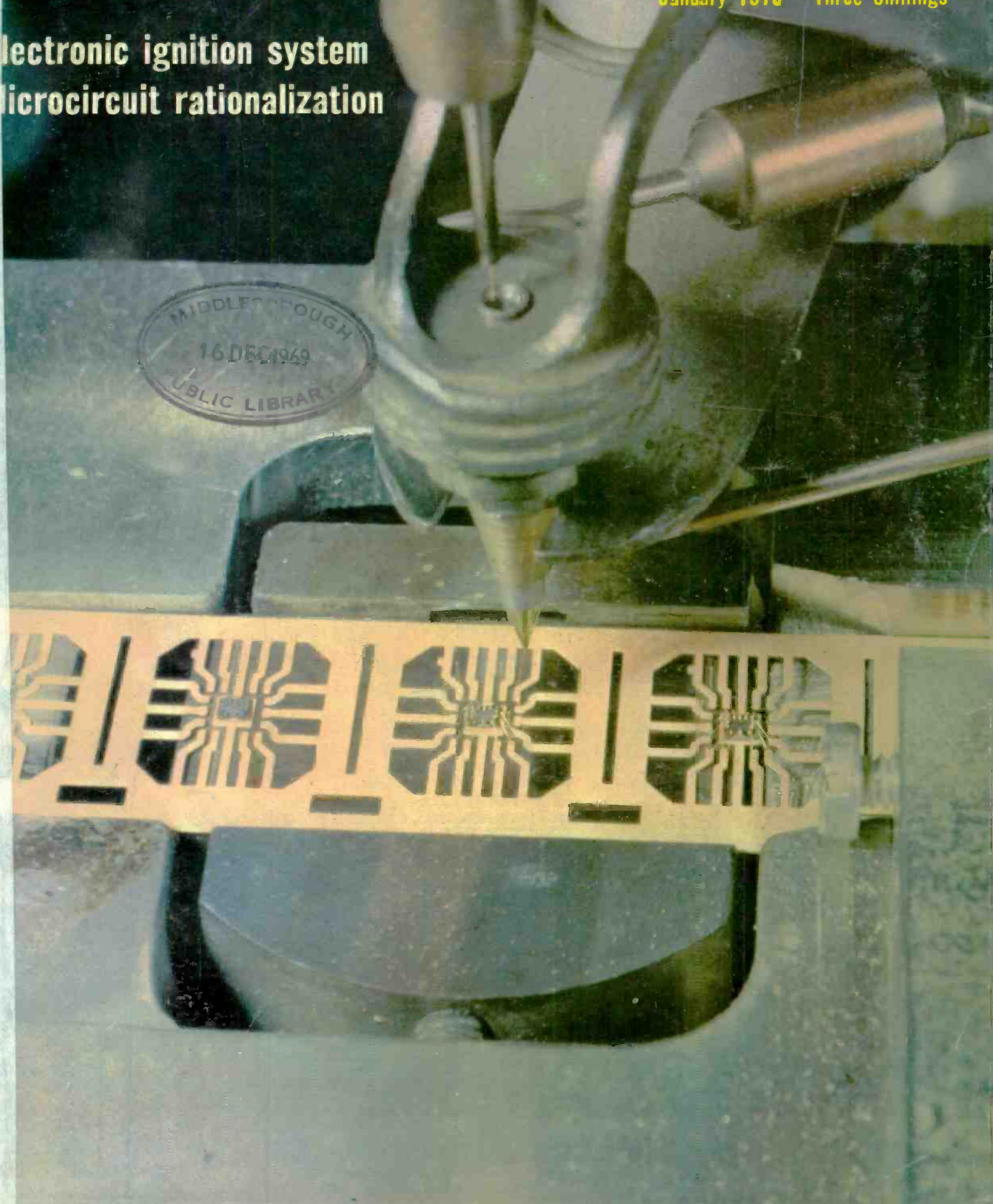
Wireless World

January 1970 Three Shillings

Electronic ignition system
Microcircuit rationalization



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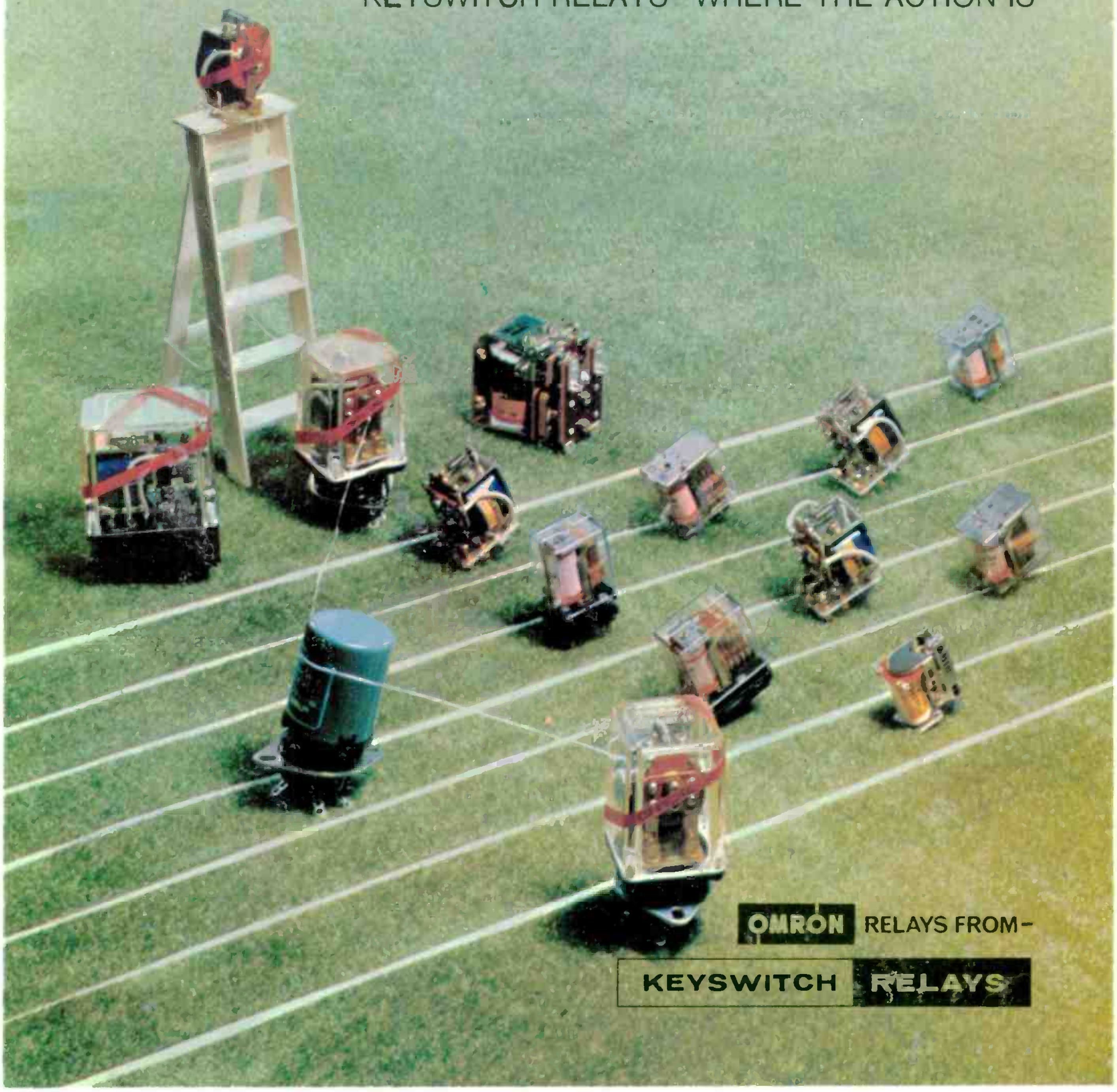

WW—001 FOR FURTHER DETAILS

Wireless World

Electronics, Television, Radio, Audio

Fifty-ninth year of publication **January 1970** **Volume 77 Number 1411**

The macrophotograph on **this month's cover** shows wires being bonded on to integrated circuits at the Mullard Southampton works. On page 6 the future of linear i.cs is discussed.

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Wireless World

"Explosion in communications"

This was the expression used by Mr. Stonehouse, Minister of Posts and Telecommunications, when he announced in the House of Commons that he was considering setting up an independent enquiry into the long-term future of broadcasting in the U.K. He referred to the need to examine the implications of new technologies, e.g. the possibility of 100 or more communication channels going into every home in Britain via a single wire or microwave link, "which would bring about an explosion in telecommunications".

One's immediate reaction to the proposed broadcasting enquiry is "what, another one!" It will be recalled that very few of the recommendations in the Pilkington report of 1962 were implemented and over the years there have been many proposals made by the various committees of enquiry or commissions which, maybe because they were too sweeping, have been turned down. It would, however, appear from the Minister's latest statement that if the proposed committee is set up it will be asked to look at the long-term future of internal telecommunications generally and not just broadcasting. If so, this is going to be a gargantuan task calling for technological forecasting. Incidentally, Professor W. H. G. Armytage, of the University of Sheffield, speaking recently to members of the Institution of Mechanical Engineers, said it now seems that "technological forecasting is, like weather forecasting, very respectable". He pointed out, however, that technological forecasting must not be confused with "the inspired doodling that has characterized science and engineering through its history . . . nor the intuitive forecasts that enabled writers like . . . Hugo Gernsback to predict radar or Arthur C. Clarke to predict the earth satellite". Professor Armytage defined it as "the application of scientific method—or objective, almost clinical method—to the analysis and forecasting of technological change".

Bearing this in mind the proposed committee could produce a really far-seeing forecast of telecommunications into the '80s and beyond; but the members will need to be supermen or they will find themselves bogged down by tradition and vested interests.

What are the prospects? The idea of a super telecommunications grid covering the whole country has frequently been suggested and with the growing use of telemetry and control systems, as evidenced by a contribution in this issue, it is fast becoming a necessity.

Such a super grid will be an amalgam of radio and cable techniques. Despite our title we are not so bigoted as to be blind to the potentialities of cable for distribution networks. It is, however, worth recalling that in the early days of this journal there was a fierce war waged between cable and wireless (apocryphal stories are told of the sabotage of cable systems in order to show that wireless was inviolable!) but a marriage was arranged. It is, of course, true to say that without radio devices (amplifiers, repeaters, and the like) the present cable networks could not have materialized.

We do not intend to gaze into our crystal ball, engage in inspired doodling or make intuitive forecasts, but the future for the electronics and radio engineers is certainly exciting.

Capacitor-discharge Ignition System

An electronic ignition system, suitable for any car, which offers a large number of advantages over conventional ignition

by R. M. Marston

When this unit is wired up to a car's existing ignition system it greatly improves the shape of the ignition voltage waveforms, and enables a more stable flame-front to be generated in the engine's cylinders. Better combustion is thus obtained, and engine performance is considerably improved.

The unit, which is known as a capacitor-discharge ignition system, confers an impressive list of benefits in terms of engine performance. It gives easy starting, even under sub-zero conditions, and also gives immunity to performance deterioration due to contact-breaker bounce. In addition it gives quicker engine warm-up, improved acceleration, better high-speed performance, and improved fuel economy (2 – 5%). Even more important, it virtually eliminates contact-breaker point burning and wear, gives greatly improved spark-plug life (typically 3 to 5 times longer than in conventional ignition systems), and overcomes the need to adjust contact-breaker and spark-plug gaps with precision.

The ignition unit can be added to any car fitted with a conventional 12-V coil ignition system irrespective of the number of engine cylinders.

Fig. 1 shows the circuit of a conventional, or inductive-discharge ignition system. The contact-breaker (c.b.) points are opened and closed by an engine-driven cam. When the points are closed, current from the battery builds up in the coil primary, to a maximum value of about 4.5A exponentially, with a time constant of L/R seconds, typical time constants are between 2 and 10ms. As the current builds up, it stores an energy 'packet' of $(L.I^2)/2$ joules, or watt-seconds, in the coil primary.

When the points open, the primary current collapses rapidly via C_1, and induces a peak potential of about 300V across the coil primary; this voltage is increased to about 30kV at the secondary winding, and this energy is transferred to the spark-plugs by the vehicles distributor. C_1 and the coil form a resonant circuit when the points are open, and the secondary voltage takes about 125μs to build up to its peak value.

Fig. 2 shows typical inductive discharge ignition performance characteristics and ignition requirements at different engine speeds; the early part of the graph, up to about 100 r.p.m., indicates typical sub-zero starting conditions, when battery voltage falls to about 10 V, compared to a normal value of 13.5 V when under dynamo charge. Note that the system operates with very little safety margin under cold-start conditions, and that the available secondary energy becomes inadequate when engine speeds reach 5,900 r.p.m., so that misfiring starts to occur above this speed.

Finally, the relatively long secondary voltage rise times of the inductive system (typically about 125μs) make the ignition system very vulnerable to high energy losses due to fouling of the spark-plug gaps by carbon and oil deposits. These deposits act as a resistance (typically about 2M Ω in cases of bad fouling) across the points. These deposits inevitably absorb some of the applied energy (power-time), and total energy absorption increases in proportion to voltage rise time and fouling resistance.

Capacitor-discharge ignition systems, on the other hand, suffer from hardly any of the snags outlined above. Fig. 3 shows the block diagram of the particular ignition system described here. A self-regulating voltage converter is used to charge storage capacitor C_1 to 400 V, almost irrespective of actual battery potential. When fully charged, this capacitor stores 0.08 joule.

When the c.b. is closed, zero input is applied to the pulse shaper, and the thyristor is off; a standing current of about 250mA is passed through the c.b. via R_1 under this condition, to keep the points 'clean'. The converter is operating, and charges C_1 to 400 V; the capacitor has a charging time constant of about 1.6ms.

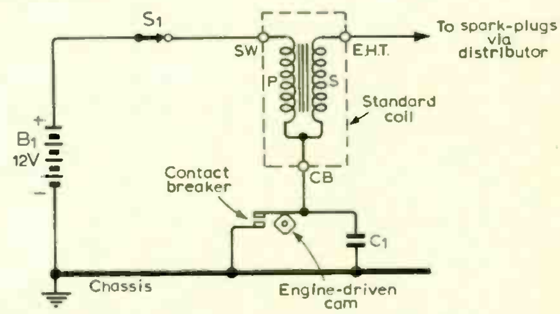


Fig. 1. Circuit of a conventional inductive discharge ignition system.

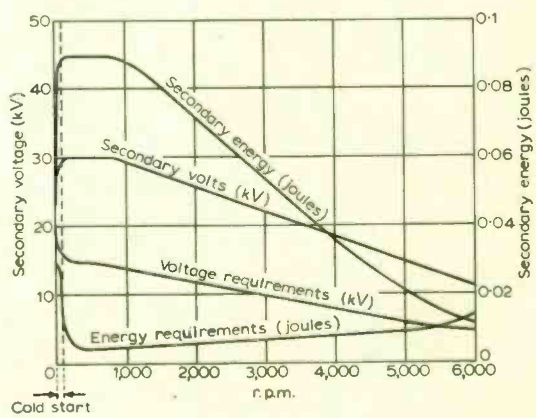


Fig. 2. Typical performance of the circuit of Fig. 1 together with engine energy requirements. The curves assume that battery voltage is normally 13.5V falling to 10V at cold start.

When the c.b. points first open, the pulse shaper operates and turns the thyristor on in about 2μs. This short circuits the output of the converter, and turns it off. Simultaneously, one side of C_1 is connected to ground and discharges rapidly into the primary of the coil; the coil steps the resulting primary voltage up to about 40kV, and the stored energy of C_1 is transferred to the spark-plugs. The secondary voltage has a rise time of only a few microseconds. C_1 and the coil form a resonant circuit when the thyristor is on, and have a typical resonant frequency of 1600Hz, giving a period of roughly 600μs. At the instant the thyristor fires, the coil's primary voltage rises (in about 2μs) to 400 V, but 300μs later the voltage falls to zero as the circuit oscillates and the thyristor turns off, preventing further oscillation. Once this happens the voltage converter re-starts and begins to re-charge C_1, even though the c.b. points may still be open. The process is repeated when the c.b. opens initially again. Note that the primary coil voltage is isolated from the vehicle's c.b. terminals, which are thus subjected only to the moderately low voltages and currents.

Fig. 4 (a) shows the actual spark voltage performance of the prototype system at different engine speeds, when fitted to different types of engine, together with worst-case ignition voltage requirements, and Fig. 4 (b) shows the system's energy generating performance. Note that both the available voltage and energy are well in excess of engine needs under all operating conditions.

The full circuit of the negative ground version of the ignition system is shown in Fig. 5. C_1a and C_1b form the 1μF energy storage capacitor. Tr_1-Tr_2, T_1 and the D_3-D_6 bridge form the self-regulating voltage converter. Tr_3 and its associated network form the bounce-suppressing pulse shaper, which fires the thyristor via C_3.

The voltage converter section operates as follows: Tr_1, and Tr_2 are an astable multivibrator which uses the halves of the centre-tapped primary of T_1 as collector loads and which generates a series of 24 V (approximately) square waves at each collector, at a frequency of roughly 50Hz. The inductive nature of T_1 causes the early part of each square wave to shoot above the normal flat top; R_{11}-R_{12} and zener diodes ZD_1 and ZD_2 are used to limit this overshoot to 28 V peak. T_1 steps the square waves up to 400 V peak at the secondary winding. This voltage is then converted to d.c. via the D_3-D_6 bridge rectifier, and used to charge C_1. It is this overshoot regulation that gives the ignition system its good cold-starting characteristics. R_6 gives the circuit a degree of protection in the event of the battery voltage (under dynamo charge) rising above 15 V, and at the same time reduces the C_1 voltage at high engine speeds.

It should be noted that, although the converter oscillates at a natural frequency of only 50Hz, it is in fact capable of giving good spark generation at c.b. frequencies in excess of 660Hz, i.e., above 20,000 r.p.m. in a four-cylinder, and above 10,000 r.p.m. in an eight-cylinder engine.

At the moment that the c.b. points first open in each ignition cycle the thyristor is triggered, so Tr_1 and Tr_2 stop oscillating; 300μs later, the thyristor then turns off, so the multivibrator starts oscillating again. The start of the first half cycle of each converter operation is thus synchronized by the c.b. At c.b. frequencies above about 100Hz, therefore, the converter starts into a half cycle each time the thyristor turns off, but the half cycle is ended prematurely when the thyristor goes on again as the c.b. opens.

The operating frequency of the converter thus synchronizes automatically to half that of the c.b. under this condition. Only a fraction of one natural half cycle is needed to charge C_1 to a useful value, so good sparks are generated up to very high engine speeds.

The c.b. bounce-suppressing and pulse shaping section of the unit operates as follows: When the c.b. points are closed, a standing current of about 250mA is passed through

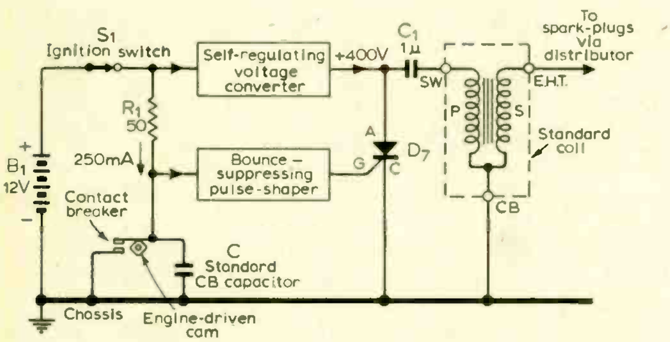


Fig. 3. Block diagram of the capacitive discharge ignition system described in the article.

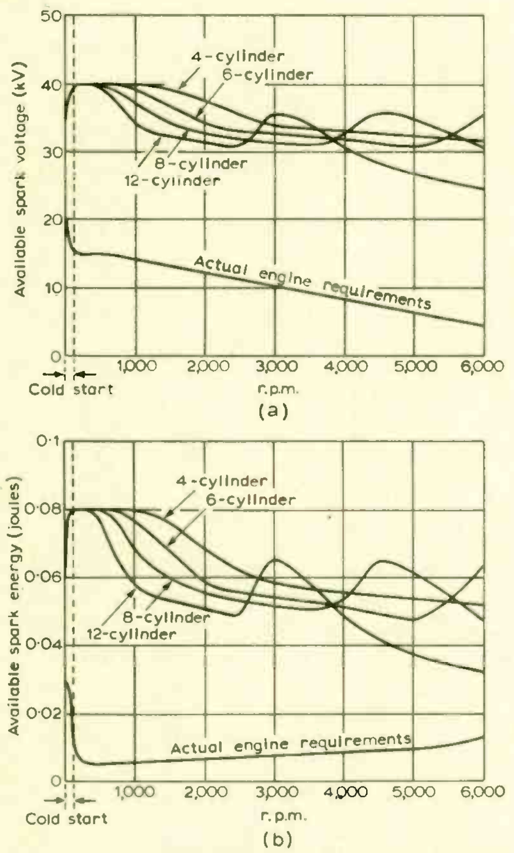


Fig. 4. Curves showing the measure performance of the capacitive discharge ignition system with the same battery voltage conditions as Fig. 2.

COMPONENTS LIST

Resistors

In the list below the prefix *R* and the suffix Ω have been omitted for clarity.

1—50*	4—470	7—270†	10—220
2—68k	5—3.3M	8—270†	11—100
3—1k	6—1*	9—220	12—100

*5-watt wire-wound
†2-watt
remainder all 0.5 watt

Capacitors

C_1a and C_1b—0.5μF. 600V working, paper or Mylar.
C_2—0.02 μF. 50V working, Mylar.
C_3—0.22μF. 50V working, Mylar.

Semi-conductors

		positive earth	negative earth
Tr_1	—	2N3055	2N3055
Tr_2	—	2N3055	2N3055
Tr_3	—	2N3702	2N3704
D_1	—	1N4001	1N4001
D_2	—	1N4001	—
D_3—D_6	—	1N4005	1N4005
D_7	—	2N3525	2N3525
ZD_1—ZD_2	—	27V, 5%, 400mW zener diodes.	

