT100	7/9	OC81D	4/-		
AD140	8/6	MAT101	8/6	OC81DM	2/6		
AD149	16/-	MAT120	7/9	OC82	4/6		
ADT140	15/-	MAT121	8/6	OC83	5/-		
AF114	6/6	OC23	8/6	OC139	8/6		
AF115	4/6	OC26	7/6	OC140	11/-		
AF116	4/6	OC28	8/6	OC169	4/6		
AF117	4/6	OC35	8/6	OC170	4/6		
AF118	4/6	OC41	5/-	OC171	4/6		
AF119	4/6	OC42	5/-	OC200	9/-		
A8Y28	7/-	OC44	4/-	OC201	11/-		
BC107	5/6	OC45	4/-	OC203	12/6		
BC108	5/6	OC71	4/-	ST140	4/-		
BC109	5/6	OC72	4/-	ST141	6/-		

SILICON POWER DIODES

60 P.I.V. 290 MA	2/-	400 P.I.V. 8 AMP	7/6
70 P.I.V. 1 AMP	3/6	700 P.I.V. 100 AMP	35/-
140 P.I.V. 165MA	1/-	800 P.I.V. 500MA	5/6
150 P.I.V. 25 AMP	10/-	800 P.I.V. 5 AMP	7/6
200 P.I.V. 5 AMP	5/6	1000 P.I.V. 6 AMP	7/6
400 P.I.V. 500MA	3/6	1000 P.I.V. 650MA	6/6
400 P.I.V. 6 AMP	5/6		

SIGNAL DIODES

IN34A	4/-
OA5	3/6
OA10	4/6
OA70	2/-
OA79	2/-
OA81	2/-
OA90	2/6
OA95	2/6

THYRISTORS SILICON CONTROL RECTIFIERS

400 P.I.V. 3 AMP	7/6	200 P.I.V. 7 AMP	15/6
100 P.I.V. 7 AMP	13/6	400 P.I.V. 7 AMP	15/6

ZENER DIODES

OAZ200	12/-	OAZ204	8/6	OAZ208	6/6	OAZ212	6/6
OAZ201	10/-	OAZ205	8/6	OAZ209	6/6	OAZ213	6/6
OAZ202	8/6	OAZ206	8/6	OAZ210	6/6	OAZ227	15/-
OAZ203	8/6	OAZ207	9/6	OAZ211	6/6		

STC. 1 WATT SERIES 5%
2.4/2.7/3/3.9/4.3/13/16/18/20/30/33 volt. 5/- each.
Z series. All voltages from 3.9-50 volt. 250 mW. 2/6 ea. 1.5 w. 4/- ea. 7 w. 5/- each.

PLEASE ADD POSTAGE

POWER RHEOSTATS

High quality ceramic construction. Windings embedded in vitreous enamel. Heavy duty brush wiper. Continuous rating. Wide range available ex-stock. Single hole fixing, ¼in. dia. shafts. Bulk quantities available.

25 WATT. 10/25/50/100/250/500/1000/1500/2500 or 5000 ohms, **14/6.** P. & P. 1/6.

50 WATT. 10/25/50/100/250/500/1000/2500 or 5000 ohms, **21/-.** P. & P. 1/6.

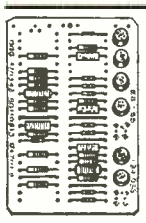
100 WATT. 1/5/10/25/50/100/250/500/1000 or 2500 ohms, **27/6.** P. & P. 1/6.

LAFAYETTE TE-46 RESISTANCE CAPACITY ANALYSER

2 pf-2,000 mfd. 2 ohms-200 megohms. Also checks impedance turns ratio, insulation. 200/250 v. A.C. **Brand New. £15.** Carr. 7/6.

T.E.40 HIGH SENSITIVITY A.C. VOLTMETER

10 meg. input 10 ranges: .01/.03/.1/.3/1/3/10/30/100/300 v. R.M.S. 4 cps.-1.2 Mc/s. Decibels—40 to +50 dB. Supplied brand new complete with leads and instructions. Operation 230 v. A.C. **£17/10/-.** Carr. 5/-.



PRINTED CIRCUITS

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/-.

ARF-100 COMBINED AF-RF SIGNAL GENERATOR

AF. SINE WAVE

20-200,000 cps. Square wave 20-30,000 cps. O/P **HIGH IMP.** 21 v. P/P 600Ω 3.8 v. P/P. R/F. 100 kc/s-300 Mc/s. Variable R.F. attenuation. Int./Ext. Modulation. Incorporates dual purpose meter to monitor. AF output and % mod. on R.F. 220/240 v. A.C. **£27/10/-.** Carr. 7/6.

TE-20RF SIGNAL GENERATOR

Accurate wide range signal generator covering 120 kc/s-260 Mc/s. on 6 bands. Directly calibrated. Variable R.F. attenuator. Operation 200/240 v. A.C. Brand new with instructions **£12/10/-**

P. & P. 7/6. S.A.E. for details.

TE22 SINE SQUARE WAVE AUDIO GENERATORS

Sine: 20 cps to 200 kc/s on 4 bands. Square: 20 cps. to 30 kc/s. Output impedance 5,000 ohms, 200/250 v. A.C. operation. Supplied brand new and guaranteed with instruction manual and leads, **£15.** Carr. 7/6.

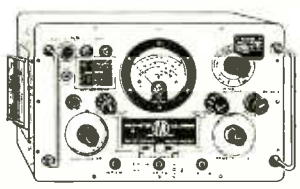
ADMIRALTY B.40 RECEIVERS

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 114lb. 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/-.

SOLARTRON CD7115.2. DOUBLE BEAM OSCILLOSCOPE

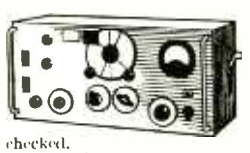
An extremely fine quality oscilloscope originally costing £400. Switched beam. Identical Y1, Y2 Amplifiers D.C. to 6 Mc/s. Sensitivity 30mV/CM to 100 V/CM. Time base 10μ/sec. to 10 M/secs. Calibrator. X amplifier D.C. to 2.5 Mc/s. Z Modulation. 110/200/250 v. A.C. Supplied in good working order. **£65** carriage £2, or available as received from Ministry unserviced **£50.** carriage £2. (Handbook **£2** extra.)

AVO CT.38 ELECTRONIC MULTIMETERS



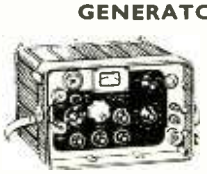
High quality 47 range instrument which measures A.C. and D.C. Voltage, Current, Resistance and Power output. Ranges D.C. volts 250mV-10,000 v. (10 megΩ-110megΩ input). D.C.-current 10μA 25 amps. Ohms: 0-1,000 megΩ. A.C. volt 100 mV-250 v. (with R.F. measuring head up to 250 Mc/s). A.C. current 10μA-25 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 -.

MARCONI TEST EQUIPMENT



EX-MILITARY RECONDITIONED.
TF 144G STANDARD SIGNAL GENERATORS, 85 Kc/s-25 Mc/s, **£25,** carr. 30 -.
TF.329G, "Q" METER, BRAND NEW, COMPLETE WITH ALL ACCESSORIES, **£75,** carr. 30 -.
T.F.195M. BEAT FREQUENCY OSCILLATOR. 0-40 kc/s, 200/250 v. A.C. **£20,** carr. 30 -.
All above offered in excellent condition fully tested and checked.
TF. 1100 VALVE VOLTMETER, Brand New, **£50.** TF. 1267 TRANSMISSION TEST SET, Brand New, **£75.**

AM/FM SIGNAL GENERATORS



Oscillator Test No. 2. A high quality precision instrument made for the Ministry by Airmec. Frequency coverage 20-80 Mc/s. AM/CW/FM. Incorporates precision dial, level meter, precision attenuator 1μV-100Mv. Operation from 12 volt D.C. or 0/110/200/250 v. A.C. Size 12 x 8½ x 9in. Supplied in brand new condition complete with all connectors, fully tested, **£45.** Carr. 20/-.

TYPE 13A DOUBLE BEAM OSCILLOSCOPES BARGAIN

An excellent general purpose D/B oscilloscope. T.B. 2 cps-750 Kc/s. Bandwidth 5.5 Mc/s. Sensitivity 33 Mv/cm. Operating voltage 0/110/200/250 v. A.C. Supplied in excellent working condition, **£22/10/-.** Or complete with all accessories, probe, leads, bk, etc. **£25.** Carriage 30/-.

Variable Voltage TRANSFORMERS

Brand new, guaranteed and carriage paid.
High quality construction. Input 230 v. 50-60 cycles.
Output full variable from 0-260 volts. Bulk quantities available.
1 amp.—**£5/10/-;** 2.5 amp.—**£6/15/-;** 5 amp.—**£9/15/-;**
8 amp. **£14/10/-;** 10 amp.—**£18/10/-;** 12 amp. **£21;** 20 amp. **£37.**

R.C.A. AR88 SPEAKERS

8in. 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.

DUBILIER NITROGEL CONDENSERS

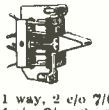
Brand new. 8 mfd. 800v. **8/6,** P. & P. 2 -; 2 mfd. 5,000 v. **42/6,** P. & P. 5/-.

AUTO TRANSFORMERS

0/115 230v. Step up or step down. Fully shrouded.
500 W. **£3/10/0,** P. & P. 6/6
1,000 W. **£5/10/0,** P. & P. 7/6
1,500 W. **£6/10/0,** P. & P. 8/6
3,000 W. **£7/10/0,** P. & P. 12/6
7,500 W. **£15/10/0,** P. & P. 20/-.

LUCAS 20/0/20 AMMETERS

Brand new, boxed. Suitable car/motorcycle. **12/6.** P. & P. 2/-.



T.M.C. 1000 SERIES KEY SWITCHES

Brand New with knobs as follows:

1 way, 2 c/o **7/6;** 1 way, 2 c/o 2b, **7/6;** 1 way 4 c/o, **8/-;** 2 way, 3m., 3m. **8/6;** 2 way, 2 c/o, 2 c/o. **8/6;** 2 way, 2 c/o., 4 c/o. **10/-.**
Post extra. Quantities available.

AVOMETERS

Supplied in excellent condition fully tested and checked. Complete with prods, leads and instructions.
Model 47A **£9/19 6**
Model 8 **£18/0 0**
P. & P. 7/6 each.

SOLARTRON MONITOR OSCILLOSCOPE TYPE 101

An extremely high quality oscilloscope with time base of 10μ/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/-.

LELAND MODEL 27 BEAT FREQUENCY OSCILLATORS

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

G. W. SMITH & Co. (Radio) Ltd.
3-34, Lisle St., W.C.2.
ALSO SEE OPPOSITE PAGE

MULTIMETERS *for EVERY purpose!*

MODEL AS-100D. 100KΩ/VOLT 5in., mirror scale. Built-in meter protection. 0 / 3 / 12 / 60 / 120 / 300 / 600 / 1,200 v. D.C. 0/6/30/120/300/600 v. A.C. 0/10μA/6/60/300MA/12 Amp. 0/2K / 200K / 2M / 200MΩ. −20 to +17 dB. **£12/10/-.** P. & P. 3/6.

NEW MODEL 500 30,000 O.P.V. with overload protection, mirror scale. 0 / .5 / 2.5 / 10 / 25 / 100 250/500/1,000 v. D.C. 0/2.5/10 / 25 / 100 / 250 / 500 / 1,000 v. A.C. 0/50μA/5/50/500 mA. 12 amp. D.C. 0/60/K6. Meg./60. Meg.Ω. **£8/17/6.** Post paid.

MODEL TE-10A. 200kΩ/Volt 5/25/50/250/500/2,500 v. D.C. 10/50/100/500/1,000 v. A.C. 0/50μA/2.5 mA/250 mA D.C. 0/6K/6 meg. ohm. −20 to +22 dB. 10-0, 100 mfd. 0.100-0.1 mfd. **69/6.** P. & P. 2/6.

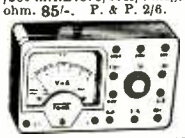
MODEL TE-12 20,000 OPV 0/0.6/6/30/120/600/1,200/3,000/6,000 V. D.C. 0/6/30/120/600/1,200 V. A.C. 0/60μA/6/60/600 mA. 0/6K/600K/6 Meg./60. Meg. Ω 50 PF. .2 MFD. **£5/19/6.** P. &P. 3/6.

MODEL TE.80. 20,000 O.P.V. 0/10/50/100/500/1,000 v. A.C. 0/5/25/50/250/500/1,000 v. D.C. 0-50μA. 5/50/500mA. 0/6K/60K/600K/6 meg. **£4/17/6.** P.P. 3/-.

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/3/30/300mA. 0/16K/160K/1.6M/16 Meg. Ω. **£5/10/-.** P. &P. 3/-.

TE-51. NEW 20,000Ω/VOLT MULTIMETER. with overload protection and mirror scale. 0/6/60/120, 1,200 v. A.C. 0/3/30/60/300/600/3,000v. D.C. 0/60μA/12/300 mA.D.C. 0/60K/6 meg. ohm. **85/-.** P. & P. 2/6.

MODEL 250J. 2,000 O.P.V. 0/10/50/500/2,500 v. D.C. 0/10/50/500/2,500 v. A.C. O/2 Meg. Ω. 0/250 mA. −20 to +36 dB. **49/6.** P. & P. 2/6.



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.

CLEAR PLASTIC PANEL METERS

First grade quality Moving Coil panel meters available ex-stock. S.A.E. for illustrated leaflet. Discounts for quantity. Type MR 38P, 1Win. square fronts.

50μA	37/6	1 amp	25/-	50V. D.C.	25/-
50-0-50μA	35/-	2 amp	25/-	100V. D.C.	25/-
100μA	35/-	5 amp	25/-	150V. D.C.	25/-
100-0-100μA	32/6	20mA	25/-	300V. D.C.	25/-
200μA	32/6	50mA	25/-	500V. D.C.	25/-
500μA	37/6	100mA	25/-	750V. D.C.	25/-
500-0-500μA	25/-	150mA	25/-	15V. A.C.	25/-
1mA	25/-	200mA	25/-	50V. A.C.	25/-
1-0-1mA	25/-	300mA	25/-	150V. A.C.	25/-
2mA	25/-	500mA	25/-	300V. A.C.	25/-
5mA	25/-	3V. D.C.	25/-	500V. A.C.	25/-
10mA	25/-	10V. D.C.	25/-	S meter 1mA	29/6
750mA	25/-	20V. D.C.	25/-	VU meter	38/6

Post Extra. Larger sizes available—send for lists.

AMERICAN RECORDING TAPES

First grade quality American tapes. Brand new and guaranteed. Discounts for quantities.

3in. 225ft. L.P. acetate	3/6
3½in. 600ft. T.P. Mylar	10/-
5in. 600ft. Std. plastic	8/6
6in. 900ft. L.P. acetate	10/-
5in. 1,200ft. D.P. Mylar	15/-
5in. 1,800ft. T.P. Mylar	32/6
5½in. 1,200ft. L.P. acetate	12/6
5½in. 1,200ft. L.P. Mylar	16/-
5½in. 1,800ft. D.P. Mylar	22/6
5½in. 2,400ft. T.P. Mylar	32/6
7in. 1,200ft. Std. acetate	12/6
7in. 1,800ft. L.P. acetate	15/-
7in. 1,800ft. L.P. Mylar	20/-
7in. 2,400ft. D.P. Mylar	25/-
7in. 3,600ft. T.P. Mylar	45/-

Postage 2/- Over £3 post paid.

TWO-WAY RADIOS

Superb quality, brand new and guaranteed.

3 Transistors **£6/15/-** pair. 4 Transistors **£6/19/6** pair. 6 Transistors **£8/12/6.** 6 Transistor De-Luxe Lafayette **£12/10/-** pair. 10 Transistor **£22/10/-** pair. 13 Transistor 500 MW 2-channel **30 Gns.** pair Post Extra.

F.M. WIRELESS MICROPHONE

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.

HOSIDEN DH04S 2-WAY STEREO HEADPHONES

Each headphone contains a 2½in. woofer and a ½in. tweeter Built in individual level controls. 25-18,000 c.p.s. 8Ω imp. with cable and stereo plug. **£5/19/6.** P. & P. 2/6.

TRANSISTORISED TWO-WAY TELEPHONE INTERCOM

Operative over amazingly long distances. Separate call and press to talk buttons. 2-wire connection. 1,000's of applications. Beautifully finished in ebony. Supplied complete with batteries and wall brackets. **£5/19/6.** pair. P. & P. 3/6.

SINCLAIR EQUIPMENT

Z12, 12 watt amplifier	89/6
PZ4. Power supply Unit	99/6
STEREO 25. Preamplifier	£9/19/6
Q.14 Speakers	£6/19/6
Micromatic Radio Kit	49/6
Built	59/6
Micro FM Radio Kit	£5/19/6
ALL POST PAID.	

SPECIAL PACKAGE DEAL!
2 Z12 amps. PZ4 Power Supply, Stereo 25, Preamplifier, **£22.** Or with two Q14 Speakers, **£35.**

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★ Electronic Components
★ Test Equipment
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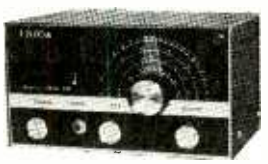
SEND NOW—ONLY 5/- P&P 1/-

UNR-30 4 BAND COMMUNICATION RECEIVER



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

LAFAYETTE MODEL HA700 AM/CWSSB AMATEUR COMMUNICATION RECEIVER

8 valves, 5 bands incorporating 2 MECHANICAL FILTERS for exceptional selectivity and sensitivity. Frequency coverage on 5 bands 150-400 Kc/s., 550-1,600 Kc/s. 1.6-4.0 Mc/s. 4.8-14.5 Mc/s., 10-5-30 Mc/s. Circuit incorporates R.F. stage, aerial trimmer, noise limiter, B.F.O. product detector, electrical bandspread, S meter, slide rule dial. Output for phones, low to 2KΩ or speaker 4 or 8 ohms. Operation 220/240 volt A.C. Size 7⅞in. × 15in. × 10in. Supplied brand new and guaranteed with handbook **36 Gns.** Carr. 10/-. S.A.E. for leaflet

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/-.**

LAFAYETTE LA-224T TRANSISTOR STEREO AMPLIFIER

19 transistors, 8 diodes, IHF music power 30 watts at 8 ohms. Response 30-20,000 ±2 db at 1 w. Distortion 1% or less. Inputs 3 mV and 250 mV. Output 3-16 ohms. Separate L. and R. volume controls. Treble and bass controls. Stereo phone jack. Brushed aluminium, gold anodised extruded front panel with complementary metal case. Size 10½in. × 3⅝in. × 7⅛in. Operation 115/230 volt A.C. **£25.** Carr. 7/6.

★ TRANSISTORISED FM ★ TUNER

6 TRANSISTOR HIGH QUALITY TUNER SIZE ONLY 6in. × 4in. × 2½in. 3 I.F. stages. Double tuned discriminator, ample output to feed most amplifiers. Operates on 9 volt battery. Coverage 88-108 Mc/s. Ready built ready for use. Fantastic value for money. **£6/7/6.** P. & P. 2/6. STEREO MULTIPLEX ADAPTORS, **5 Gns.**

GARRARD DECKS SPECIAL OFFERS!

Brand new and guaranteed.
SP25 Mk. II, less cartridge, **£11/11/-.**
LAB80 Mk. II, less cartridge, **£23/10/0.**
LAB80 Mk. II, less cartridge, with WB2 base, **£27/10/-.**
401 Transcription, less cartridge, **£27/6/-.**
Carriage 7/6.

RECORDING HEADS

Reuter ¼-track. As fitted to Collaro Mk. IV and Studio Decks. High imp. record play back, low imp. erase. Brand new. **19/6** pair. Post Extra.

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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 gains controls. 115/250 V. A.C. Mains. Beautifully designed. Size: 7 × 15 × 10in. With instruction manual and service data. **£37/10/-.** **Carriage 12/6.**

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TYPE 1035

General purpose A.C. coupled. TYPE 1049 L.F. D.C. coupled, **£35** each. Carr. 30/-.

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Latest release of **RCA COMMUNICATIONS RECEIVER AR88:** Brand new and in original cases—A.C. mains input 110 v. or 250 v. Freq. in 6 bands 535 Kc/s-32 Mc/s. Output impedance 2.5-600 ohms. Complete with crystal filter, noise limiter, B.F.O., H.F. tone control, R.F. & A.F. variable controls. Price: **£87/10/-** each, new. Carr. £2. Same model as above in secondhand cond. (guaranteed working order), **£45.** Carr. £2.

SET OF VALVES: new, **£3/10/-** a set, post 7/6; available with Receiver only. **SPEAKER:** new, **£3** each, post 10/-. **HEADPHONES;** new, **£1/5/-** a pair, 600 ohms impedance. Post 5/-.

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HRO RECEIVER. Model 5T. This is a famous American High Frequency superhet, suitable for CW, and MCW., reception crystal filter, with phasing control. AVC and signal strength meter. Freq. range 50 kc/s. to 30 mc/s., with set of nine coils. Receiver only in working order, **£18/10/-**, carr. 15/- each. Set of nine coils, **£12/10/-**, available only with set. Power unit for HRO 100/240 v. A.C., **£2/15/-**, carr. 10/-.

SPECIAL OFFER: Complete HRO SET (Receiver, Coils and Power Unit) for **£30**, plus 30/- carr.

HRO-M-SETS available with UX type valves; secondhand cond., with 5 coil and power unit, **£20** each, carr. 30/-.

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ROTARY TRANSFORMERS: 24 v. input, 175 v. at 40mA output, 25/-, plus 2/- post. 12 v. input, 225 v. at 100 mA output, 25/-. plus 3/- post (All the above are D.C. only).

ROTARY CONVERTERS: Type 8a, 24 v. D.C., 115 v. A.C. @ 1.8 amps. 400 c/s 3-phase, **£6/10/-** each, 8/- post. Converter 12 v. D.C. input, 110 v. A.C. 60 c/s output, **£15** each, £1 carr.

AVO MULTIRANGE No. 1 ELECTRONIC TEST SET: £25 each, carr. £1.

AVOMETERS: Model 47A, **£9/19/6** each, 10/- post. Model 7x, **£13/10/-** each, 10/- post. Excellent secondhand cond. (Meters only). (Batteries and Leads extra—at cost).

OSCILLOSCOPE Type 13A, 100/250 v. A.C. Time base 2 c/s.-750 Kc/s. Bandwidth up to 5 Mc/s. Calibration markers 100 Kc/s. and 1 Mc/s. Double Beam tube. Reliable general purpose scope, **£22/10/-** each, 30/- carr.
COSSAR 1035 OSCILLOSCOPE, £30 each, 30/- carr.
COSSAR 339 OSCILLOSCOPE, double beam, **£10** each, 30/- carr.