Transformer T_1

Modified l.t. or battery charger transformer rated at least 30VA. A 240V primary, 17V secondary, 2A tranformer is suitable when modified as per text.

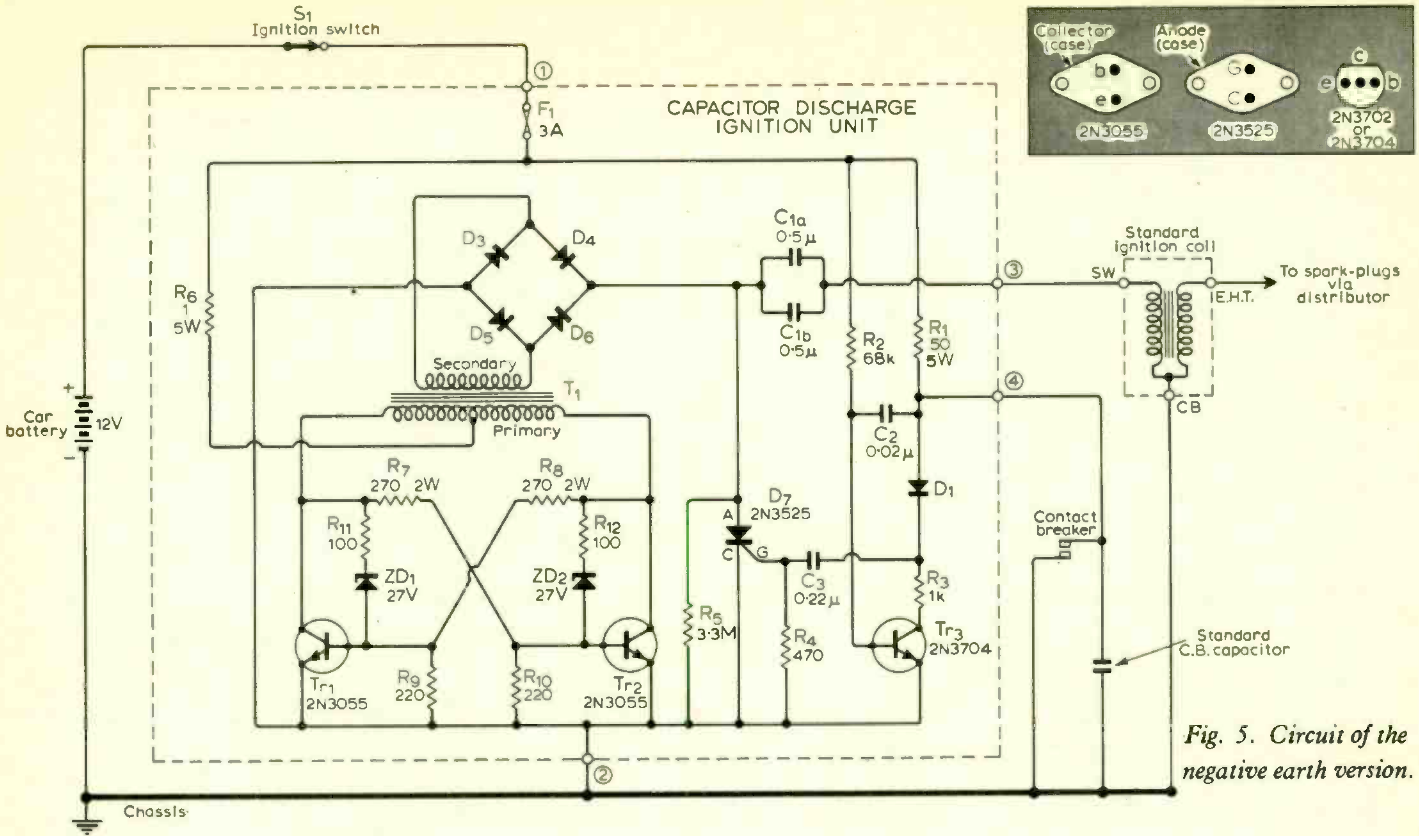
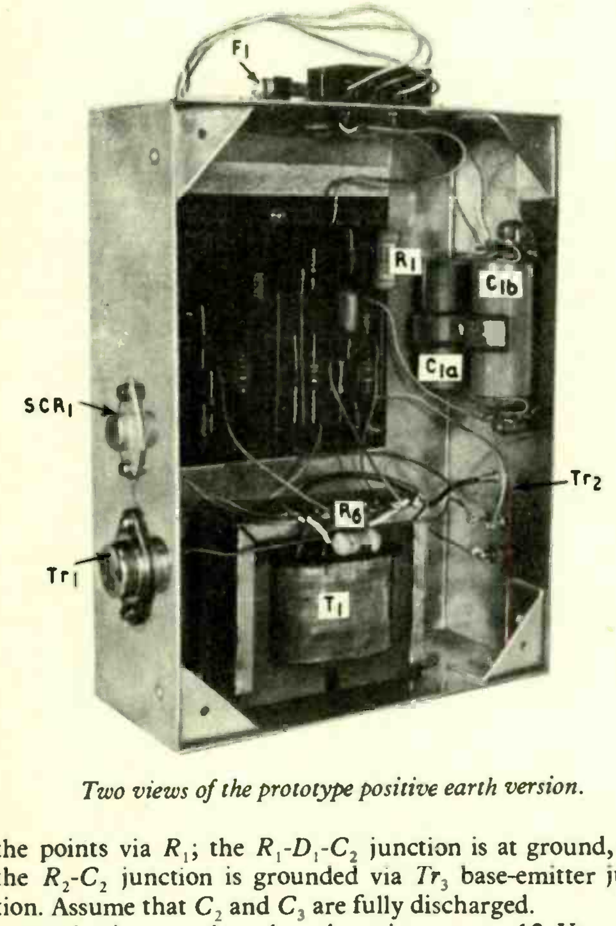


Fig. 5. Circuit of the negative earth version.



Two views of the prototype positive earth version.

the points via R_1; the R_1-D_1-C_2 junction is at ground, and the R_2-C_2 junction is grounded via Tr_3 base-emitter junction. Assume that C_2 and C_3 are fully discharged.

At the instant that the c.b. points open, 12 V appear across the points, and C_3 charges rapidly via R_1-D_1 and the thyristor gate which turns on. Simultaneously, C_2 charges rapidly via R_1 and Tr_3 base so that Tr_3 turns on.

At the instant that the points close again, the R_1-D_1-C_2 junction once more drops to ground volts; C_3 is still fully charged, however, and remains so, since D_1 is reverse biased under this condition; C_2 is also fully charged, but, since its R_1-D_1 side has been pulled down to ground volts, it drives Tr_3 base sharply negative, so Tr_3 is cut off. C_3 thus has no discharge path at this stage, and retains full charge. Consequently, should the points bounce open again at this stage (point bounce only occurs within the first two or three hundred micro-seconds of initial point closure), the thyristor will not be triggered back on again. Now, as soon as the points close, the C_2 charge starts to leak away via R_2, and eventually, after about 600μs, the charge falls to near-zero and Tr_3 is biased on via R_2. Once it is turned on, Tr_3 provides a discharge path for C_3 via its collector and R_3 and R_4; C_3 then discharges rapidly, with a time constant of about 35μs. At the end of this period, C_2 and C_3 are once more fully discharged, and the thyristor is ready to be triggered on again.

Thus, the thyristor is triggered on as soon as the points open, but can not be operated again until the points open again after being fully closed for at least 600μs. The thyristor is thus immune to false triggering by c.b. point bounce.

The positive ground version of the ignition system is shown in Fig. 6. This is similar to that described above, except that a few circuit polarities are changed and the thyristor is triggered on with a negative pulse applied to its cathode via D_2.

The only problem involved in the construction of the unit is that of finding transformer T_1. This is an iron-cored unit with a turns ratio of 15:1 at a power rating of 30VA or greater, and with a centre-tapped low-voltage winding. The easiest way to obtain this unit is to re-wind an existing l.t. or battery-charger transformer. The winding procedure is very simple, and the following is an account of that used on the prototype:—

The transformer is required, before modification, to have a basic turns ratio of 15:1 or less. Any l.t. or battery-charger transformer that meets this and the 30VA power requirement can thus be used. The prototype unit started life as a 240 V:17 V, 2 A battery-charger transformer, and thus satisfied the above specification. Once selected, the low-voltage winding of the unit must be re-wound and centre-tapped to give an exact 15:1 ratio, i.e., a ratio of 240 V:16 V

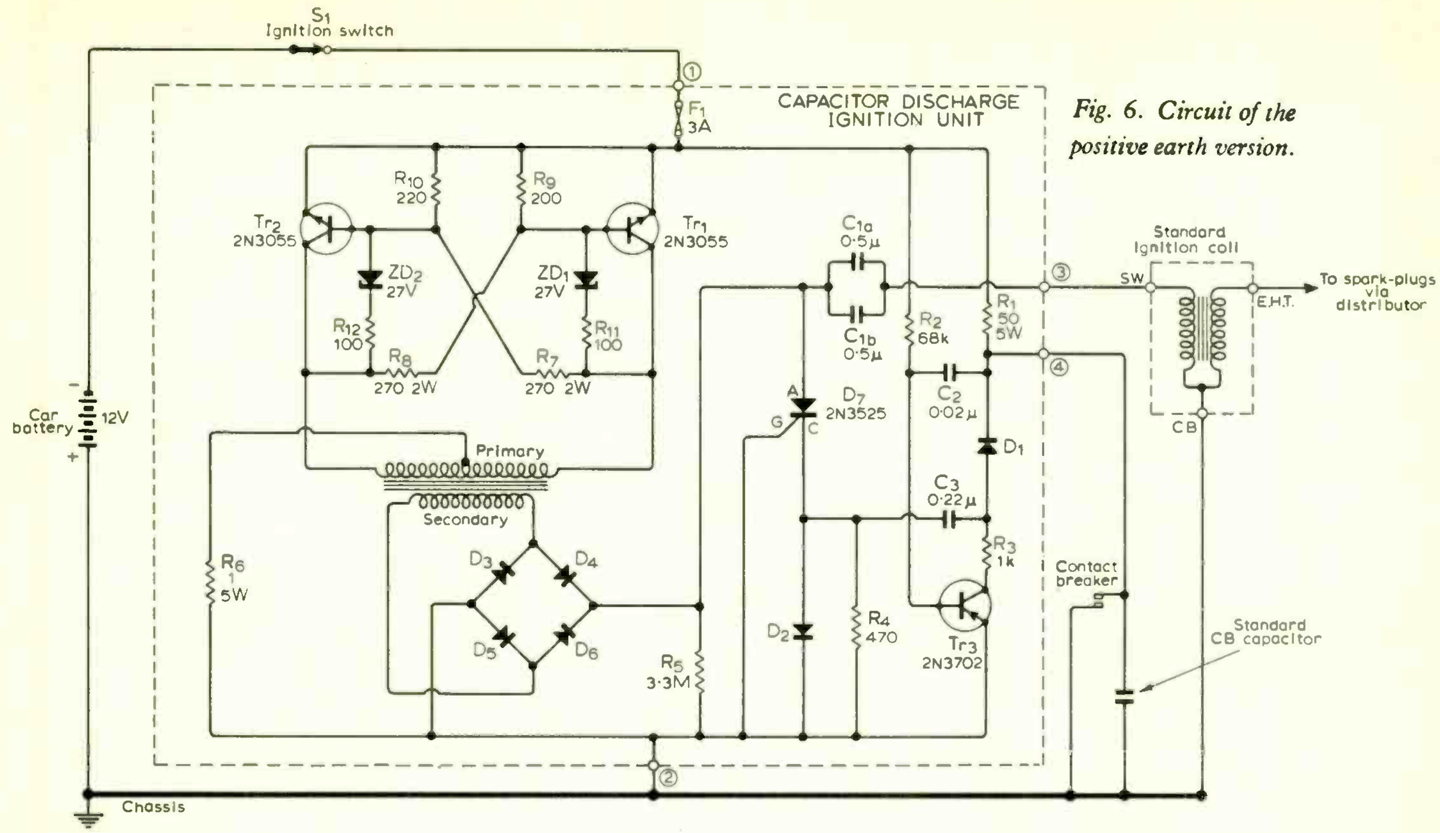


Fig. 6. Circuit of the positive earth version.

in this particular case.

To rewind the transformer, remove its securing clamp and dismantle its iron core laminations (making note of their method of assembly), and then remove the coil bobbin. Next, unwind the entire low-voltage winding (which is invariably the outer winding on the bobbin), and carefully note the total number of turns used; now divide the number of turns by the original value of l.t. voltage, to give the transformers basic turns-per-volt value. On the prototype, total turns were 134, and the original voltage was 17, giving a turns-per-volt value of 7.9. Now calculate the l.t. voltage needed to satisfy the 15:1 final turns ratio of the transformer (16 V in this case) and multiply by the turns-per-volt value (7.9) to give the total number of turns to be rewound (128); now re-wind this number of turns on the bobbin to form the primary of the ignition unit transformer, taking care to make a tap at the half way mark. Finally, re-assemble the core laminations and re-fit the transformer clamp; the transformer is then complete and ready for use. The original mains primary is now of course the secondary of the new transformer.

Construction of the rest of the unit should present no problems, and it can be wired-up direct from the circuit diagram. The prototype positive ground version of the unit (see photographs) is mounted in an 8 × 6 × 2½-in metal box; the two power transistors (Tr_1 and Tr_2) and the thyristor are mounted, via insulating washers, to the box surface (which acts as a heat sink); most of the remaining components are mounted on a piece of Veroboard Panel; external connections to the unit are made via a 4-way terminal block.

When construction is complete, give the unit a simple functional check by connecting terminal ② to chassis and terminal ① to the 'hot' side of the car's battery; a "humming" noise should now come from the unit, indicating that the converter section is operating, and total current consumption should be roughly 800mA; approximately 400 V should be available between the anode and cathode of the thyristor when tested with a 20,000 Ω/volt meter. If this test is satisfactory, the unit can now be fitted to the car.

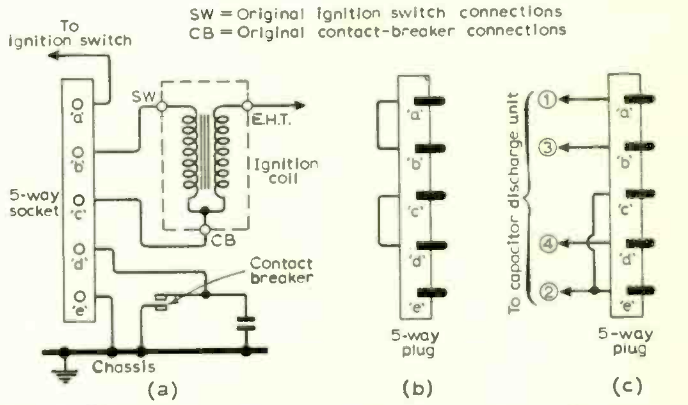


Fig. 7. Plug and socket connections required for fitting the unit to a vehicle. Unplugging the plug (c) and inserting the plug (b) into socket (a) changes from conventional to capacitive discharge ignition system.

The complete unit can be either mounted in the glove compartment (as in the case of the prototype), or can be fixed to the rear fire-wall of the engine compartment (but not close to the exhaust system). The unit can be either wired directly to the existing coil and c.b. assembly, or, preferably, can be wired to these components via a 5-way plug and sockets (Fig. 7), in which case the driver can change from conventional to capacitor discharge ignition by simply fitting an alternative plug into the socket.

Once wiring is complete, turn on the ignition, operate the starter, and check that the system functions well under actual driving conditions; there is no need to re-adjust c.b. or spark-plug gaps, etc.

Results vary from one car to another, but improvements are particularly evident in cars that have covered a considerable mileage since their last tune-up.

Finally, once the unit has been found to perform satisfactorily over a reasonable mileage, it is recommended that the entire circuit be covered with an electrically insulating coat of water-proof paint or varnish, to exclude the harmful effects of moisture. The unit can then be expected to operate correctly for the life of the vehicle.

The Future of Linear I.C.s

A few simple integrated circuits, with guaranteed long-term availability, could meet nearly all the needs of the industrial manufacturer

*by R. Hirst**

Linear integrated circuit packages have been available for a relatively short period in Britain. By virtue of the techniques employed and the expense incurred in developing and manufacturing monolithic circuitry reasonably large production quantities are required to make the selling price compatible with circuits manufactured from discrete components. This fact in itself restricts the market to which the initial product may be tendered as the industrial design engineer, with a relatively small piece-part requirement, is unable to incorporate devices that are essentially made for the domestic sphere. While the majority of linear integrated circuits will meet industrial requirements, it is the fear of an abrupt cessation in supply at the end of two or three years, due to the biennial change in the requirements of the mass radio and television market, that causes the main concern to the long-term industrial user.

Linear integrated circuit manufacturers seem unable to grasp this situation and continue to pour into the market complex, incompatible and non-interchangeable units mounted in a multitude of mechanical assemblies as can be seen from Table 1.

Based upon a simple survey it would seem reasonable to maintain production of one or two devices that at the present time have more than paid for their tooling costs by virtue of large-scale distribution. It would be necessary to inform the industrial equipment manufacturer which devices would be available for a relatively long time. The consumption, based upon this type of selling, could be surprisingly large and the risk to semiconductor manufacturers spread over a much greater number of customers.

To show how simple linear integrated circuitry could be, the following excursionary appraisal of the requirements of a substantial portion of the industrial consumer has been presented. There would appear to be four main areas in which integrated circuitry could be used to great advantage, these are: switching, l.f. amplification, h.f. amplification, frequency conversion.

Switching: This appears to have been adequately covered by the majority of semiconductor manufacturers and it is possible to obtain devices from different manufacturers that are directly interchangeable. The presentation has stabilized in the shape of fourteen-lead dual-in-line packages, usually epoxy encapsulated. The cost of the pack approaches or improves upon the cost that may be achieved by discrete techniques and the only aspect that now remains is to have more standardization and interchangeability.

TABLE 1
Characteristics of some i.c. amplifiers

type	response at −3dB	gain (dB)	supply volts	pack
SN777	d.c. — 100kHz	70	4.5	*
SN7510	d.c. — 40MHz	42	+8 & −8	*
SN7510L	d.c. — 40MHz	42	+8 & −8	TO-99
TAA111	d.c. — 150kHz	62	7	TO-76
TAA121	d.c. — 150kHz	74	7	TO-76
TAA131	d.c. — 20kHz	56	5	*
TAA141	d.c. — 20kHz	56	5	TO-76
TAA300	d.c. — 25kHz	50	9	TO-74
TAA310	d.c. — 15kHz	100	7	TO-74
TAA293	d.c. — 600kHz	80	6	TO-74
TAA263	d.c. — 600kHz	77	8	TO-72
TAA350	d.c. — 12MHz	80	6	TO-74
TAA231	d.c. — 30MHz	20	12	TO-78
F104A	d.c. — 35MHz	20	20	TO-74
F104B	d.c. — 45MHz	20	20	TO-74
CA3011	0.1 — 20MHz	60	10	TO-74
CA3020	d.c. — 6MHz	58	9	TO-74
CA3021	d.c. — 2.4MHz	56	+18 & −6	TO-74
CA3023	d.c. — 16MHz	53	+18 & −6	TO-74

* Flatpack

L.F. amplification: As the majority of integrated circuits are d.c.-coupled, it would seem reasonable to lump together the l.f. and h.f. requirements thus reducing the consideration of linear amplification to a single unit. This device is described under the heading of h.f. amplification.

H.F. amplification: There is an integrated circuit available on the market with a flat frequency response up to 45MHz which is entirely d.c.-coupled. This device is being used in large quantities in the manufacture of domestic radio and television. It is a Mullard unit type F104B and is mounted in a 12-pin TO—5 can. The internal circuit of this device is shown at the left-hand-side of Fig. 1 and it can be seen to be very simple in design but nevertheless adequate in performance. A variety of response curves may be obtained by changing the value of

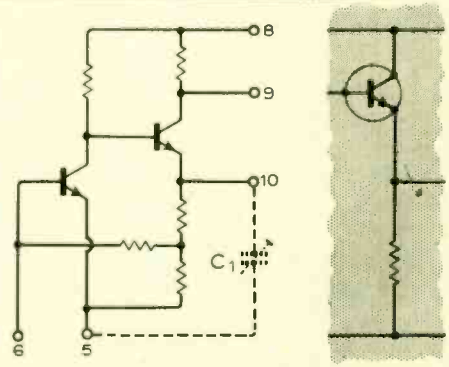


Fig. 1. The Mullard F104A/B is shown on the left which can fulfil nearly all the industrial manufacturers needs for l.f. and h.f. amplification. The shaded area contains an emitter-follower circuit which can be added so that the circuit can be made to drive long coaxial lines.

C_1 as shown in the graph of Fig. 2. The circuit in the shaded portion of Fig. 1 is a directly coupled emitter-follower which can be used to reduce the output impedance so that the unit may be terminated in a coaxial lead to feed a further unit which could be some distance from the amplifier.

This circuit has been used in a number of assemblies operating from 100Hz to 30MHz and it was found that by substantially increasing the value of C_1 that the gain at 100kHz could be increased from 20dB to 30dB if some increase in harmonic distortion could be tolerated. From the curves in Fig. 2 it is obvious that, if the amplifier is used in a relatively narrow band, the value of C_1 may be altered to accurately provide a given level of gain. For instance with C_1 in the order of 25pF the gain at 50MHz would be approximately 26dB. However, if the value of C_1 was reduced to 12pF the gain would have decreased to something in the order of 19dB. As C_1 is an external component it is an easy task to use a ceramic trimmer adjustable from 5pF to 25pF to take up the gain spreads of the integrated circuit.