RELAYS: Relay Unit (with 9 American relays) 24 v. D.C., 250 ohm coils, heavy duty, M. & B. 30/- each, 4/- post. GPO Type 600, 10 relays @ 300 ohms with 2M and 10 relays @ 50 ohms with 1M., **£2** each, 6/- post.

CALIBRATION TACHOMETER Mk. II: Maxwell Bridge Type 6C/869, **£25** each, £2 carr.

ROTAX VARIAC & METER UNIT: Type 5G.3281. Reading 0-40 v., 0-40 mA and 0.5 amps., all on 275 deg. scales, **£30** each, £2 carr.

MARCONI IMPEDANCE BRIDGE, TF-373: inductance 5μh-100H in 5 ranges capacity 5pF-100μF in 5 ranges, resistance .05 meg.-1 meg., power supply 250 v. A.C., **£37/10/-** each, carr. 15/-.

HEWLETT PACKARD TYPE 400C: 115 v./230 v. input 50/60 c/s. Freq. range 20 c/s-2 Mc/s. Voltage range: 1mV-300 v. in 12 ranges. Input impedance 10 megohms. Designed for rack mounting, **£30** each, carr. 15/-.

TCS MODULATION TRANSFORMERS, 20 watts, pr. 6,000 C.T., sec. 6,000 ohms. Price 25/-, post 5/-.

CONDENSERS. 10 mfd. 1,000 v., 12/6, post 2/6. 8 mfd., 1,200 volts, 12/6, post 3/-. 8 mfd. 600 volts., 8/6 post 2/6. 0.25 mfd., 2 kv., 4/- post 1/6.

AUTOMATIC PILOT UNIT Mk. 2. This complex unit of diodes and valves, relays, magnetic clutches, motors and plug-in amplifiers, with many other items, price **£7/10/-**, £1 carriage.

FOR EXPORT ONLY: B.44 Trans-ceiver Mk. 11I. Crystal control, 60-95 Mc/s.

AMERICAN EQUIPMENT: 5C-640 Transmitter, 100-156 Mc/s, 50 watt output. For 110 or 230 v. operation. ARC-27 trans-ceivers, 28 v. d.c. input. Also have associated equipment. BC-375 Transmitter. BC-778 Dinghy transmitter. SCR-522 trans-ceiver. Power supply, PP893/GRC 32A; Filter D.C. Power Supply F-170/GRC 32A: Cabinet Electrical CY 1288/GRC 32A; Antenna Box Base and Cables CY 728/GRC; Mast Erection Kits, 1186/GRC; Receiver type 27 8B; Directional Antenna CRD.6; Comparator Unit, CM.23; Directional Control CRD.6, 567/CRD and 568/CRD; Azimuth Control Units, 260/CRD. Test Set URM.44, complete with Signal Generator TS.622/U.

SIGNAL GENERATORS:

MARCONI TF-144G: freq. 85 Kc/s-25 Mc/s, internal and external modulation, power supplies 200/250 v. A.C. (secondhand cond), price **£25** ea.; or available in transit case, complete with spares, in first class condition, **£30** ea., carr. on both 30/- ea.

TS155c/UP (as new): price **£75** each, carr. £1.

CT53. Freq. range 8.9-300 Mc/s. with Calibration chart. Output 1μV-100 mV. internal square wave and sinewave modulation at 100 c/s., external modulation 50 c/s-10 Kc/s., 230 v. A.C. Complete with chart, etc., price **£27/10/-** ea., carr. £1.

MARCONI TF801A/1 Freq. 10-300 Mc/s., 4 bands, output 200 mV, Attenuator 0-110dB. Input 75 ohms. **£65** each, carr. £1.

MARCONI TF516-F/1: Covering 10-18 Mc/s., 33-58 Mc/s., 150-300 Mc/s. **£12/10/-** each, carr. £1.

MARCONI CT218: price **£65** each, carr. 30/-.
CT.480 and 478: 1.3-4.2 Mc/s., F.M. or A.M., price **£75** each, carr. 30/-.

AN/USM44, T.S. 510/U Signal Generator (Hewlett Packard), 115 v. A.C., 10-420 Mc/s in 5 Bands, **£85** each, carr. £1.

NIFE BATTERIES: 6 v. 75 amps., new, in cases, **£15** each, £1 carr.; 6 v. 160 amps., new in cases, £25 each, £1/10/- carr.; 4 v. 160 amps, new, in cases, £20 each, £1/10/- carr.

L.R.7 Cells, only 1.5 v. 75 amps., new, **£3** each, 12/- carr.
The above batteries are low resistance designed to give a heavy surge for starting and can be stored for long periods without any effect to their performance.

FUEL INDICATOR Type 113R: 24 v. complete with 2 magnetic counters 0-9999, with locking and reset controls mounted in a 3in. diameter case. Price 30/- each, postage 5/-.

UNISELECTORS (ex equipment): 10 Bank 50 Way, alternate wipe, **£2/5/-** ea. 6 Bank, 25 Way, alternate wipe, **£2/2/6** ea. 8 Bank, 25 Way, **£2/5/-** ea. 6 Bank, 25 Way, £2 ea. 4 Bank, 25 Way, 35/- ea. All the above are 75 ohm coil. Postage 4/- per uniselector.

FREQUENCY METERS: 1M 13 or BC-221; 125-20,000 Kc/s., **£25** each., carr. 15/-. TS.175/U, **£75** each, carr. £1. TS323/UR; 20-450 Mc/s., **£75** each, carr. 15/-. FR-67/U: This instrument is direct reading and the results are presented directly in digital form. Counting rate: 20-100,000 events per sec. Time Base Crystal Freq.: 100 Kc/s. per sec. Power supply: 115 v., 50/60 c/s., **£100** each, carr. £1.

CT.49 ABSORPTION AUDIO FREQUENCY METER: freq. range 450 c/s-22 Kc/s., directly calibrated. Power supply 1.5 v.-22 v. D.C. **£12/10/-** each, carr. 15/-.

AMERICAN EQUIPMENT: Power supply, PP893/GRC 32A; Filter D.C. Power Supply F-170/GRC 32A: Cabinet Electrical CY 1288/GRC 32A; Antenna Box Base and Cables CY 728/GRC; Mast Erection Kits, 1186/GRC; Receiver type 27 8B; Directional Antenna CRD.6: Comparator Unit, CM.23; Directional Control CRD.6, 567/CRD and 568/CRD; Azimuth Control Units, 260/CRD. Test Set URM.44, complete with Signal Generator TS.622/U, **£100** each, £2 carr.

CATHODE RAY TUBE UNIT: With 3in. tube, colour green, medium persistence complete with nu-metal screen, **£3/10/-** each, post 7/6.

APNI ALTIMETER TRANS./REC., suitable for conversion 420 Mc/s., complete with all valves 28 v. D.C. Dynamotor and 3 relays, 11 valves, price **£3** each, carr. 10/-.

GEARED MOTORS: 24 v. D.C., current 150 mA, output 1 r.p.m., 30/- each 4/- post. Assembly unit with Letcherbar Tuning Mechanism and potentiometer, 3 r.p.m., **£2** each, 5/- post.

MOTORISED ACTUATOR: 115 v. A.C. 400 c/s. single phase, reversible, thrust approx. 3 inches complete with limit switches, etc. Price **£2/10/-** each, postage 5/- (ex equipment).

Actuator Type SR-43: 28 v. D.C. 2,000 r.p.m., output 26 watts, 5 inch screw thrust, reversible, torque approx. 25 lbs., rating intermittent, price **£3** each, post 5/-.

FRACTIONAL MOTORS & FANS: Low inertia Motor 5UD/5361, Type 903, 24 v. input D.C., **£2/10/-** each, 5/- post.

Model PM84: 28 v. D.C. @ 2 amps., 4,500 r.p.m., output 40 watts continuous duty complete with magnetic brake. Price **£2** each, postage 4/-.

Model SR-2: 28 v. D.C. 7,000 r.p.m., duty intermittent, output 75 watts, price 25/- each, postage 4/-.
A.C. Motor 115 v. 50 c/s. 1/300 H.P., 3,000 r.p.m. Capacitor 1mfd., 25/- post 3/-. Dalmotor SC5, 28 v. D.C. at 45 amps; 12,000 r.p.m. output 750 W. (approx. 1 h.p.), brand new, **£2/10/-** each, post 7/6.

T.S.382 U AUDIO OSCILLATOR; 115 v. A.C., freq. range 20-200,000 c/s per sec. in 4 ranges. Continuous wave output volts 0-10 in 7 ranges, **£40** each, carr. £1.

T.S.155c/U PULSE GENERATOR; 115 v. A.C., freq. range 2,700-3,400 Mc/s. Pulse output trigger repetition rate 80-2,600 per sec. **£75** each, carr. £1.

TELEPHONES (PORTABLE) TYPE "F." Suitable for all outdoor activities up to a range of 5 miles. Price **£7/10/-** each, as new, complete with carrying case. Carr. 10/-.

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SENSATIONAL VALUE IN HIGH FIDELITY STEREO SYSTEMS

'Plan 3' 30 Watt System

★ Goldring Transcription Turntable
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★ Super 30 Amplifier.
★ E8 Equipment Cabinet.
★ Pair of Stanton Mk. IIIS L/Speaker Units.

Special inclusive price. Fully wired units ready to "plug in." Saving £18 on total cost. Send S.A.E. for leaflet. Carr. 35/- **79½ Gns.**

Extremely attractive cabinets finished in Satin Teak Veneer. Tinted Perspex hinged lid with satin chrome handle.

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★ Garrard SP25 Mk. II Turntable.
★ Goldring C890 Ceramic P.U. Cartridge.
★ Super 30 Amplifier.
★ E8 Equipment Cabinet.
★ Pair Stanton Mk. IIIS L/Speaker Units.

Special inclusive price. Fully wired units ready to "plug in." Saving £18 on total cost. **69½ Gns.** Carr. 35/-.

Inc. Garrard SP25 Mk. II 4-speed Player Unit (with heavy cast turntable) mounted on plinth with leads and plugs and fitted Goldring C890 high compliance ceramic cartridge with diamond stylus. Assembled TA12 Stereo Amplifier in cabinet and pair of Dorset Speaker Units. Special inclusive price Saving **£12** on total cost. Carriage 35/-. Perspex cover **59/9** extra with above only. **46 Gns.**
Or Dep. **£7/6/-** and 9 mthly. payments **£5/3/-** (Total **£53/13/-**).

Matched for optimum performance and comparing favourably with equipment at almost twice the cost. Send S.A.E. for leaflet.

AUDIOTRINE HIGH FIDELITY LOUDSPEAKERS

Heavy cast construction. Latest high efficiency ceramic magnets. Treated cone surround giving low fundamental resonance. "D" indicates Tweeter Cone providing extended frequency range. Impedance 3 or 15 ohms. Response 40-18,000 c.p.s. Highly recommended model capable of outstanding performance. Exceptional value.

HF850D 8"x5", 8watt	£2	9	9	**HF120** 12in. 15 watt	£3	9	9
HF800D 8in. 8 watt	£2	19	9	**HF120D** 12in. 15 watt	£3	19	9
HF811D 8in. 10 watt	£4	19	9	**HF126** 12in. 15 watt	£4	9	9
HF101D 10in. 15 watt	£5	19	9	**HF126D** 12in. 15 watt	£5	5	0

Following super efficient types have rolled rubber surround and 15,000 line ceramic magnet. Response 30-20,000 c.p.s.

HF815D 8in. 10 watt £5 19 9 **HF 105D** 10in. 15 watt £6 15 0

RECORD PLAYING UNITS

All types available on Credit Terms.

Ready for plugging in to Amplifier or Tape Recorder.

RP2 Consisting of Garrard SP25 Mk. II with heavy cast turn table and fitted Goldring C890 high compliance ceramic Stereo/Mono cartridge with diamond stylus, plinth and cover. Normally approx. £26. Carr. 15/-. ONLY **22 Gns.**

RP3 As above but with Goldring Lenco GL68 Transcription unit and C890 Cartridge. Normally approx. 32 gns. Carr. 15/-. ONLY **27½ Gns.**

RP3M with Pickering Magnetic Cartridge. Normally approx. 39 gns. **35½ Gns.**

AUDIOTRINE PLINTHS

for Record Playing units. Teak finish. Cut for Garrard. 1,000, 2,000, 3,000 AT60, SP25 or Goldring GL68. Available with clear Perspex cover as illustrated. **£5/19/11** complete. Carr. 8/6 or slightly deeper type cut for TA12 but suitable for Super 15 and 30, **£6/19/11** inc. cover. Carriage 8/6. Perspex cover sold separately at **3 gns.** Limited number, slightly damaged but repaired by manufacturer, **39/9** to clear.

66/-

TA6 6-7 WATT HIGH FIDELITY AMPLIFIER

Solid State Circuitry

Employing latest type Transistors. 200-250 v. A.C. mains operated.

Frequency Response 30-20,000 c.p.s. —2 dB Harmonic Distortion 0.3% at 1,000 c.p.s. Separate Bass and Treble "lift" and "cut" controls. 3 inputs sockets for Mike, Gram, Radio or Tape Input Selector Switch. Output 3-15 ohm speakers. Max. Sensitivity 5mV. Fully enclosed enamelled case, 9½ × 2⅝ × 5¼in. Attractive brushed silver finish facia plate 10½ × 3⅛in. and matching knobs. Complete kit of parts with full wiring diagrams and instructions. Or factory built with 12 mths. guar. Post paid **8 gns.** Carr. 7/6. **6 Gns.**

HI-FI LOUDSPEAKER ENCLOSURES

All types of pleasing modern design, acoustically lined and ported. Finished in Satin Teak veneer.

JE8. Size 20 × 11 × 8in. Gives pleasing results with any 8in. Hi-Fi Speaker. **4 Gns.**

SE8. For optimum performance with any Hi-Fi 8in. speaker. Size 22 × 15 × 9in. **5 Gns.**

SE10. For 10in. Hi-Fi Speaker. Size 24 × 15 × 10in. **6 Gns.**

SE12. For outstanding performance with any 12in. Hi-Fi speaker. Cut for tweeter. Size 25 × 16 × 10½in. **7 Gns.**

ALL LEADING MAKES HI-FI EQUIPMENT IN STOCK

INTEREST CHARGES REFUNDED

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R·S·C TA12 13 WATT STEREO AMPLIFIER

FULLY TRANSISTORISED, SOLID STATE CONSTRUCTION, HIGH FIDELITY OUTPUT OF 6.5 WATTS PER CHANNEL. Designed for optimum performance with any crystal or ceramic gram. P.U. cartridge, Radio, Tuner, Tape Recorder, "Mike," etc. ★ 3 separate switched input sockets on each channel. ★ Separate Bass and Treble controls. ★ Slide Switch for mono use. ★ Speaker Output 3-15 ohms. ★ For 200-250 v. A.C. mains. ★ Frequency Response 30-20,000 c.p.s. —2 dB. ★Harmonic Distortion 0.3% at 1,000 c.p.s. Hum and Noise —70 dB. ★ Sensitivity (1) 390 mV (2) 50 mV (3) 100mV (4) 2mV. ★ Handsome brushed silver finish facia and knobs. Complete kit of parts with full wiring diagrams and instructions.

11 Gns. Carr. 7/9. Factory built with 12 months guarantee. **15 Gns.** Carr. 7/9. Or Deposit **£4/16/-** and 9 monthly payments **29/-** (Total **17 gns.**) Teak finished cabinet as illustrated **£3/13/6** extra. Or larger size as used in Stereo System **4 Gns.**

R.S.C. HIGH FIDELITY SPEAKER SYSTEMS

FR1a Consisting of high quality 12in. 12,000 line Bass Speaker cross-over unit and Tweeter. Smooth response and extended frequency range ensure surprisingly realistic reproduction. Impedance 15 ohms. Rating 10 watts. Response 40-20,000 c.p.s. **5 Gns.** Carr. 6/6

FR1b Inc. HF126 Bass Speaker cross-over and Tweeter. Rating 15 watts. Recommended Cabinet type SE12. **6 Gns.** 6/6

FR2 10 Inc. powerful 10in. 15 watt HF105 Bass Speaker with roll rubber surround and 15,000 line ceramic magnet, plus Choke/capacitor cross-over and highly efficient cone type Tweeter. Response 30-20,000 c.p.s. substantially flat throughout the audible range. Impedance 8-15 ohms. Really excellent value at (**Recommended cabinet SE10**) **7 Gns.** Carr. 6/6

FR3b 3 speaker System consisting of HF122L 12in. 20 watt Bass speaker with roll rubber cone surround to obtain extremely low fundamental resonance, 5 in 10,000 line middle speaker, high flux cone type tweeter, and appropriate choke/capacitor cross-overs. Impedance 15 ohms. Frequency response 20-20,000 c.p.s. Will provide sound quality to satisfy the most discriminating listener. Circuit and recommended cabinet size supplied. Only **11 Gns.**

HIGH FIDELITY LOUDSPEAKER UNITS

Cabinets of latest styling Satin Teak or Walnut, acoustically lined (and ported where appropriate). Credit Terms available.

DORSET Size 16 × 11 × 9in. Response 45-18,000 c.p.s. Rating 8-10 watts. Fitted Audiotrine HF810D speaker. 3 or 15 ohms. **£8.19.9**

DORCHESTER Size 24 × 15 × 10in. Fitted Audiotrine HF101D Speaker. Rating 15 watts. Impedance 3 or 15 ohms. Frequency response 30-20,000 c.p.s. **12½ Gns.**

GLOUCESTER Size 25 × 16 × 10in. 12in. High flux. 12,000 line speaker. Cross-over unit and Tweeter. Rating 10 watts. Smooth response 40-20,000 c.p.s. Impedance 15 ohms. Outstanding value. **12½ Gns.**

STANTON Mk. 1118. Size 18 × 11 × 10in. Rating 10 watts. Incorporating Audiotrine HF815 Speaker with rolled rubber surround and 15,000 line magnet. Handsome Scandinavian design pressurised cabinet. Response 30-20,000 c.p.s. Impedance 3 or 15 ohms. The deep excursions of the cone produce powerful bass notes, High Flux tweeter extends frequency range above audibility. Excellent transient response ensures smooth realistic output. **16 Gns.**

LINEAR LP/1 TAPE PRE-AMPLIFIER

Switched Equalisation. Positions for recording at 1⅞in., 3¾in., 7½in. per sec. and Playback. EM84 Recording Level Indicator. Designed primarily as the link between a Magnavox Tape Deck and Hi-Fi amplifier suitable most Tape Decks. Terms available. **10½ Gns.**

TWO-WAY TELEPHONE AMPLIFIERS

Speak and listen with both hands free. Compact, solid state, Standard PP3 battery operation. Excellent value at **£3.19.9**

R.S.C. STEREO/20 HIGH FIDELITY AMPLIFIER

PROVIDING 10/14 WATT ULTRA LINEAR PUSH-PULL OUTPUT ON EACH CHANNEL. SUITABLE FOR "MIKE" GRAM., RADIO OR TAPE. 7 valves ECC83 (2), ECL86 (4), EZ81. **Frequency Response:** ±2 dB 30-20,000 c.p.s. **Hum level** 65 dB down. **Sensitivity:** 20 millivolts max. **Harmonic Distortion** (each channel): 0.2%. ★ **Four-position tone compensation and Input Selector Switch.** ★**Stereo/Mono switch.** ★ **Neon panel indicator.** ★ **Handsome Perspex Frontplate.** ★ **Separate Bass and Treble controls.** Output transformer High-quality sectionally wound. Outputs for 3 and 15 ohm speakers.

Complete kit with point-to-point wiring diagrams and instructions. **14 Gns.** Carr. 12/6

Or factory assembled with our usual 12 months guarantee. **19 Gns.** Carr. 12/6. Or send Dep. **£4/10/-** and 9 mthly. pmts. of **£2** (Total **£22/10/-**). *Send S.A.E. for leaflet*

R.S.C. AIIT 15 WATT HIGH FIDELITY AMPLIFIER

DUAL PURPOSE P.A. or HI-FI SOLID STATE CIRCUITRY

★**3 input sockets.** ★**2 vol. controls, for mixing purposes.** ★ **Input Selector.** ★**Output for speakers between 3 and 15 ohms.** ★**Separate Bass and Treble controls.** Suitable for Gram., Radio, Tape, Microphone, or Guitar P.U. For Vocal and Instrumental groups. Frequency response 20-40,000 c.p.s. —3dB. Hum Level —80dB. Harmonic Distortion 0.2% at 10 watts R.M.S. Operation on 200-250 v. A.C. mains. Size 9½ × 2½ × 5½in. Complete Kit of parts with comprehensive wiring diagrams and instructions. **9 Gns.** Carr. 9/6.

Or Factory built with 12 mths. guarantee. **13 gns.** Carr. 9/6. Terms: Deposit **£4** and 9 monthly payments **25/6** (Total £15/9/6).

R.S.C. TFM1 TRANSISTORISED VHF/FM RADIO TUNER

Total cost of parts with detailed wiring diagrams and instructions. Carr. 10/-. **12½ Gns.**

Or factory-built **16¾ Gns.** Or in Teak finished cabinet as illustrated. **19¼ Gns.** Terms: Deposit **£5** and 9 monthly payments **£2.** Total **£23.**

★ **High Sensitivity.** ★ **200-250 v. A.C. Mains operation** ★ **Sharp A.M. Rejection.** ★ **Drift free reception.** ★ **Output ample for any amplifier (approx. 500 mV.).** ★ **Simple alignment instructions.** ★ **Output available for feeding tuning meter.** ★ **Output for feeding Stereo Multiplexer.** ★ **Tuner head using Silicon Planar Transistors.** ★ **Designed for standard 80 ohm co-axial input,** Visually matching our Super 15 and 30 amplifiers and of the same high standard of performance eliability. The pre-wired tuning head facilitates speed and simplicity of construction. Printed circuitry. Only first grade components used. A quality product at half the cost of comparable units. **Stereo version available. All parts 17¾ Gns. Assembled 22¼ Gns. In cabinet 25¼ Gns.** Carr. 10/-.