Obviously this package does not deliver a great deal of power but it may be terminated in one or more stages to give the required output level. It may also be preceded by an emitter-follower in order to increase the input impedance should the need arise. At frequencies below 10MHz the small value of C_1 is unlikely to promote sufficient change in gain to enable the variable capacitor to take up the spreads from circuit to circuit and it is probable that if a considerable gain change is required at the lower frequencies it will be necessary to alter the value of the series input resistor. However, as previously indicated, if C_1 is replaced by a fixed large value of capacitor the gain can be adjusted over a considerable range, but it then becomes necessary to change a capacitor physically, rather than make a simple adjustment. This amplifier has now been produced by Newmarket Transistors Ltd, under the title MC 809 and is a thick film device mounted in a dual-in-line package.

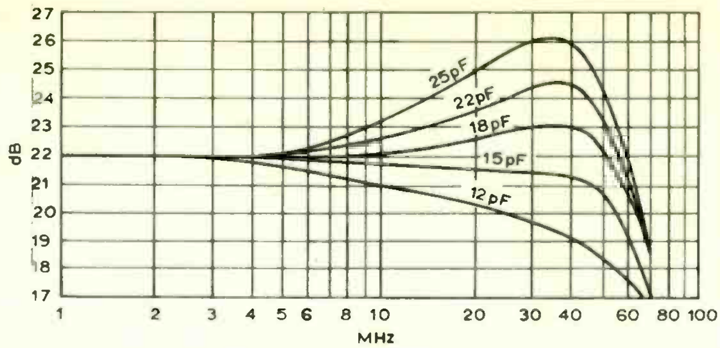


Fig. 2. Frequency response of the F 104 B with different values for C_1.

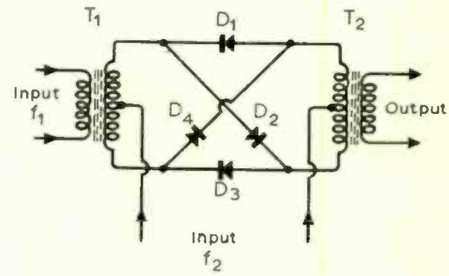


Fig. 3. Basic ring modulator circuit.

Frequency conversion: Fig. 3 shows a simple ring modulator circuit using four diodes and two transformers. This unit may be manufactured from discrete components but the degree of balance required for industrial applications, over a wide temperature range, cannot be easily achieved unless the diodes are carefully matched and mounted in a common heat-simulating device. With the aid of standard monolithic techniques this type of modulator may be readily presented on one chip thus ensuring that the elements have a similar temperature coefficient and are mounted in close proximity.

At the present time transistor monolithic ring modulators are available on the market as standard units but unfortunately the frequency range is very limited and cannot be considered for high-frequency work.

The circuit of Fig. 3 is not the only method of obtaining balanced frequency conversion but it is a simple device that can have a very wide and flat frequency response providing that the transformers are designed correctly. A unit of this nature has a considerable field of application throughout the military and industrial manufacturing industry.

Conclusion: Little has been done to establish the needs of industrial manufacturers as far as integrated circuits are concerned. If just one or two of the more simple integrated circuits, at present available to the domestic consumer, were to be classified as devices with long-term availability, the military and industrial manufacturer would undoubtedly respond by including such units in future designs.

During some recent observations into designs promoted by just one industrial manufacturing company it was noted that during the past three years, sixteen totally different amplifiers had been designed to achieve a small signal gain of between 20 and 30dB at 100kHz. Each one of these amplifiers could easily have been replaced by the circuit indicated in Fig. 2 without any detriment to the performance. Some startling but accurate conclusions were reached when cost estimates were prepared for the development and manufacturing cost of the discrete assembly on one hand, and the integrated assembly, on the other.

In the instance of the sixteen amplifiers designed around discrete components, it was ascertained that a total of 2 man-years were involved in the engineering, drawing and planning. The total annual consumption of the final amplifiers was small in the order of 500 units, costing approximately £5 each. The total cost over a manufacturing period of five years was as follows: development—£8,000; 2,500 units—£12,500; giving a total expenditure of £20,500.

Replacing these sixteen different designs with a common integrated circuit the development period could be reduced to one half man-year costing about £2,000 leaving a total of £18,500 to be spread over 2,500 integrated units giving a unit price of £7 8s for a simple three-stage device. There is no reason why a semiconductor manufacturer could not make a substantial profit at such an elevated unit price. The advantage to be gained by the industrial manufacturer at such a price would not be directly financial but a reflection in the substantial period of time that a skilled engineer would now have to devote to the more elaborate task of system design.

The modern circuit engineer is now likely to find that his services are more and more in demand in the laboratory of the semiconductor manufacturer where, chemistry, physics and electronics come close together. There is a vast shortage of skilled engineers in every country and it has to come that the majority of skills available will be employed in the design of systems using integrated circuitry as the basic building blocks. This does not detract from the skill of the circuit engineer but to the contrary indicates that a much higher degree of skill must be used in planning the minimum number of configurations to be used over a very wide and varied market.

* *Communication Division, S.T.C. Ltd.*

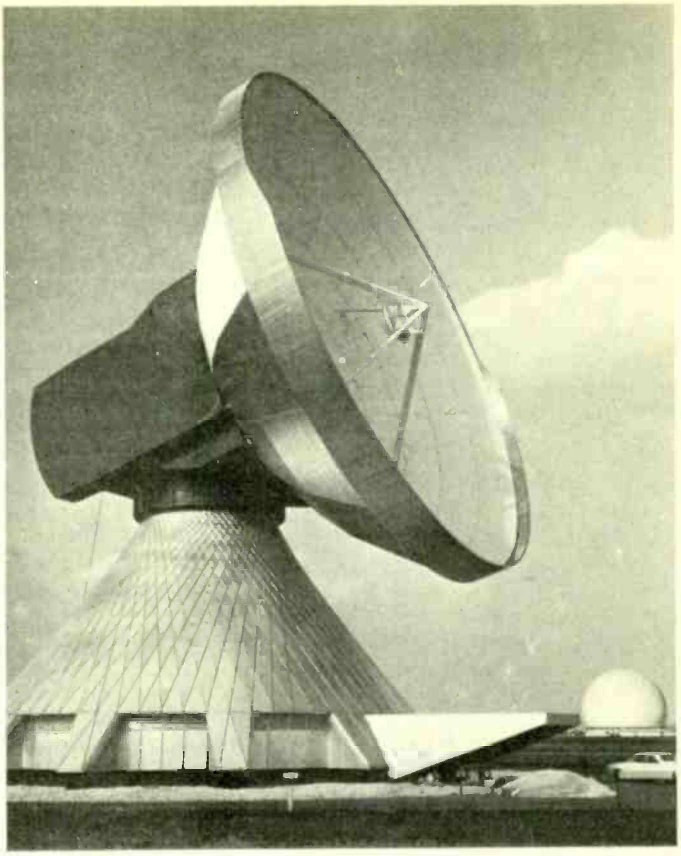
Corrections

J. Dinsdale, author of "**A Design in Retrospect**" in the November issue, writes: "There is an unfortunate ambiguity in Fig. 5 which does not make it clear whether the mk I or mk II design is being discussed. It is important that the earphone-loading network (shown in the dotted box) is connected in place of the loudspeaker in whichever design is being used. On no account should there be a direct d.c. path from the collector of Tr_6 to ground, as Fig. 5 could imply." Also for May read April in ref. 9.

The values of two resistors in the **Wien Bridge Oscillator** on page 575, December issue, were incorrect in the diagram. For 68k and 33k, read 6.8k and 3.3k.

See also page 11 for addendum to last month's **"Letters"**.

News of the Month



Raisting's second paraboloid. In the background is the radome of the first aerial

American radio and TV production

It would appear from the latest figures issued by the U.S. Electronic Industries Association that there is a grave decline in the indigenous radio industry. Not that the sales of domestic receivers have declined but that there has been a growing influx of imported sets while the number of home-produced models has decreased.

The total sales of domestic a.m. and f.m. receivers produced in the U.S. during the first nine months of 1969 was 3.58M compared with 4.15M during the same period in 1968. Imports, however, rose by about 5M to 24.6M of which some 4M eventually bore U.S. company labels. The picture in car radio is very different. Of a total of 8.87M units (a slight increase on the 1968 figure for the same period) just over 1.2M were imported.

Of a total of 9.85M television receivers sold during January-September 1969 (of which over 4.6M were colour) 1.23M imported sets bore U.S. labels and a further 1.58M carried foreign labels. Incidentally, about 13% of the colour receivers sold in the U.S.A. during the first nine months of 1969 were imported.

Figures for the disposal of receivers in the U.K. (supplied by the British Radio Equipment Manufacturers' Assoc.) do not show imported equipment. Disposals of domestic radio receivers declined from 762,000 for the first nine months of 1968 to 547,000 for the same period in 1969. Car radio sets dropped from 309,000 to 262,000. Monochrome television receiver deliveries declined from 1,220,000 in 1968 to 1,172,000 in 1969 and colour sets from 89,000 to 77,000.

German satellite earth station

Germany's earth station at Raisting, near Munich, now has a second paraboloid aerial. This, like its counterpart at the U.K. Goonhilly station, will enable communication to be maintained via satellites in both the eastern and western hemispheres.

The main physical difference between Raisting's aerials I and II is that the designers have dispensed with the use of the radome cover in the latest installation. Although this gave protection from the weather it also created a problem—a film of water or ice on the radome caused background noise. Aerial II is fitted with 5000 infra-red radiators to prevent icing. The dish is 28.5m in diameter and the gain 60dB which corresponds to a power gain of one million as compared with an isotropic radiator operating at 4GHz. Maser pre-amplifiers with a 25-MHz bandwidth were originally used in the receiving section of the earth station, but parametric amplifiers with a 500-MHz bandwidth and a gain of 10,000 have now been installed by Siemens who undertook the refurbishing of the station.

Information service for engineers

INSPEC the Institution of Electrical Engineer's information service in physics, electrotechnology and control, is to launch a selective dissemination of information (SDI) service in electronics in January. It will be available on an individual or group subscription basis in the United Kingdom only. Periodical articles on all aspects of electronics, published in English or English translation, will form the basis of the service. The institution plans to start a comprehensive SDI service covering all languages and the complete subject range of INSPEC in 1971. This service is part of the overall plan for the development of a comprehensive information service, which is being supported by the Office for Scientific & Technical Information of the Department of Education & Science. For the past year the SDI service in electronics has been limited to some 600 research workers as part of a government-supported information research project. Further information and details may be obtained from the manager, INSPEC SDI Investigation, I.E.E. 26 Park Place, Stevenage, Herts.

Cranfield Institute of Technology

Cranfield College of Aeronautics, which was founded at Cranfield, Bedford, in 1947, has been granted a Royal Charter to become the Cranfield Institute of Technology with power to award its own higher degrees. As its original title implies it has been concerned principally with aeronautics but in future its object will be "to advance, disseminate and apply learning and knowledge in the disciplines of the sciences, engineering, technology and management". The Institute will also pay particular attention to "the educational needs of industry, commerce and the public services".

Laser space communication

The first laser communications system to be used in a satellite is to be developed by Aerojet-General Corp., of Azusa, Calif., under contract to NASA. The equipment is to be used aboard the Applications Technology Satellite—F (ATS) which is scheduled for launching from Cape Kennedy into a synchronous orbit in 1972. The contractors will develop both the spacecraft equipment and the associated ground equipment. When ATS—G is launched in 1974 the laser communications experiment may be extended to include spacecraft-to-spacecraft links.

Conferences on tape

"Cassette Colloquia" is the name of a programme begun by the Institute of Electrical and Electronics Engineers to keep its members technically up to date. Cassette recordings of special seminars, workshops, sessions etc, conducted by the I.E.E.E. will be available to members and non-members. The recording technique for the cassettes involves speech compression without pitch change. This, in conjunction with editing, allows 2½ hours of material to be converted to 75 minutes in the cassette of a recent meeting. A cassette containing this length of recording costs $10.

V.H.F. complaints

The B.B.C. has completed an analysis of reports of unsatisfactory v.h.f. reception (during 1968/69) which shows that more than 50% of the complaints were due to the use of inadequate aerials or to faulty or maladjusted receivers. A great deal of dissatisfaction could be avoided, it is said, if dealers would advise when an external aerial is necessary and would also make sure that customers know how to tune their receivers.

Full colour spectrum from infra-red

New phosphors, employing rare earth elements in crystals, have been found by workers at Bell Telephone Laboratories to convert infra-red radiation into any colour of the rainbow. The source of infra-red energy is a gallium arsenide diode. The initial use of the combination of GaAs diodes and infra-red-to-visible phosphors was reported by General Electric. The phosphors can be painted on the diodes—green or red light is produced by certain crystals containing erbium or holmium, and blue light using thulium. With one of the phosphors, colours gradually change from green through yellow, off-white, and orange, and finally to red, as power is increased. The red light so produced is as bright as that emitted directly by other solid-state lamps.

WWV standard frequency transmissions

The National Bureau of Standards (U.S. Department of Commerce) in Boulder, Colo., is responsible for the operation of four radio stations (WWV, WWVB and WWVL at Fort Collins, Colo., and WWVH, Hawaii) that transmit accurate time and frequency information. The formats of two of these stations, WWV and WWVH, are being reviewed for possible changes and modification. A questionnaire has been sent to many known users of the broadcast services and any other users (government, military, industrial, scientific or private individuals) who wish to receive the questionnaire are asked to write to WWV 1969, National Bureau of Standards, Boulder, Colo. 80302.

For the record, station WWV has been transmitting standard radio frequencies on a regularly announced schedule since March 1923 and WWVH began supplementing the broadcast services of WWV from a site on Maui, Hawaii, in 1948. Both stations broadcast the same services on high-frequency carrier waves. Stations WWVB and WWVL at Fort Collins transmit on l.f. and v.l.f. The services of all four stations are described in publication 236, NBS Frequency and Time Broadcast Services, available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for 25 cents.

TV camera for low-light levels

A television camera, type GTNV-1 capable of producing pictures from scenes illuminated at light levels equivalent to starlight, has been introduced by STC. Minimum scene-illumination requirement for the camera, is about 2×10^{-5} ft. candles so that it can respond to scenes that are invisible to the human eye. A vidicon tube is used in conjunction with a three-stage image intensifier having a very high overall gain. Typical brightness magnification is 35,000 times. No especially contrived illumination such as infra-red beams, or reliance on self-emitted infra-red is necessary. For use underwater, where there is very little light, a clearer picture is obtained by using the natural light available rather than an artificial source, the light from which tends to be scattered back to the camera and so degrading the picture.

The STC low-light television camera with cover removed

W.W. Diary

The larger-page size 1970 *Wireless World* Diary (5 × 3 inches) has enabled a more readable type to be used for the information section which includes those features found to be most acceptable to users. They include formulae, circuits, aerial data, colour television and stereo broadcasting characteristics, transistor data, frequency allocations, addresses of organizations and many other facts and figures.

The Diary, which has a week-at-an-opening, costs 10s (leather) or 7s (rexine).

American incentive licensing allocations

Although the U.S. Federal Communications Commission recently suspended the application of proposals for increasing the sub-allocations of h.f. bands available only to amateurs holding Extra Class licences, there remain substantial portions of the bands available only to those holding Extra Class and Advanced Class licences, as part of the policy of encouraging American amateurs to study for the more advanced licence examinations, in a scheme introduced in November 1969. The first 25 kHz of the 3.5, 7, 14 and 21-MHz bands are available only to Extra Class telegraphy; the frequencies 3.8 to 3.9, 7.2 to 7.25, 14.2 to 14.275 and 21.25 to 21.35MHz are now all subject to reservations for either Extra Class only or for Extra Class and Advanced Class telephony. Our correspondent Pat Hawker says British amateurs have expressed opposition to an A.R.R.L. proposal that American telephony operation should be authorized in the band 14.1 to 14.2MHz.

Mysterious generation of u.h.f. exploited

An unexplained phenomenon, discovered at RCA Laboratories in 1967, has been harnessed by RCA to produce the most powerful pulses of radio energy in the u.h.f. range yet achieved by a solid-state device. The effect occurs in avalanche diodes, when they are placed in a circuit tuned to oscillate at frequencies lower than those at which the diodes are supposed to be able to oscillate. For reasons that are still not fully understood, when electrical pulses are now applied to the diodes, they abruptly enter an "anomalous mode" of operation and begin to produce microwave oscillations with powers and efficiencies substantially higher than normal. It is reported that by combining five such devices in a single tiny package and operating them in the anomalous mode, microwave pulses with peak powers above 1,200W have been produced with efficiencies above 25%.

Letters to the Editor

The Editor does not necessarily endorse opinions expressed by his correspondents

Transistor Distortion Characteristics

Mr. Linsley Hood's results (given in his November article) are rather unexpected, in one respect. A perfect transistor would exhibit a voltage gain independent of h_{fe}, and, in his particular test circuits, independent of the load resistance as well. Yet the reported figures, even allowing for the imperfections of the transistors, are at variance with this expectation. They are also at variance with my own measurements.

In a practical circuit, the voltage gain is very nearly $g_m . R_L$, for a planar transistor with low "extrinsic base resistance". Now g_m is a function of the collector current, not the current amplification factor. It is about 40 I_C. Thus a transistor operating at $I_C = 1$mA has a g_m of about 40mA/V.

The voltage gain is therefore $40 . I_C . R_L$. In Mr. Hood's tests, $I_C . R_L$ was kept constant, so one would have expected the voltage gain to be constant, to a first approximation, irrespective of the variations in h_{fe}, I_C, and R_L. In circuit A, for example, $I_C . R_L$ was fixed at 5, so the expected voltage gain is 200, not 40–140 as reported.

My own quick tests on a silicon planar transistor (BFY51) produced the expected results: the voltage gain with 5V dropped across the load was 185–210 for loads of 1–8·2kΩ; i.e., and 8 to 1 variation in collector current. There is clearly something wrong somewhere.

In the case of alloy transistors, the extrinsic base resistance is comparatively high, and changes the performance appreciably. At the higher collector currents and lower values of h_{fe}, this resistance (perhaps a few hundred ohms) is comparable with the "true" input resistance $25 . h_{fe}/I_E$. Its effect is to reduce the apparent g_m and also to make the transistor operate, not as a purely voltage-driven stage, but in a mode between voltage drive and current drive. This latter effect improves the linearity It follows that the linearity of any voltage amplifier stage can be improved by inserting base resistance. The price you pay is in reduced gain and increased noise. (Much the same effects are obtained by the use of an unbypassed emitter resistance.)

If large output voltage swings are taken, distortion due to Early Effect may become important. (This was reported by Dr. Bailey in connection with one of his power amplifiers, where the driver stage had to deliver large swings.) It may well be that a low-h_{fe} transistor shows less of this distortion than a high-h_{fe} one, though correct selection of types is perhaps better than selecting for low h_{fe}.

G. W. Short,
South Croydon,
Surrey.

The author replies

I was pleased to read Mr. Short's letter, and I note with interest, his argument that a transistor should, ideally, always give an identical stage gain, as a voltage amplifier. However, this is not the situation one finds in practice, nor is it the conclusion one draws from gain calculations made using the classical formula,[1] using the conventional h parameters, for a common emitter configuration.

$$M = \frac{1}{h_{re} - \frac{h_{ie}}{Z_L}\left(\frac{1 + h_{oe} Z_L}{h_{fe}}\right)}$$

assuming $Z_{gen} = 0$.

Taking the transistor type which he quotes, and obtaining the typical values for the h parameters, h_{ie}, h_{oe}, h_{re} and h_{fe} from the Mullard data sheets, the calculated stage gains for a BFY51, under ideal conditions of zero source and emitter impedance, vary from 210 to 319 over the range of collector loads 1 to 10kΩ.

However, there is a less complex formula quoted by Manasse[2], using the concept of the "h determinant" Δ_h, (Δ_{he} is equal to $h_{ie} . h_{oe} - h_{fe} . h_{re}$),

$$M = \frac{h_{fe} . R_L}{R_L . \Delta_{he} + h_{ie}}.$$

Since over the range of loads in question with a BFY51, Δ_{he} is very small, this approximates to—

$$M \approx \frac{h_{fe} . R_L}{h_{ie}}$$

So, if the input impedance of the transistor increases linearly with the product $h_{fe} . R_L$ (and h_{fe} may remain nearly constant), the theoretical condition could be met. Normal device shortcomings, such as doping inhomogeneity, carrier trapping and the base-emitter spreading resistance presumably give rise to the failure of the theoretical model.

However, with regard to the gain figures I quoted for the devices I examined, it had not been my intention that these values for gain should be taken as the voltage gain of such devices under ideal voltage amplifier conditions. Alas, low-distortion signal generators do not have zero output impedance. My intention was, rather, to establish a form of "figure of merit" for such devices, and to determine the comparative performance, say, of germanium versus silicon and n-p-n versus p-n-p. In this context the fact that the signal generator had not a zero impedance output was not of importance.

In fact, the apparatus used was a Solartron VF252 precision millivoltmeter, a Radiometer BKF5H distortion meter and a Marconi TF1101 low-distortion oscillator, with 1kHz output filter. (The modulus of the output impedance of the Marconi oscillator is 660 ohms, which accounts for the actual stage gain being lower than the calculated zero input impedance value.) It was remiss of me not to mention in the article the source impedance used, but, surely, if one really wanted to know what the typical stage gain of a particular device would be under zero input and zero emitter resistance conditions, one would calculate it from the formulae, rather than try to measure it with a possibly very untypical component.

With regard to the point raised by Mr. Engstrom in his letter in the December issue, may I say that the points he raises are agreed. The treatment of transistor voltage amplifier non-linearities on the basis of variation in the input admittance is, indeed, the classical approach. However, I quote Mr. P. J. Baxandall's observation that in transistor circuit design it is much more fruitful to consider the devices as voltage amplifiers; and treat their non-linearities on that basis, rather than to endeavour to swamp the input impedance changes by the inclusion of massive input or emitter circuit impedance.

J. L. Linsley Hood

References

1. "Transistor Circuit Design", Walston and Miller, pp. 98–99.
2. "Modern Transistor Electronics, Analysis and Design", Manasse *et al*, (Prentice Hall), pp. 46–49.

Stereo gramophone pickups

The most interesting and timely article by Mr. Stanley Kelly on stereo gramophone pickups in the December issue prompts me to raise two points. First, although in reviewing the dynamics of the transducer-stylus-groove system, Mr. Kelly does assume a compliance for the disc material of 3×10^{-8}cm/dyne, neither he, nor any other authority that I am aware of, tells us very much about the behaviour of disc material. What, for example is the effect of temperature upon it and are there significant differences between various record manufacturers' products in this respect. I have long felt that the characteristics of record material and, above all, resonances which occur within the disc and the effect that different modes of bedding records on the turntable have upon this, are worthy of close examination.

Secondly, Mr. Kelly's reference to novel principles for pickups (strain-gauge and photo-electric) recalls another possibility which must be of particular appeal to readers of *Wireless World*, because its life-force is h.f. The mono version of this type of pickup uses a conventional stylus flexibly anchored at the rear end carrying, instead of coils or magnets, a simple vane of quite negligible mass. The movements of the stylus due to the groove modulation causes relative movement between the vane and a fixed plate or electrode which is continuously energized to emit a constant high frequency e.m.f. The stylus-driven vane is connected to a tiny "receiver"—merely a tuned miniature pot-core inductance, and semiconductor diode. The amount of h.f. energy reaching this receiver at any instant depends upon the instantaneous position—hence impedance—which the vane forms with the fixed plate or pole; in short the h.f. energy input is amplitude modulated by the movements of the vane. The diode delivers an audio-frequency product to a load resistance of 100kΩ, or so, and this is conducted away to the input of the record player amplifier.

The system is readily adapted to stereo by the employment of two vanes at right angles. The same h.f. pole is easily adapted to energize both vanes; the receiver and diode are, of course, duplicated—one for each vane; and the a.f. currents from them are the two inputs to the stereo channels. Unaffected by d.c. or 50-cycle a.c. fields—magnetic or electrostatic—and potentially capable of outputs normally met with in crystal pickups, the advantages are evident and more than overcome the need for the oscillator necessary to energize the "pole". Such an oscillator can easily be housed within the pickup arm if need be. Indeed, why should we not go the whole way to achieve the ideal *completely conductorless* pickup arm—no filamentary wires, no mercury baths—just two oscillators in the pickup head, *frequency-modulated* by the same two moving vanes and one common fixed plate; two transmitters, in fact, transmitting over a few inches to two miniature f.m. receivers strategically placed at the side of the turntable.

H. J. N. Riddle,
Sherborne,
Dorset.

The author replies

With reference to Mr. H. J. N. Riddle's letter, the values quoted for disc material were obtained by direct measurement by myself, and are indicative of present day vinyl products. For any given record material the absolute value of compliance is a function not only of the record material, but also of stylus radius, stylus pressure, the mechanical impedance with reference to the stylus tip, and temperature; it not only varies between record manufacturers but to a second order from batch to batch of record material.

Additionally, a given record does tend to harden with time and over a period of years the effective compliance decreases. Although one tacitly assumes that the impedance of the record as seen by the stylus tip is a pure compliance, this is more of a pious hope than fact. There are the inevitable loss components and the variation of impedance with frequency suggests a more complex structure than a simple *RC* combination.

I agree with Mr. Riddle that the characteristics of the disc material are taken too much for granted and although at various times I have investigated particular facets of this interesting problem, the finances of a private laboratory cannot unfortunately accommodate the detailed investigation that this subject requires.

With reference to the stereo capacitor type of pickup, one such unit has been produced in Japan and during the past few years I have received samples of this device. Unfortunately, the first was damaged in transit, and the second unit exhibited lack of stability, presumably due to frequency variation of the h.f. oscillators. Additionally, the setting up of the two transmitters and receivers was critical if audible beat noises between the two systems were to be eliminated. The mechanical characteristics of the moving vane are not simple, acceptable signal-to-noise ratio controls the minimum change of capacitance and this in turn determines the vane's dimensions, which are larger than would have been expected.

I agree that on paper at least the variable capacitance type of pickup is very attractive, expecially if one can fit the complete transmitter within the pickup head shell. My own thoughts on the matter are to use a single r.f. transmitter phase modulated by each channel with suitable decoding systems.

Stanley Kelly

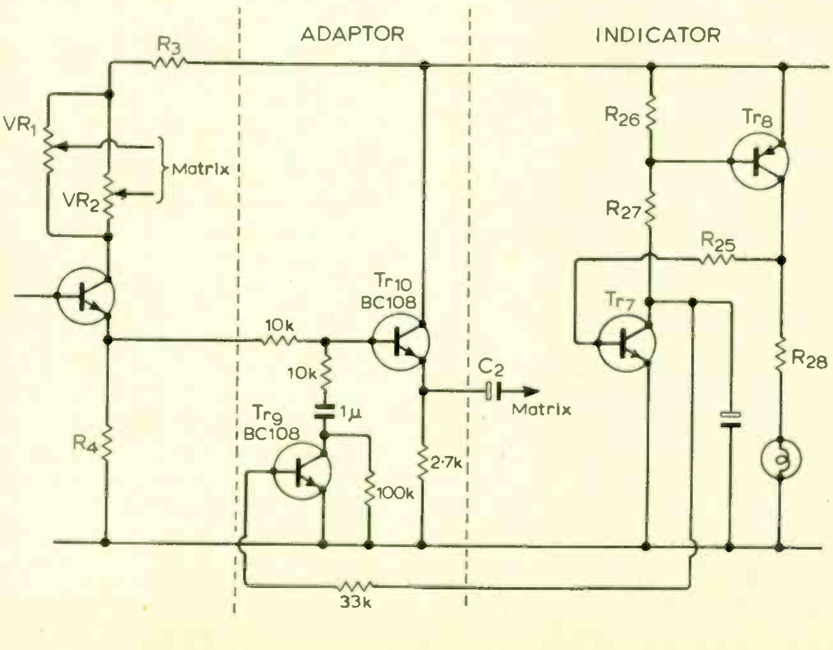
Stereo decoder adaptor

We regret that the circuit was omitted from the letter under the above heading on p. 565 in the December issue. To avoid ambiguity we are reprinting the letter with the diagram.

Having seen the circuit for a stereo decoder adaptor in "Circuit Ideas" in the September issue I am prompted to send you a much simpler circuit which I have been using for several months.

Instead of having a variable gain amplifier on each channel a 0.5 attenuator is placed before the decoding matrix when a mono programme is being received. With a mono signal Tr_9 saturates and earths one end of the attenuator chain formed by the two 10k Ω resistors. Thus only half the mono sign is applied to the matrix. On stereo Tr_9 is off and the full signal is applied to the matrix. The 100k Ω resistor ensures that the 1µF capacitor does not have to change its charge when going from mono to stereo.

A. Royston,
University of Warwick,
Coventry.



Circuit Ideas

Constant current generator

Dual transistors are used to ensure cancellation of thermally variant transistor parameters in the simple constant current generator shown.

By suitably proportioning the resistor values the drift of the constant current due to variation of transistor base-to-emitter junction voltage, collector-to-base leakage current, and current gain are cancelled out.

For cancellation of base-to-emitter voltages the necessary circuit relationship is:

$$R_3 = R_4.$$

To assist stable operation with change of leakage current and gain the remaining resistors are proportioned to satisfy the equality:

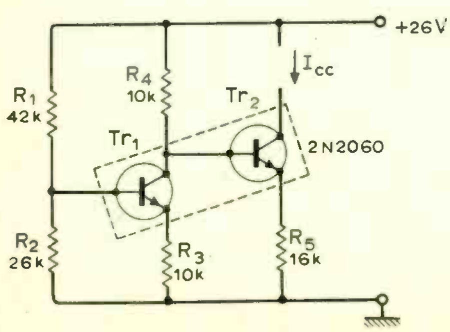
$$R_5 = \frac{R_1 R_2}{R_1 + R_2}.$$

The output current is given, with good accuracy, by:

$$I_{cc} = \frac{V_{cc}}{R_5}\left(1 - \frac{R_2}{R_1 + R_2}\right)$$

The transistors should be operated with equal emitter currents to ensure tracking of the two base-to-emitter voltages with temperature.

The resistors should be wire-wound types with low temperature coefficients. The differential temperature coefficient of the resistor pairs R_1, R_2 and R_3, R_4 is more important than the absolute temperature coefficient.



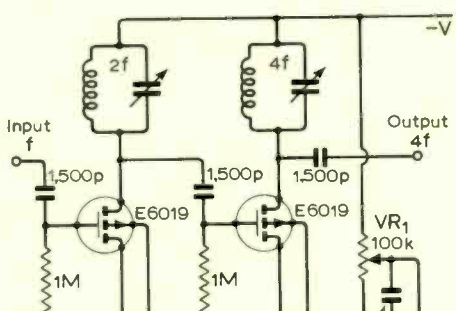
The measured temperature coefficient of I_{cc} is typically 0.0015%/°C over the temperature range 0 to 100°C.

As shown the constant current is directly proportional to the supply voltage. To make the constant current independent of the supply, resistor R_1 may be replaced by a temperature-compensated zener diode. An additional resistor (R_b) is then required in series with the base of transistor Tr_1, such that $R_b = R_5$.

M. CADWALLADER,
London N.W.3

A M.O.S.T. frequency-doubler chain

The high impedance of m.o.s. transistors allows tuned frequency doublers to be cascaded without requiring impedance transformation. The use of enhancement devices eliminates the need for a separate bias supply. The arrangement is shown in the diagram. The potentiometer is adjusted to provide the required bias



for maximum efficiency. Since C_{iss} is not highly dependent on the applied gate voltage, adjustment of VR_1 does not detune the preceding circuit. Doublers are not prone to feedback and interaction problems so that dual m.o.s. devices such as the Marconi-Elliott E6029 could be used. The circuit will operate up to 150MHz with the high g_m devices of the E6019, E6029 series.

J. A. ROBERTS,
University College,
Swansea.

Negative resistance of transistor junction

If the emitter-base junction of a silicon planar transistor is reverse biased, it behaves as a zener diode, with a typical breakdown voltage of 7-10V. If the base is left open-circuit and connection is made to the collector instead, the "zener diode" has a negative resistance characteristic. The effect is exhibited by most

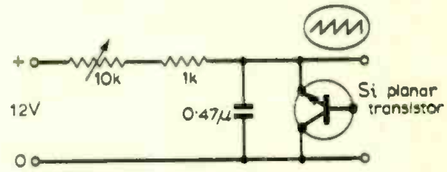
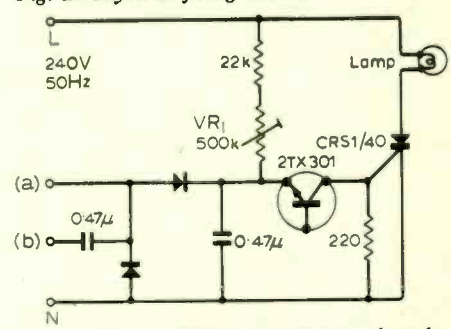


Fig. 1. Test circuit giving ramp waveform.

Fig. 2. Thyristor firing circuit.



n-p-n silicon planar transistors, but by few p-n-p types. The relaxation oscillator in Fig. 1 can be used as a test circuit.

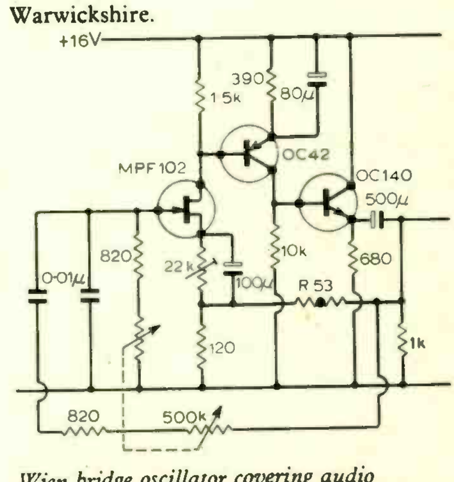
The device is also useful for firing thyristors. Fig. 2 shows a simple half-wave lamp-dimming circuit which can be controlled manually, by VR_1, or by a d.c. input 0 and 10V at (a) or an a.c. input 0 to 10V peal-to-peak at (b).

J. A. H. EDWARDS,
Leicester.

Low-distortion 30Hz-20kHz oscillator

The circuit is a Wien bridge oscillator employing an f.e.t. to reduce damping on the bridge and allow the use of a 500kΩ twin potentiometer. Harmonic distortion of the prototype was reduced to less than 0.05% over the whole band with the aid of the 22kΩ preset resistor.

C. A. PYE,
Exhall,
Warwickshire.



Wien bridge oscillator covering audio range with no capacitor switching. (C. A. Pye)

Amorphous Semiconductors

An electronic engineer's view after a recent conference at Cambridge

by J. E. Carroll. Ph.D.

About 350 pure and applied physicists with a sprinkling of electronic engineers were in the Cavendish Laboratory, Cambridge, from September 24th to 27th,* to discuss the amorphous and liquid state. Amorphous materials with their lack of obvious structure have for a long time posed fundamental problems of description to the pure physicist, but the applied physicist and engineer are not attracted to a field unless they have a whiff of a practical application. Although negative resistance and switching effects have been reported as long ago as 1962[1], this whiff of practical utility was not scented by the technical hounds until 1968 when Ovshinsky[2] published a letter entitled 'Reversible electrical phenomena in disordered structures'. The title appears harmless but the contents suggested the use of amorphous semiconductor material in the application of switches with a high ratio of 'on' to 'off' impedance and also in the application of memory devices. Applications to the communications industry and logic functions in computers are then obvious if the device is a success. At first sight there appear to be several useful technological features: apparent lack of sensitivity of the material to small amounts of impurity, the devices can be used in thin film form that would be compatible with modern integrated circuit technology, no power consumption to maintain the memory, to name a few of the more obvious advantages. This then accounts for a small technical explosion of interest in this field. This article attempts to give a simple account of these amorphous semiconductors and their associated potential devices in the light of the recent Cambridge conference.

The amorphous state

First, let us ask the question, what is an amorphous material? An initial definition would be a material that exhibited no structure or order. So no matter where we looked, we should see a random spacing of atoms in the material. Although partially true, this is too naive. The solid material has to be bound together by some cohesive force. This cohesive force can then impose constraints on the extent of the disorder. It is well known that the outermost electrons (valence electrons) of any atom determine the chemical properties of the atom, or in other words determine how one atom binds itself to any other. One type of binding together of atoms is called *covalent* binding. The valence electrons are shared between pairs of neighbouring atoms, lowering the potential energy of the pair and so binding them together. This binding can extend throughout the crystal. Fig. 1(a) indicates such a scheme for say crystalline germanium. Each atom shares four electrons with neighbouring atoms and this completes a relatively stable configuration. In Fig. 1 (b) the same scheme is shown in a disordered array but to preserve the binding the bonds are still linked. The technical jargon says that the co-ordination number of each atom is preserved. This imposes constraints on the short-range order (say over a couple or so of atoms spacing). To appreciate this fully one needs to go to quantum theory of electron orbitals, but this is not necessary here. However, over larger distances disorder prevails and the atom spacing and positioning become quite random. A slightly more realistic model is obtained by allowing for several of the valence bonds to be broken, or dangling as they are often referred to. This is shown schematically in Fig. 1(c). It is such covalent amorphous materials, but with more complex structures, that have been causing most interest since in many ways they behave like intrinsic conventional semiconductors. There are, of course, other amorphous materials such as amorphous metals. In this latter case the atoms are bound together by a sea or jellium of almost free electrons shared between a large number of atoms. The binding imposes no long- or short-range order and the conduction is not significantly changed between the crystaline and amorphous states. At present these latter materials are not of interest.

Returning to the covalent amorphous semiconductors, we find further evidence for the short-range order in the absorption of certain wavelengths of light. If a

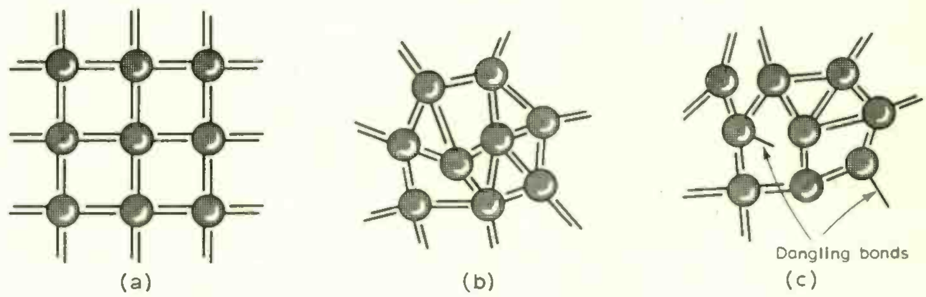


Fig. 1. Covalent binding (schematic) (a) crystalline state (b) amorphous state (c) amorphous state indicating dangling bonds.

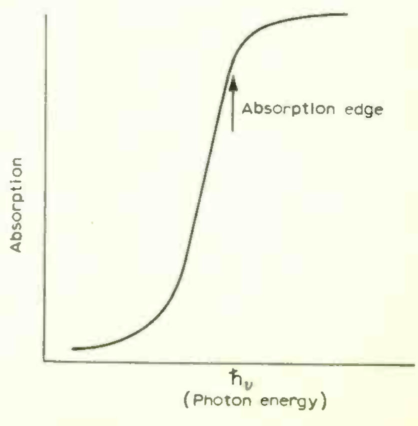
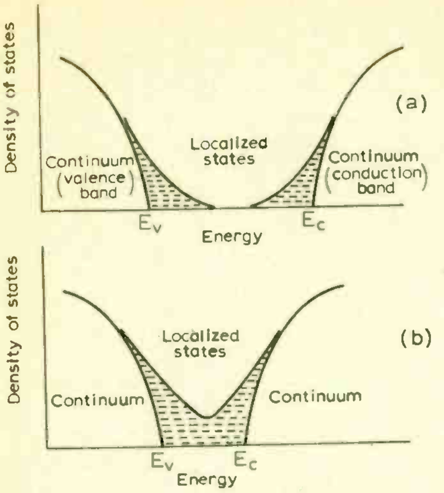


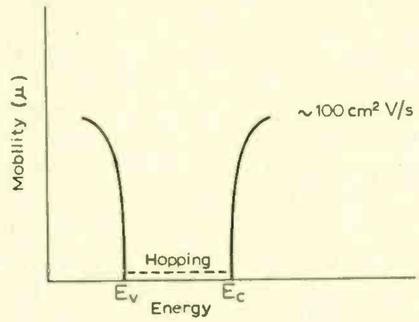
Fig. 2. Absorption edge (schematic). Absorption of light by a crystal against light frequency.

* International Conference on Amorphous and Liquid Semiconductors, sponsored by the Royal Society. The proceedings to be published in a special volume of the *Journal of Non-crystalline Solids*, published by North-Holland Publishing Company, Amsterdam.



(Left). Fig. 3. Density of electron states in amorphous semiconductor (a) non-overlapping localized states (b) overlapping localized states.

(Below). Fig. 4. Electron mobility against energy.



photon of light has sufficient energy to break a valence electron bond in a semiconductor then it can become strongly absorbed by the material. Thus if the absorption of light shows a marked edge to it as the wavelength of light is changed (Fig. 2) then this is evidence of a uniform binding energy throughout the body of the crystal. Qualitatively similar optical effects are found in amorphous and crystalline material, though often with different magnitudes. From the existence of these effects it can be inferred that there is considerable uniformity of the electronic structure close to each atom. In other words there is indeed a short-range order in the amorphous material. Now as one of the speakers at the conference asked 'what is a forbidden gap but the binding energy of the valence electrons?' The absorption edge energy is indeed one of the ways of measuring the gap between the valence and conduction band energies in conventional semiconductors. Thus we still expect to find a similar gap in amorphous semiconductors. However, although all gaps are forbidden, some are more forbidden than others! In amorphous material there are lots of broken valence bonds. Although annealing the material can reduce their number, their density is still very high. It is so high in fact that any 'free' electrons, introduced by impurities (on the classical semiconductor basis of creating electrons) become trapped in these dangling bonds. As a consequence the conductivity of the material is not altered even by an appreciable amount of impurity in the material. This is in complete contrast to conventional semiconductors. These traps have a continuum of energies and can in some cases fill up the conventional energy gap. Thus the density of electron states available to electrons with different energies can be drawn schematically as in Fig. 3(a). There is a continuum of states as found in conventional semiconductors but also a high density of localized states forming tails to the continuum. These localized states are in effect the broken valence bonds discussed above. To the electrical engineer who uses frequency filters these tails (or tales) appear most plausible! If one randomly alters the inductances and capacitances of the periodic chain of these elements that form a frequency filter, then one finds that the cut-off frequencies become diffuse and propagation is possible for regions extending into the formal stop band of the filter. Thus changing the periodic structure of the crystal in a random way would be expected to allow a certain amount of propagation of the quantum electron waves outside their normal permitted range of frequencies or energies. The farther away from the formal permitted energies the more likely are the states to be localized (in the filter analogy the states are a result of local resonances in the filter structure). These tails of localized states extend both from the band of valence electron energies and the conduction band energies. In some materials these tails can overlap (Fig. 3(b)) so that the whole gap is filled with traps. This latter picture is believed to be the relevant one for the glasses that exhibit switching and memory[3].

Conduction can occur as in a conventional semiconductor. The electron moves in an electric field and gains energy, thus moving to a higher energy state. This is readily possible for electrons in the conduction band where there is a continuum of empty states above the electrons' particular state. It is also possible in the valence band provided that there are vacancies, or holes as they are called, in the occupation of the upper electron states in that band. These holes then permit the electrons to gain energy in an electric field and so allow conduction. An important difference between the amorphous and crystalline state is the magnitude of the mobility. The increase in disorder implies that the electrons have many more collisions as they move. For a given field the electrons' drift velocity is a good order of magnitude lower than in the useful crystalline semiconductors. The mobility is then around 100 cmV/s^2 for these amorphous materials. There is a second mechanism that is called 'hopping'. In the high density of localized electron states in the gap, electrons can hop from one state to another under the action of an electric field. However, this hopping process results in a negligible mobility. We therefore arrive at the picture of a 'mobility gap'. Although there may be a high density of electron states throughout the energy 'gap' in amorphous materials, none the less the mobility of any electrons filling those states can probably be ignored. The idea is shown schematically in Fig. 4.