R.S.C. SUPER 15 HI-FI AMPLIFIER

SOLID STATE UNITS

R.S.C. SUPER 30 STEREO AMPLIFIER

FULLY TRANSISTORISED 200/250 v. A.C. Mains.
OUTPUT 10 WATTS R.M.S. cont. into 15 ohms.
15 WATTS R.M.S. cont. into 3-4 ohms.
LATEST MULLARD TRANSISTORS. AD149, AD149, OC127Z, OC81Z, OC44, OC44, OC81Z, OC44, AC107.
5 POSITION INPUT SELECTOR SWITCH
EQUALISATION to Standard R.I.A.A. and C.C.I.R. Characteristics for Gram and Tape Heads.
FULL TAPE MONITORING FACILITIES
SENSITIVITIES: Magnetic P.U. 4mV. Crystal or Ceramic P.U. 400 mV. Microphone 4.5 mV. Tape Head 2.5 mV. Radio/Aux. or Ceramic P.U. 110 mV.
FREQUENCY RESPONSE: ±2 dB 20-20,000 c.p.s.
TREBLE CONTROL: +15 dB to −14 dB at 10 Kc/s. **NEG. FEEDBACK:** 52 dB.
BASS CONTROL: +17 dB to −15 dB at 50c/s. **HUM LEVEL:** −75 dB.
HARMONIC DISTORTION at 10 watts R.M.S. 1,000 c.p.s. 0.25%. Carr. 12/6.
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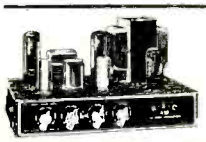

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2µF	..	3 volt	8µF	..	6 volt	100µF	..	6 volt
2µF	..	9 volt	8µF	..	50 volt	100µF	..	9 volt
2µF	..	70 volt	8µF	..	275 volt	150µF	..	12 volt
2µF	..	150 volt	10µF	..	25 volt	200µF	..	3 volt
2µF	..	350 volt	16µF	..	150 volt	200µF	..	4 volt
2.5µF	..	16 volt	20µF	..	3 volt	250µF	..	2.5 volt
2.5µF	..	25 volt	20µF	..	6 volt	250µF	..	9 volt
3µF	..	3 volt	20µF	..	9 volt	320µF	..	2.5 volt
3µF	..	25 volt	20µF	..	15 volt	250µF	..	9 volt
3.2µF	..	6.4 volt	25µF	..	6 volt	350µF	..	10 volt
3.2µF	..	64 volt	25µF	..	12 volt	400µF	..	2.5 volt
4µF	..	4 volt	25µF	..	25 volt	400µF	..	15 volt
4µF	..	12 volt	30µF	..	6 volt	500µF	..	4 volt
4µF	..	25 volt	30µF	..	10 volt	500µF	..	6 volt
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0.01µF	400 volts	.. .. ..	4d	1µF	125 volts	.. ..	1/6
68pF Tubular pulse ceramic	.. ..	6d each					

VERY SPECIAL VALUE! Silver Mica, Ceramic, Polystyrene Condensers. Well assorted. Mixed types and values, **10/-** per 100.

RESISTORS. Give-away offer! Mixed types and values, ¼ to ½ watt,
6/6 per 100 or **55/-** per 1,000.
Also ½ to 3 watt close tolerance. Mixed values, **7/6** per 100; **55/-** per 1,000.

WIRE-WOUND RESISTORS
1 watt, 3 watt, 6 watt, 6d each, 7 watt and 10 watt 9d each. 20 assorted:— 10/-

CONNECTING WIRE. THIN, P.V.C. INSULATED
10yd, 1/-; 100yd, **7/6**; 500yd, **25/-** (post 4/6); 1,000yd, **40/-** (post 6/-).

VALVES. BRAND-NEW AND BOXED. ROCK-BOTTOM PRICES;

DY87	.. ..	6/9	EY51	.. ..	8/9	PCL85	.. ..	8/5
EABC80	.. ..	7/-	EY86	.. ..	8/9	PCL86	.. ..	8/5
ECC82	.. ..	7/4	EY87	.. ..	8/9	PFL200	.. ..	11/8
ECC83	.. ..	7/4	PABC80	.. ..	7/1	PL36	.. ..	10/1
ECL80	.. ..	7/1	PC97	.. ..	10/6	PL81	.. ..	8/5
ECL86	.. ..	8/5	PCC84	.. ..	7/4	PL83	.. ..	8/5
EF80	.. ..	7/1	PCC89	.. ..	10/6	PL84	.. ..	6/6
EF85	.. ..	7/1	PCF80	.. ..	8/5	PL500	.. ..	12/5
EF183	.. ..	9/5	PCF86	.. ..	10/1	PY32	.. ..	9/-
EF184	.. ..	9/5	PCL82	.. ..	8/5	PY81	.. ..	6/9
			PCL83	.. ..	9/10	PY82	.. ..	4/9
			PCL84	.. ..	8/5	PY800	.. ..	6/9

A further 10% discount will be given on lots of 50 of any one type.

RECORD PLAYER CARTRIDGES
Acos GP67/29 Mono, **15/-**; Acos GP91/35C Stereo compatible, **20/-**; Acos GP94/1 Stereo, **25/-**. All with needles.

TRANSISTORISED SIGNAL INJECTOR KIT, 10/-. SIGNAL TRACER KIT, 10/-

VEROBOARD. All sizes in stock.

2½in × 1in	0.15 matrix	.. ..	1/1	17in × 3⅞in	0.15 matrix	..	14/8
2½in × 3⅞in	0.15 matrix	.. ..	3/3				
2½in × 5½in	0.15 matrix	.. ..	3/11	5in × 5½in	0.1 matrix	..	3/11
3⅞in × 3⅞in	0.15 matrix	.. ..	3/11	3⅞in × 2½in	0.1 matrix	..	3/9
3⅞in × 5in	0.15 matrix	.. ..	5/6	5in. × 3⅞in	0.1 matrix	..	5/2
17in × 2½in	0.15 matrix	.. ..	11/-	3⅞in × 3⅞in	0.1 matrix	..	3/11

SPECIAL OFFER!
Cutter and 5 Boards 2½in × 1in. **9/9**. Cutter only, **7/6**. Pin insert Tool, **9/6**. Terminal Pins. Packed of 36, **3/6**.

BARGAIN OFFER!
Few only Multimeters, 1,000Ω per volt, **45/-**; 20,000Ω per volt, **80/-**.

Orders by post to:—

G. F. MILWARD, 17 PEEL CLOSE, DRAYTON BASSET, Staffs.

Please include suitable amount to cover postage. Stamped addressed envelope must be included with any enquiries. Regret unable to accept orders below 10/- by post. For customers in the Birmingham area goods may be obtained from Rock Exchanges 231 Alum Rock Road, Birmingham 8. (All POST orders to Drayton.)

TELEPRINTERS · PERFORATORS
REPERFORATORS · TAPEREADERS
EDITING & REPRODUCING SETS

Codes: Int. No. 2 Mercury/Pegasus, Elliot 803, Binery and special purpose Codes.

2-5-6-7-8- TRACK AND MULTIWIRE EQUIPMENT

TELEGRAPH AUTOMATION AND COMPUTER PERIPHERAL ACCESSORIES

Picture Telegraph, Desk-Fax, Morse Equipment; Pen Recorders; Switchboards; Converters and Stabilised Rectifiers; Tape Holders, Pullers and Fast winders; Governed, Synchronous and Phonic Motors; Teleprinter Tables and Cabinets; Silence Covers; Distortion and Relay Testers; Send/Receive Low and High Pass filters; Teleprinter. Morse, Teledots Paper, Tape and Ribbons; Polarised and specialised relays and Bases; Terminals V.F. and F.M. Equipment; Telephone, Carriers and Repeaters; Multiplex Transmitters; Diversity Frequency Shift, Keying Equipment; Line, Mains Transporters and Suppressors; Racks and Consoles; Plugs, Sockets; Key, Push, Miniature and other Switches Cords, Wires, Cables and Switchboard Accessories; Teleprinter Tools; Stroboscopes and Electronic Forks; Cold Cathode Matrics; Test Equipment; Oscilloscopes; Miscellaneous Accessories and Spares.

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Gaiety Works, Ackerman Street, Tring, Herts.
Tel.: Tring 3476 (3 lines) Cables: RAHNO TRING
STD: 044-282 TELEX 82362

WW—118 FOR FURTHER DETAILS

HOWELLS RADIO LTD.

MINISTRY OF AVIATION INSPECTION APPROVED

TRANSFORMERS
STANDARD RANGE OR DESIGNED TO YOUR SPECIFICATION.
0-50KVA, "C" CORE, PULSE, 3 PHASE, 6 PHASE, TOROIDS, ETC.
Transformers for 20W Transistor Amplifier (W.W., Nov. 1966).
Driver **22/6** Carr. 2/-
Mains **29/6** Carr. 4/6
L.P. Filter, Chassis Mounting **11/6.** Carr. 1/-.
L.P. Filter, Printed Circuit Mounting **14/6.** Carr. 1/-.

***MAINS TRANSFORMERS**
350-0-350 v. 60 mA., 6.3 v. 2 A. **£1/15/-.** Carr. 4/6.
500 v. 300 mA. 6.3 v. 4 A., 6.3 v. 1 A. **£3/12/6.** Carr. 5/6.
500-0-500 v. 0.25 A., 6.3 v. 4 Act., 6.3 v. 3 Act., 5 v. 3 A. **£4/10/6.** Carr. 6/6.
525-0-525 v. 0.5 A., 6.3 v., 6 Act., 6.3 v., 6 Act., 5 v. 6 A. **£5/5/-.** Carr. 6/6.

***LOW VOLTAGE**

30-0-30 v. 4 A.	**£2/5/6.** Carr. 5/6.
15 v. 2 A.	**£1/12/6.** Carr. 3/-.
15 v. 6 A.	**£2/1/-.** Carr. 4/6.
15 v. 10 A.	**£2/15/-.** Carr. 5/6.

TRANSISTOR POWER SUPPLY TRANSFORMER
0-2-4-6-8-10-20-30-40-50 v. 2 A. £4/10/-. Carr 6/-.
***PRIMARIES** 10-0-200-220-240 v.

CHASSIS, CABINETS & PRECISION METALWORK

ELECTRONICS — DEVELOPMENT & ASSEMBLY

CASH WITH ORDERS PLEASE

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ZaeruX BRAND

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 0

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., 3 amps., stud mounted: Gate voltage 3.25 v. at 120 mA..... 12/6
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DRY REED INSERTS

Glass dry reed inserts approx. 1in. dia. x 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.

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/-.

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Apart from full range of semiconductors listed in our catalogue (available on request) we offer the following:

COMPLEMENTARY PAIRS

AC128/AC176 Germanium. 13/-; 2N697/2N1132 Sil. 27/-; ASY26/ASY28 Germanium. 12/-.

AM/FM/SW SETS

2-AF125 Mixer/Oscillator; 2AF126 (I.F.); 1-AC126 (Audio); 2, AC128 (Push-pull output). 21/- per set, post paid.

GERMANIUM GENERAL-PURPOSE TRANSISTORS

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

WHEN ORDERING BY POST PLEASE ADD 2/6 IN £ FOR HANDLING AND POSTAGE.

NO C.O.D. ORDERS ACCEPTED.

ALL MAIL ORDERS MUST BE SENT TO HEAD OFFICE AND NOT TO RETAIL SHOP

MOVING COIL METERS

1.5% accuracy top quality panel meters. Available from stock. Leaflet on request.

Current Production — ZaeruX — First Quality

VALVES FOR EXPORT

Here are a few examples from our stock of over 2,500 types. Prices are for direct export, for valves type marked and bulk packed, in lots of 100 per type minimum.

Prices in U.S. dollars.

OA2	0.36					6V6GT	0.38
OA3	0.69	5U4GB	0.45	6BE6	0.26	6X5GT	0.35
OC3	0.55	5V4G	0.59	6BG6G	0.70	310A	2.52
OD3	0.52	5Y3GT	0.42	6C5GT	0.56	311A	3.50
1B3GT	0.42	5Z4G	0.49	6CY5	0.45	328A	2.80
2C40	7.70	5Z4GT	0.52	6J4	0.73	329A	2.80
2D21	0.45	6AK5	0.42	6J5GT	0.42	807	0.77
3B28	3.50	6AS7G	1.40	6J6	0.26	811A	4.20
3BP1	5.80	6BU6	0.22	6L6GC	0.58	813	9.80
3E29	6.30	6B4G	1.50	6SL7GT	0.45	829B	6.30
5U4G	0.35	6BA6	0.21	6SN7GT	0.38	832A	5.95

FULL EXPORT PRICE LIST AVAILABLE ON REQUEST.

FULLY GUARANTEED — ZaeruX BRAND — VALVES FIRST QUALITY

OA2	6/-	6AM6	5/6	6CS6	7/-													HL23DD	6/-
OA3	9/-	6AM4	6/6	6CW4	12/-													HL41	4/-
OB2	6/-	6AN7	4/-	6CY5	7/-													HL42DD	7/-
OB3	8/-	6AC5GT		6CY7	11/-														8/-
OC2	15/-		10/-	6D3	7/6													HL92	6/-
OC3	6/-	6AC7	4/-	6D4	17/6													HL94	7/-
OD3	6/-	6AD4	15/-	6D6	3/-													KT8	30/-
1A5GT	5/-	6AF4A	9/-	6DC6	12/6													KT32	6/6
1A7GT	7/-	6AF6G	11/-	6DK6	8/-													KT41	7/6
1AN2	10/-	6AG5	2/6	6DQ6	11/-													KT44	5/-
1AD4	14/-	6AG7	6/-	6D84	15/-													KT63	6/-
1B3GT	8/-	6AH6	10/-	6E5GT	8/-	7AG7	7/-	12SK7	6/-	30P12	13/-	329A	30/-	5726	7/-	B65	5/6	DY802	9/-
1B35A	25/-	6AJ5	9/-	6EA8	11/-	7B5	10/-	12SL7GT		30P13	10/-	367	35/-	5727	10/-	C1K	70/-	E80CC	20/-
1B59	100/-	6AJ8	5/3	6EH7	6/-	7B6	11/-		7/6	30P16	7/-	393A	30/-	5749	10/-	C1108	160/-	E80CF	27/6
1C5GT	5/-	6AK5	5/-	6EJ7	6/-	7B7	7/-	12SN7GT		30P18	6/-	394A	35/-	5751	10/-	C1112	230/-	E80F	20/-
1G4GT	8/-	6AK5W	9/-	6F1	14/-	7B8	8/-		7/6	30P19	14/-	408A	27/6	5763	12/-	CBL31	15/-	E80L	15/-
1G6GT	7/-	6AK6	10/-	6F6G	5/-	7C6	6/6	12SQ7	7/6	30PL1	15/-	615	25/-	5814	9/-	CC3L	3/-	E81L	20/-
1H5GT	6/6	6AL5	3/-	6F8G	5/-	7C7	5/-	12SY7	6/-	30PL13	16/-	705A	20/-	5823	13/-	CCH35	9/-	E83F	20/-
1L4	2/6	6AM6	4/-	6F11	6/-	7E5	5/-	12Y4	2/6	30PL14	16/-	715A	30/-	5842	60/-	CY1	8/-	E88CC	12/6
1N5GT	8/-	6AN8	10/-	6F12	4/-	7E7	10/-	13D3	5/-	35A3	9/-	715B	60/-	5847	60/-	CY31	7/-	E90CC	10/-
1P39	11/-	6AQ5	5/6	6F13	6/6	7H7	6/-	13E1	190/-	35A5	10/-	715C	70/-	5881	17/6	D A30	10/-	E92CC	7/-
1R4	5/-	6AQ6	10/-	6F14	15/-	7K7	10/-	14A7	10/-	35B5	12/-	801A	7/6	5947	40/-	DA100		E180CC	8/-
1R5	6/-	6AR5	6/-	6F15	11/-	7Q7	9/-	14B7	17/-	35C3	6/6	802	60/-	5963	10/-		120/-	E180F	17/6
1S4	5/-	6AU6	6/-	6F17	6/-	7R7	12/-	16A5	5/-	35D5	12/-	803	40/-	5965	5/-			E182CC	
1S5	4/6	6AS6	6/-	6F18	7/6	7S7	22/-	16A6	7/-	35L6GT	8/-	804	80/-	6064	8/-	DAF91	4/6		23/-
1T4	3/-	6AS7G	15/-	6F20	10/-	7Y4	8/6	16Y3	13/6	35W4	4/6	807	9/-	6072	12/-	DAF92	6/-	E188CC	15/-
1T5GT	6/-	6AT6	4/6	6F23	14/-	7Z4	6/-	17Z3	5/6	35Z3	10/-	808	15/-	6073	9/-	DAF96	6/6	E280F	35/-
1U4	5/-	6AU4GT	9/-	6F24	12/-	9BW6	7/-	18GV8	8/6	35Z4G	4/-	811A	30/-	6074	9/6	DC90	8/-	E810F	52/6
1U5	6/-	6AU5GT		6F25	14/-	9D7	7/-	19AQ5	5/-	35Z4GT	8/6	812A	57/6	6080	27/6	DCC90	10/-	EABC80	
1V2	10/-		20/-	6F28	13/-	9JW8	9/-	19G6	15/-	35Z5GT	6/-	813	80/-	6111	12/6	DCH4/1000	20/-		6/6
1X2B	7/-	6AU6	5/-	6F32	3/-	9U8	6/-	19H4	70/-	42	6/-	815	35/-	6135	10/-	DCX4/5000	80/-	EAC91	4/-
1Z2	25/-	6AU8	9/-	6F33	15/-	10C1	13/-	19Y3	5/-	45IU	7/-	816	25/-	6136	9/-	DET22		EAF42	8/6
2A7	8/-	6AV5GA		6GA8	10/6	10C2	15/-	20CV	62/9	50A5	12/-	816	25/-	6146	27/6		105/-	EB41	7/-
2C26A	7/-		11/-	6H6	3/-	10D1	7/-	20D1	9/-	50B5	6/3	828	80/-	6159	32/-			EB91	3/-
2C40	65/-	6AV6	5/-	6J4	9/-	10F3	8/-	20L1	16/-	50BM8	7/3	829B	60/-						
2C42	25/-	6AW8A		6J4WA	12/-	10F18	7/8												
2C46	30/-		12/6	6J5	7/6	10L1	7/6												
2C50	30/-	6AX4GT		6J5GT	5/-	10P13	15/-												
2C51	8/-		8/-	6J6	3/6	10P14	16/-												
2C52	12/-	6AX5GT		6J7	8/-	10T1	12/6												
2C53	65/-		12/6	6K8G	4/-	11D3	7/-												
2CW4	12/-	6AX7	11/-	6L6GB	8/-	11D5	7/-												
2D21	5/6	6B4G	15/-	6L6WGB		11E2	20/-												
2E22	30/-	6B7	5/-		17/6	12AC6	8/-												
2E24	42/6	6B8	7/-	6L7	5/6	12AD6	9/-												
2G21	14/-	6B8G	2/6	6L18	6/-	12AE6	7/6												
2X2	4/-	6BA6	4/-	6LD20	5/-	12AH7GT													
2X2A	8/-	6BE6	4/6	6N7GT	6/6		5/-	20P1	12/-	50C5	6/-	832	20/-	6197	20/-	DET23		EBC21	7/6
3A3	11/-	6BG6G	12/-	6P1	11/-	12AL5	7/-	20P3	12/-	50CD6G		837	15/-	6293	60/-		105/-	EBC33	7/-
3A4	4/-	6BH6	7/6	6P5GT	8/-	12AQ5	7/-	20P4	19/-		27/6	866A	14/-	6360	25/-	DF91	3/-	EBC41	8/6
3A5	10/-	6BJ6	7/6	6P25	17/-	12AT6	4/6	20P5	19/-	50L6GT	7/6	866E	20/-	6463	7/-	DF92	2/6	EBC81	6/-
3B7	5/-	6BK4	20/-	6P28	12/-	12AT7	4/-	24B1	110/-	53KU	12/6	866JR	25/-	6807	150/-	DF96	6/6	EBC90	4/6
3B22	45/-	6BK7A	9/-	6Q7	7/-	12AU6	5/-	25A6G	5/-	62BT	20/-	872A	50/-	6922	12/6	DH81	12/6	EBC91	5/-
3B24	15/-	6BL7GTA		6R7	6/-	12AU7	5/8	25BQ6G		71A	13/-	884	10/-	6939	40/-	DH101	7/6	EBF2	12/-
3B28	40/-		10/-	6S2	6/6	12AV6	5/8		12/-	77	5/-	885	12/6	7199	15/-	DK32	7/-	EBF80	7/6
3C45	60/-	6BL8	6/6	6S7	10/-	12AV7	8/-	25C6	10/-	78	5/-	930	32/-	7360	30/-	DK40	10/-	EBF83	8/-
3D6	3/-	6BM8	6/-	6SA7	7/-	12AW6	20/-	25E5	9/-	80	7/-	931A	65/-	7586	22/6	DK91	6/-	EBF89	6/6
3D21A	35/-	6BN6	7/6	6SG7	6/-	12AX7	5/6	25L6GT	6/6	83	15/-	954	5/-	7591A	20/-	DK92	7/6	EBL21	10/-
3E29	60/-	6BQ6G	11/-	6SH7	4/-	12AY7	10/-	25Y5	10/-	85A1	25/-	955	3/-	7788	55/-	DK96	7/6	EBL31	22/6
3Q4	7/-	6BQ7A	7/-	6SJ7	7/-	12BA4	9/-	25Z4G	8/-	85A2	7/6	956	2/-	7895	22/6	DL63	8/-	EC86	11/6
3Q5GT	6/6	6BR7	15/-	6SK7	6/-	12BA6	6/-	25Z5	8/-		105/-	957	5/-	8005	105/-	DL66	20/-	EC88	10/-
3S4	5/-	6BS7	25/-	6SL7GT	6/-	12BE6	5/6	25Z6GT		85A3	5/6	958	4/-	8013	25/-	DL68	12/6	EC90	4/-
3V4	6/-	6BW6	12/-	6SN7GT		12BH7	8/-		11/-	90AG	48/-	959	8/-	8020	20/-	DL69	12/6	EC92	6/6
4B32	80/-	6BW7	10/-		5/6	12HY7A		26A7GT		90AV	48/-	991	7/-	8136	15/-	DL91	5/-	EC93	9/-
4H1	4/-	6BX7GT		6SQ7	7/-		10/-		25/-	90C1	12/-	1267	20/-	9002	5/6	DL92	5/-	ECC33	10/-
4X250B			13/-	6SS7	3/-	12C8	4/6	27M1	65/-	90CG	25/-	1629	17/6	9003	9/-	DL93	4/-	ECC34	8/-
	200/-	6BY6	10/-	6T8	6/6	12E1	20/-	28D7	15/-	90CV	25/-	2050	15/-	9005	15/-	DL94	6/-	ECC35	17/-
5AN8	11/-	6BZ6	6/-	6T8A	8/6	12E14	50/-	30A5	7/-	95A1	5/6	4212E	300/-	A1834	15/-	DL95	6/6	ECC40	9/6
5D21	70/-	6BZ7	10/-	6U4GT	12/-	12F5GT	7/-	30AE3	7/6	101D	70/-	5545	150/-	A2134	8/-	DL96	7/-	ECC70	20/-
5R4GY	9/-	6C4	4/-	6U5G	8/-	12J5GT	3/-	30C1	6/3			5551A	300/-	A2293	19/-	DL810	12/6	ECC81	4/-
5T4	8/-	6C5GT	6/6	6U8	6/6	12J7GT	7/-	30C15	13/6	150B2	11/-	5552A	420/-	AC/HL/DD		DLS10	20/-	ECC82	5/6
5T8	10/-	6C6	4/-	6U8A	9/6	12J8	10/-	30C17	14/6	150B3	8/-	5642	11/-		8/-	DLS16	20/-	ECC83	5/6
5U4G	5/-	6C8G	8/-	6V4	5/-	12K5	10/-	30C18	14/-	150C4	9/-	5643	30/-	AC/TH1	8/-	DLS19	25/-	ECC84	5/6
5U4GB	6/6	6C21	100/-	6V6GT	8/-	12K7GT	7/-	30F5	14/-	211	30/-	5651	7/6	AC/VP2		DM70	5/6	ECC85	5/-
5U8	8/-	6CA4	5/-	6X4	4/-	12K8	8/-	30FL1	15/-	262B	35/-	5654	9/-		15/-	DM71	6/-	ECC86	7/-
5V4G	7/6	6CA7	9/6	6X8	12/-	12Q7GT	5/6	30FL12	17/-	301A	25/-	5670	10/-	ACT9	460/-	DM160	8/-	ECC88	8/-
5Y3GT	5/-	6CB6	5/-	6X5GT	5/-	12S07	4/-	30FL13	8/-	304TH		5672	6/-	ARP38	12/-	DY30	8/-	ECC91	3/6
5Z4G	7/-	6CD6GA		6Y6G	11/-	12SF5	9/-	30FL14	14/-		280/-	AZ11	7/6			DY80	7/-	ECC189	7/-
5Z4GT	7/6		20/-	6Z4	5/-	12SG7	5/-	30L1	5/6	307A	10/-	5678	8/-	AZ31	9/-	DY86	6/-		11/-
6/30L2	12/6	6CH6	8/-	7A4	8/-	12SH7	4/-	30L15	15/-	313C	25/-	AZ41	7/-			DY87	6/-		
6A6	4/-	6CL6	9/-	7A8	5/-	12SJ7	4/-	30L17	15/-	313CA	25/-	5696	6/-	B36	7/6				

EC80	8/-	EF40	8/6	GC10A	25/-	PABC80		PEN46	6/-	U403	7/-								
EC81	6/6	EF41	8/6	GC10B	35/-		7/6	PEN220A		U404	5/-								
EC82	6/6	EF42	11/-	GC10D	47/6	PC86	10/6		7/-	U600	35/-								
EC83	6/6	EF80	4/6	GC12/4B		PC88	10/6	PEN383	9/-	U801	17/-								
EC84	8/-	EF83	9/6		15/-	PC92	7/6	PEN384	7/-	U4020	7/6								
EC85	6/6	EF85	6/6	GC11/4B		PC900	8/6	PEN453DD		UABC80									
EC86	6/-	EF86	6/-		47/6	PCC84	5/6		10/-		5/3								
EC88	10/-	EF89	5/6	GC12/4B		PCC85	7/-	PENA4	7/6	UAF42	9/-								
EC90	4/-	EF90	2/6		45/-	PCC88	11/-	PENDD-		UB41	10/-								
EC92	6/6	EF91	4/-	GC13	15/-	PCC89	10/6	4020	10/-	UBC41	7/-								
EC93	9/-	EF92	11/-	FG67	60/-	PCC189		PF818	14/-	UBC81	8/-								
ECC33	10/-	EF93	6/-	GC10/4B			11/-	PFL200		UBF80	6/-								
ECC34	8/-	EF94	6/-		15/-	PCC805			13/6	UBF89	7/6								
ECC35	17/-	EF183	6/-	GC47/6			15/-	PL21	5/6	UBL21	10/-								
ECC40	9/6	EF184	6/-		12/-	PCC806		PL36	9/-	UC92	6/-								
ECC70	20/-	EH90	7/-	GU18	85/-		15/-	PL38	16/-	UCC84	9/-								
ECC81	4/-	EK90	4/6	GU20/21		PCE800	15/-	PL81	7/-	UCC85	6/6								
ECC82	5/6	EL34	9/6		12/-	PCF80	6/3	PL82	7/-	UCC86	9/-								
ECC83	5/6	EL36	8/6	GU50	95/-	PCF82	6/-	PL83	6/6	UCC87	6/6								
ECC84	5/6	EL38	22/6	GZ30	35/-	PCF84	8/-	PL84	6/-	UCC88	6/6								
ECC85	5/-	EL41	8/6	GZ31	7/-	PCF86	8/-	PL302	14/-	UCC89	9/6								
ECC86	7/-	EL42	9/6	GZ32	5/6		14/6	PL500	13/6	UCH21	9/6								
ECC88	8/-	EL50	8/-	GZ33	10/-	PCF87		PL504	14/-	UCH42	9/6								
ECC91	3/6	EL81	9/-	GZ34	12/6	PCF800		PL508	10/-	UCH81	9/-								
ECC189	7/-	EL82	8/-	GZ37	10/-		13/6	PL509	16/-	UCH81	6/3								
	11/-	EL83	6/6	HD24	12/6	PCF801	9/-	PL519	16/-	UCL81	9/-								
		EL84	4/6	HL2	4/-	PCF802	9/-	PL802	16/-	UCL82	7/6								
		EL85	7/6	HL2K	4/-	PCF805	14/-	PL803	16/-	UCL83	9/-								
						PCF806	13/-	PL4500	16/-	UF41	9/-								
						PCH200		PL4501	16/-	UF42	9/-								
							12/-	PL4502	16/-	UF43	8/-								
						PCL80	15/-	PL4503	16/-	UF80	6/6								
						PCL81	9/-	PL4504	16/-	UF85	7/3								
						PCL82	7/-	PL4505	16/-	UF86	9/-								
						PCL83	8/6	PL4506	16/-	UF89	7/-								
						PCL84	7/6	PL4507	16/-	UL41	8/6								
						PCL85	8/6	PL4508	16/-	UL84	6/6								
						PCL86	8/-	PL4509	16/-	UM4	10/-								
						PCL88	16/-	PL4510	16/-	UM80	5/-								
						PCL800	16/-	PL4511	16/-	UU5	8/-								
						PCL801	16/-	PL4512	16/-	UU8	7/-								
						PEN45	6/6	PL4513	16/-	UU9	7/6								
						PEN45DD		PL4514	16/-	UU10	8/-								
							12/-	PL4515	16/-	UY41	6/6								
								PL4516	16/-	UY82	9/6								
								PL4517	16/-	U85	6/-								
								PL4518	16/-	VP41	5/-								
								PL4519	16/-	VP210	7/-								
								PL4520	16/-	VR105	6/-								
								PL4521	16/-	VR150	6/-								
								PL4522	16/-	VU39	8/-								
								PL4523	16/-	VU111	7/6								
								PL4524	16/-	W61	15/-								
								PL4525	16/-	W107	7/-								
								PL4526	16/-	W729	10/-								
								PL4527	16/-	X66	7/-								
								PL4528	16/-	XB1	12/6								
								PL4529	16/-	XC11	12/6								
								PL4530	16/-	XC12	6/6								
								PL4531	16/-	XC12T	8/-								
								PL4532	16/-	XC13	14/-								
								PL4533	16/-	XC23	15/-								
								PL4534	16/-	XC25	7/-								
								PL4535	16/-	Y63	8/-								
								PL4536	16/-	Z520M	25/-								
								PL4537	16/-	Z700U	8/-								
								PL4538	16/-	Z759	24/-								
								PL4539	16/-	Z800U	20/-								
								PL4540	16/-	Z801U	30/-								
								PL4541	16/-	Z803U	15/-								
								PL4542	16/-	Z900T	13/-								
								PL4543	16/-	CV74	80/-								
								PL4544	16/-	CV5	95/-								
								PL4545	16/-	CV54	110/-								

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ELECTROVALUE

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★ **MINI** TRANSISTORS WITH **MIGHTY** SPECIFICATIONS

Low Cost, Plastic Encapsulated, Silicon

2N4285 pnp high reverse base-emitter voltage rating BVcbo, BVceo, BVebo all over 35V. f_T = 7MHz minimum. h_{FE} 35 to 150 @ Ic = 10mA. Vce (sat) 0.5 V.max. @ 10 = 10mA, Ib = 1mA.

2N4286 npn high gain h_{FE} = 100 min. @ Ic = 10μA, 150 to 600 @ Ic = 1mA. BVcbo over 30V., BVceo over 25V; f_T = 280MHz typ @ Ic = 1mA.

2N4289 pnp high gain h_{FE} = 100 min. @ Ic = 100μA, 160 min. @ Ic = 1mA. BVcbo over 60V., BVceo over 45V., f_T = 170MHz typ @ Ic = 2mA.

2N4291 pnp large signal high gain h_{FE} = 100 to 300 @ Ic = 100mA, Vce = 10V. BVcbo over 40V, BVceo over 30V, Vce (sat) = 1.5V max. @ Ic = 100mA, Ib = 10mA.

2N4292 npn UHF, low noise. f_T = 570MHz typ Ic = 2mA, Vce = 5V. h_{FE} = 50 typ. Bvcbo over 30V., BVceo over 15V, N.F. 6dB max. @ Ic = 1mA, f = 100mHz.

2N3794 npn large signal high gain (complementary to 2N4291). BVcbo over 40V, BVceo over 20V.; h_{FE} = 100 min. @ Ic = 100mA.

All of the above are rated at 500mA max. Ic, 200mW max. @ 25°C. Size 0.175 × 0.090 × 0.090in. high. Lead arrangement: in-line.

B5001 POWER type on T066 size base, npn high gain. Collector isolated from mounting surface (500V) insulation). Dissipates 14.3W. max. @ Tc = 100°C and Vce = 10V. Vceo (max.) = 35V., Ic (max.) = 3A, Ib (max.) = 1A, Tj(max.) = 150°C. h_{FE} = 100 to 175 @ Ic = 0.5A (yellow selection). Vce (sat) = 1.2V. max. @ Ic = 1A, Ib = 50mA.

The seven types above are offered at the following low prices: 2N4285 to 2N4292, 2N3794, 3/3 each; B5001 (yellow) 13/6.

★ PEAK SOUNDS PRODUCTS

CIR-KIT No. 3 Pack, 12/6: adhesive copper strip, 5ft. × ⅛in. or ¼in., 2/-: 100ft. × ⅛in. or ¼in., 30/-. Perforated board 0.1in. matrix 5in. × 3⅞in., 4/-; 2⅞in. × 3⅞in. 2/6.

TRANSISTORISED STEREO AMPLIFIER AND PRE-AMP SAS-8

Complete kit of this very popular and efficient amplifier:—

16 watts total output	£10/10/-.
Power supply kit,	£3.
Cabinet,	£3.

15% **DISCOUNT** on whole order and post free when purchasing an SA8-8!

★ EXTRA VALUE IN SEMICONDUCTORS

Silicon: many types in stock including:
BC107, 45V, β125-500, 2/9: BC108, 20V, β125-900, 2/6: BC109, 20V, β240-900, 2/9: BC167, 50V, β125-500, 2/6: BC168, 20V, β125-900, 2/-: BC169, 20V, β240-900, 2/6.
BC109 and BC169 are low noise types, BC167, BC168 and BC169 are plastic.
Best value for High Power: 2N3055, 115W., 100V, 16/6: 2N3054, 90V., f_T 25MHz typ., £1.
Field Effect: MPF105, gm 2 to 6mA/V., 8/-. 2N3819, 14/6. VHF and fast switching: BSX20, f_T 600MHz, 4/6.
High gain: 2N3390, β400-1250, 6/-. Low Noise: 2N3707, 4/6: 2N3391A, 5/6: 2N4058 (pnp), 5/6. Sub-Miniature: BC122, 30V., 50mA, 80mW, 250MHz, 1 × 1.5 × 2 mm., 6/6. Low cost: 2N2926, 18V, 120MHz, 2/6 (our colour selection). Also: 2N3702, 4/-: 2N3703, 3/9: 2N3704, 4/-: 2N3705, 3/8: BFY50, 5/3.
GERMANIUM; many types in stock including:
RF, VHF: NKT603F, 6/-: NKT613F, 5/9: NKT677F, 4/5. Low noise: 2G308, 6/9: 2G309, 7/9: NKT275, 3/8. Still running well: 2N1302, 2N1303, 3/6: 2N1304, 2N1305, 4/-: 2N1306, 2N1307, 6/-: 2N1308, 2N1309, 7/11.
High Power: NKT403, 14/10: 2N2147, 16/9: matching, 1/- pr. Complementary Output: AD161 (npn), 9/-; AD162 (pnp), 9/-.
SILICON DIODES; Low cost: 1S940, 30V. 75mA., 1/-: OA202, 150V. 160mA, 2/-: BY238, 850V, 500mA, 3/11: 1N5054, 800V, 1A, 4/9: BYZ13, 200V. 6A., 8/-.
ZENER DIODES; 400mW, 5%, 2.7V. to 33V. (E24 values), 5/3.
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★ SUPER QUALITY NEW RESISTORS

Carbon film low noise high stabs:

Power		Range	Series	Per doz.	Per 100
1/8W	5%	5.1Ω to 330kΩ	E24	1/10	14/6
1/8W	10%	1Ω to 4.7Ω	E12	+½d per resistor	
1/8W	5%	390KΩ to 1MΩ	E12		
1/4W		4.7Ω to 10MΩ	E12	1/9	13/6
1/2W	5%	4.7Ω to 10MΩ	E24	2/2	17/-
1W	10%	4.7Ω to 10MΩ	E12	3/3	25/10

1/6 per 100 less in complete 100's of one ohmic value. 1W type 4d each. Please state values required.
QUALITY CARBON SKELETON PRE-SETS; 100Ω, 250Ω, 500Ω, 1kΩ, 2kΩ, 2.5kΩ, 5kΩ, 10kΩ, 20kΩ, 25kΩ, 50kΩ, 100kΩ, 250kΩ, 500kΩ, 1MΩ, 2MΩ, 2.5MΩ, 5MΩ, 10MΩ. Available in horizontal or vertical mounting, 1/- each. Low cost volume controls: 100Ω to 10MΩ lin., 5kΩ to 5MΩ log., 2/3 each. Log stereo: 100kΩ, 250kΩ, 500kΩ, 1MΩ, 2MΩ, L.S., 9/-, D.P. sw. 12/6. Ceramics: 100, 220, 470, 1000, 2200, 4700pF, 500V., 5d: 0.01, 0.02, 0.05μF 50V., 5d. Electrolytics: 5, 10, 25, 50μF, 10V.; 5, 10μF, 25V., 9d: 100, 200μF 10V.; 25, 50μF 25V., 1/-.
SUB-MIN C426 RANGE (μF/V); 10/2.5, 8/4, 6.4/6.4, 4/10, 2.5/16, 1.6/25, 1/40, 0.64/64, 1/8 each. 40/2.5, 32/4, 25/6.4, 16/10, 10/16, 6.4/25, 4/40, 2.5/64, 1/6 each. 500/2.5, 400/4, 320/2.5, 320/6.4, 250/4, 200/6.4, 200/10, 160/2.5, 125/4, 125/10, 125/16, 100/6.4, 80/2.5, 80/16, 80/25, 64/4, 64/10, 50/6.4, 50/25, 50/40, 40/16, 32/10, 32/40, 32/64, 25/25, 20/16, 20/64, 16/40, 12.5/25, 10/64, 8/40, 5/64, 1/4 each.
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ELECTROVALUE

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1A3	5/6	6F8	7/-	30A5	9/-	1S401	6/-	BSY28	5/-	OC44M	5/6
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1AC6	11/-	6F14	17/6	30C1	9/6	1S7062	4/6	BSY53	7/6	OC71	4/-
1AH4	12/6	6F16	11/6	30C15	15/-	2G301	6/-	BSY65	5/-	OC76	5/-
1AX2	13/7	6F18	9/6	30C17	15/-	2G302	6/-	OC20	15/-	OC78D	2/6
1C1	8/6	6F20	12/6	30C18	12/6	2G303	7/-	OC23	12/6	OC81DM	3/-
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1D5	9/-	6F25	16/-	30FL1	14/6	2G308	9/-	OC28	12/6	OC122	12/6
1E7	9/-	6F28	15/-	30L1	8/6	2G371	4/6	OC29	15/-	OC140	9/6
1F2	5/6	6F30	9/6	30L17	18/-	2G381	5/-	OC35	10/-	OC169	5/-
1F5	10/6	6FD12	8/6	30P12	15/-	2G401	5/-	OC41	6/-	OC170	5/-
1G4	10/-	6FW8	14/-	30P18	8/6	2G402	6/-	OC42	5/-	OC204	12/6
1H4	10/-	6G6	3/6	30PL1	15/-	2G414	5/-	OC44	4/-	OC206	17/6
1H6	9/-	6GM8	8/6	35A3	11/-	2G415	4/6	OC45	3/6	ORP12	8/6
1LD5	7/8	6GW8	10/6	35B5	14/-	2G416	5/-	OC45M	4/-	RA8310AF	
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6AS6	7/-	7H7	8/-	DF92	4/-	600/6	7/6	TK25	5/-	XC141	7/6
6AS7	17/6	7J7	16/-	DH63	7/6	AAY12	5/-	TK31C	6/-	XC156	15/-
6AU4	11/-	7L7	12/-	DH79	8/6	AAZ12	4/-	TK36	4/-	XB121	7/6
6AU6	7/-	7R7	14/-	DH118	9/6	AAZ17	2/6	TK37	4/-	Z Range	
6AV5	13/-	7V7	10/-	DH142	9/6	AC107	10/-	TK41	4/6	Zener	
6AW8	15/-	7X7	24/6	DH149	9/6	AC126	6/6	TK42	4/-	Diodes	
6AX5	15/-	7Z4	8/6	DK91	8/6	AC128	6/6	TK44	4/-		3/6 ea.
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6BG6	14/6	12SA7	12/-	DL93	5/6	ACY17	8/6	VA1018	2/6	ZB16	3/6
6BJ6	22/6	12SF5	11/-	DL95	8/6	ACY18	5/6	VA1026	2/6	ZB22	4/6
6BK4	25/-	12SG7	7/-	DN143	13/6	ACY20	5/-	VA1036	2/-	ZF9.1	4/6
6BK8	9/6	12SJ7	5/6	DY87	9/6	ACY21	6/-	VR35	6/6	ZF30	4/6
6BM8	10/-	12SL7	9/6	EAC91	6/-	ACY22	3/6	VR875	5/6	ZL Range	
6BN5	9/6	12SR7	7/-	EB34	2/6	AD140	16/-	VR9B	8/6	Zener	
6BQ5	9/6	12SX7	10/-	EBC33	9/6	AD149	16/-	XA101	2/-	Diodes	
6BQ7	10/-	12U5	9/-	EBC81	9/6	AD162	8/-	XA102	3/6		5/- ea.
6BR7	17/6	12Y4	4/6	EBF80	9/6	AF102	18/-	XA112	2/6	ZS Range	
6BT4	9/6	13D2	7/6	EBF89	8/6	AF114	6/6	XA103	2/-		7/6 ea.
6BW7	12/6	13D6	9/-	EBL31	25/-	AF116	6/6	XA104	2/-	ZR21R	10/-
6BX7	15/6	13GC8	18/6	ECC81	5/-	AF117	5/-	XA151	3/-	ZS10	3/-
6BY7	7/6	14E6	5/-	ECC82	8/6	AF118	10/-	XA152	3/-	ZT45	6/6
6BX7	12/-	14L7	9/6	ECC85	8/6	AF125	6/6	XA161	5/-	19H1	24/6
6C5	7/-	1487	17/6	ECC88	11/6	AF126	6/-	XA162	5/-	19T8	10/-
6C8	9/-	15CW5	8/6	ECF82	9/-	AF127	6/-	XA703	7/6	19Y5	7/6
6C10	11/-	15D2	5/-	ECF86	12/6	AF178	12/6	XD201	2/-	20L1	15/-
6C16	9/6	15E	10/-	ECH42	11/-	AF186	17/6	XB102	2/-	20P3	14/-
6CA4	6/6	16A8	10/6	ECH83	9/6	AFZ11	17/-	XB103	2/-	20P5	21/6
6CB6	6/6	17C8	8/6	ECL80	8/6	AFZ12	10/-	XB133	3/-	21A6	9/6
6CD7	14/6	17Z3A	7/6	ECL83	12/6	ASY26	6/6	XC101	3/-	25A6	7/-
6CG7	9/-	19AQ5	7/6	ECL85	13/6	ASY28	6/6	XC121	3/6	25C5	12/-
6CJ5	11/6	19BG6	9/6	EN21	3/6	ASY86	6/6	XC131	8/-	25E5	12/6
6CK5	11/-	19BY7	10/-	EN21A	5/-	ASZ20	7/6	XC141	4/-	25L6	8/6
6CL6	11/-	19DC8	9/-	EN22	5/-	ASZ23	30/-	XC142	9/6	30FL12	
6CM5	10/6	19FC8	9/-	EN23	4/-	AU101	30/-	XC155	12/6		14/6
6CN6	27/6	19SU	7/6	EN34A	2/-	BA110	7/6	X8101	5/-	30FL13	
6CS6	9/-	19U3	7/6	EN42	10/-	BA131	2/6	X8104	3/6		12/6
6CU6	13/-	20D1	11/-	EN43	2/6	BC107	6/-	XU604	4/6	30FL14	
6CV7	10/6	20P1	14/-	EN205	2/6	BC108	5/-	XU614	4/6		16/6
6CW5	10/-	20P4	21/6	EN254	7/6	BC109	6/-	ZB4.3	4/6	30L15	14/6
6CY5	9/-	20Y40	9/6	EN255	7/6	BCY10	7/6	ZB10	4/6	30P4	11/6
6D2	5/6	21B6	9/6	IN430	35/-	BCY12	7/6	ZF12	4/6	30P16	9/-
6D4	20/-	25BQ6	14/-	IN459	5/-	BCY31	13/6	ZF15	4/6	30P19	15/-
6D8	12/6	25CU6	14/-	IN540	7/6	BCY33	7/6	ZR11	7/-	30PL13	
6DA6	7/6	25FG6	15/-	IN703A	3/6	BCY34	8/6	ZR21	10/-		15/-
6DK6	10/-	25W4	15/6	IN1084	5/-	BCY38	9/6	ZR31	25/-	30PL14	
6DL5	9/-	25Y5	12/-	IN916	4/-	BCZ11	10/-	ZR32	25/-		15/-
6DR8	9/6	25Z4	10/-	IN1570	6/6	BF80	10/-	ZS51	3/-	31A3	8/6
6DT6	9/-	25Z5	10/-	IN2374	15/-	BFY17	7/6			31GZ37	
6E5	10/-	25Z6	13/-	1844	3/6	BFY50	8/6	Z872	7/6		14/-
6EH7	9/6	26A6	22/6	18001	7/6	BFY51	7/-	OC22	10/-	35A5	12/-
6EL6	9/6	26AQ6	9/-	18111	4/-	BFY52	8/6	OC25	7/6	35C5	8/6
6ET6	12/-	28AK8	8/6	18115	6/-	BFY53	6/-	OC26	6/-	35L6	10/-
6F1	16/-	28D7	11/-	18131	4/3	B8Y25	4/-	OC36	12/6	35Z3	12/-
6F6	7/8	28GB5	16/6	18203	4/6	B8Y27	6/6	OC43	9/-	35Z4	6/-

FULLY DETAILED LISTS ON APPLICATION.