Since any free electrons become trapped by the unfilled valence bonds one is not surprised to find that these semiconductors only exhibit what is termed an intrinsic conduction. Conduction only occurs in proportion to the amount that the thermal agitation can free electrons from their bonds. The addition of impurities makes little effect on this process. The classical behaviour of an intrinsic semiconductor's conductivity is given by $\sigma = \sigma_0$ exp. $-(\Delta E/2kT)$ where ΔE is the band gap energy, or close to this value. This result is also found for amorphous semiconductors of the covalent type. An important consequence of this intrinsic behaviour is that the resistance of any specimen decreases as the temperature increases (more electrons produced to conduct electricity by more bonds breaking). This leads to thermal runaway under some conditions and in turn can lead to negative resistance and switching.

Practical devices

Let us now describe two types of device that were being demonstrated in experimental form by Energy Conversion Devices at the Cambridge conference. They both use films (circa 1 micrometre thick) of an amorphous semiconductor known as a chalcogenide glass. The first type of device is the Ovonic Threshold Switch, or O.T.S., named after Ovshinsky who first reported it in 1968. The threshold voltage is around ten volts and the off resistance can be as high as tens of megohms. As the threshold voltage is reached so the current rises to a few microamps and then switches to many milliamps. The switching time can be extraordinarily fast and this leads to problems in surge currents through the device that can degrade the performance if they are not limited. In the 'on' state the device impedance drops to around 100 ohms (all these figures depend on geometry and so must only be taken as indicating orders of magnitude). The device then remains in the on state provided that the current is above a minimum sustaining value of around 10 mA, or equally the device voltage does not fall below about a volt. If the current does fall below this sustaining level then the device reverts to its high resistance state. Provided that surge currents are limited it is claimed that these switches can be recycled almost indefinitely. The characteristics for the O.T.S. are shown schematically in Fig. 5(a). It should be pointed out that there is evidence against the existence of a closely defined threshold voltage since some workers find that this varies statistically from one switching operation to another[6]. This point was hardly made at the Conference.

Closely allied to the O.T.S. is the O.M.S. or Ovonic Memory Switch. Energy Conversion Devices were exhibiting an experimental thin film array of these devices. In this type of device the conducting state of the glass is permanently, although reversibly, changed by the application of the switching voltage, which must be maintained for a time measured in milliseconds. The switch will then move to its low resistance state and remain in this state even though the current and voltage are removed. The device can then form part of a memory store. The low resistance state may be changed back by applying a current of around an ampere for about 100 microseconds. This then restores the device to its high impedance state. Fig. 5(b) indicates schematically the action of this device. To read the state of the memory one applies a voltage from a source with a medium impedance. In the low impedance state the fraction of the voltage dropped across the switch is negligible and so a voltage sensor across the switch can register zero. In the off state the full voltage appears across the switch so the voltage sensor indicates a unity value. This 'read' process can be made extremely rapid so that at present the memory could find applications in a 'read mostly' or 'read only' type of memory store. Ovshinsky used a material with a composition of $Te_{48}As_{30}Si_{12}Ge_{10}$ for his switches and reduced the arsenic content to around 5% for the memory devices. However, it is not known or, at least, reported what determines whether a device will be a memory, a threshold switch, both or neither!

The chalcogenide glasses used for these devices are covalent amorphous semiconductors and so exhibit a negative temperature coefficient for their resistivity. It is natural to think of the switching as possibly being caused by thermal runaway. Indeed at the Cambridge conference evidence was presented that showed the thermal runaway model fitted several experimental facts. It may, at first sight, be thought that such a mechanism could not account for switching in the subnanosecond speeds that are observed with these devices. However, although the speed of switching is fast, there is a delay of the order of a microsecond before the actual switching occurs. Moreover, it is known that a device with a negative temperature coefficient of resistivity will form a current-controlled negative resistance and in these types of negative resistances the current tends to flow in filaments. This bit of physics can be qualitatively understood by considering a set of parallel and equal negative value resistors. If one resistor takes slightly more than its fair share of current then its resistance falls and it will take more current and so on until all the current is going into the one resistor. Filament formation can imply that the heat required for increasing the conductivity in the filament need only be very small. However, although the thermal runaway theory fits many facts, Professor H. Fritzshe maintained that even with filament formation there was not enough heat for the filament to reach the required temperature to explain its low resistance, as measured experimentally. It may be that heat causes some slight reversible structural change so that the conduction is no longer intrinsic. Professor H. K. Henisch in another paper suggested that electrical charge effects of the carriers could account for the switching with the current maintaining a plasma in the switch when in the on state. The neutral plasma of charge carriers could imply a high current but low voltage while recombination of the holes and electrons would imply that a minimum sustaining current was required for the plasma. Elsewhere Professor Sir Nevill Mott[4,5] has suggested that tunnelling of charge carriers through Schottky barriers set up at the electrodes could result in switching. It is safe to say that at present there is no definitive theory on the switching effects in these glasses and indeed it may be a combination of effects is required to explain the facts.

The memory type of device is almost certainly connected with a structural change of the amorphous material caused by heating in a filament. A very beautiful bit of evidence for this theory was given by Dr. C. Sie of Energy Conversion Devices in a film shown to the conference delegates. In a particular material ($As_{55}Te_{35}Ge_{10}$) the switching time is very slow and Dr. Sie filmed the device under a microscope and showed the filament growing from the anode. On first applying the voltage, in excess of the switching threshold, the surface of the semiconductor changed its reflectivity slightly accompanied by a current rise. But then one saw (Fig. 6) a filament growing slowly from the anode towards the cathode contact of the device. As the filament moved towards the cathode the threshold voltage for current switching decreased until, when the filament had fully formed, the threshold voltage was zero and the device was perfectly ohmic in a low resistance state. A microprobe analysis of the composition of the filament showed that it had changed its composition from $As_{55}Te_{35}Ge_{10}$ to $As_{38}Te_{58}Ge_{4}$. Temperature analysis with a micro-radiometer showed that the material heated as the current initially started but that as the filament passed under the radiometer the temperature dropped. The velocity of propagation of these filaments could vary depending on material. Rough orders of magnitude suggested the variation was between 100 cm/sec to 10^{-2} cm/sec.

Conclusions

It is clear that much technical, technological, and theoretical work remains to be done with many elegant experiments along the way. Some elementary ideas are clear for the amorphous semiconductors but the rigorous theory on which to base quantitative work is lacking. For the practical devices the mechanisms by which they work are only just emerging. The memory device is almost certainly made possible by a change of phase along a filament; this change being induced by heating. The switching device is possibly tied up with a number of effects such as space charge, heating and contact conditions. But as one speaker at the conference said 'although we look through a glass, we look through a glass darkly'. This leaves lots of fascinating questions to be answered. Indeed switching and memory devices may not be the only uses that more knowledge about these materials could bring. It may be possible to develop specific glasses to absorb

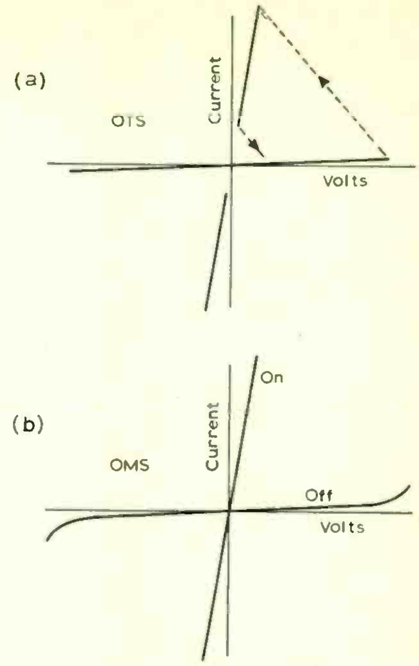


Fig. 5. Ovonic switches (a) the ovonic threshold switch: O.T.S. (b) the ovonic memory switch: O.M.S.

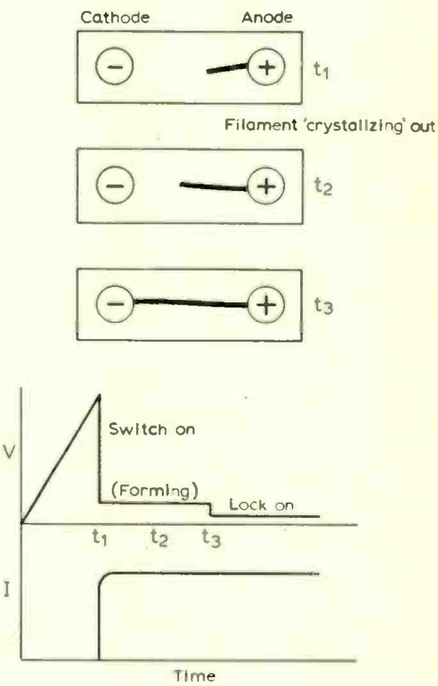


Fig. 6. Schematic of filament formation in memory device. When the voltage exceeds the threshold the current increases (switches on) but the filament takes time to form travelling from the anode. When fully formed the device resistance is lowest. This is termed locked on.

harmful wavelengths of radiation or indeed respond electrically to other wavelengths of light that existing technology does not permit. The biggest question for the industrialist is perhaps whether it will be worth the cost. The Cambridge conference probably ensured that firms with a current programme will maintain a holding programme of work. Then at least they have a hand in the field to pluck the flowers if they suddenly bloom in the spring. The lack of technological know-how is unlikely to encourage many new firms to undertake their own research.

Acknowledgements

The author is indebted to Professor Sir Nevill Mott for allowing him to attend the conference at the last moment in spite of a full house.

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Amateur h.f. band

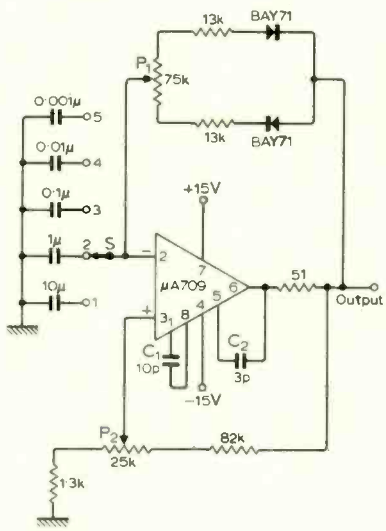
For many years, amateurs in Europe and Africa have been encouraged by the I.A.R.U. Region 1 Bureau to observe voluntarily an international "band plan" on the h.f. bands in order to reduce mutual interference between amateurs using different modes. While, at times, infringements of the plan can be heard (particularly the intrusion of 'phone operation into the c.w. segments), the band plan has undoubtedly played a major role in maintaining orderly operation. The band plan was modified slightly at the Brussels I.A.R.U. Conference a few months ago, and is now as follows: 3.5 to 3.6MHz c.w. only; 3.6 to 3.8 c.w. and 'phone; 7.0 to 7.04 c.w. only; 7.04 to 7.1 c.w. and 'phone; 14.0 to 14.1 c.w. only; 14.1 to 14.35 c.w. and 'phone; 21.0 to 21.15 c.w. only; 21.15 to 21.45 c.w. and 'phone; 28.0 to 28.2 c.w. only; and 28.2 to 29.7 c.w. and 'phone. Radio teleprinter operation is recommended around 14.09 MHz.

Application Notes

Circuitry selected from device manufacturers' literature

Square-wave generator

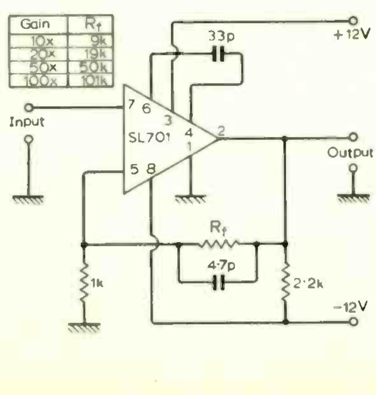
The circuit given below operates over the following five frequency ranges: 2-20Hz, 20-200Hz, 200Hz-2kHz, 2-20kHz, and > 20kHz. P_2 is a coarse frequency control and P_1 is a fine frequency control



which operates by varying the hysteresis cycle. Extracted from "The Application of Linear Microcircuits", Vol.1, SGS Ltd.

General-Purpose Amplifier

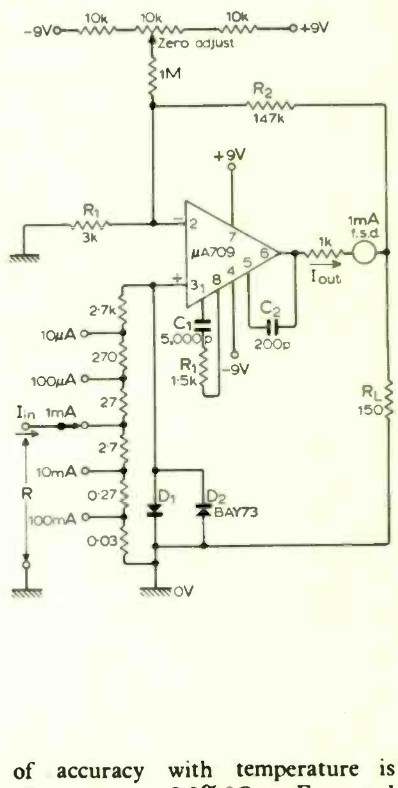
The gain of this amplifier is set by the resistor R_f: 10, R_f = 9k Ω; ×20, R_f = 19k Ω; ×50, R_f =



50k Ω; ×100, R_f = 101k Ω Typical drift is quoted as 15μV/°C. Extracted from Plessey Technical Communication No. 7.

D.C. microammeter

Below is the circuit of a low voltage-drop microammeter which will give an accuracy of 1% at ambient temperature if a good quality meter and accurate resistor values are used. Variation



of accuracy with temperature is given as 0.2% °C. Extracted from: "The Application of Linear Microcircuits", Vol.1, SGS Ltd.

Magnetoresistance and its Application

Mean-square ammeter and d.c. transformer

by B. E. Jones, M.Sc., Ph.D.*

The magnetoresistance effect and the related Hall effect displayed by a semiconductor under a magnetic field have become of interest in recent years with the advent of extremely high-mobility materials.[1,2] Both effects arise from the action of the externally-applied magnetic field in producing a sideways deflection of the mobile carriers taking part in the conduction process.

The magnetoresistance effect is a phenomenon in which the resistivity of a semiconductor material is considerably increased by a magnetic field whenever the carrier mobility has a large value, for example in indium antimonide or indium arsenide intermetallic compound semiconductors. It has been shown that the total resistance of a rectangular specimen of such a semiconductor shows a square-law increase at small magnetic fields (up to about 0·3 T†) and a linear increase at high magnetic fields (Fig. 1 and Table 1). The magnitude and characteristics of the effect depend largely on the geometry as well as the material itself.[3] For suitably designed components the typical dependence of R_B/R_0 on magnetic flux density B applies to frequencies well into the gigahertz range. Wafer-shaped configurations exhibit their greatest sensitivity with the field perpendicular to the plane surface.

The electrical properties of a semiconductor are usually sensitive to temperature, and the magnetoresistance effect is no exception. Resistivity usually decreases with temperature and the larger the semiconductor surface area, the smaller the temperature coefficient In Table 1, one device has a temperature coefficient of $-1{\cdot}8\ \%/^\circ$C, while a slightly bigger and less sensitive device has a smaller temperature coefficient of $-0{\cdot}12\ \%/^\circ$C, both figures at $B = 0$, and temperature 25°C (these coefficients increase with B).

The linear magnetoresistance effect at relatively high magnetic fields has been used to produce a multiplying action, particularly for power measurement from direct current to microwaves.[3] A transducer for displacement measurement based on the effect gave a large output of 5 V d.c. at 500 μm displacement, without using electronic amplifiers, over a working temperature range -320°F to $+200$°F.[2] A magnetoresistance can obviously be used for magnetic-field measurement, particularly weak fields, and has been employed as a modulator of d.c. currents and voltages, as a contactless variable resistor and been applied to a brushless d.c. motor.[1]

Two further application of magnetoresistances are described below. In the first case use is made of the square-law characteristic at low values of magnetic-flux density, to produce a simple clip-on mean-square ammeter (0–25 A) of very low input impedance suitable for measuring practically any current waveform. In the second case, magnetoresistance is used as a magnetic-flux error detector in a feedback circuit to provide a simple d.c. transformer (0–1 A) for clip-on purposes.

*Electrical Engineering Laboratory of Manchester University

†T is the symbol of the tesla, the SI unit for magnetic flux density ($\equiv 10^4$ gauss)

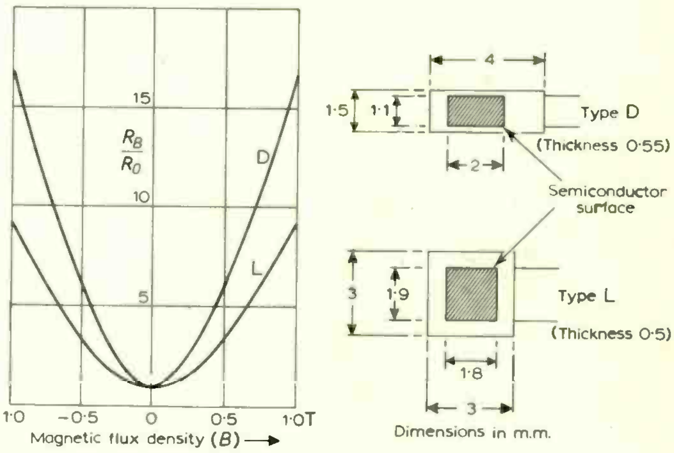


Fig. 1. Magnetoresistance relation R_B/R_0 as a function of the magnetic flux density B for two commercial devices.

Table 1

Characteristics of Magnetoresistance Elements

Type	R_0 at 25°C (Ω)	R_B/R_0 factor $B = \pm 0{\cdot}3$ T, 25°C	Temp. coeff. at $B = 0$, 25°C (%/°C)
FP28D470	470	3	−1·8
FP17L100	100	1·9	−0·12

Note. The magnetoresistance elements are indium antimonide type made by Siemens & Halske A.G. and are obtainable in the U.K. from R. H. Cole Electronics Ltd., 7–15 Lansdowne Road, Croydon, CR9 2HB.

Mean-square ammeter

The circuit used to test the mean-square ammeter scheme employing magnetoresistance is shown in Fig. 2. A gap is cut in one half of the small ferrite ring sufficient to take magnetoresistance R_1 mounted with silicon grease on a thin copper plate (the airgap also linearises the relation between magnetic flux and cable current; actually flux density in the ring

$$B = \frac{1{\cdot}26\ I}{(l_i/\mu + l_g)}\ \mu T,$$

where I is cable current, l_i and l_g are mean length of magnetic circuit and airgap width respectively in metres, and μ is the ferrite magnetic relative permeability). To allow temperature compensation a second magnetoresistance R_2 is similarly mounted on the plate, but situated outside the magnetic circuit. To provide a meter deflection linearly related to change in R_1 caused by flux changes, both R_1 and R_2 are connected in a bridge circuit whose other two arms are current sources and the choice of out-of-balance detector (resistance R_d) depends on accuracy and ruggedness required. The current sources are provided by two silicon transistors in a long-tailed pair arrangement with a well-defined voltage on the bases. With flux at zero ($I = 0$), potentiometer P_1 can be adjusted to balance the bridge.

For low flux densities $R_1 = R_0 + KI^2$, and for the case $I = i \sin \omega t$, it has been shown[4] that, considering only first-order terms, the mean detector current is given by the expression

$$I_d \approx \frac{KI_1}{R_d + R_2 + R_0}\cdot\frac{i^2}{2}\left[1 - \frac{3K}{2}\cdot\frac{i^2}{2}\bigg/(R_d + R_2 + R_0)\right]$$

assuming $I_1 = I_2R_2/R_0$, where I_1 and I_2 are the collector currents of transistors Tr_1 and Tr_2 respectively. It is evident that the detector current is proportional to the mean-square current $i^2/2$ in the

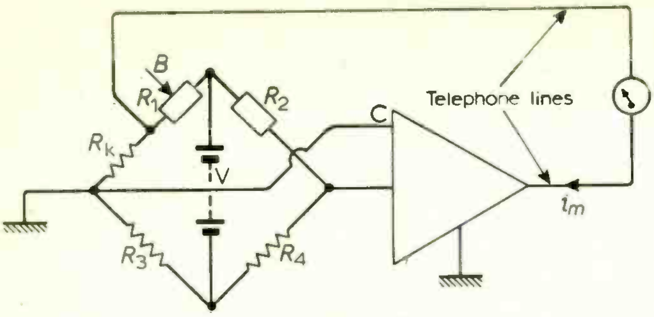


Fig. 2. Mean-square ammeter circuit. F_1 = type A_1 manganese zinc ferrite (Ferroxcube toroid FX 1322) (i.d. = 6·35 mm, l_i = 2·76 cm, l_g = 0·59 mm, μ_{min} = 100). T_{r1}, T_{r2} = type C444 transistors (SGS Fairchild). R_1, R_2 = type FP28D470 magnetoresistances (see Fig. 1 and Table 1).

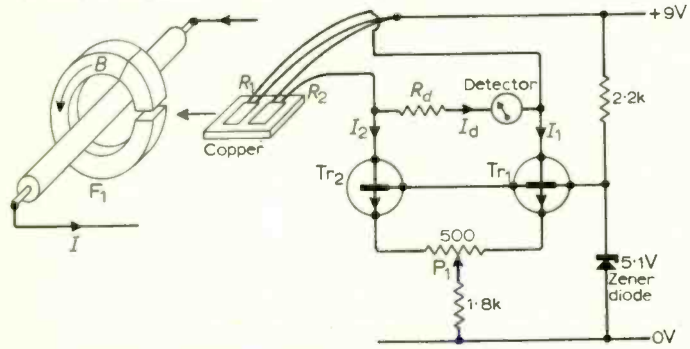


Fig. 3. Bridge containing compensating resistor R_k.

cable, provided the term after the minus sign in the expression for I_d is small. With $R_2 \simeq R_0 \simeq 470\ \Omega$, $K \simeq 0{\cdot}04\ \Omega/A^2$, so that for 2% accuracy when $i^2/2 = 25$ A, R_d should have a value of about 900 Ω and $I_d \simeq 15\ \mu$A if $I_1 \simeq 1$ mA (this value for I_1 restricts magnetoresistance dissipation to about 1/2 mW).