SEE LIND-AIR OPPOSITE

LIND-AIR (ELECTRONICS) LTD.

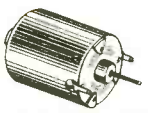
London's Leading Component Shops

25 & 53 TOTTENHAM CT ROAD LONDON W.1. **Tel: 01-580 4534/7679**

Open 9-6 p.m. Monday to Saturday inclusive. Open Thursday until 7 p.m.

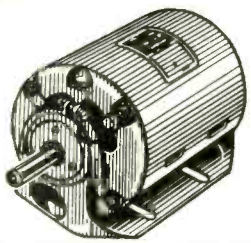
ALL POST ORDERS TO
Dept. WW568
25 Tottenham Court Road,
London, W.1

MOTOR BARGAINS



Ideal for model makers, record players, tape decks, etc.
6.3 D.C. Mono. 10,900 r.p.m. at 230 mA. 1¼in. × 1in. dia. 8haft ¼in. long × 3/64in. dia., **9/6** P. & P. 2/6.
9 v. D.C. Gram., deck replacement motor. 2in. × 1½in. dia. Shaft ¼in long × 3/32 in., **17/6.** P. & P. 2/-.

⅛th H.P. MAINS MOTOR

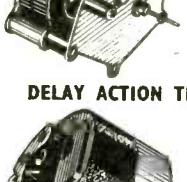


Made by Crompton Parkinson. Single phase ⅛th H.P. motor. 230/250v. 50 cycles. 1.3 amps. 1,425 r.p.m. Continuous rating. 8pindle 1¼in. × ¼in. dia. Overall size less spindle approx. 4in. × 4in.
Perfect condition. A bargain for the for the workbench. ONLY **79/6.** Carr. 20/-. ¼ H.P. motor also available **99/6.** Carr. 20/-)

SELECTOR DRIVE

Numerous applications. Electromagnet and brass tooth wheel. A switch wafer and contacts are coupled to this and arranged to be on for 10 pulses and off for 15. An auxiliary contact is normally on but off 1 in every 25. Complete with suppressor, resistors, plus series contact for continuous operation. Ideal window displays, switching lamps, models, etc. 12v. or 24v. D.C. Brand new and boxed **12/6.** P. & P. 2/6.

SYNCHRONOUS CLOCK MOTORS



Geared for 40 revolutions per hour. 230 v. 50 cycles, with mounting flanges. Size approx. 1¾in. deep × 2¾in. dia.
ONLY **22/6.**
P. & P. 2/6.

DELAY ACTION TIME SWITCH

Made by Smiths. A.C. operation 200/250 v. Double pole, will give time delay from 0-10 minutes. Size 2¼in. dia. × 2¼in. long, inc. ¼in. × ¾in. dia. spindle. BARGAIN PRICE **17/6.** P. & P. 2/6.

AUTO TRANSFORMERS

Input 0-200, 220, 240v.	Output 110v.		600 w.	£6 9 6
			1,000 w.	£9 9 0
			1,500 w.	£15 15 0
50 w. ...	£1 7 6		2,000 w.	£18 10 0
75 w. ...	£1 17 0		3,000 w.	£25 10 0
100 w. ...	£2 5 0		4,000 w.	£34 18 0
150 w. ...	£2 15 0		0.30 v. 1 amp.	30/-
200 w. ...	£3 5 0		0.30 v. ½ amp.	17/9
300 w. ...	£4 5 0		0.30 v. 2 amp.	37/6
400 w. ...	£4 19 6		0.30 v. 3 amp.	42/-
500 w. ...	£5 9 6		Post extra.	

MAINS TRANSFORMERS

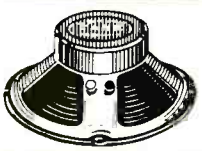
Input 200-250 v. 50 c/s'

24 v. 3 amp.	£2 12 6	24 v. 8 amp.	£5 5 0
24 v. 3 amp.	£3 15 0	24 v. 12 amp.	£6 15 0

Post extra.
Mains and Output Transformer Lists available on request.

SEE OPPOSITE

UNREPEATABLE BARGAINS!



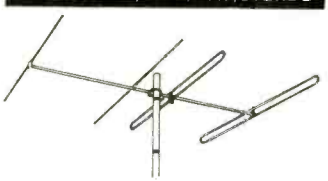
FANE 122/17 12in. 25 WATT HEAVY DUTY HI-FI LOUD SPEAKERS. With high efficiency Anisotropic Ferrite magnet. 17,000 gauss. Imp. 3-5 ohms. Brand new and guaranteed. List price **£12.** LIND-AIR PRICE **£8/19/6.** P. & P. 7/6.

EMI COMBINATION LOUDSPEAKERS
13½ × 8½in. Elliptical with 3½in. dia. Tweeter. Imp. 8 ohms. Power handling 10 watts. Brand new and guaranteed. List price £8/5/-. LIND-AIR PRICE **99/6.** P. & P. 7/6. (Also available without Tweeter **59/6.** P. & P. 7/6).

Fane 301 3in. TWEETERS, 1mp. 3-5 ohms. 17,000 gauss. 12 watt. Brand new and guaranteed. List price £3/15/-. LIND-AIR PRICE **59/6.** P. & P. 3/6.

GOODMANS SPEAKER BARGAINS
5in. 3 ohm. **15/6**; 6in. 3 ohm, **29/6**; 8in. 3 ohm **32/6**; 10in. 5 ohm **65/-**; 10in. × 8in. 3 ohm, **32/6**; Tweeter **19/6.** P. & P. 3/6 per Speaker.

AERIALS. TV/UHF/VHF/STEREO



NEW J-BEAM F.M. Aerial for Stereo Reception, 4-element outdoor Band II VHF/FM Stereo Aerial (as illus.). With Mast Clamp **87/-.**
CRESTA Room Aerial Band I/II/III. Cream or black, **26/6.**
VEEMASTER Table Top VHF/UHF Tunable Aerial. Chrome or grey. **76/6.**
YAGAL All Channel Table Top Aerial, BBC1/2/ ITV/VHF. **65/-.**
HL523 LOFT AERIAL. H.L.O. V × 5 for vertical Band I/III. With mounting arm and bracket. **53/-.**
NEW MAJOR. 10-element BBC2 aerial for loft or outdoor fixing. With roller bracket for up to 2in. dia. mast. **45/9.**
VANTENA Table Top V Aerial, BBC/ITV. **26/6.**
H1 HUNTER 13-element BBC2 Aerial as above, **57/-.**
EI EXPLORER. 18-element BBC2 Aerial, as above **69/-.**
LOFT SIX. 6-element BBC2 Aerial for loft or outdoor fixing. With arm and bracket. **37/6.**
Please add 4/- postage.

MULTIMETERS

MODEL TTC1001.
20,000 O.P.V. with overload protection. D.C. Volts 5, 25, 125, 500, 2,500v. A.C. volts 10, 50, 250, 100 v. D.C. mA. 250mA-50A. With prods and carrying case. ONLY **85/-.** P. & P. 3/6.

MODEL TTC.1030.
50,000 O.P.V. D.C. Volts, 0.3, 12, 60, 120, 300, 600, 1,200v. A.C. Volts, 6, 30, 120, 600, 1,200v. D.C. mA. 03-300. With prods and carrying case. ONLY **£11/19/6.** P. & P. 5/-.

STEREO HEADPHONES

Enjoy Stereo Sound as you have never heard it before. **MODEL TTC, G1111** as illustrated. Soft padded earphones. Adjustable headband. Impedance 8 ohms per phone. Frequency range 25-13,000 cps. With 5ft. lead. Price **69/6.** P. & P. 4/6. Other similar types available.
AKAI, ASE8S, 8 ohms, **£6/6/-. CORAL E102** 16 ohms **£5/19/6. EAGLE SE1** 16 ohms. **79/6. T.T.C. Stethoscope** 8 ohms, **49/6.** P. & P. 4/6 each.

GARRARD DECKS

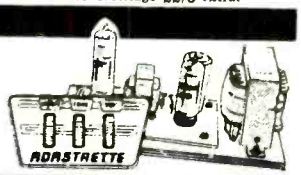
3000 with Sonotone 9TAHC Stereo Cartridge	£9 19 6
3000 with Sonotone 9TAHC Diamond Stereo Cartridge	£10 19 6
AT60 Mk. II less cartridge	£13 19 6
AT60 Mk. II with Decca Deram Stereo Cartridge	£18 14 0
SP.25 Mk. II less cartridge	£11 19 6
SP.25 Mk. II with Decca Deram Stereo Cartridge	£16 14 0
AP75 less cartridge	£23 4 11
LAB.80 Mk. II less cartridge	£24 19 6

All plus P. & P. 12/6.
Mono Cartridge **17/6** extra. Stereo Cartridge **22/6** extra.

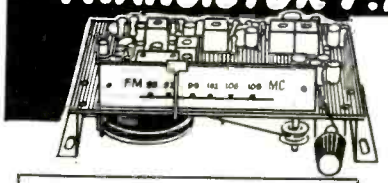
TEAK FINISH PLINTHS with perspex cover 8½gns. (for LAB80 8½gns.). P. & P. 12/6. Agents for Thorens, Dual Goldring, etc.

2-3 WATT AMPLIFIER

An ideal basis for building your own portable record player. Just add speaker and turntable and you will have an above-average model for a mere fraction of the cost. 2-3 watt printed circuit, with control panel on flying lead. On, OFF, TONE CONTROL AND VOLUME, colourful escutcheon. Brimar valves: EZ80, ECL82 and composite installation booklet. Price **85/-** P. & P. 3/6.



TRANSISTOR F.M. TUNER



Save £2.2.0

6 Transistor FM tuner. Frequency range 88-108 Mc/s. Size 6 × 4 × 2½in. Ready built for use with most amplifiers. 9v. battery operation. Complete with instructions. List price 9 gns.

LIND-AIR PRICE
7 gns.
P. & P. 4/-.

Multiplex adaptor for above for Stereo Radio Reception. **£5.19.6**

MAGNAVOX-COLLARO 363 TAPE DECKS

The very latest 3-speed model—1⅞, 3¾, 7½ i.p.s. available with either 2 track or 4 track head. Features include: Pause control digital counter, fast forward and rewind; new 4 pole fully screened induction motor; interlocking keys. Size of top plate 13½ × 11 × 5¼in. deep below unit plate. For 200/250 v. A.C. mains 50 c.p.s. operation. New, unused and fully guaranteed.

2 track model **£10/10/0** 4 track model **£13/9/6** Carriage and Packing 7/6.

FOR USE WITH ABOVE TAPE DECKS. 2 track model **£14/19/6**; 4 track model, **£15/19/6.** Carriage and packing 7/6.

MARTIN TAPE AMPLIFIERS

BARGAIN OFFER! FANTAVOX CASSETTE TAPE PLAYER

Specially designed to replay the well-known and popular Musicassettes—prerecorded tape cassette offering a wide choice of all types of music from pop to classical. Up to 40 minutes of quality reproduction through built-in speaker. Simple off/play and volume controls. Fully transistorised operating on 6 penlight batteries. Modern compact styling with earpiece socket and wrist strap. Size 6½ × 4½ × 2in. LIND-AIR PRICE **£9/19/6.** Carr. Pkg. & Ins. 5/-.

LINEAR AMPLIFIERS

Latest A.C. Mains Models offering highest quality at modest cost.

LT66. All Transistor 12 watts Stereo. Inputs for Tuner, Gram, Mike. Separate Bass, Treble, Balance and Volume Controls, **£15/15/-.** Carr. 7/6. Teak case **£3/10/-** extra.
PTA15 (as illus.). All Transistor, 15 watts Mono. Inputs for Tuner, Gram, Mike, Guitar, Bass, Treble and Two volume controls, **£15/15/-.** Carr. 7/6. Teak case, **£3/10/-** extra.
LT45. 2 VALVE 5 watts Mono. Inputs for Tuner, Gram Bass, Treble and Volume controls, **£6/19/6.** Carr. 5/6, Metal cover **15/-** extra. Full details sent on request.

9 in 1 ELECTRONIC KIT

Build nine different projects from one basic kit—no mechanical knowledge required. Build a Police Siren, Metronome, Morse Code amplifier, Electronic Massager, W/T Transmitter, Radio Telephone, One transistor Radio, Two-transistor Radio, Electronic Music Kit. Completely safe-operated on 9v. PP3 battery. Complete with simple step by step instructions. ONLY **69/6.** P. & P. 5/-.

EXTENSION TELEPHONES

ONLY
37/6
P. & P. 5/-

Complete with lead, automatic dial numbered 1-10 and internal bell. Guaranteed perfect working order. Made by famous manufacturer to G.P.O. Specification.

PP3 Eliminator. Play your pocket radio from the mains! Save £s. Complete component kit comprises 4 rectifiers—mains dropper resistances, smoothing condenser and instructions. Only **6/6** plus 1/- post.

MINIATURE WAFER SWITCHES

4 pole, 2 way—3 pole, 3 way—4 pole, 3 way—2 pole, 4 way—3 pole, 4 way—2 pole, 6 way—1 pole, 12 way. All at **3/6** each, **36/-** dozen, your assortment.

WATERPROOF HEATING ELEMENT
26 yards length 70W. Self-regulating temperature control, **10/-** post free.

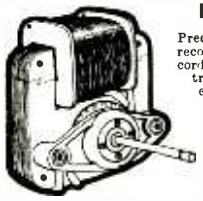
A.E.I. FRACTIONAL H.P. MOTOR 200/250 v. 50/60 c.p.s. enclosed, continuous rating 1/40 h.p., ex. equipt. Perfect order **19/6** plus 4/6.
A.C. FAN, powerful mains motor with 6½in. blade, ideal blow or extract. **17/6** plus 3/6.
1.2 v. NICKEL CADMIUM CELLS, dia. ⅞in. by 1in. thick (approx.) **3/6** each, charger for two cells, **12/6.**
OIL THERMOSTAT, Teddington type, T.B.B. with capillary tube and sensor adjustable by knob (not supplied), controls ½ h.p. motor or up to 15 amp. resistive load, **9/6.**
5 PUSH SWITCH, one push operates mains on/off switch, the other four operate various on/off and change/over switches, **2/6.**

QUICK CUPPA

Mini Immersion Heater, 350w. 200/240 v. Boils full cup in about two minutes Use any socket or lamp holder. Have at bedside for tea, baby's food, etc. **19/6.** post and insurance 1/6.

NO SOLDERING POCKET 3

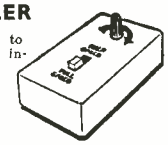
Lots of fun to build and good results when finished, complete kit with detailed instructions and crystal earpiece, batteries, 1/2d. extra— **£5** value for only **19/6.** plus 3/- post & ins.



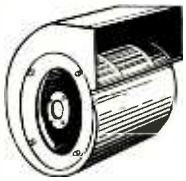
MAINS MOTOR

Precision made—as used in record decks and tape recorders—ideal also for extractor fan-blower, heater, etc. New and perfect. Snip at **9/6.** Postage 3/- for first one then 1/- for each one ordered, 12 and over post free.

DRILL CONTROLLER



Electronically changes speed from approximately 10 revs. to maximum. Full power at all speeds by finger-tip control. Kit includes all parts, case, everything and full instructions. **19/6,** plus 2/6 post and insurance. Or available made up **32/6,** plus 2/6 P. & P.



CENTRIFUGAL FAN

CENTRIFUGAL BLOWER or extractor by Torrington very low noise but large capacity air flow, designed for central heating and air conditioning, ideal also for fume extraction over cooker, duct type outlet, 200/250 v. 50 C.P.S. motor, **£3/19/6** post and insurance 7/6.

THIS MONTH'S SNIP

FULL FI 12 INCH LOUDSPEAKER. This is undoubtedly one of the finest loudspeakers that we have ever offered, produced by one of this country's most famous makers. It has a die-cast metal frame and is strongly recommended for Hi-Fi load and Rhythm Guitar and public address.
Flux Density 11,000 gauss—Total Flux 44,000 Maxwells—Power Handling 15 watts R.M.S.—Cone Moulded fibre—Freq. response 30-10,000 c.p.s.—Input Impedance 15 ohms—Main resonance 60 c.p.s.—Chassis Diam. 12in.—12⅝in. over mounting lugs—Baffle hole 11in. Diam.—Mounting holes 4, holes—¼in. diam. on pitch circle 11¾in. diam.—Overall height 5¾in. A £6 speaker offered for only **£3/9/6** plus 7/6 p & p. Don't miss this offer.

GARRARD Model 3000

This is one of the latest products of the World's most experienced maker of fine record reproducers. Its superior features include—automatic playing of up to 8 mixed size records—stopping and starting without rejecting—manual playing—pick-up pivots to give low stylus pressure—large diameter turntable for max. stability adjustments include pick-up height—pick-up dropping position and stylus pressure. Size is 13¼ × 11⅞in., clearance 4⅛in. above, 2⅛in. below—Fitted with the very superior ceramic stereo cartridge type 9TAHC with diamond stylus which is listed at over £4. Price **complete £9/19/6,** carr. and ins. 7/6.

BARGAIN OF THE YEAR

MICRO-SONIC 7 transistor Key chain radio in very pretty case, size 2⅞in. × 2¼in. × 1in.—complete with soft leather zipped bag. Specification: Circuit: 7 transistor superheterodyne. Frequency range: 530 at 1600 Kc/s. Sensitivity: 5 mv/m. Intermediate frequency 465 Kc/s., or 455 Kc/s. Power output: 40 mW. Antenna: ferrite rod. Loudspeaker: Permanent magnet type. In transit from the East these sets suffered slight corrosion as the batteries were left in them but when this corrosion is cleared away they should work perfectly—offered without guarantee except that they are new. **19/6** plus 2/6 post and ins., less batteries.

INFRA-RED BINOCULARS

These infra-red binoculars when fed from a high voltage source will enable objects to be seen in the dark, provided the objects are in the rays of an infra-red beam. Each eye tube contains a complete optical lens system as well as the infra-red cell. These optical systems can be used as lenses for T.V. cameras—light cells, etc. (details supplied). The binoculars form part of the Army night driving (Tabby equipment). They are unused and believed to be in good working order but sold without a guarantee. Price **£3/17/6,** plus 10/- carr. and ins. Handbook 2/6.

MAINS TRANSISTOR POWER PACK

Designed to operate transistor sets and amplifiers. Adjustable output 6 v., 9 v., 12 volts for up to 500 mA. (class B working). Takes the place of any of the following batteries: PP1, PP3, PP4, PP6, PP7, PP9, and others. Kit comprises mains transformer rectifier, smoothing and load resistor, condensers and Instructions. Real snip at only **16/6,** plus 3/6 postage.

FLOOD LAMP CONTROL

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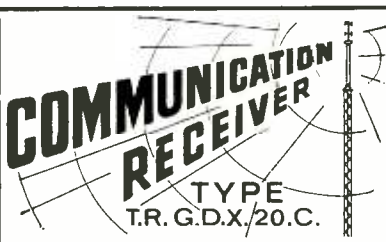

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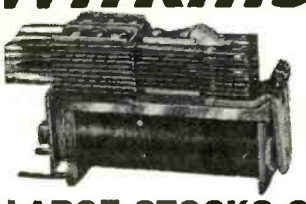

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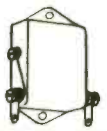

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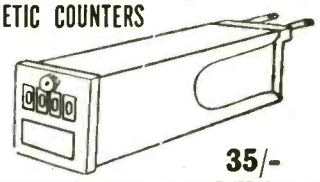

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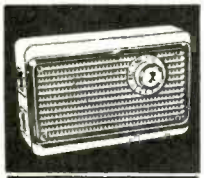
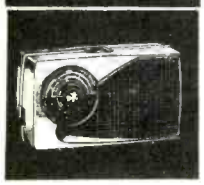
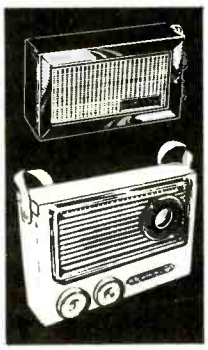


TRANSONA FIVE MED. LONG & TRAWLER BAND. 5 transistors and 2 diodes, ferrite rod aerial, tuning condenser, volume control, 3in. speaker, 6½×4¼×1¼in. **Total Building Costs 42/6.** P. & P. 3/6. Plans and Parts list 1/6 (free with parts).



MELODY MAKER SIX. Med. & Long Waves & Extended Med. Wave Band. 6 transistors and 2 diodes. Push-pull output, tuning condenser, high "Q" ferrite rod aerial. 3in. speaker, etc. 6½×3¾×1½in. **Total Building Costs 69/6.** P. & P. 3/6. Plans and parts list 2/- (free with parts).



POCKET FIVE. MED. & LONG WAVES & EXTENDED MED. WAVE BAND. 5 transistors and 2 diodes, ferrite rod aerial, tuning condenser. 3in. speaker, etc. 5¼×1½×3¼in. **Total Building Costs 39/6.** P. & P. 3/6. Plans and Parts list 1/6 (free with parts).

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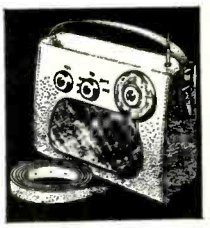

ROAMER SIX. 6 wavebands—MW1, MW2, SW1, SW2, LW and Trawler Band. 6 transistors and 2 diodes. Ferrite rod and telescopic aerials. 3in. speaker. Tip grade components. Size 7½×5½×1½in. **Total Building Costs 79/6.** P. & P. 3/6. Plans and parts list 2/- (free with parts).

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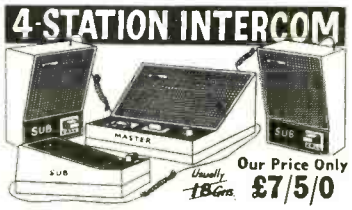

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(Special Offer—**£14/10/-**, post free if all above kits ordered at same time or built and tested for **£18** post free).