To check accuracy and linearity of the magnetic circuit a high impedance d.c. galvanometer (R_d = 12 kΩ, 2 μA f.s.d.) was used as detector in the circuit of Fig. 2. There was less than 1% inaccuracy in the overall square-law characteristic for full-scale deflection when $I_{r.m.s.}$ = 25 A at 50 Hz (the maximum flux density was only 0·07 T). The impedance of the ammeter is inductive, given by that of a single-turn on the magnetic core. With the core of Fig. 2, at 50 Hz, $X_m \simeq 6\ \mu\Omega$.

Alternative arrangement

If it was desired to use a cheap standard rugged moving-coil meter as indicator at some distance from the point of measurement, the arrangement of Fig. 3 could be used. In this, R_k is a fixed compensating resistor in the branch of the bridge which contains the active element R_1; R_k is also connected to the output circuit of the d.c. amplifier. The input of this amplifier is connected to the output of the bridge and the amplifier output current i_m passes through R_k.

When a cable current (I) is present, the bridge is unbalanced, a voltage e is produced at the amplifier input and generates the current i_m. This current causes a compensating voltage at the terminals of R_k which is opposed to the error voltage generated by the change of resistance R_1. The current i_m increases until these two voltages balance. It has been shown[4] that

$$i_m = VKI^2/2R_k(R_k + R_0)$$

provided

$$[2(R_k + R_0) + KI^2]/A \ll R_k(R_k + R_0)$$

$R_1 = R_0 + KI^2$, V is the battery voltage across the bridge and $A = i_m/e$ is the amplifier gain. Thus i_m is independent of A and linearly related to I^2 so that a milliameter M will indicate the mean-square of the cable current. It is clear that R_k can be used as a range change control.

D.C. transformer

The alternating current transformer employs a large number of turns to keep small the magnetizing current required to produce the magnetic flux that opposes the flux produced by the current to be measured. Thus overall the current ratio of the transformer is accurately defined in terms of the turns ratio of the windings. The principle of minimum flux change has the advantage of operating the magnetic core material in a small fixed region of its magnetic characteristic, so that nonlinearity in this characteristic has negligible effect on performance. The principle has been used for direct-current measurement by employing magnetoresistance to measure d.c. flux.

The basic circuit employed to test the idea is shown in Fig. 4. A square ferromagnetic circuit containing an airgap and winding surrounds the insulated cable whose direct current is to be measured. Two magnetoresistances (R_e' and R_e) are attached with silicon grease to a thin copper plate to equalize their temperatures. They are connected in series and driven by a diode low-voltage source (V_d) to restrict dissipation. The active resistance R_e' is in the airgap, while the temperature compensating resistance R_e remains outside the gap. Because of the square-law characteristic of R_e' it is necessary to operate it at a constant bias flux density (B_k), and this is produced by a stable fixed current (I_k) in the feedback winding (W).

If a direct current (I) occurs in the cable, a change of flux will occur in the magnetic circuit, R_e' resistance will change, as will the voltage (V) at the connecting point of R_e' and R_e. This voltage on being amplified by A and applied to resistance R_m, will produce a current (I_f) in the feedback winding (W) so as to produce a flux in the magnetic circuit to oppose the original flux produced by I. If the gain in the flux detector circuit and the voltage gain (A) are high, then the resultant flux change in the magnetic circuit will be very small, and I and I_f will be simply connected by the expression $I = NI_f$, where N is the number of turns of the feedback winding. The current I_f can be measured by means of a d.c. ammeter in series with the output of the amplifier.

The integrated amplifier has high gain (about 45,000) and produces a noise voltage of about 0·5 μV referred to its input, so it is necessary to use a 0-50 μA meter in a low-pass filter circuit. When $I = 0$, zero meter deflection is obtained by adjustment of a stable offset current I_0.

It has been shown[4] that I and I_f are in fact related by the expression

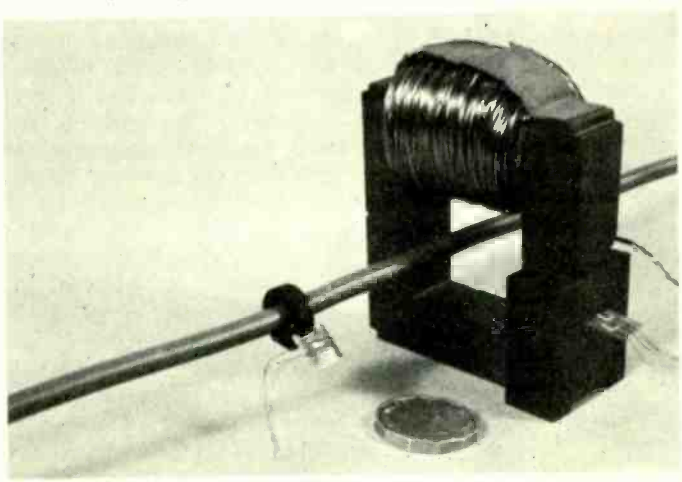
$$\frac{I_f}{I} = \frac{1}{N}\frac{1}{[1 + 1/K]}$$

where

$$K = \frac{NAR_ePB_k}{V_dR_mR_e'(l_i/\mu + l_g) \times 397},$$

the open-loop gain, P is the dissipation in R_e', l_i and l_g are mean magnetic-circuit length and airgap width respectively, and μ is the ferrite magnetic relative permeability. With values $N = 500$, $A \simeq 45{,}000$, $R_e \simeq R_e' \simeq 100\ \Omega$, $P \simeq 1$ mW, $B_k \simeq 0{\cdot}06$ T, $V_d \simeq 0{\cdot}7$ V, $R_m \simeq 500\ \Omega$, $l_i = 18{\cdot}7$ cm, $l_g = 0{\cdot}89$ mm and $\mu \simeq 1{,}000$, K has a value of about 10.

The amplifier gain fall-off is arranged to start at about 20 Hz



The magnetic circuits for the mean-square ammeter (left) and the d.c. transformer (right) are shown here. The magnetoresistances are also visible, but in operation one would be in the air gap.

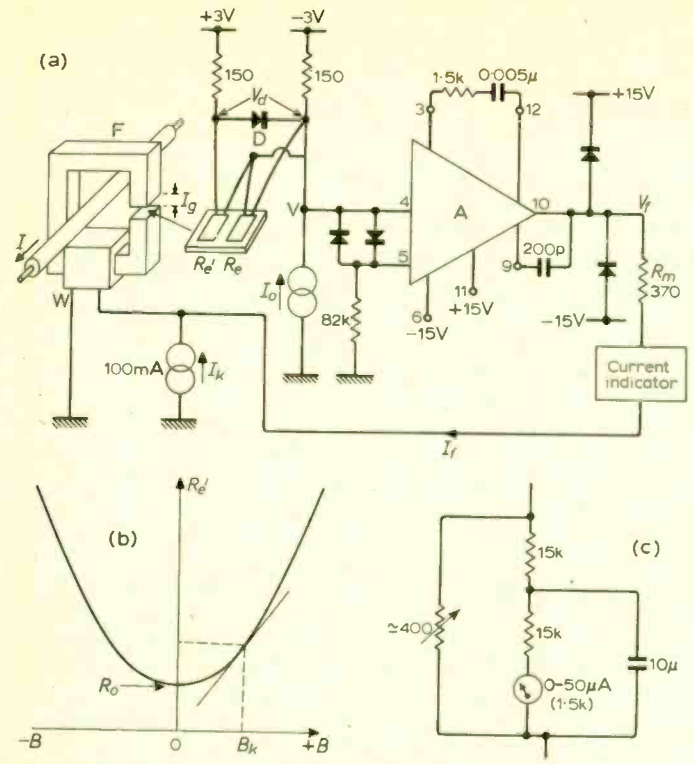


Fig. 4. Direct-current transformer. The basic circuit diagram (a) has R_e', R_e = type FP17L100 magnetoresistances (see Fig. 1 and Table 1). All diodes = silicon, type ZS72 (Ferranti). F = manganese-zinc ferrite, grade A5 (l_g = 0·89 mm, l_i = 18·7 cm, μ = 1,000 (Ferroxcube U-cores FX1795). W = 500 turn (N) winding of 24 s.w.g. A = 45,000 ±50% (MC1709CP integrated amplifier, Motorola).

to reduce noise and avoid instability problems. With full-scale deflection on the meter when I = 1 A, linearity is much better than 1% above I = 0·2 A; below this value amplifier nonlinearity at low signal levels has some effect. Wide variation in the cable diameter and position of cables in the magnetic circuit has no noticeable effect on readings. The input impedance of the transformer is very low by virtue of the effective high reluctance of the magnetic circuit. The current indicator could be at a considerable distance from the rest of the circuits.

Temperature effects

In both the experimental circuits utilizing magnetoresistances described above, the limit to current sensitivity and measurement accuracy is primarily fixed by drift, due to amplifier drift and magnetoresistance temperature dependence. Low temperature coefficient magnetoresistances, operated with minimum self-heating in compensating balanced arrangements should be used, and if necessary further temperature compensation can be achieved by a series thermistor or a parallel metal resistor. Amplifier drift can be reduced by using a d.c. chopper amplifier arrangement.

The experimental circuits described indicate two further useful applications of magnetoresistances. Both circuits are relatively simple and are useful for measuring currents in insulated cables by clipping a measuring head on to the cable. The mean-square ammeter is suitable for measuring practically any current waveform, while the direct-current transformer will measure low-frequency currents (for example, less than 10 Hz) where ordinary current transformers are inadequate.

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[2] Yuan, L. T.; "Magnetoresistive transducer", *Solid State Electronics*, 1966, Vol. 9, pp. 497-502.

[3] Kataoka, S.; "Multiplying action of the magnetoresistance effect in semiconductors and its application to power measurements", *Proc. I.E.E.*, 1964, Vol. III, No. 11, pp. 1937-1947.

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Announcements

"U.H.F./S.H.F. Techniques" is the title of a course of six evening lectures to be held at Norwood Technical College, Knight's Hill, London S.E.27, commencing February 3rd. Fee 15s.

M.E.C.–Electrosil Merger. Miniature Electronic Components Ltd, of Woking, has been merged with the Electrosil Group and all future enquiries and orders should be placed with Electrosil Ltd, P.O. Box 37, Pallion, Sunderland, Co. Durham.

Compat Telecommunications, a wholly owned subsidiary of Compat Corporation of New York, has established offices in Woolmead House, Woolmead, Farnham, Surrey, to handle all of the business of its parent company outside the U.S.A. Compat are manufacturers of computer-controlled data communications equipment.

Radiatron Components Ltd has been formed to operate in association with Radiatron Ltd and to deal with a wide range of components. It will handle the Elma range of collet knobs, stud switches, Elmaset instrument cases and readout counters. Both companies will operate from 76 Crown Road, Twickenham, Middx.

Racal Electronics and **Kelvin Hughes** have agreed to work in partnership on a range of h.f., s.s.b. marine radiotelephones. Racal have a contract from Kelvin Hughes for the design and manufacture; Kelvin Hughes the world-wide marketing of the products.

Industrial Control Systems Ltd have moved to 78-90 Clarke Road, Northampton. (Tel: Northampton 32417).

The Crawley offices and laboratories of **Pye Unicam Ltd** have been transferred to the company's head office at York Street, Cambridge, CB1 2PX.

Microwave & Electronic Systems Ltd, of Midlothian, Scotland, has moved its sales office to 66 Tilehurst Road, Reading, Berks. (Tel: Reading 581937/8.)

G. A. Stanley Palmer Ltd have been appointed sole **U.K. agents** for the range of miniature electrolytic aluminium capacitors manufactured by the International Electronics Corporation of Long Island, N.Y.

Hayden Laboratories Ltd, East House, Chiltern Avenue, Amersham, Bucks, have been appointed exclusive U.K. agents for **Spinner GmbH,** of Munich, W. Germany, manufacturers of radio frequency connectors, directional couplers and other specialized items associated with radio-frequency cables and waveguides.

Nobel Electronics, of Welling, Kent has signed a three-year agreement as sole **U.K. and European agents** for Plastic Capacitors Ltd, Maydown, Co. Londonderry, N. Ireland.

Montclair Electronics Inc, of New York, have appointed G. A. Stanley Palmer Ltd as sole U.K. agents for a range of **magnetic reed relays** and switches from the General Reed Company.

Low-distortion Bias and Erase Oscillator

Evolving a current switching design to give a predictable and stable output level and with no trimming requirement for low distortion

by D. Griffiths, Ph.D.

The design of a good bias and erase oscillator for a tape recorder is not easy. For stable biasing a constant output voltage is required, yet any limiting action in the oscillator must not be allowed to distort the sine-wave drive since this would increase the background tape noise. The circuit should be efficient so that the least expensive semiconductors can be used and, ideally, it ought to be designed to work straight off without any complex setting-up procedures, especially those required to minimize the distortion.

The oscillator was required to operate a Ferrograph Series 6 tape deck but using the procedure outlined below it should be possible to alter the component values to make it suit almost any other recorder.

Specification

The Ferrograph handbook gives the inductance of the two-track FE16 erase head as 1·5mH (per track), requiring 80mA at 27–30V and 68kHz; the record head only requires about 5mA at 15V. The power required from the drive circuit is fortunately not $0{\cdot}08 \times 30 = 2{\cdot}4$ watt but depends only on the losses in the heads; a perfect inductor can not have a net dissipation of energy. Since the erase head has a mu-metal core it is only useful to measure its loss under actual working conditions, for it is quite hopeless to try to extrapolate data on iron-cored inductors.

In the absence of a suitable measuring bridge the losses in this head were assessed by observing their damping effect on a tuned circuit resonating at 68kHz with 30V across it.

The inductance of this test circuit should be less than, say, one fifth of that of the tape head so that the resonant frequency is not too greatly changed by the extra head inductance, but the waveform need only be roughly sinusoidal.

It was found that each winding of the FE16 head introduced the same damping effect on the test circuit as did a 3·3kΩ resistor. Under operating conditions in a parallel resonant circuit the head could thus be thought of as a perfect 1·5mH inductor in parallel with a 3·3kΩ resistor, resulting in power dissipation of about 0·25 watt.

At this point one has to face firmly the problem of ensuring a constant output voltage. The necessary limiting action can use the "curvature of the characteristics" of the active circuit elements but designability is sacrificed and well stabilized power supplies are required to maintain operation in the critical region. Some form of a.g.c. could be employed but amplitude overshoot at switch on must be avoided. This is also a problem with thermistor stabilization. The alternative scheme chosen here is to send constant current pulses of a suitable shape through a tuned circuit coupled to the tape heads and rely on a reasonable Q value to reduce the harmonics sufficiently. This filtering is more effective than one might imagine since the harmonic amplitudes decrease with increasing order, while the attenuation of the tuned circuit also rapidly increases with rising frequency. With transistors or valves it is a simple matter to generate well enough regulated driving pulses for this application but the feasibility of the scheme depends entirely on maintaining a good Q in the filter despite the loading of the losses in the tape heads.

Current switching

Ideally the reader should now turn up *Wireless World* for November and December 1962 to an article by R. C. Foss and M. F. Sizmur which gives an admirably lucid account of current switching sine wave oscillators. Their first diagram is reproduced here as Fig. 1 and is a good starting point. When the current generator is first connected to the tuned circuit the voltage at point (A) will swing below $+E$ with a period governed by the resonant frequency. The size of this swing depends on the losses in the LC circuit, as well as the magnitude of the drive current. Eventually the voltage at (A) swings back up towards $+E$, even with the constant current generator still connected. When the voltage across the resonant circuit is zero (i.e. when the point (A) is at $+E$ again) we choose to switch the current supply into a bypass resistor R_{bp}. The point (A) then continues its upward voltage swing and but for the losses this would take it as far positive above $+E$ as it had been below $+E$ half a cycle earlier; the current generator has infinite output impedance and cannot load the LC circuit. When the voltage at (A) eventually falls to $+E$ again we reconnect the current supply to the tuned circuit and the cycle repeats.

As a step to a practical realization Fig. 2 shows the next stage of complication and is also from Foss & Sizmur's article. Here the tail current I_t is alternately switched between the transistor and the diode by the action of the voltage induced in the base winding N_b which is coupled to the tuned circuit. As indicated, a phase reversing connection is necessary so that when the point (A) is below $+E$ the base end of N_b is positive with respect to ground and the transistor conducts as required. But for this base winding voltage and

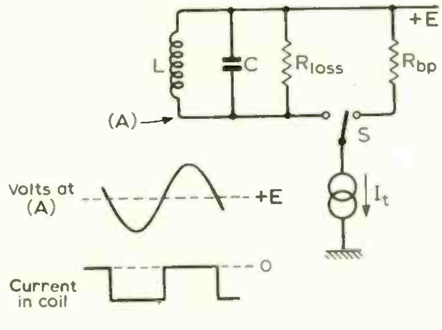


Fig. 1. Principle of a current switched LC oscillator.

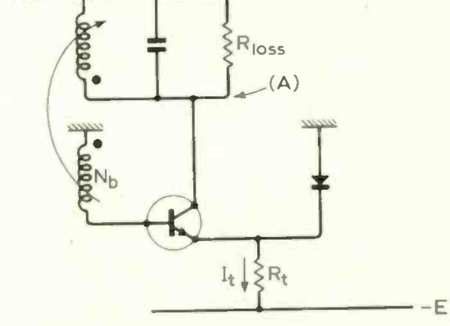


Fig. 2. Tail current is switched between the transistor and the diode.

V_{be}, the tail current driving the LC resonator would be E/R_t. The tuned circuit is only lightly damped by the transistor as the collector is a high impedance point.

In Fig. 3 the diode is replaced by another transistor with its collector connected to a similar LCR circuit as that on the left hand side. Except for the brief instant of current changeover, the tail current flows only through either Tr_1 or Tr_2. Whichever transistor is off will have its collector above $+E$ while the other collector is equally below $+E$. That is, the voltages at (A) and (B) see-saw about the positive supply rail.

It is now only a small step to the final arrangement shown in Fig. 4. A single tuning capacitor is employed across a centre tapped inductor which has an additional winding to provide the required bias and erase voltages. As only a positive supply rail was available, the bottom of the tail resistor is connected to ground and the centre tap of the base winding supplied with a suitable potential stabilized with a zener diode. A pair of plastic encapsulated transistors is used for each switch to give the collector dissipation required when both erase heads are simultaneously connected in two channel operation. The 15Ω emitter resistors help to equalize the current in each pair and are useful inspection points at which to observe the individual current waveforms. The 2·2kΩ base resistors are a personal whim to reduce possible excessive base currents when trying out the prototype.

We choose to make the reference voltage defining the tail current about 2·5V above common. There are two reasons for using such a small value. First, that the collector voltages can have a large excursion which will entail a lower step-up ratio to achieve the desired output volts and hence a lower reflected loss from the heads, giving a better Q factor in the filter. The second reason is connected with reducing the output distortion, as discussed later.

To see if the negative going excursions are bottoming the transistors one does not check the voltage waveform at the collectors (!) since the flywheel effect of the high Q tuned circuit dominates the response; it is more useful to examine the tail voltage across R_t as shown in Fig. 5 and look for the 'dents' indicated. It must be remembered that during the off half cycle the transistor experiences a maximum collector voltage equal to the supply plus the amplitude of the downward swing. 12V r.m.s. is about the maximum reasonable collector excursion with the circuit values shown in Fig. 4. The maximum collector voltage is thus about 22 + (12 × 1·4) V. Even allowing for a peak emitter voltage of 3V (see Fig. 5), this uncomfortably exceeds the maximum recommended V_{ce} = 30V of the 2N3704 transistors used in the prototype.

If the tail current is assumed to be constant during each cycle, the collector dissipation can be easily calculated once the mean collector-emitter voltage is known over the conducting half cycle. Since the average value of a half-sinewave is 0·64 times its peak value and if the collector peak swing is 12 × √2 volts, then the collectors are on average 12 × √2 × 0·64 = 11V below 22V when conducting, i.e. 11V. When operating, an Avo indicated 2·6V d.c. across the tail resistor, giving a tail current of 52mA. On average, V_{ce} = 11 − 2·6 = 8·4V and if the current is equally shared between each pair of transistors, the mean collector dissipation is 8·4 × 0·052 × 0·5 × 0·5 ≈ 110mW, with the second factor of 0·5 arising from the on-off time ratio.

If the two erase tracks are in use together, the extra drive can be achieved by suitably reducing the tail resistor and there is still a reasonable margin of collector dissipation in hand. This circuit is not very efficient in terms of power consumption; the four transistors dissipate ≈ 450mW to overcome a head loss of 250mW.

Although a good L/C ratio is needed to minimize losses in the tuned circuit primary, the maximum allowable primary inductance is set by the Q value which has to be maintained in spite of the damping effect of the tape head losses. With a 1:2 step-up ratio between primary and secondary the equivalent loss resistance of 3·3kΩ looks like 820Ω across the primary circuit. If the circuit shows a Q value of Q_f at resonant frequency ω_f, the dynamic resistance of the circuit is $Q_f\omega_f L$. Clearly, in this case, we need $Q_f\omega_f L \leq 820\Omega$.

Now how much Q_f is needed? Foss and Sizmur show that with square current pulses the ratio of the n^{th} harmonic voltage V_n to the fundamental V_1 is given by:

$$\frac{V_n}{V_1} = \frac{1}{(n^2 - 1).Q_f}$$

As a square wave can only generate odd harmonics, the third order one will be the principal component and with Q = 10 its amplitude will be 1·25% of the fundamental. Since it is planned to use something a little less brutal than square driving pulses, this Q value should suffice. For operation at 68kHz this fixes L at 0·25mH. A 30mm diameter ferrite pot core, Mullard LA 2202, was used (with a permeability of 63) giving 1mH for 60 turns. The primary was wound in bifilar fashion to give 30 turns centre-tapped, with 60 turns on the secondary. 28 s.w.g. enamelled copper wire was used for both windings. The working flux density in this application is in the region of 50–100 gauss.

The tuning capacitor has to be larger than the value required to tune the 0·25mH primary inductance to 68kHz since the inductance of the tape head is reflected into the resonant circuit with a magnitude reduced by the square of the

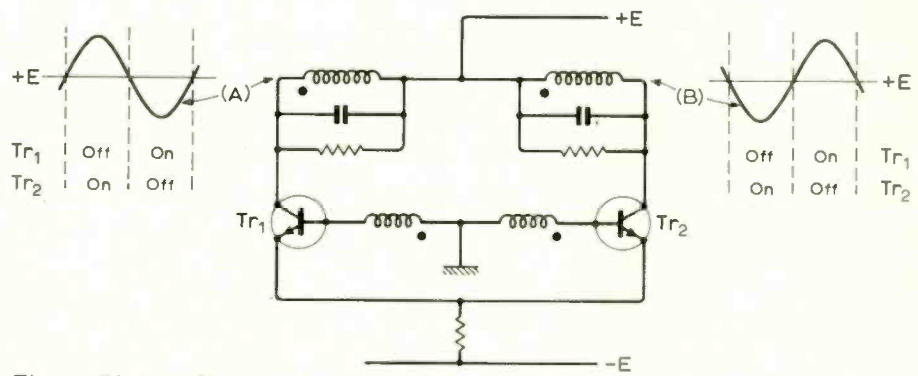


Fig. 3. Diode of Fig. 2 replaced by second transistor.

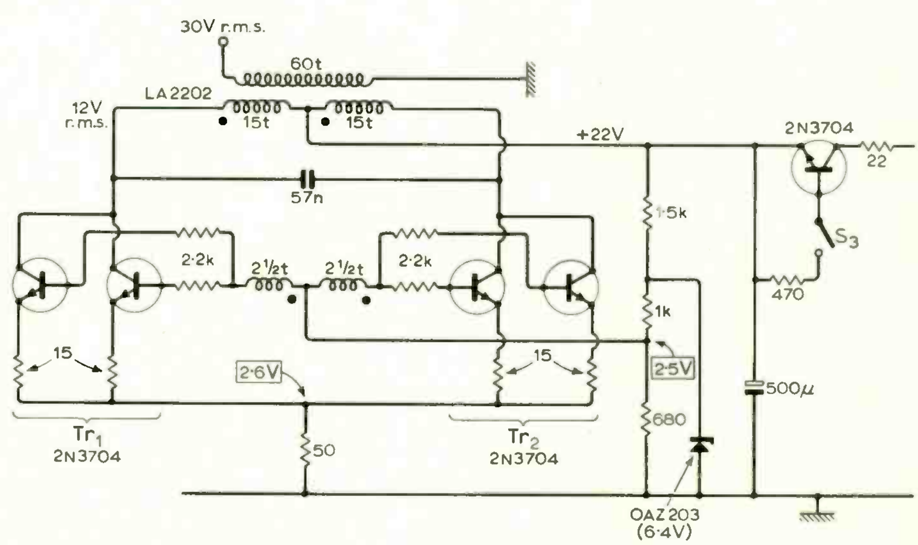


Fig. 4. Practical oscillator circuit.

step-down turns ratio; the total inductance is thus lowered since "inductors in parallel add like resistors in parallel". The secondary winding itself does not behave as a separate inductor since the induction in it is solely determined by that needed to balance the primary applied voltage. If the a.c. voltage across a coil does not depend on the rate of current change through it, then it does not have inductive properties.

Although Ferrograph quote a nominal erase inductance of 1·5mH, their suggested operating point of 80mA and 30V r.m.s. indicates a working inductance more like 0·9mH. As the Vinkor pot core was used without an adjuster, its inductance would be about 10% below nominal. Together with the slight contribution from the recording head, the total effective inductance would thus require about 51,000pF to tune it to 68kHz; in practice 10% tolerance 47,000pF and 10,000pF capacitors were used in parallel. If tuned filters are used as bias rejectors in the recording amplifiers, it will be important to keep the same bias frequency on single and two track operation. The extra inductance of the second head would lower the frequency further and a suitable extra tuning capacitor would have to be switched in.

It must be confessed that there is a little bit more complication in Fig. 4 than was admitted in earlier paragraphs and this concerns the shape of the current pulses. A square pulse with its sharp edges is obviously a rather poor approximation to the required output waveform and something a little more sinewave-like would ease the filtering problem. Now one cannot go to the limit and use an exactly sinewave current drive derived from the output waveform as there is then no limiting action, other than unintentional clipping and bottoming, etc. As a compromise we use a current pulse which is "partly square and partly sine". This is illustrated in Fig. 5 which shows the alternating voltage waveform across the 50Ω resistor, superimposed on the calculated d.c. level which could not be observed with the a.c. coupled scope available.

The squarewave part of the current waveform is developed by the long tail switching action; the sinewave part has a similar amplitude and is derived from the filtered output. This is achieved by giving the base windings a suitable number of turns so as to inject an appropriate amount of sinewave signal in series with the steady d.c. reference level. However, one must be careful in selecting the amplitude of this a.c. component otherwise the maximum reverse bias rating of the emitter-base junctions will be exceeded and extra protective diodes will be needed; the reverse emitter-base rating for the 2N3704 is given as 5 volts. It is important to recognize that the 'off' base junction sees both base windings in series generating the reverse voltage.

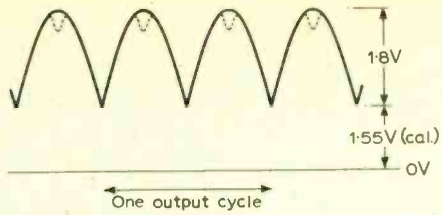


Fig. 5. Waveform across tail resistor. 'Dents' in the peaks indicate that the collectors are bottoming.

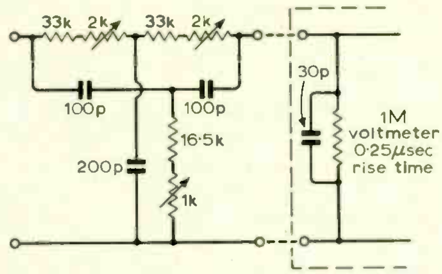


Fig. 7. Twin-T filter for 68kHz.

Fig. 6 shows the base of Tr_2 $+V_b$ above V_{ref} derived from the zener diode. But for the V_{be} of this 'on' transistor and the voltage drop across its 15Ω emitter resistor the top of the tail resistor would also be $+V_b$ above its d.c. level, taking the emitter of Tr_1 with it (in the positive going direction). Meanwhile the voltage $-V_b$ on the left hand base winding is holding the base of this transistor down $-V_b$ below V_{ref}.

The 1·55V d.c. level in Fig. 5 assumes a V_{be} of 0·7V and allows for the two 15Ω resistors in parallel. The mean level of the a.c. component is $1{\cdot}8 \times 0{\cdot}64 = 1{\cdot}15$V and thus an Avo on a d.c. range across the tail resistor should register $(1{\cdot}55 + 1{\cdot}15) = 2{\cdot}7$V. This agrees well with the 2·6V observed. Evidently the steady current component is 32mA and the r.m.s. a.c. contribution is 25mA. In a Fourier representation of a square wave, the first harmonic has an amplitude of $4/\pi$ times the amplitude of the square wave. Adding these two contributions to the voltage developed across the dynamic resistance seen in the primary circuit, one can estimate the loss resistance at 570Ω, corresponding to a working Q of 6—which is rather below the design figure.

The 500μF reservoir capacitor in Fig. 4 ensures that the oscillations decay smoothly when the circuit is switched off, thus helping to keep the tape heads demagnetized. The decay time is 0·5–1s. Switch S_3 is controlled by the deck selector knob and operates via the series 2N3704 to minimize peak current through the switch contacts. The 22Ω resistor ensures that the initial charging current of the 500μF capacitor does not greatly exceed the maximum transistor current rating of 800mA.

Performance

After all that story, how does it do its job? The amplitude of the output

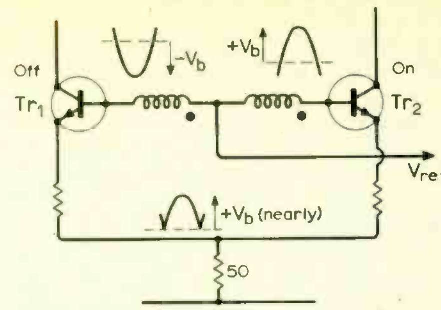


Fig. 6. How base-winding voltages add to build up reverse emitter-base voltage.

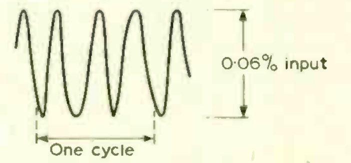


Fig. 8. Residual waveform at the base winding after passing through the twin-T filter.

slowly increases by 2–3% during the first half minute or so after switch on and this is probably due to heating of the transistors. A 40°C rise in junction temperature would lower V_{be} by about 90mV and thus increase the standing tail current enough to account for this observed rise in output. This effect could be reduced by increasing the tail voltage, remembering to add diodes to protect the base-emitter junctions from excessive reverse voltages arising from the necessary accompanying increase in sine wave drive. It is doubtful if the present small change in biasing could possibly be detected by its effect on the recorded signal. Changes in the supply voltage only slightly affect the oscillator output as might be expected; a 10% reduction in supply potential reduced a 28V output by just under 1·5%.

In the absence of a wave analyser, a simple passive twin-T rejector was used to filter out the fundamental to see what was left. Fig. 7 shows the filter circuit, and Fig. 8 shows a sketch of the residual signal from the 16V bias at a recording head on single channel operation. The amplitude of this residual is 0·06% of the input level and appears to be largely 3rd harmonic as expected. A sine wave input of 3×68kHz to the filter was attenuated by about 7dB as seen on the voltmeter, so it seems likely that these distortion products do not have an amplitude exceeding, say, 0·2% of the fundamental. This seems quite satisfactory and shows that the idea of using current pulses with the "edges rounded off" does indeed greatly reduce the output distortion while still retaining an adequate stability of output level. With a working Q of 6, square drive pulses would have given a 3rd harmonic component an order of magnitude greater at 2% of full output. Judged audibly, the tape hiss is very low and BASF double play tape on the Ferrograph appears to give a peak signal-to-hiss ratio in the upper fifties of decibels.

Industrial Telemetry

Some recent supervisory and control schemes

by R. E. Young

The early 1960s saw major developments take place in industrial telemetry[1], largely as the result of the wide introduction of solid-state equipment and digital techniques. Rapid expansion then followed in step with the accelerating demand for these forms of automation backed by the extremely high reliability that they had been shown to give.

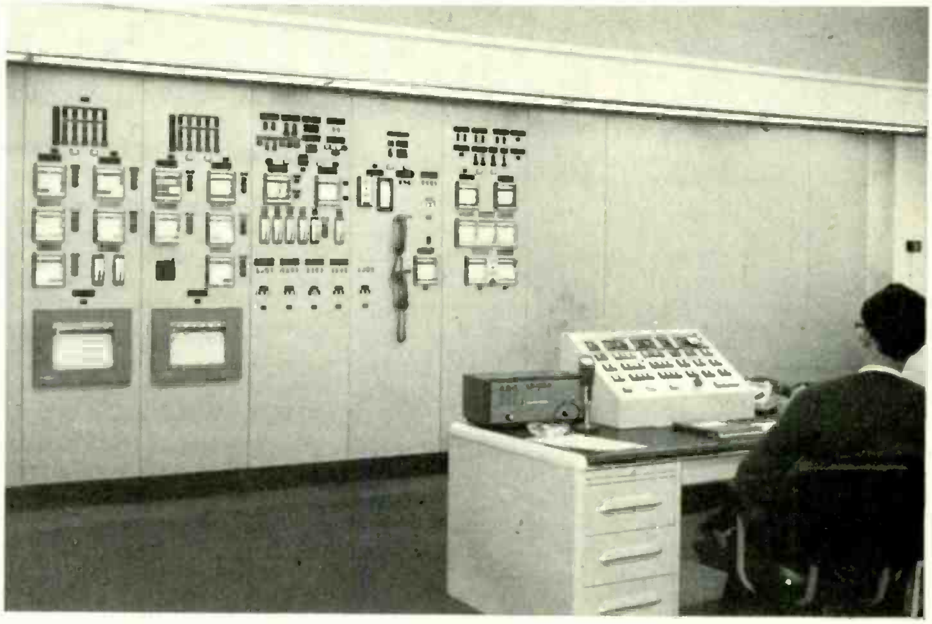
Much of this expansion occurred in the public utility field, authorities being strongly influenced in their policy by the almost overwhelming growth of "service" distribution networks, e.g. for electricity and water, and the increasing cost of manning them in the conventional way.

In general, the economy shown by the adoption of supervisory telemetry methods increases with the size and complexity of the project. Furthermore, the most favourable conditions for setting up such remote control systems are usually found with high concentrations of population and industry.

Thus in a large scale installation for electricity supply in the Far East control is exercised over the distribution network for the urban area of Kuala Lumpur[2], three bulk supply stations and a total of fifteen substations being covered by the first phase of the scheme.

Recently commissioned, this is a classical digital supervisory system with time-division multiplexed telemetering and telecontrol, and employing the interrogation/reply, or responder, techniques which are used almost exclusively for this work[3]. With time-division operation, each information source is scanned in turn, and in these systems this is achieved by interrogating each source in terms of the unique (digital) address allocated to it.

Measurement or equivalent data points are grouped in blocks of addresses according to priority, so that the period which elapses between successive scans of a given point represents the "updating" time for its particular address block. With the exception of control functions, the various groups of addresses are interrogated in accordance with a pre-determined scan cycle, system programming being arranged to interlace these addresses within the overall scan period. Typically, an updating period of 11 seconds is realized for some 80 measurement addresses; while alarm indication (e.g. for abnormal transformer oil temperature), carrying more urgency, is given a block updating time of 5 seconds.


Control room at the Shell shore terminal at Bacton for their North Seas gas project.

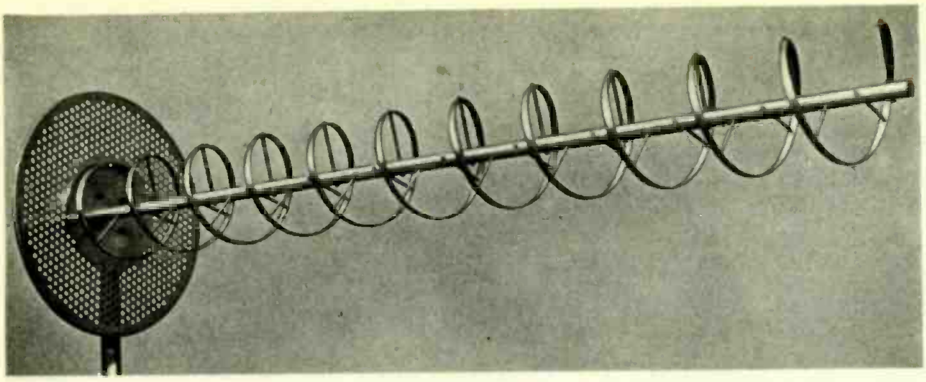
Control instructions are also sent out by interlacing, but this is done by interrupting the routine scan cycle and thereby extending it for the additional time-sharing to take place. The same system word format is used for the control "way" addresses as for monitoring, and also in both cases the encoded replies sent back from the outstation follow the same pattern.

Obviously, measurements and monitoring information generally must be presented as far as is possible without any likelihood of there being any ambiguity or misinterpretation of the intelligence. It is of interest that the network electrical measurements, viz. voltage, power, reactive power and current, are displayed in analogue form on conventional d.c. moving-coil meters. This involves the use of an individual digital-analogue convertor for each meter as the incoming signals are handled digitally throughout the logic system. It may be taken that the factor of additional cost is considered more than offset by the advantages accruing from working with a familiar form of display. Also it may be noted that the eight-bit binary number d.a.c.s which are employed, and are of the "successive approximation" type, act as information stores over the measurement updating period.

Communication between master and outstations is by "four-wire" working using special modems* developed to give maximum speed data transmission over nominal 3kHz bandwidth circuits. These links are set up either in existing pilot cables where suitable spare cores are available or in the main communication cables run along the power network routes. Protection against extraneously induced high voltages is provided at all station line terminations by lightning arrestors and isolation transformers.

The other main area of application for supervisory telemetry systems is the monitoring and control of oil and natural gas pipe line schemes. Here inaccessibility of wellheads and pumping stations is a

* *modulator-demodulator (unit), "four-wire" working demands two conductor pairs, one for "go", one for "return".*



Helical aerial supplied by C & S Antennas Ltd for the North Sea gas radio links.

major driving force in the adoption of such schemes; these conditions, compared with those associated with most public utility networks, tend to impose more severe restrictions on the choices open to the telemetry system designer. Thus with projects such as the North Sea installations, the virtually inescapable use of radio links produces a "design constraint" which affects the whole system.

The same basic time-division digital techniques are employed, however, for these installations as for the public utility networks; and logic circuit blocks and address-reply methods are essentially the same. The telemetry installation for the B.P. group of wells in the West Sole field[4] is typical of such practice for North Sea operations, the outstations on the project's three wellhead platforms—"A", "B" and "E1"—being under the supervisory control of the shore station at Easington, Yorks. As commissioned, the system capacity is 22 measurements, 120 monitor and alarm indications, together with 41 well control functions; the routine scan updating time is 25 seconds.

One of the main system operational requirements arising from its production control function is the calculation of mass flow for each of the eleven wellheads involved. These corrected values have to be obtained in terms of differential pressure type flow measurements and corresponding manifold pressures; and initially a study was made of using an individual analogue computer at each wellhead. However, it proved possible to centre this function on a single digital computer which is fed with the data in digitized form, and which gives flow rates as a 3-digit numerical indication up to a maximum per wellhead of 59.9 million cu.ft./day.

In general, measurements are displayed on the mimic control panel with three-digit representation for temperature and four for pressure, a "scaling" facility being incorporated in the transfer from binary code input to the decimal reading output. Accompanying this implied degree of resolution, a 12-bit format is used for both addresses and replies, each carrying three additional parity bits for error checking. With the system parameters obtaining in this case, the address/reply cycle time becomes 570 milliseconds. For transmission over the radio links, the address and reply pulse trains are converted in a frequency shift keying modem to a "tone" input for the transmitter—2.3kHz for binary '0' and 2.7kHz for binary '1'.

The u.h.f. radio link scheme adopted for this project operates in the 460-MHz band and inevitably invites comparison with the offshore wellhead control scheme at Das Island in the Arabian Gulf (Umm Shaif oilfield). Described originally in 1964[5], this employs a microwave, 3cm ('X' band) link based on a commercially available transmitter magnetron with a rated peak power output of 2.5 kW in the centre of the band. The main point of interest in the present context is that in this earlier scheme a single transmitter is used with radiation from a "cheese" reflector giving a half power beamwidth of about 40° in azimuth to cover the fan-like sector in which the wellheads are grouped.

In contrast the North Sea u.h.f. system utilizes a two stage "hand-on" arrangement for signal transmission between wellhead platforms. The primary link is established between the Easington master and the outstation on platform A, working between this platform and both platforms B and E1 being on a "broadcast" as distinct from a beamed mode. Thus the transmitters on B and E1 operate on a shared frequency, and, in order to avoid radiating together, "come on the air" only when their own plant addresses are received.

Helical aerials mounted on 200-ft towers are used for transmission and reception on shore and at the platforms. The 11-turn helical elements, made by C & S Antennas Ltd, have a rated beamwidth of 30° to half power points with a v.s.w.r. of 1.5 over the operating bandwidth of 400-500 MHz.

The radio link equipment itself is solid-state throughout; Standard Telephones and Cables type HTR20 f.m. transmitter/receivers being employed with a nominal transmitter power output of 5 watts. This output is obtained from a varactor tuned to act as a trebler stage fed at 133.3—163.3MHz from two preceding trebler stages which have a modulated input at 14.8—17.8MHz. This latter input is obtained from a two-stage phase modulator with crystal oscillator reference drive. Two stages of amplification are interposed between the modulator and the first set of treblers which is followed by three more stages of amplification to give the input to the final varactor trebler. A tunable bandpass filter is placed in the output from this varactor stage to act as a harmonic suppressor.

In the double superheterodyne receiver the first mixer is preceded by a two section bandpass filter and two stages of r.f. amplification. The bandpass filter is largely responsible for the degree of r.f. selectivity and second channel rejection achieved. A single crystal oscillator feeds both mixer stages, the higher local oscillator frequency required for the first mixer being obtained by multiplication by six (doubler followed by trebler). This avoids the production of spurious beats which is possible with two separate oscillators, "spurious responses" being given as below —80dB. Intermediate frequencies are 70MHz and 10.7MHz with an initial local oscillator frequency of 55—68MHz, fed to the second mixer, and multiplied to 330—408MHz for the first mixer. The output of the second mixer, nominally at 10.7MHz, is fed into a crystal filter to give selectivity at this frequency and thence to a wideband amplifier which provides the input to the limiter and discriminator stages. Both the wideband amplifier and these stages are constructed as linear integrated circuits. Performance criteria are based on a minimum acceptable signal/noise ratio of 20dB; while, for the individual radiation requirement of the broadcast mode, carrier "on" switching time is given as not more than 1mS.