Circuit diagram, construction details and parts list (free with kit) **1/6** (8.A.E.).

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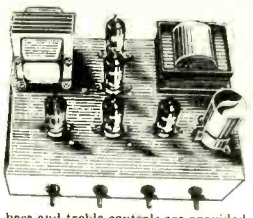
10/14 WATT HI-FI AMPLIFIER KIT



A stylishly finished monaural amplifier with an output of 14 watts from 2 EL84s in push-pull 8uper reproduction of both music and speech, with negligible hum. Separate inputs for mike and gram allow records and announcements to follow each other. Fully shrouded section wound output transformer to match 3-15Ω speaker and 2 independent volume controls, and separate bass and treble controls are provided giving good lift and cut. Valve line-up: 2 EL84s, ECC83, EF86, and EZ80 rectifier. Simple instruction booklet 1/6 (Free with parts). **All parts sold separately. ONLY £7/9/6.** P. & P. 8/6. Also available ready built and tested complete with standard input sockets. **£9/5/-.** P. & P. 8/6.

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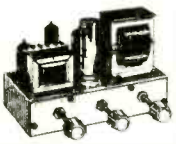

Designed for Hi-Fi reproduction of records. A.C. mains operation. Ready built on plated heavy gauge metal chassis, size 7½in. w. × 4in. d. × 4¾in. h. Incorporates ECC83, EL84, EZ80 valves. Heavy duty, double wound mains transformer and output transformer matched for 3 ohm speaker, separate bass, treble and volume controls. Negative feedback line. Output 4½ watts. Front panel can be detached and leads extended for remote mounting of controls. The H A34 has been specially designed for us and our quantity order enables us to offer them complete with knobs, valves, etc., wired and tested for only **£4/5/-.** P. & P. 6/-.

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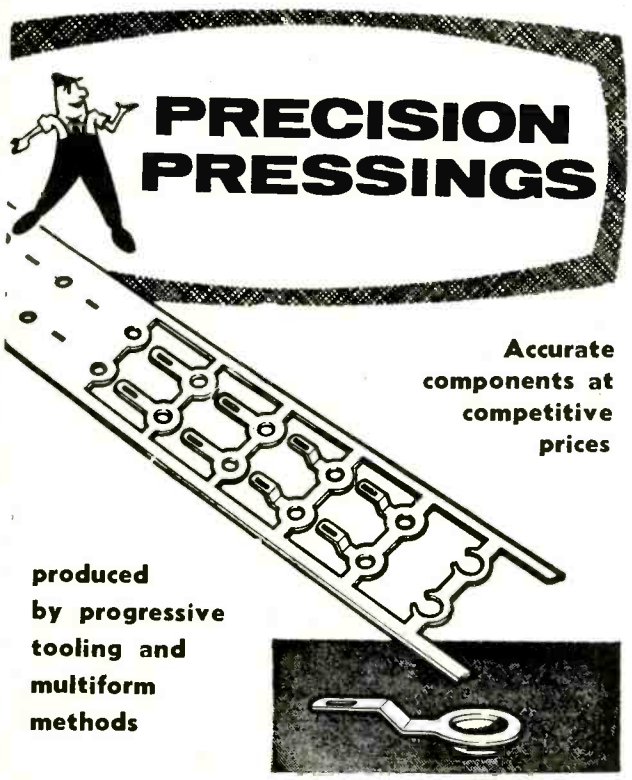

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1S4	4/9	6F23	11/6	10F1	15/-	30FL1	15/-	AC/TH1		EB34	7/6	EF39	5/-	GZ33	12/6	PCL86	8/3	UBC41	6/6
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1U4	5/6	6F28	10/6	10F18	9/-	30FL14	12/6	AC/TP	19/6	EB91	2/3	EF41	9/-	GZ37	14/6	PEN45	7/-	UBF80	5/6
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2D21	5/6	6G6G	2/6	10P13	15/6	30L15	14/-	AC/VP2	11/-	EBC41	7/3	EF50	2/6	PEN46	4/-	UBL21	9/-	VP23	2/6
3A4	3/6	6H6GT	1/6	10P14	15/6	30L17	13/-	ATP4	2/3	EBC81	6/3	EF54	6/-	PEN383	9/6	UC92	5/6	VR75	21/-
3A5	8/-	6J5G	3/9	12A6	5/-	30P4	11/6	AZ1	8/-	EBC90	3/9	EF73	6/6	PEN383	9/6	UCC84	8/-	VR105	5/-
3B7	5/-	6J5GT	4/6	12AC6	8/-	30P4MR		AZ31	7/9	EBC91	5/-	EF80	4/6	PEN384		UCC85	6/6	VR150	5/-
3D6	3/9	6J6	3/-	12AD6	9/-		13/-	AZ41	6/6	EBF80	5/9	EF83	9/9	PFL200	13/6	UCF80	8/3	VT61A	7/-
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3Q5GT	6/6	6J7GT	8/6	12AT6	4/6	30P19	11/-	CL33	19/6	EBF89	5/9	EF86	6/3	PL36	9/9	UCH42	8/6	VU120	12/-
3S4	4/9	6K6GT	5/-	12AT7	3/6	30PL1	15/-	CV6	10/6	EBL21	10/3	EF89	4/9	PL38	19/9	UCH81	6/-	VU120A	12/-
3V4	5/6	6K7G	1/3	12AU6	4/9	30PL13	15/-	CY1C	6/6	EC52	4/3	EF91	3/3	PL81	7/6	UCL82	7/-	VU133	7/-
5R4GY	8/9	6K7GT	4/6	12AU7	4/6	30PL14	15/-	CY31	7/9	EC53	12/6	EF92	2/6	PL81A	7/6	UCL83	9/6	W61M	24/6
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TH233	6/9	U403	6/6	ACY20	4/9	BY100	3/6	OA5	1/9	OC75	2/-								
TP2620	7/6	U404	7/6	ACY21	5/9	BY101	11/6	OA9	2/6	OC76	3/-								
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UAF42	9/6	VP2B	9/6	AD149	8/-	BY234	4/-	OA73	3/-	OC79	8/-								
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UBC41	6/6	VP4A	14/6	AF114	4/-	BY238	4/-	OA81	1/9	OC81D	2/-								
UBC81	6/6	VP4B	11/-	AF115	3/-	BYZ12	5/-	OA85	1/6	OC81M	5/-								
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UBF89	5/9	VP23	2/6	AF117	3/4	CG12E	4/-	OA90	2/6	PER PAIR									
UBL21	9/-	VR75	21/-	AF118	3/-	CG64H	4/-	OA91	1/9	OC82	2/3								
UC92	5/6	VR105	5/-	AF124	7/6	GD3	6/6	OA95	1/9	OC82D	2/6								
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UCL82	7/-	W61M	24/6	AF180	9/6	GD11	4/-	OAZ20110	6/6	OC170	2/6								
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U22	5/9	AC107	3/6																
U25	12/6	AC113	5/-																
U26	11/-	AC114	8/-																
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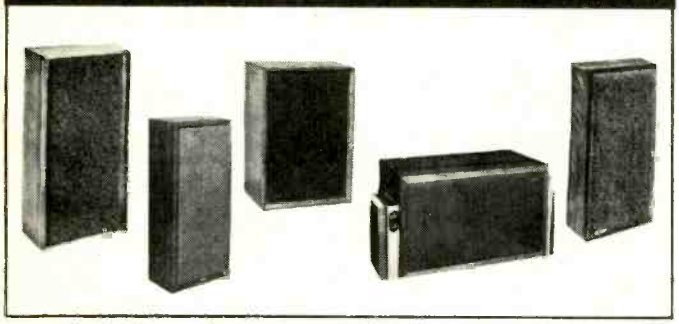

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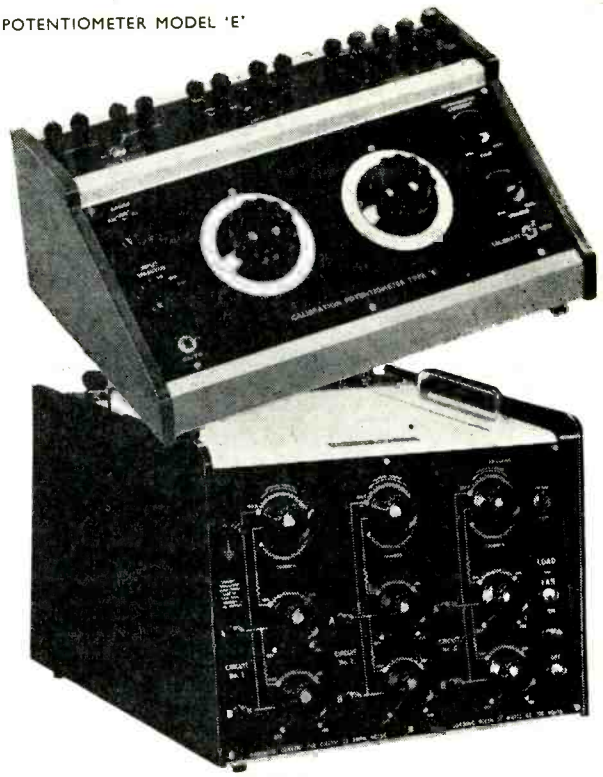

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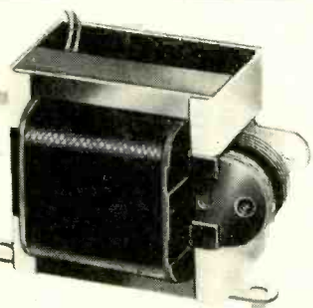

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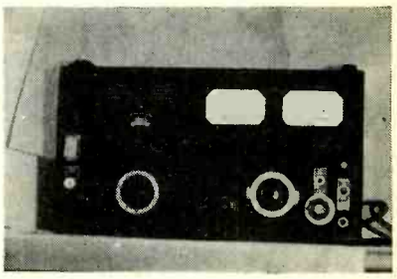

BOONTON STANDARD SIGNAL GENERATOR MODEL 80. Frequency 2-400 Mc/s. in 6 ranges. AM., 400 and 1,000 c/s. and external modulation. Provision for pulse modulation. Piston type attenuator 0.1μ-100 mV separate meter for modulation level and carrier level. Precision flywheel tuning. 117 v. A.C. input. With instruction manual, **£95.** Carriage 30/-.

MARCONI SIGNAL GENERATOR TYPE TF 144G. 85 kc/s.-25 Mc/s. Excellent laboratory tested condition, with all necessary accessories with instruction manual, **£45.** P. & P. 15/-.

SIGNAL GENERATOR PORTABLE TS 13/AP, with self-contained wavemeter and power monitor. Freq. 9305-9445 Mc/s. Peak power output, C.W pulsed 50μW per ½ F.S.D. Pulsing 1-2μsec. wide, delay 5,200μsec. PRR 350-4,000 c/s. **£50.** P. & P. 20/-.

BC 221 FREQUENCY METERS. 125-20,000 kc/s. Accuracy 0.01%. Complete with individual Calibration book. In brand new condition with headphones and instruction book. **£45.** P. & P. 20/-. Mains P.S.U. for above, **£11/10/-.** Carriage 5/-. Stabilised PSU for above £16 Carriage 5/-.

TEST SET TS 12AP STANDING WAVE INDICATOR EQUIPMENT. Used for testing 3 cm. circuit components. Should be used with a suitable signal source such as above described TS 13 Signal Generator. **£25.** P. & P. 10/-.

MARCONI VIDEO OSCILLATOR TF 885A Sine wave output 25 c/s to 5 Mc/s in 2 bands, Squarewave output 50 c/s to 150 c/s in 2 bands. Freq. accur. ±2% ±2 c/s. Power supply 100/125/200/250 v. A.C. **£55.** Carriage 40/-.

MARCONI SIGNAL GENERATOR TF 801/A/1. 10-300 Mc/s. in 4 bands. Internal at 400 c/s. 1 kc/s. External 50 c/s to 10 kc/s. Output 0-100 db below 200 mV from 75 ohms source. **£85.** P. & P. 20/-, including necessary connectors, plugs, and instruction manual.

R.F. METERS. 300 mA. 2in. clip fix. 19/-. 300 mA. 2½in. flush. 27/6.

SIGNAL GENERATOR TYPE TS 418. Signal frequency 400-1,000 Mc/s. direct calibration. Pulse rate 40-400 c (X1 or X10), pulse delay variable, less than 3μsec. to more than 300μsec. Pulse width variable less than 1μsec. to more than 10μsec. Polarity—internal or external sources, positive or negative pulses. AM & CW. Output attenuator 0.2μV to 200mV continuously variable. In fully tested condition, **£150.** Carriage paid.

ENGLISH ELECTRIC INSULATION TESTER. 10kV D.C. with built in ionisation amplifier. **£35.** P. & P. 15/-.
Variable Condenser 200pF., 1,000 v. **12/6.** P. & P. 5/-.

U.H.F. SIGNAL GENERATOR 710A. MADE BY R.C.A. Output frequency 370 to 560 Mc/s. Output voltages 1μv. to 90mv. Directly calibrated in megacycles (.5% accuracy). 400 cycles internal modulation, external modulation up to 1 Mc/s. may be applied by means of the input cable supplied with the instrument. Power supply 105/125 v. In excellent condition and guaranteed **£42/10/-.** Carriage 30/-.

PRECISION VHF FREQUENCY METER TYPE 183. 20-300 Mc/s with accuracy 0.03% and 300-1,000 Mc/s with accuracy 0.3%. Additional band on harmonics 5.0-6.25 Mc/s with accuracy $\pm -2\times10^{-4}$. Incorporating calibrating quartz 100 kc/s $+ -5\times10^{-5}$ 120/220 v. A.C. mains. **£85.** Carriage £2.

PHASE MONITOR ME-63/U. Manufactured recently by Control Electronics Inc. Measures directly and displays on a panel meter the phase angle between two applied audio frequency signals within the range from 20-20,000 c.p.s. to an accuracy of ±1.0°. Input signals can be sinusoidal or non-sinusoidal between 2 and 30 v. peak. In excellent condition together with handbook and necessary connector. **£45.** Carriage 30/-.

V.H.F. CIRCUIT MAGNIFICATION METER TYPE TF 886A. Apart from directly reading Q in the range 15-170 mc/s (in 4 bands) this instrument may be used for indirectly measuring induction of coils, phase defects of capacitors, dielectric losses, etc. by resonance methods. Magnification ranges 6-180; 150-450; 400-1,200. Test Circuit Capacitor 12 to 85pF calibrated in 1pF divisions, with additional interpolating dial. Power supply 200 to 250 v. and 100 to 150 v. **£95.** Carriage 30/-.

NOISE GENERATOR MARCONI TYPE TF 1106. The TF 1106 provides standard noise outputs for determining the noise factor of A.M. & F.M. receivers at any frequency from 1 to 200 mc/s. It is calibrated directly in noise factor, making measurements a routine operation. Noise output calibration 0-30 in four ranges. Accuracy ±0.5 dB. Frequency range 1-200 mc/s. Output impedance 52 or 71 ohms. Power supply 100-125 v. or 200-250 v. **£55.**

AVO VALVE TESTER, with instruction book, **£45.** Carriage 30/-.

AIRMEC FREQUENCY STANDARD METER TYPE 761. 10c, 100c, 10kc, 100kc, 1Mc. **£80.** Carriage 30/-.
SOLATRON OSCILLOSCOPE Laboratory type CD 643. **£130.** Carriage 40/-.
COSSOR OSCILLOSCOPE TYPE 1049. £45. Carriage 30/-.

As above but Type 885a/1, 0-12 mc/s in 3 bands. **£85.** Carriage 40/-.

END OF RANGE ITEMS
Offered at special low prices as only a few left, all are in fully tested guaranteed condition.
VALVE VOLTMETER TS 428B/1. £10/10/-. P. & P. 5/-.

P. C. RADIO LTD.
170 GOLDHAWK ROAD, W.12
SHEpherd's Bush 4946

VALVES

AC/HL	6/-	EC91	3/-	FW4/500	6/-	PL81	8/-	TP25	5/-	VL8631	35/-	3A146J	55/-	6AK8	6/5	6F7	6/-	6SQ7GT	6/-
AL60	5/-	ECC33	12/-	FW4/800	10/-	PL82	8/-	TT11	3/-	VP23	2/6	3A167M	55/-	6AL5	3/-	6F8G	5/-	6S87	2/-
AR8	5/-	ECC81	4/-	G/371K	57/6	PL83	6/9	TT15	35/-	VP133	9/-			6AL5W	7/-	6F12	4/-	6V6G	3/6
ARP3	3/-	ECC82	4/3	G1/370K	20/-	PL84	7/3	TTR31	45/-	VR99	7/6	3B7	5/-	6AM5	2/6	6F13	5/-	6V6GT	7/6
ARP12	3/6	ECC83	6/3	G50/2G	5/-	PL500	15/6	TZ40	40/-	VR105/30	7/-	3B24	14/-	6AM6	3/-	6F17	5/-	6V6M	8/-
ARTP1	6/-	ECC84	6/-	G120/1B	17/6	PX4	14/-	TZ0502	4/-		6/-	3D6	3/-	6AQ5	5/6	6F32	3/-	6X4	4/-
ATP4	2/3	ECC85	5/4	GM4	45/-	PX25	12/6	TZ20	16/-	VR150/30	6/-	3E29	50/-	6AQ5W	9/-	6F33	15/-	6X5G	5/-
AZ31	10/6	ECC88	7/-	GTE175M	12/-	PY33	9/3	U12/14	7/-	VU39	7/-	3Q4	8/-	6A86	6/-	6G6G	2/6	6X5GT	6/-
BD78	40/-	ECC91	4/-	GU50	28/-	PY80	15/6	U18	6/-	W118	8/-	3Q5GT	6/-	6A87G	14/-	6H6GT	1/9	6Y6G	8/-
BL63	10/-	ECF80	7/6	GZ32	11/6	PY81	6/3	U25	13/-	W119	9/-	3S4	5/9	6AT6	4/6	6H6M	3/-	6-30L2	14/3
BT35	15/-	ECF82	7/6	GZ34	11/6	PY82	5/9	U26	16/-	X65	5/-	3V4	6/6	6AU6	5/9	6J4WA	12/-	6Z4	5/-
BT45	150/-	ECH35	11/-	H30	3/6	PY83	6/9	U27	8/-	X66	7/6	4D1	4/-	6AX4	8/-	6J5	7/-	7B7	7/-
BT83	35/-	ECH42	10/6	HL2	4/-	PY800	10/3	U52	4/6	X76M	7/-	5A173G	5/-	6B7	5/6	6J5G	2/6	7C5	12/6
CV102	1/-	ECH81	5/9	HL2K	2/6	PY801	10/3	U81	8/-	X79	8/-	5A174G	5/-	6B4G	15/-	6J6	3/6	7C6	6/-
CV103	4/-	ECH83	8/6	HL23DD	5/-	QQV03-10	27/6	U191	12/6	X118	8/-	5B251M	40/-	6B8G	2/6	6J6W	6/-	7C7	6/-
CV315 (matched pairs)	120/-	ECL80	6/9	HL41	4/-	QQV06-40	85/-	U404	6/-	X145	8/-	5B252M	35/-	6BA6	4/6	6J7G	5/-	7F8W	12/6
CV315 (single)	50/-	ECL82	6/9	HVR2	9/-	QQV06-40A	100/-	U801	19/6	X63	6/6	5B254M	40/-	6BA7	12/6	6J7M	8/-	7H7	5/6
CY31	7/6	ECL83	10/9	KT8C	22/-	Q8150-15	7/6	UABC80	6/-	Y65	4/-	5B/255M	35/-	6BE6	5/3	6K6GT	8/-	7Q7	7/-
D41	3/3	ECL86	9/3	KT66	18/6			UAF42	10/6	Z800U	20/-	5R4GY	9/-	6BJ6	8/6	6K7	6/-	7V7	5/-
D77	3/-	EF36	3/6	KT67	45/-			UBC41	8/-	Z801U	20/-	5T4	7/-	6BJ7	7/-	6K7G	2/-	7Y4	9/3
DA100	£6	EF37A	8/-	KT71	7/6			UBF80	7/6	Z900T	12/-	5U4G	4/6	6BQ7A	4/-	6K7GT	4/9	7Z4	4/6
DAF96	6/-	EF39	6/-	KT76	7/-			UCC85	7/6	1B22	30/-			6BR7	9/-	6K8G	4/-	9D6	2/-
DD41	4/-	EF40	9/3	KT88	27/-													10F9	9/-
DET20	2/-	EF41	10/-	KTZ63	7/-													10P14	18/6
DET25	10/-	EF80	5/3	L63	6/-													11E2	15/-
DF91	3/-	EF85	7/6	MH4	5/-													12A6	3/6
DF92	2/6	EF86	6/9	MH41	8/-													12AT6	5/3
DF96	7/3	EF89	6/9	MHLD6	7/6													12AT7	4/-
DK92	8/6	EF91	3/-	ML6	6/-													12AT7WA	6/6
DK96	7/3	EF92	2/6	N34	8/-													12AU7	4/3
DL63	8/-	EF95	5/9	N78	15/-													12AV6	6/3
DL92	4/-	EF183	7/-	OA2	6/6													12AX7	6/3
DL93	4/-	EF184	6/-	OB2	6/9													12AY7	10/6
DL94	6/6	EH90	7/6	OB3	7/-													12BA6	6/3
DL96	8/-	EL31	15/-	OC3	6/-													12BE6	5/9
DLS10	9/6	EL32	3/9	OD3	6/-													12BH7	3/6
DY86	6/9	EL34	11/-	OZ4A	5/-													12C8	3/-
DY87	7/-	EL35	5/-	P41	4/-													12E1	17/-
E80F	18/-	EL38	17/6	PABC80	8/-													12H6	3/-
E88CC	8/-	EL41	9/3	PC86	10/3													12J7GT	6/6
E90CC	10/-	EL42	11/-	PC88	9/9													12K7GT	5/-
E92CC	5/-	EL84	4/9	PC97	8/-													12K8M	8/-
E180CC	7/-	EL85	8/6	PC900	9/9													12Q7GT	5/-
E182CC	18/-	EL91	2/6	PCC84	6/3													12SC7	4/-
E1148	2/6	EL95	5/9	PCC89	11/6													12SG7	4/6
E2134	8/-	EL360	18/-	PCC189	10/6													12SH7	3/-
EA50	1/-	EM31	5/-	PCF80	7/-													12SJ7	4/-
EABC80	7/6	EM80	8/-	PCF82	6/3													12SK7	5/6
EAC91	3/-	EM81	8/-	PCF84	9/3													12SL7GT	7/-
EAF42	9/3	EM84	8/3	PCF86	9/3													12SN7GT	6/6
EB91	2/-	EM87	11/-	PCF801	9/6													12SR7	5/-
EBC33	8/-	EN92	5/-	PCF802	10/3													12Y4	2/-
EBC41	9/9	ESU74	80/-	PCF805	12/6													13D1	4/-
EBC81	5/9	EY51	8/-	PCF806	14/6													13D5	5/6
EBF80	7/6	EY86	7/3	PCF808	14/6													1487	17/3
EBF83	8/6	EY91	2/6	PCL81	10/3													19AQ5	5/9
EBF89	7/9	EZ40	8/-	PCL82	8/-													19E2	15/-
EC53	12/6	EZ41	8/-	PCL83	9/6													19G3	40/-
EC70	4/-	EZ80	5/9	PCL84	8/-													19G6	15/-
EC90	4/-	EZ81	5/3	PCL85	9/3													19H4	65/-
				PCL86	9/3													20A1	35/-
				PFL200	14/6													20P4	22/-
				PL36	9/9													25L6GT	7/3
				PL38	18/3													25Y5	6/-
																		25Z4G	9/3
																		25Z5	7/6
																		25Z6GT	9/6
																		28D7	6/-
																		30C15	15/6
																		30C17	15/6
																		30C18	16/-
																		30F5	16/-
																		30FL1	17/3

TRANSISTORS ZENER DIODES, ETC.

OA5	3/-	OC41	6/-	2N1040	20/-	AF124	7/6	CRS1/20	9/6	JK9A	22/6	Q895/10	5/-	UCF80	9/6	1G5GT	6/-	5V4G	7/6	6BR8	5/-	6K8GT	7/3
OA10	3/-	OC70	4/-	2N1090	7/6	AF125	6/6	CRS1/30		JK10A	15/-	Q81200	10/-	UCH42	9/3	1D8GT	6/-	5X4G	8/6	6BW7	11/6	6K25G	24/-
OA47	2/6	OC71	3/-	2N1091	9/6	AF126	6/-		10/-	JK10B	15/-	Q81202	8/-	UCH81	6/9	1G6GT	6/-	5Y3GT	5/9	6C4	3/6	6L5G	6/-
OA79	2/6	OC72	5/-	2N1306	7/6	AF127	6/-	CRS1/35		JK11A	12/6	QV04/7	8/-	UCL82	8/3	1L4	2/6	5Y3WGTB		6C5G	2/6	6L6GA	9/-
OA81	2/-	OC73	6/-	2N1307	7/6	AF139	10/-		11/6	JK19A	22/6	QQZ04-15		UCL83	10/6	1LA6	6/-		9/-	6C5GT	6/-	6L6G	6/9
OA90	2/-	OC76	5/-	28303	10/-	AF178	12/6	CRS1/40		JK20A	17/6	R10	17/6	UF41	10/6	1LC6	7/-	5Z4G	7/7	6C6	4/-	6L7G	4/-
OA200	2/6	OC81D	3/-	AC107	10/-	AFY19	22/6		12/6	JK21A	12/6	RG1-240A	57/6	UF89	6/9	1LH4	4/-	6AB7	4/-	6C8G	6/6	6L34	3/-
OA202	3/6	OC82	5/-	AC126	6/6	ASY26	6/6	CRS3/05		JK100B	15/-		28/-	UL41	9/9	1R5	6/-	6AC7	3/-	6C21	80/-	6N7G	5/9
OA210	7/6	OC139	7/6	AC127	7/6	ASY28	6/6		6/-	MAT100	7/9	SP61	3/3	UL84	7/-	1S4	5/-	6AG5	2/6	6CH6	7/-	6P25	19/6
OA211	9/6	OC169	5/-	AC128	6/6	ASZ21	12/6	CRS3/20		MAT101	8/6	STV280/40	24/-	UU5	7/-	1S5	4/6	6AG7	6/-	6CL6	9/-	6S7	7/-
OAZ2001	1/-	OC170	5/-	AC176	7/6	ASZ23	30/-		10/-	MPF10211	/-	STV280/80	90/-	UY21	10/6	1T4	3/-	6AH6	11/6	6CW4	13/9	6SA7	7/-
OAZ2011	0/-	OC200	7/6	ACY17	8/6	AU101	30/-	CRS3/30		MPF103	9/6	SU2150A	10/-	UY41	7/6	2A3	5/-	6AJ7	3/-	6D6	3/-	6SA7GT	6/6
OAZ202	to	OC201	10/-	ACY18	5/6	BC107	6/-		11/6	MPF10410	/-	S11E12	10/-	UY85	5/9	2D21	4/9	6AK5	5/-	6F23	13/-	6SC7	7/-
OAZ206	8/6	OC202	12/6	ACY19	6/6	BFY51	5/-	CRS3/40		HPF10510	/6	TDO4-20	70/-	V246A/1K	190/-	3A4	4/-	6AK6	6/-	6F5GT	8/-	6SC7GT	5/-
OAZ207	9/6	OC203	10/6	ACY20	5/-	BFY53	5/6		12/6	MA8508A	F	TP22	5/-			3A108A	35/-	6AK7	6/-	6F6G	4/-	6S6G7	7/-
OAZ208	to	OC204	17/6	ACY21	6/-	BSY25	4/-	CS4B	25/-		12/6											6S8J7	5/-
OAZ213	6/6	OC205	12/6	ACY22	3/6	BSY27	6/6	GET102	6/-	SX645	15/-											6SJ7GT	6/6
OAZ223	to	OC206	17/6	ACY28	4/6	BSY28	5/-	GET103	4/6	X8101	15/-											6SK7	7/-
OAZ225	10/-	IN21	3/6	AD140	16/-	BSY51	7/6	GET105	8/6	Z Range												6SL7GT	5/6
OC16	15/-	IN21B	5/-	AD149	16/-	BYZ10	12/-	GET111	9/-	Zener diodes												6SN7GT	4/6
OC22	10/-	IN25	12/-	AEY11	15/-	BYZ11	10/6	GET115	9/-	3/6 ea.													
OC23	12/6	IN43	4/-	AEY12	12/6	BYZ12	10/-	GET116	8/6	Z2A range													
OC24	15/-	IN70	4/-	AF102	18/-	BYZ13	6/-	GET872	6/-	7/6 ea													
OC25	7/6	IS111	4/-	AF114	6/6	BYZ15	20/-	GET880	9/-	ZL range													
OC26	6/-	IS113	4/6	AF115	6/-	BYZ16	15/-	GEX54	2/6	5/- ea.													
OC28	12/6	IS115	6/-	AF116	6/6	CR74	17/6	GJ6M	4/6	ZS range													
OC35	10/-	2N585	7/6	AF118	10/-	CRS1	105/-	GT43	5/-	7/6 ea.													

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.

COLOMOR

THE VALVE WITH A GUARANTEE

30FL12	19/6	1625	6/-
30FL13	9/3	1629	4/6
30FL14	16/-	2051	5/-
30L15	17/3	4043C	35/-
30L17	17/3	4313C	20/-
30P12	13/-	5676	10/-
30P19	12/3	5678	10/-
30PL1	14/-	5696	6/-
30PL14	18/4	5704	9/-
33A/101K	9/-	5726	7/-
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35T	17/6	6064	7/-
35W4	5/-	6065	8/-
35Z3	11/3	6080	22/-
35Z4GT	7/6	6146	28/-
35Z5GT	6/-	8013A	25/-
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38	4/-	9001	3/-
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59	6/-	E4504/B/16	70/-
75	5/6	O9J	75/-
76	5/-	VCR97	32/6
77	6/6	VCR139A	
78	5/-		30/-
80	5/6	VCR517	50/-
81	9/-	VCR517B	
83	10/-		55/-
84	5/-	VCR517C	
85A2	8/-		45/-
282A	£5	3EG1	40/-
307A	5/6	2FP7	25/-
313C	25/-	5CP1	30/-
357A	70/-	88D	80/-
368AS	30/-	5FP7	26/7
393A	27/6	Photo Tubes	
446	8/-	GS16	12/6
703A	30/-	931A	62/6
705A	20/-	6097C	350/-
715B	50/-	Special Vlvs.	
717A	3/-	ACT6	£8
803	22/6	ACT9	£16
807	9/-	CV1031	70/-
808	8/-	CV2339	£20
813	75/-	K301	£4
815	35/-	KRN2A	70/-
829B	50/-	1B24	25/-
832A	45/-	2J22	£2 2/10/-
843	5/-	WL417A	
866A	16/-		30/-
884	10/-	3J/92/E	
9 4	4/6		£37/10/-
9 5	2/6	714AY	£4
9 6	2/-	725A	
9 7	5/-		£7/10/
9 58A	4/-		

MUIRHEAD-WIGAN DECADE OSCILLATOR D650B, £55 Carriage 30/-.

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
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/-
2 amp. 2in. 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 2½in. 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/-

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/-.
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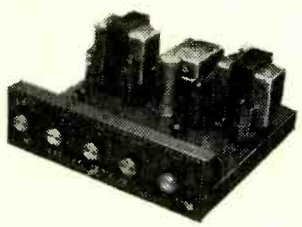

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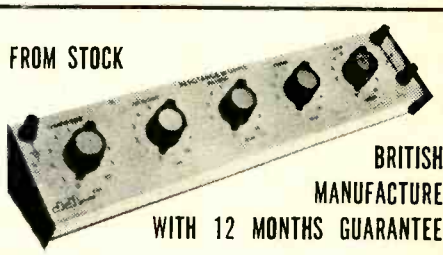

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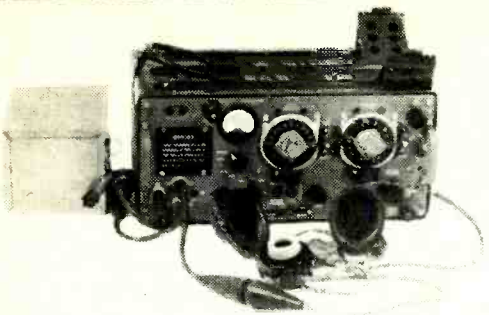
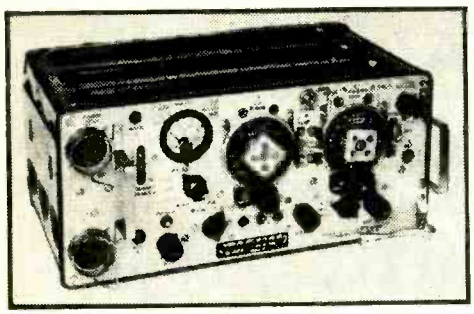


TRANS/RECEIVER TWO-TWO

This is one of the Latest Releases by the Govt. of an extremely recent R/T set covering 2-8 Mc/s in two switched Bands, containing 13 Valves (3 EL32s in TX Output) which can be used for Morse CW or R/T. Also has Netting Trimmer, BFO, RF & EF Controls, Switched Meter for checking all parts of set, Size 17in. x 8in. x 12in. Power required LT 12 volts DC, HT 325 Volts D.C. **Supplied Brand New** and Boxed with **Headphones & Mike**, also **Two Spare Valves** and Circuit of set. **Few only at £5/10/-**, Carr. 30/-. New Plug in Power Supply made by us for either 12 volts D.C. Input **£5/10/-** or 200/250 Volts A.C. **£3/17/6.**

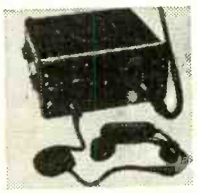
LARGE QUANTITY OF SARAH V.H.F. TRANS/RECEIVERS AVAILABLE FOR IMMEDIATE EXPORT.

General information. This set is normally carried in the life jacket of Airmen, it is a complete miniature lightweight radio Trans/Receiver, which is used to give a Beacon plus two way speech communication in the event of finding themselves in the sea. It comprises a Transmitter-Receiver, a speech unit, a coding unit and a power supply either Battery OR Transistor. These three items are permanently interconnected and all units are completely sealed and watertight using a combined speaker/Mike, Press to talk or listen buttons, Fold up aerial, a total of three Valves are used, power required 6.3 Volts LT 90 Volts and 435 Volts DC RT. Frequency 243 Mc/s. Transmitter output pulse power—Beacon 15 Watts, Talk 3 Watts. **Supplied in maker's boxes** in Grade I condition singly at **45/-**, post 5/- with circuit. New batteries if available **7/6** each.



FAMOUS ARMY SHORT-WAVE TRANSRECEIVER MK. III

This set is made up of 3 separate units: (1) a two valve amplifier using a 6V6 output valve; (2) (some only, not built in the very latest models) a V.H.F. transreceiver covering 229-241 Mc/s using 4 valves; (3) the mainshort wave transmitter/receiver covering in two switched bands, just below 2 Mc/s-4½ Mc/s, and 4½ Mc/s-8 Mc/s (approx. 160-37.5 metres) using 9 valves. For R.T., C.W. and M.C.W. The receiver is superhetrodyne having 1 R.F. stage, frequency changer, two I.F. (465 Kc/s) signal detector, A.V.C. and output stage. A B.F.O. included for C.W. or single side-band reception. T.X. output valve 807, other valves octal bases. Many extras, e.g. netting switch, quick flick dial settings, squelch, etc. Power requirements LT 12 volts, HT receiver 275 volts D.C. HT transmitter 500 volts D.C., size approx. 17½ x 7½ x 11ins. Every set supplied in new or as new condition in carton with book including circuits, only **£4/10/-** or Grade 2 slightly used **50/-**, or Grade 3 used but complete, **35/-**. Carr. ALL 15/-. WE MAKE A MAINS 200/250 VOLT POWER UNIT in louvred metal case to plug direct into set power socket to run (1) receiver, **70/-** post 5/-. (2) TX and RX, **£6/10/-**, post 7/6. (3) 12 volt D.C. P.U. (original) fair condition, **40/-**, Carr. 5/-. A charge of 10/- to unpack and test the receiver of these sets is made only if requested. Headphones & Mike, **15/-**, new and boxed.



This is a modern self contained tunable V.H.F. low powered frequency modulated transreceiver for R.T. communication up to 8-10 miles. Made for the Ministry of Supply at an extremely high cost by well - known British makers, using 15 midget B.G. 7 valves, receiver incorporating R.F. amplifier. Double superhet and A.F.C. Slow motion tuning with the dial calibrated in 41 channels each 200 kc/s apart. The frequency covered is 39 mc/s-48 mc/s. Also has built-in Crystal calibrator which gives pips to coincide with marks on the tuning dial. Power required L.T. 4½ volts, H.T. 150 volts, tapped at 90 volts for receiver. Every set supplied complete with valves and crystals. New in carton, complete with adjustable whip aerial, and circuit. **Price £4 10s 0d,** carriage 10s.

V.H.F. TRANSRECEIVER MK. I/I

JOHN'S RADIO OLD CO-OP, WHITEHALL ROAD, DRIGHLINGTON, BRADFORD.

Tel.: DRIGHLINGTON 2732

HAMMERLUND SP600JX COMMUNICATION RECEIVER High quality communication receiver. Frequency range 540kc/s-54Mc/s. in 6 switched bands, also 6 crystal controlled channels. Stability of 0.01% or better. Second channel rejection of 70dB down and spurious responses are are least 100dB down. Band width 20 c/s to 13 Kc/s. Crystal filter with crystal phasing control. This 20 valve receiver operates from:—110/250 V. 50/60 c/s. Perfect working order, **£125** ex works.

HALLICRAFTER 36A. 27.8 to 145 Mc/s in 3 bands. A.M. F.M. and variable B.F.O. 110/250 V. 50/60 c/s. First class condition. Fully tested, **£50.** P. & P. 40/-.

R209 COMMUNICATION RECEIVER 1 to 20 Mc/s in 4 bands. A.M. F.M. variable B.F.O. Built-in speaker and 6 V. D.C. power pack (new condition). **£15.** P. & P. 25/-.

CR100 MARCONI COMMUNICATION RECEIVER. 60 Kc/s to 30 Mc/s in 6 bands. Crystal filter B.F.O. 2 R.F. stages. Noise limiter. 110/250 V. 50/60 c/s. New. Fully tested. **£30.** P. & P. 40/-.

CR 300/2 MARCONI COMMUNICATION RECEIVER. 15 Kc/s to 26 Mc/s in 8 bands. Built-in crystal calibrator. A.V.C. C.W. bypass filter. Built-in speaker. Good working order. **£25.** P. & P. 40/-.

B40 MURPHY COMMUNICATION RECEIVER. High quality 10 valve receiver. 650 Kc/s to 30 Mc/s. in 5 bands. Two R.F. stages. 3 I.F. stages. Bypass filter. Noise Limiter. B.F.O. Built-in speaker. 230 V. 50/60 c/s. Fully tested. Perfect condition. **£22/10/-.** P. & P. 35/-.

B41. L.F. version of above. 15 kc/s to 700 Kc/s. In 5 bands. Perfect condition. Fully tested. **£15.** P. & P. 35/-.

BC221 FREQUENCY METERS. 125 to 20 Mc/s, with built-in Ministry stabilised 230/250 V. A.C. power pack In first class condition with calibration charts. Fully tested. **£45.** P. & P. 15/-

T.F.801B/3/S MARCONI SIGNAL GENERATOR. Frequency range 12-485 Mc/s in five ranges. Directly calibrated frequency dial. Output waveform: C.W. sine wave A.M., internal modulation frequency 1,000 c/s output: a normal, continuously variable directly calibrated from 0.1μV-0.5 V: b, high—up to 1 V. Modulated for 2 V. unmodulated, output impedance 50 ohms. Fine frequency tuning control, carrier. On/off switch, built-in crystal calibration for 2 Mc/s. and 10 Mc/s. Stabilised voltage supply. In perfect working order. **£115.** P. & P. 30/-.

CT218 MARCONI SIGNAL GENERATOR T.F.937. Covers 85 Kc/s to 30 Mc/s in 8 switched ranges. Effective length of film scale is 50ft. Output level variable in 1dB steps from 1 uV to 100 mV (75Ω). Also 1 V. output 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. F.M. at frequencies above 394 kc/s. Variable mod. depth 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 x 20½ x 17½in. Weight 117 lbs. Fully tested and guaranteed. In new condition, **£65.** P. & P. 50/-.

TF885 MARCONI VIDEO OSCILLATOR. Sine wave output 25 c/s. to 5 Mc/s in 2 bands, square wave output 50 c/s to 150 c/s in 2 bands, with calibrated output meter. Power supply 100/125/200/250 V. A.C. First class condition. Fully tested, **£110.** P. & P. 45/-.

DOUBLE BEAM OSCILLOSCOPE TYPE BA. Time base 2 c/s to 750 kc/s. Bandwidth up to 5 Mc/s. Calibration markers up to 100 Kc/s and 1 Mc/s. Complete with probe, operation instructions and circuit. 100/250 V. 50 c/s. First class condition. Fully tested, **£22/10/-** P. & P. 35/-.

AVO VALVE TESTER. Will test old and modern valves. In carrying case. New condition. **£15/10/-.** P. & P. 17/6.

COLLINS T.C.S. TRANSMITTER AND RECEIVER. Freq. 1.5 to 12 Mc/s in 3 bands. V.F.O. and crystal control, 25 W. output. In good condition, in pairs, **£16.** P. & P. 30/-.

CANADIAN MARCONI C52. Freq. 1.75 Mc/s. to 16 Mc/s in 3 bands. Power ouptut 75 W. R.T. 110 W. C.W. Complete station. In new condition. 12 V. D.C. Working. Fully tested. **£50.** P. & P. 60/-.

31 SETS MK. II TRANS-RECEIVER V.H.F. 40 to 48 M.W.C. tunable. **70/-.** P. & P. 7/6.

88 SETS WALKIE TALKIES. 40-42 Mc/s. Crystal controlled. 4 channels. Modern design. **60/-.** P. & P. 7/6.

B44 V.H.F. RADIO TELEPHONE. 60 to 95 Mc/s. Built-in 12 V. D.C. power pack. **£7.** P. & P. 15/-.

No. 52 RECEIVERS, FIRST CLASS CONDITION, TESTED £8/10/-. P. & P. 17/6.

INVERTERS, LELAND AIRBORNE PRODUCTS. 28 V. D.C. input. Output 115/200-115 V. 2.2-6.5 amps. 400 c/ps. 750/750 V. A. 3/1 PH. With built-in stabilisers. **£20.** P. & P. 25/-.

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BECKMAN EXPANDED SCALE VOLTMETER. 105 to 125 V. A.C. 3½in. panel mounting. Ex-equipment. 50/-. P. & P. 6/-.

CORNELL DUBILIER RADIO NOISE FILTER. 9 amps. 0 to 1,000 cycles, 8/6 P. & P. 2/6. Also 20 amp models, **10/6.** P. & P. 2/6.

HELIPOTS V 1,000 OHM LIN. TOL. 3%, 30/-. P. & P. 2/6. Ten turn.

ELAPSED TIME INDICATORS. 9,999·9 hrs. 115 V. 60 c/s. 2.5 W. 25/-. 115 V. 380-420 c/ps. 30/-. P. & P. 3/-. Panel mounting 1¾in.

ALLIED CONTROL CO. INC. RELAYS. 4 PDT sealed contacts. 1 amp. 26.5 V. D.C. 200 ohm. Dia. 1in., L. 1¼in. Sealed. Ex. equip. 30/-. P. & P. 2/6.

6 PDT CONTACTS 5 AMP. 26.5 V. D.C. 200 ohm. 40/-. P. & P. 2/6.

ELECTRONIC SPECIALITY CO., VOLTAGE SENSOR SEALED. 3 PDT. Adjustable drop out, pick up, 24 to 50 V. 3¼in. length, 1¾in. width. 60/-. P. & P. 3/6.

CUTLER & HAMMER RELAYS, SEALED. 3 P.S.T. 100 AMP CONTACTS, 28 V. D.C. 45/-. P. & P. 5/-.

1 P.S.T. 200 AMP. CONTACTS, 28 V. D.C. 25/-. P. & P. 3/-.

1 P.S.T. 50 AMP. CONTACTS, 28 V. D.C. 20/-. P. & P. 3/-

3 P.S.T. 25 AMP. CONTACTS, 28 V. D.C. 30/-. P. & P. 3/6.

1 P.S.T. 200 AMP. CONTACTS. Also D.P.S.T. 10 amp. contacts, 28 V. D.C. 35/-. P. & P. 4/-.

All above relays will work satisfactorily on 12 volts D.C.

1 P.S.T. 50 AMP. CONTACT COIL. 115 V. A.C. 50 or 400 c.p.s., 25/-. P. & P. 3/-.

A.G.A. OF AMERICA TIME DELAY RELAY. 2 P.D.T. Range .050-10 secs. 28 V. D.C. coil. Length 4 x 1⅞ x 1⅛in. 50/-. P. & P. 3/6.

A. W. HAYDON CO., INC. Time delay relays. 4 P.D.T. We have these relays in the following times: 1-2-10-15-30-115-180-240-360-600 secs. 28 V. D.C. 2¼ x 1⅞ x 1⅛in. Price on application.

WE HAVE A SELECTION OF MINIATURE SYNCHRO, RECEIVERS, TRANSMITTERS, TORQUE CONVERTERS AND GEAR TRAINS, ETC.

VARIABLE RESISTORS, 10 ohms, 4 amps. 17/6. P. & P. 3/-.

SMITHS 8-DAY WALL CLOCKS. Jewelled escapement. Excellent timekeeper. 50/-. P. & P. 3/6.

SEND 3/6 P.O. FOR CATALOGUE

G. BURT

13 PROSPECT PLACE,
HYTHE,
NR. SOUTHAMPTON,
HAMPSHIRE.

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DISPLAYED SITUATIONS VACANT AND WANTED: £6 per single col. inch.
LINE advertisements (run-on): 7/- per line (approx. 7 words), minimum two lines.
Where an advertisement includes a box number (count as 2 words) there is an additional charge of 1/-.
SERIES DISCOUNT: 15% is allowed on orders for twelve monthly insertions provided a contract is placed in advance.
BOX NUMBERS: Replies should be addressed to the Box number in the advertisement, c/o Wireless World, Dorset House, Stamford Street, London, S.E.1.
No responsibility accepted for errors.

Advertisements accepted up to MAY 10 for the JUNE issue, subject to space being available.

SITUATIONS VACANT

TAPE recorder engineer required.—01-636 8177. [2001

TV Field Service Engineer, £1,000, London area. 5-day week.—Phone Mr. Simmons, Edgware 7291. [1997

EXPERIENCED cinema sound engineer required for service and installation, good salary and conditions.—Box WW2002, Wireless World.

GRAMPIAN REPRODUCERS, Ltd., Hanworth Trading Estate, Feltham, Middx., require senior and junior engineers for development work with audio frequency equipment.—Apply Dept. RB. [223

RADIO and tape recorder testers and trouble shooters required; canteen, excellent rates of pay, 8 a.m. to 5 p.m., 5-day week.—Elizabethan Electronics, Ltd., Crow Lane, Romford, Essex. Tel. Romford 64101. [1999

BRITISH ANTARCTIC SURVEY requires wireless operators to serve in the Antarctic; candidates must be able to transmit and receive at 20 w.p.m.; salary according to qualifications.—Applications to 30, Gillingham St., London, S.W.1. [2005

BRITISH ANTARCTIC SURVEY has vacancies for young men to operate and maintain automatic ionosonde in Antarctica; commencing salary from £864 according to qualifications.—Applications to 30, Gillingham St., London, S.W.1. [2006

WEST London Aero Club invite "A" and "B" licensed engineers with capital and/or necessary equipment to commence Radio Workshop. Alternative propositions may be considered. Write full details to—White, Waltham Airfield, near Maidenhead, Berks. [68

ELECTRONIC mechanics required by G.L.C., varied, interesting work on installation, maintenance and repair of 16mm projection equipment, P.A. systems, radio, T.V. and recording equipment; driving experience desirable; £19/11/6 for 40-hour week, plus incentive bonus.—Write, giving details of age and experience, to the Director of Mechanical and Electrical Services (Estab.), 1, Queen Anne's Gate Buildings, Dartmouth St., S.W.1. [2009

THE University of Leeds:—Technician or senior technician required for Electronics Workshop of Chemistry; it will be an advantage to have had experience in construction of electronic units; 5-day week of 37½ hours; salary in range £722 to £1,225; starting point according to experience and qualifications.—Applications in writing to Mr. S. Walker, Supervisor of Electronics Workshops, School of Chemistry, The University, Leeds, 2. [2010

NORTH-EAST Essex Technical College and School of Art, Sheepen Road, Colchester, Essex. Department of Science. Lecturer Grade I.—A graduate to teach physics to mainly O.N.C. (Sciences) and H.N.D. (Engineering) courses is required for the 1st September, 1968; applicants should preferably have some experience in teaching; salary scale: Lecturer, Grade I, £1,035-£1,735 per annum; assistance may be given towards removal expenses.—Further details and application form from the Principal to be returned within fourteen days of the advertisement. [2008

SENIOR and junior laboratory staff required for physics and electronics laboratories to take part in the construction and development of apparatus for new experiments and projects; senior technician (ref. ST. ET) to take charge of electronics teaching laboratory and be responsible for supervising and training staff; technicians or junior technicians (ref. T. ET) for physics and electronics teaching laboratories; experience in electronic circuitry and construction or vacuum techniques an advantage; salary scale (including London Allowance) senior technician £10,47-£1,335 p.a.; technician £722-£1,117 p.a.; junior technician £402-£655 p.a., depending on age, qualifications and experience; day release facilities; further details (quote reference) and application forms from the Laboratory Superintendent, Department of Physics, Chelsea College of Science and Technology, Manresa Rd., London, S.W.3. 01-352 6421. [2007

BOOKS INSTRUCTIONS, ETC.

BOUND volumes of "Wireless World," 1947 to 1964, £10 the set, buyer collects.—Please write D. J. East, 11, Empress Ave., Farnborough, Hants. [230

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

SERVICE & REPAIRS

REPAIRS.—Our modern service department equipped with the latest test equipment including a wow and flutter meter and multiplex stereo signal generator is able to repair Hi Fi and tape recording equipment to manufacturers' standard.—Telesonic Ltd., 92, Tottenham Court Rd., London, W.1. 01-636 8177. [21

FOR SALE AND WANTED ADVERTISEMENT FORM

TURN TO PAGE No. 125

ELECTRONIC DESIGN & DEVELOPMENT ENGINEERS (ALL GRADES) SALARIES UP TO £2,800 P.A.
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DRAUGHTSMEN, PRODUCTION ENGINEERS

We have over 500 registered vacancies for above types of engineers in the Home Counties and South England areas. If you have had at least 2 years' experience in British Industry and require a job which offers first class prospects, top salaries and interesting work.

Phone (any time day or night) or write to:—

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The Civil Service

Professional and Technical 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**: £800 (at 18 or under)-£1,200 (at 25 or over)-£1,790.
Salaries increased for officers serving in 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. **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)

TECHNICAL CLASS GRADE III OFFICERS AND DRAUGHTSMEN MINISTRY OF DEFENCE (NAVY DEPARTMENT)

About 30 posts for men as Technical Class Grade III Officers and Draughtsmen at Belfast, Copenacre (Wilts.), Gosport, Llangennech (Carms.), London and Perth.

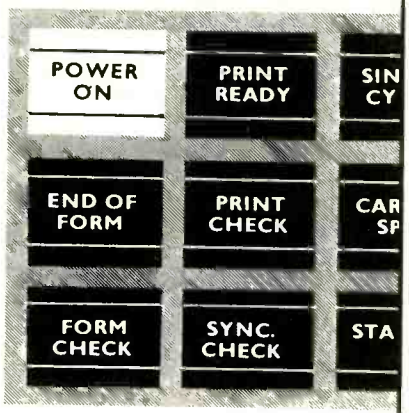
DUTIES: Problems associated with the support, maintenance and repair of naval aircraft, involving inspection, diagnostician work, rate-fixing planning, work study, preparation of repair schedules, technical administration and drawing office duties.

QUALIFICATIONS: Full apprenticeship or equivalent plus practical experience in above field(s); O.N.C. in mechanical or electrical engineering, *or* an appropriate City and Guilds Technicians Certificate, e.g., the Mechanical Engineering Technicians Part II (Advanced) Certificate (No. 293), the Electrical Technicians Final Certificate (No. 57), or the Telecommunications Technicians Final Certificate (No. 49), *or* equivalent or higher qualification.

SALARY (national): Technical Class Grade III £895 (at age 21)-£1,040 (at 25)-£1,149 (at 28 or over)-£1,283. Draughtsman £776 (at age 21)-£1,030 (at 25)-£1,154 (at 28 or over)-£1,263. Salaries somewhat higher in London. Promotion prospects. Non-contributory pension.
(Reference: S/6896/68.) Closing date 3rd May, 1968.

APPLICATION FORMS are obtainable from the Secretary, Civil Service Commission, Savile Row, London, W.1. Please quote appropriate reference.

Engineers



IBM will train you for a career in data processing

To become a successful IBM Data Processing Customer Engineer you need more than engineering qualifications. You need to be able to talk confidently and well to any level of customer management and to have a pleasing personality in your work. As a DPCE, you work in direct contact with your customers, on some of the world's most advanced data processing equipment.

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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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You need five GCE 'O' levels, an aptitude for mechanics, a good understanding of electrics, a clear logical mind, and the ability to get on well with people.

Send details of training, experience and age to Mr D. J. Dennis, IBM United Kingdom Limited, 389 Chiswick High Road, London W4. Quote reference E/WW/381.

IBM

TELECOMMUNICATIONS

We have vacancies for Fault Finders, Testers, and Inspectors to work on interesting and advanced equipment including H.F. SINGLE SIDEBAND, V.H.F. RADIO TELEPHONES, U.H.F. MINIATURE EQUIPMENT.

Transistor experience is essential. Vacancies exist at all levels and training will be given where necessary.

Apply: **Personnel Manager, CAMBRIDGE WORKS LTD., Haig Road, Cambridge.**

MISCELLANEOUS

METALWORK, all types cabinets, chassis, racks, etc., to your own specification, capacity available for small milling and capstan work up to 1in bar. PHILPOTT'S METALWORKS, Ltd., Chapman St., Loughborough. [17

ARTICLES FOR SALE

JR60, TR10, C/R, £21/10; evenings.—8, Sunridge Ave., Welling, Kent. [221

SERVICE sheets, radio, T/V, etc.; 550 £10, clean.—Tel.: 01-590 0479. [226

400 speakers, 5in, 8 ohm, ex stock.—Box WW2000, Wireless World.

VACUUM pumps, gauges, etc, recorders, general scientific and laboratory equipment, catalogue.—V. N. Barrett & Co., Ltd., 01-654 6470. [69

AVO Valve Characteristic Meter Mk. IV, as new; £75. Solatron 'Scope CD1014.3 double beam portable; £65. Reasonable offers considered.—Box W.W. 231., Wireless World.

THE LIVERPOOL CLINIC
MYRTLE STREET, LIVERPOOL 7.

Applications are invited for the post of Medical Physics Technician in the Department of Nuclear Medicine. Person appointed will be required to maintain nucleonic and electronic equipment and would be expected to assist in the design and building of new equipment and modification of existing apparatus. Duties are principally in the Liverpool Clinic, but at times extend to other hospitals in the region.

The possession of a Higher National Certificate or equivalent is desirable. Grade II to V according to qualifications and experience. Salary range according to grade. Grade V £711 to £1,004; Grade IV £850 to £1,050; Grade III £980 to £1,300; Grade II £1,250 to £1,591. Application forms and Job Description from the Hospital Secretary to be returned by 22nd April, 1968. (3090)

NEWCASTLE GENERAL HOSPITAL
(1060 beds)

TWO MEDICAL PHYSICS TECHNICIANS GRADE III (specialising in electronics) required for the Regional Neurological Centre to work in electronics laboratory on design and development of apparatus concerned with neurology and neurosurgery. There is considerable scope for initiative and the successful candidates will be expected to hold H.N.C. qualification, although consideration will be given to those with O.N.C. and experience in a similar field.

Whitley Council conditions of service. Salary scale £980-£1,300.

Applications, with names and addresses of two referees, to Hospital Secretary, Newcastle General Hospital, Newcastle upon Tyne NE4 6BE, within two weeks.

Government of KENYA
REQUIRES
ASSISTANT TELECOMMUNICATIONS ENGINEERS

for the Police Department, on contract for one tour of 24 months in the first instance. Commencing basic salary according to experience in scale Kenya Shillings 21,000 rising to K. Shgs. 27,780 a year (£Stg. 1225-£Stg. 1620) liable to Kenya Income Tax. In addition an allowance, normally tax free, ranging from £Stg. 720 to £Stg 816 a year will be paid by the British Government direct to an officer's bank account in the United Kingdom. Gratuity 25% of total salary drawn or 45% if no overseas terminal leave taken. Free passages. Accommodation provided at moderate rental. Generous education allowances. Outfit allowance. Contributory pension scheme available in certain circumstances.

Candidates, up to 50 years of age, must have served an approved apprenticeship and possess the City and Guilds Telecommunications Technician's Certificate or equivalent. They must have had at least five years' experience in Telecommunications engineering including considerable practical experience with fixed, mobile and portable Telecommunications equipment operating in the H.F. (including S.S.B. and I.S.B.) and V.H.F. (AM and FM) bands and associated aerial and mast installation plus a knowledge of transistorized and modern equipment. A knowledge of V.F. Multiplex equipment is essential and experience in Radio Teleprinter equipment would be an advantage.

Apply to CROWN AGENTS, M. Dept., 4 Millbank, London, S.W.1., for application form and further particulars, stating name, age, brief details of qualifications and experience, and quoting reference M3B/61095/WF

SYSTEMS ASSISTANT

required by a leading glass container manufacturer to maintain and install measurement and control systems. Applicants should have O.N.C. Electrical or C. & G. Electrical Installation work course (C) and be familiar with the principles of temperature, pressure flow, measurement and automatic control devices. A knowledge of fuel control elements, circuit diagrams, electro pneumatic circuiting would be desirable.

Rockware Glass Ltd. is an expanding company in the glass container field and offers a competitive salary for this post as well as a generous non-contributory pension and Life Assurance scheme.

Applications, in writing to

Personnel Officer,

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An English Electric Company

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Britain's leading growth Company in the field of Microwave Measurement is creating a new position which will involve producing technical data sheets, laying out advertising, co-ordinating and writing press releases and other duties normally associated with Publicity. Also involved will be the writing of instruction manuals for our wide range of Microwave Instruments.

To be able to bring the necessary technical background to the work it is likely that the suitable candidate would have, at the least, an O.N.C. (Electrical) or equivalent.

To apply send a brief outline of career to date to the Directorate of Personnel (WW2792.A), The English Electric Company Limited, Strand, London, W.C.2, or telephone Mr. M. G. Amos, Personnel Manager, on Stevenage 2311.

Design Draughtsman

Pye Telecommunications offer outstanding opportunities for senior design draughtsmen in the expanding field of radio communications.

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to assist in the design, construction and maintenance of electronic equipment used in psychological research.

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TECHNICIANS

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Applications are invited from appropriately qualified engineers with experience in television broadcasting, sound and vision. We would also like to hear from engineers qualified to H.N.C. level in electronics with experience in allied fields, e.g. manufacturing, servicing and installation. Colour experience would be an advantage.

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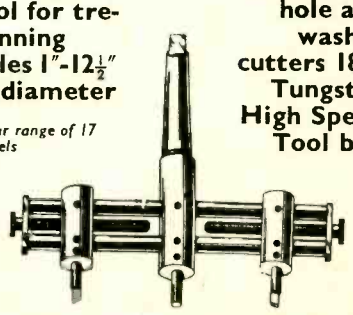

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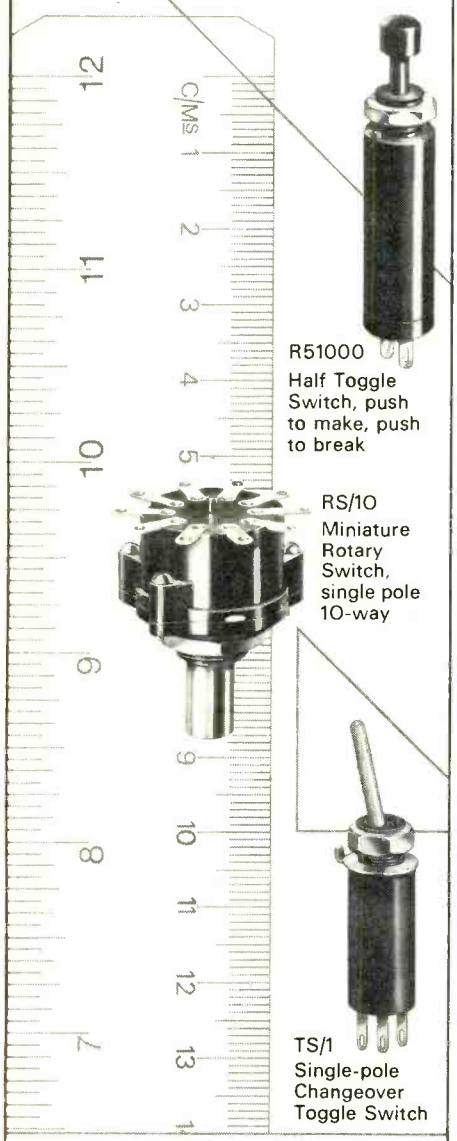

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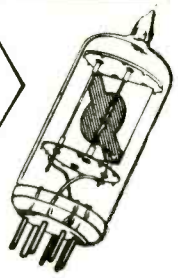

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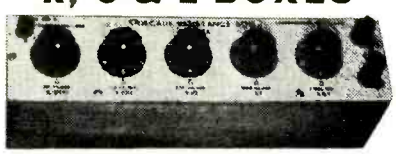

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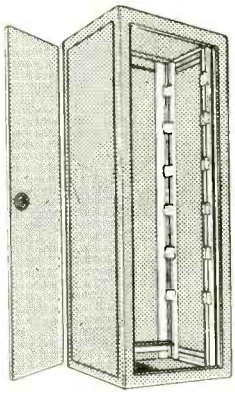

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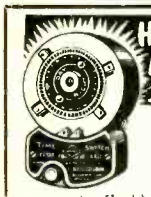

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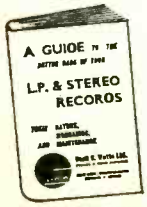

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2N1305 Rca	4/6 ea.	V30/201P New	4/6 ea.
MA393	3/6 ea.	V60/10P New	4/- ea.

VALVES

2D21	3/6 ea.	CV286	3/6 ea.
6AK5	3/- ea.	CV287	5/6 ea.
6BR7	6/- ea.	CV345	10/- ea.
6CH6	3/6 ea.	CV422	7/6 ea.
6SN7	2/6 ea.	CV448	4/6 ea.
12SN7/B36	2/- ea.	CV858	2/6 ea.
DL92/94	3/- ea.	CV2235	7/6 ea.
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R17	5/6 ea.	CV4014	2/6 ea.
R19	6/6 ea.	CV4024	3/- ea.
		CV4064	12/6 ea.

BROOKS CRYSTALS 500 kc/s 2, 5, 10 mc/s, **10/-** ea.

RELAYS

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3000 Series 5 k/ohms, 2 pole make HD contacts, **3/6** ea. 3000 Series 1,000 ohms, all multi bank, state min. requirement. **2/-** ea.

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Siemens miniature with dust cover, 6 pole make or brake, 1,250 ohms. Brand new, boxed, **4/6** ea. American miniature 4 pole co 12/24V 200 ohms, sealed **5/6** ea.

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BELLING & LEE 10 pin enclosed plug/open socket, **4/6** pair.

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- **Press Day 10 May for June 1968 issue.**

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			REMITTANCE VALUE.....		ENCLOSED

Please write in block letters with ball pen or pencil.

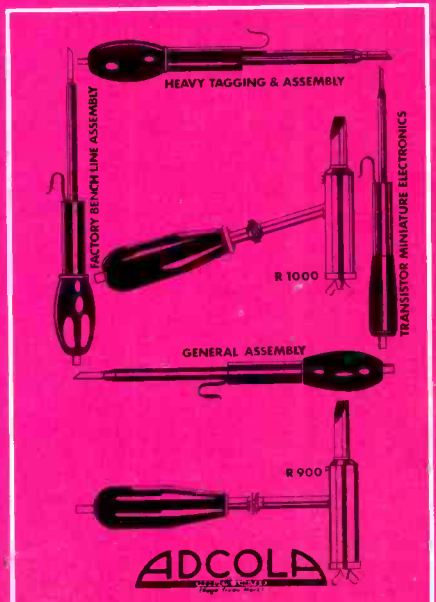
NUMBER OF INSERTIONS.....

INDEX TO ADVERTISERS

Appointments Vacant Advertisements appear on pages 111-118

Printed in Great Britain by Southwark Offset, 25 Lavington Street, London, S.E.1, and Published by the Proprietors, ILIFFE TECHNICAL PUBLICATIONS LTD., Dorset House, Stamford St., London, S.E.1, telephone 01-928 3333. *Wireless World* can be obtained abroad from the following: AUSTRALIA and NEW ZEALAND: Gordon & Gotch, Ltd. INDIA: A. H. Wheeler & Co. CANADA: The Wm. Dawson Subscription Service, Ltd.: Gordon & Gotch Ltd. SOUTH AFRICA: Central News Agency, Ltd.: William Dawson & Sons (S.A.) Ltd. UNITED STATES: Eastern News Co., 306 West 11th Street, New York 14.

wouldn't you be hopping mad with all those hands and 3,400 years to wait for Adcola?



Adcola soldering equipment covers the most comprehensive range of modern soldering equipment in the world. Impeccable quality and technical efficiency are features in all Adcola precision tools. The unique design of the heating element allows for any voltage range 6/7v and 230/250v supplies and temperature from 250°C to 410°C. Instruments operating at special high temperatures can be supplied on request. Replacements of every description are always available and easily fitted. Should you require it our Service Department is always at your disposal. Minimum of delay.

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14	.080	2.032	65.7	60.8
16	.064	1.626	102	96.2
18	.048	1.219	182	170
19	.040	1.016	262	244
20	.036	.914	324	307
22	.028	.711	536	508
24	.022	.558	865	856
26	.018	.46	1292	1279
28	.014	.375	1911	1892
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34	.009	.233	4950	4895

STANDARD ALLOYS INCLUDE

TIN/LEAD	B.S. GRADE	LIQUIDUS MELTING TEMP °C.	LIQUIDUS MELTING TEMP °F.
60/40	K	188	370
Savbit No 1	—	215	419
50/50	F	212	414
45/55	R	215	419
40/60	G	234	453
30/70	J	255	491
20/80	V	275	527

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L.M.P.	Contains 2% Silver for soldering silver coated surfaces	179	354
P.T.	Made from Pure Tin for use when a lead free solder is essential	232	450
H.M.P	High melting point solder to B.S. Grade 5S	296-301	565-574

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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.

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

wire stripper and cutter

model 8

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

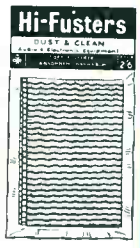
recording tape splicer

model 20

Precision made, chrome plated complete with razor cutter. Provides quick and accurate tape editing. Standard model for ¼" tape. **model 21** NEW ½" type is available for computer and video tape.

B

hi-fusters—size L pack of 2



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C

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D

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