"Telegrid" master programming control System

As already indicated for the two schemes described, system working speed (data handling speed) is kept relatively low, i.e. the equivalent of a narrow-band telephony channel is generally employed for communication in present generation supervisory telemetry projects. Nevertheless, these communication links must be highly "secure" and, equally important, economic in the full sense of the word; and with the ever growing demand for telecommunication channels, this latter condition is becoming increasingly difficult to meet. This difficulty is encountered whether line or radio working is adopted because of limited capacity—scarcity of installed cables, particularly in built-up areas, and on the radio side, severely restricted channel allocations for such applications.

It is with this background that the Telegrid proposals were put forward as a means of "multiplying" the number of existing communication channels by what may be called supra-multiplexing under the control of a master programming source. The scheme, proposed by G. S. Kermack, managing director of Serck Controls, makes specific communication channels available to users, grouped on a network basis, in accordance with a time sharing schedule held in sequence by narrow band synchronizing signals. Planning of such a scheme would have to be on a national scale, although operation might be on a regional basis within the national framework.

In one suggested embodiment of the scheme (Figs. 1 and 2), four networks are time multiplexed under the control of broadcast synchronizing signals. Network allocation, as shown, would be electricity, gas and water for a distribution group, together with an emergency or stand-by network available to take over from any one of the other three. Alternatively, network 4 could be utilized to give a low speed data transmission facility over a large area in the event of, say, major floods occurring.

The programming of these networks is carried out by a combination of imposed synchronization and delay timing. For this the networks are grouped into two pairs, with the first member of the pair taking the external synchronizing signals, and the second becoming operative after a predetermined time delay following the commencement of the first network scanning cycle or sub-programme.

The main technical feature of the system is the form of coded signals used for programming the networks. These signals are built up from "pips", i.e. short bursts, of tone which can be broadcast from a low-frequency (say 300kHz) transmitter to cover a regional area. In addition to their task of time division synchronization, these master programming signals perform two other functions:—

(i) Designation and identification of the network to be activated;

(ii) "Start" the individual network scanning cycle after receipt of the correct combination of signals.

The latter provision is achieved by arranging that the five pips must have been preceded by the six pips before the "five-pip" group is opened up, and conversely. If this sequence is not maintained owing to the absence of a signal or the presence of spurious signals, then the networks are not activated until the correct sequence is re-established, i.e. the system has been made to "fail-safe".

From the diagram it will be seen that guard spaces form part of the timing pattern. These take care of short-term variations and fault condition in individual sub-programmes.

Other developments employing these techniques can be envisaged, as, for example to arrange for each pip or burst of tone to contain a predetermined number of cycles, and, by counting at the receiving end, to obtain further complementary checking and possibly more precise synchronization.

One of the main advantages of the system is that with an accurately maintained pip (tone) frequency, say at 400 Hz, the signal extraction band-pass filters can be made extremely sharp and only a "crevasse" is required within the synchronizing channel transmission spectrum. Furthermore, with such band-pass filters (e.g. crystal or mechanical type) high rejection of spurious signals is obtained.

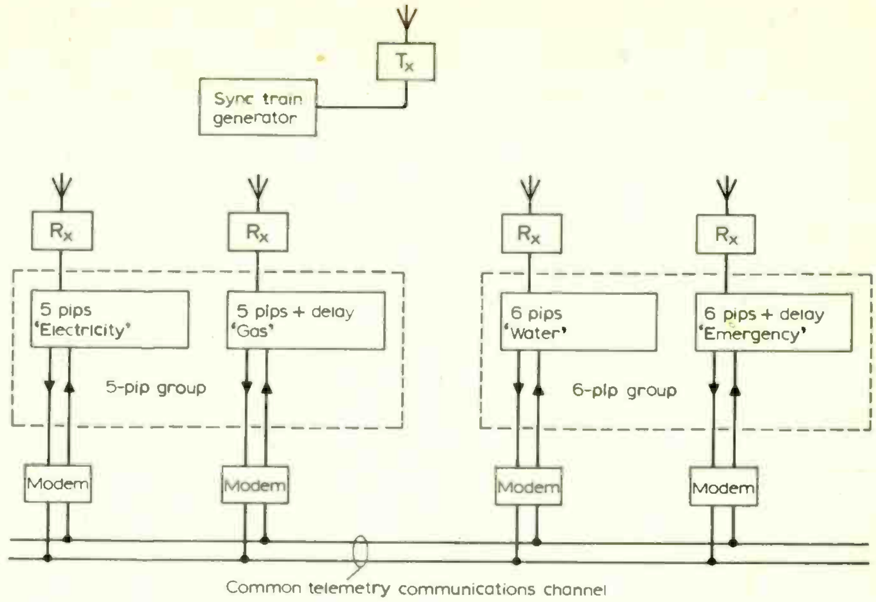


Fig. 1 "Telegrid" diagrammatic network arrangement.

Television Link on Low Bandwidth Cable

Television, as a time-division system, is part of the telemetry family; and in presenting visually inaccessible conventional gauges and similar instruments fulfils a specific telemetering function. One of the main attractions of such presentation is that effectively there is no updating delay, and—often of more importance—rapid changes in quantities can be seen on analogue displays via a television link, whereas they are beyond the capability of the comparatively slow scanning telemetry system.

To speed up these telemetry scanning rates to give the equivalent of a television system, though theoretically possible, becomes prohibitive in cost. There are instances, therefore, when a television scheme provides the most economic way of tackling an unconventional instrumentation problem, this being much more marked when it can be used for other monitoring duties as well.

A variant of such a scheme is represented by the East Anglian Water Company's closed-circuit television installation at Lowestoft where the emphasis is on surveillance rather than instrument monitoring. The outstanding feature of this project is the video link. As far as is known, this is the first time that a link has provided operationally acceptable picture quality over a 5.2 mile (8.35 km) length of "telephone grade" cable without intermediate repeaters.

This link is of interest on two counts. The first is the potential offered by the equalization and allied techniques which have been developed and shown to be effective under these conditions for high-speed pulse transmission. This aspect bears directly on the problem of obtaining maximum data transmission speed on restricted bandwidth circuits, and also on the improvement in error rate produced by equalizer correction of signal distortion.

The second point is that compromise on picture standards had to be reached but that it proved possible to use a field rate of 50 per second instead of the much lower rate proposed at first in view of the "no-repeater" and other limitations. It was clear that a 405-line interlaced structure was the absolute maximum that could be attempted in terms of frequency and this had the advantage that comparatively low-cost U.K. standard camera and monitor equipment could be employed.

The S.T.C. ten-pair cable installed by the water company between its intake and borehole station at Belaugh and the Horning master control for both

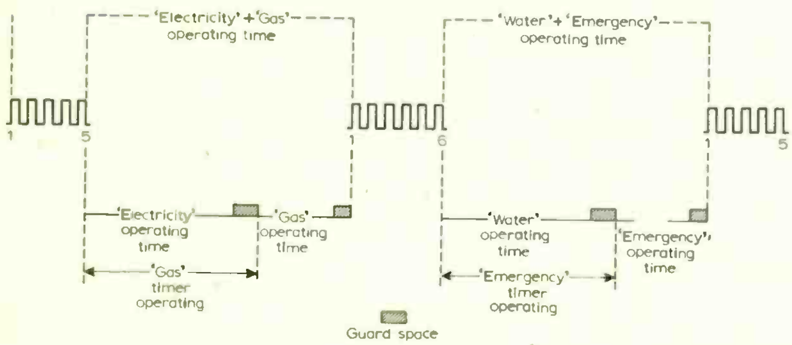
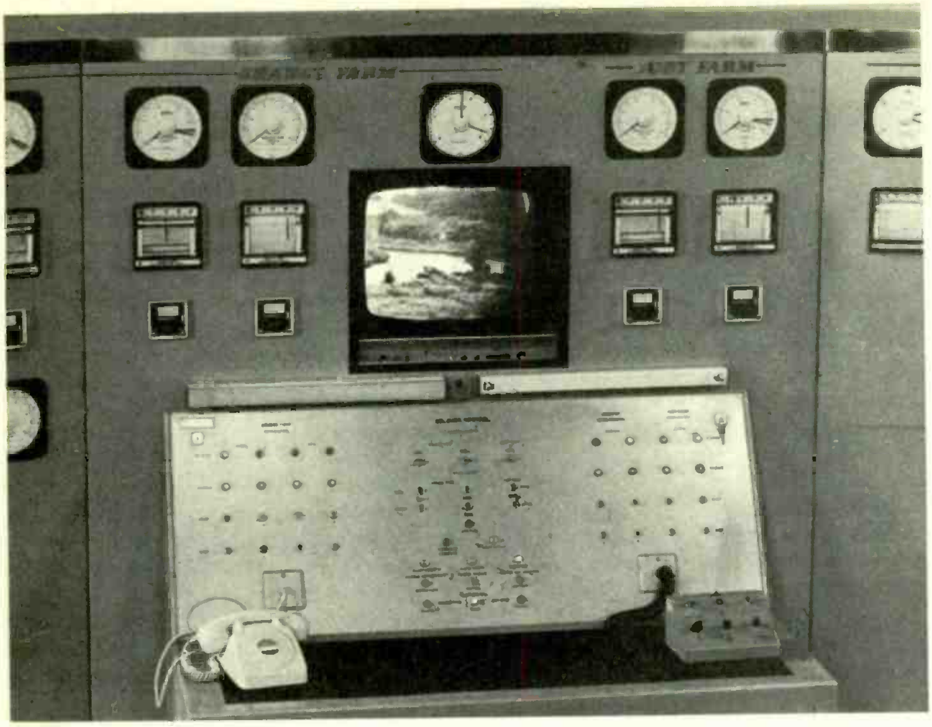


Fig. 2 Overall timing pattern of "Telegrid".



Telemetry and television supervisory control position at the Horning master station of the East Anglian Water Company showing monitor picture as received over the low bandwidth cable link.

telemetry and television signal transmission is of the polythene insulated type with outside steel tape armouring acting as a screen. Diameter overall is some 22mm, individual conductors being of 0.9mm diameter. Conductor resistance is given as 44.2 ohms per mile at 15°C, with attenuation at audio frequencies of 1.20 dB/mile and crosstalk between pairs better than −80dB measured on site. Attenuation reaches a value of some 80dB down at 1.2MHz with an unequalized frequency response approximating to the form $1/\sqrt{\text{frequency}}$.

In the final solution, the video circuit was established as two conductor pairs diametrically opposite each other in the cable and connected in parallel. This was found marginally better than a single pair circuit; and at the output of the receiving end equalizing amplifier a uniform response within 2dB is obtained up to 1MHz. The overall response is about 6dB down at 1.2MHz with relatively sharp cut-off thereafter.

It should be noted that a contribution to improved high-frequency response is made by including pre-emphasis in the transmitting characteristic. This amounts to 10dB with a 3dB point at 200kHz. The necessary phase equalization is carried out at the receiving end, some 0.5 microsec. correction being given at 1MHz.

Finally a "crispener" is incorporated to sharpen up fast edges in the video waveform by speeding up their rise times in a non-linear network. The crispener unit embodies an input filter to extract the fast edges from the equalized video waveform for feeding to the non-linear system. This filter operates by signal subtraction referred to a wideband delay line to give a Gaussian type response. After leaving the non-linear network, the artificially sharpened edges are recombined with the original video waveform, the delay time in the filter being compensated by introducing a corresponding delay in the main video path.

The results obtained in respect of signal/noise ratio, better than "dusk" camera input level (10 foot–candles), can be ascribed to the precautions taken, e.g. with regard to common mode rejection (receiving head amplifier rejection ratio of 70dB), and to the maintenance of electrical balance about earth at the appropriate points in the sytem. The picture reproduction gains considerably from the crispening technique, although quite acceptable without it; a rise time of less than 800 nanosec being obtained on a 10kHz square wave as measured at the input to the crispener. The overall picture quality also benefits from the use of a monitor with a black level clamp.

Acknowledgement must be made to L. G. Davis, of Glenn Sound Services, who was responsible for the special television link equipment described, and to Serck Controls for supplying details of the two supervisory schemes covered in the first part of the article.

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Reprints from W.W.

We regret the delay in the publication of the reprint of the articles covering the Bailey 30-W and 20-W amplifiers and pre-amplifier. This is now available. For the convenience of new readers we give below the full list of *W.W.* reprints obtainable from the Trade Counter, Dorset House, Stamford Street, London S.E.1. Prices include postage and packing.

No. 1. **High-fidelity Amplifiers** by A. R. Bailey (Nov. and Dec. 1966, and May, June and Nov. 1968). Contains articles on 20- and 30-W amplifiers; a pre-amplifier; and an output transistor protection plus modifications and relevant correspondence. Price 5s.

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Wireless World Audio Signal Generator (Nov. and Dec. 1963). Price 3s.

Active Filters

6. Lead-Lag network and positive gain

by F. E. J. Girling and E. F. Good**

The well-known Sallen-and-Key low-pass and high-pass circuits provide two of the most useful building bricks for applications where only low or moderate values of Q factor are needed. They are practical examples of the second type of active system analysed in Part 4, a lead-lag or lag-lead network and positive gain, with input connections changed to give low-pass or high-pass response as the case may be.

A notch (or zero) in the stop band is easily obtained by adding a parallel path. This gives a section with a characteristic useful in the realisation of a high-order filter as a cascade (or product) of factors.

Adaptations which give "tuned-circuit" response are also described.

The Sallen-and-Key circuit

The lead-lag network in a loop with positive gain, K, has been analysed in general terms in Part 4. This analysis can be applied to the Sallen-and-Key low-pass circuit, Fig. 1(a), by reference to Fig. 1(b), which shows the same circuit with the input V_1 shorted out and a floating generator V_2 introduced into the feedback path. If now the loop is supposed opened at X and the freed end of V_2 earthed, it can be seen that μ is given by the transfer function of the lead-lag network, equn. (19), Part 3, multiplied by K, i.e.

$$\mu = \frac{KpT_2/b}{1 + p(T_1 + T_2/b) + p^2T_1T_2}, \quad (1)$$

where

$$T_1 = C_1(R_1 + R_2),$$

$$T_2 = C_2R_2R_1/(R_1 + R_2).$$

With the loop closed, therefore, since $\beta = 1$,

$$\frac{V_{out}}{V_2} = \frac{\mu}{1-\mu} = \frac{KpT_2/b}{1 + p\{T_1 + (1-K)T_2/b\} + p^2T_1T_2}. \quad (2)$$

Now the argument used in Part 4 for deriving equn. (39) from equn. (38) gives, if proper note is taken of the change of suffixes as between Fig. 11(b), Part 4, and the present Fig. 1,

$$\frac{V_2}{V_1} = \frac{1}{pC_2R_2} = \frac{b}{pT_2}. \quad (3)$$

Hence

$$\frac{V_{out}}{V_1} = \frac{K}{1 + pT/q + p^2T^2}, \quad (4)$$

where

$$T^2 = T_1T_2 \quad (5)$$

and

$$\frac{1}{q} = \left(\frac{T_1}{T_2}\right)^{\frac{1}{2}} + \frac{1-K}{b}\left(\frac{T_2}{T_1}\right)^{\frac{1}{2}}. \quad (6)$$

Alternative analysis as a series-feedback system

The Sallen-and-Key circuits are commonly used with $K = 1$ (nominally), obtained from an amplifier controlled by 100% series negative feedback. Such an amplifier is most simply represented by the cathode follower, as explained in Part 1 and as used again in the present Part in Fig. 4. Figs. 2(a) and (b) are a reminder of the identity between a cathode follower and a high-gain sign-inverting amplifier with 100% series feedback, and show that essentially the only difference is in the practical matter of where the circuits are earthed. To clarify the identity the output-current circuit in each case is completed by including R_L and by drawing a short circuit through the h.t. batteries X and any other bias supplies, since it must be assumed that they show negligible impedance to signal frequencies. Ordinarily, of course, the cathode follower, Fig. 2(b), is drawn with the "earthed", or common, line at the bottom. Since

$$K = A/(A+1) \quad (7)$$

$K \to 1$ only as $A \to \infty$.

By using the enhanced emitter follower, Fig. 3(a), values of A of several hundreds are readily obtained; and it may sometimes be useful to extend this type of connection to triples, etc. If an operational amplifier is to be used, one with differential input and which can take 100% feedback is needed, Fig. 3(b). An operational amplifier should give the low voltage drift obtainable from a long-tailed-pair input stage, which would be useful in an l.p. filter required to pass zero-frequency (d.c.) signals.

In the ideal case, $K = 1$, equn. (6) reduces to $q = (T_2/T_1)^{\frac{1}{2}}$, and hence $T_2 = qT$ and $T_1 = T/q$. For finite A, substitution from equn. (7) into equn. (6) gives

$$\frac{1}{q} = \left(\frac{T_1}{T_2}\right)^{\frac{1}{2}} + \frac{1}{b(A+1)}\left(\frac{T_2}{T_1}\right)^{\frac{1}{2}}. \quad (8)$$

This is the same as equn. (39) of Part 5, and is algebraic proof of the identity of

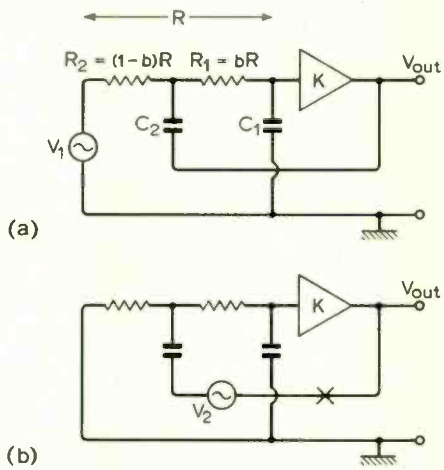


Fig. 1. (a) Sallen-and-Key low-pass filter; (b) the same with V_1 short-circuited and a new source V_2 introduced to facilitate analysis as a lead-lag loop with positive gain.

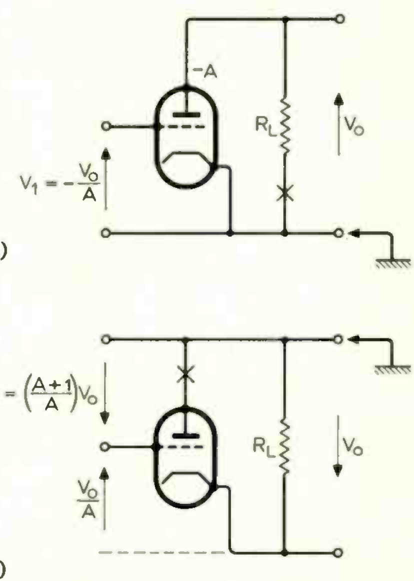


Fig. 2. Example of an active device—a valve: (a) in common-cathode connection, i.e. as a high-gain amplifier, $V_0/V_1 = -A$; (b) in common-anode (cathode-follower) connection, i.e. with 100% series negative feedback, $V_0/V_2 = A/(A+1)$.

* Royal Radar Establishment.

the Sallen-and-Key circuit and the lag-and-integrator loop with series feedback (Fig. 15 of Part 5), which was mentioned in Part 1. The identity may also be demonstrated graphically as shown in Fig. 4. This is an application of the identity shown in Fig. 2. The only difference between the two circuits is that in (a) terminal 2 of the output is shown earthed, and in (b) terminal 1. But since in neither—in so far as the diagrams tell the whole truth about the circuits—does any current flow in the earth lead, the change makes no essential difference and may be regarded as only a device for marking the node which is to be taken as the reference point of potential.

The triode valve in Fig. 4, as elsewhere, is intended as a universal symbol for a three-terminal amplifier. When more complex amplifiers are used, the identity may not be seen so clearly. A multistage amplifier used as a voltage follower will be wired up somewhat differently from when it is used as a high-gain sign-inverting amplifier, because of the practical requirement in each case for operation from an earthed power supply. Similarly if an operational amplifier with differential input is used, the internal workings are somewhat different in the two connections. But as all are close approximations to an ideal three-terminal amplifier the essential identity remains. The two separate drawings of Fig. 4 are, moreover, not really needed. The change of earth point can be made by the disconnection marked X and the reconnection marked with an arrow head.

Compensation for finite internal gain

If A is finite and positive, application of 100% feedback gives $K < 1$, since $K = A/(A+1)$. The theoretically best way of making $K \to 1$ very closely is to make $A \to \infty$. But in some situations it may be helpful to use an amplifier of moderate internal gain and reduce the feedback, Fig. 5(a), so that

$$K = \frac{A}{A+1}\cdot\frac{r_2 + r_1}{r_2} = 1, \qquad (9)$$

which is obtained when

$$r_2 = r_1/A. \qquad (10)$$

This artifice, which is easily applied when the amplifier is, for example, an enhanced emitter follower, Fig. 5(b), allows the use of the ideal design values. It is important to remember, however, that K (and consequently q) is just as sensitive to changes in A as before. Caution is needed, therefore, if this method is used to obtain values of q much beyond the reach of the same amplifier without compensation. There is no complete substitute for high internal gain.

In the alternative analysis (or synthesis) (i.e., as a lag and an integrator in a

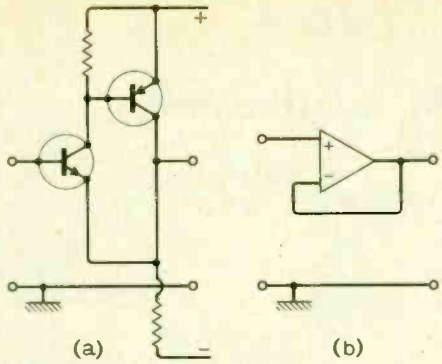


Fig. 3. Possible amplifier configurations for $K \to 1$.

negative-feedback loop) the parallel argument is that finite gain, A, in the integrating amplifier can be compensated by applying positive feedback (feedback fraction $1/A$) to the amplifier to make its gain apparently infinite, and further that the adjustment is no more critical in the one case than in the other.

In both methods of analysis over compensation produces a regenerative term (negative damping) which subtracts from the positive damping designed into the circuit, and q is higher than intended; but only if the magnitude of the negative term exceeds the positive will the system oscillate, although, of course this is no criterion of satisfactory performance.

It follows also that working the Sallen-and-Key circuit with $K > 1$ is equivalent to working the integrating amplifier in the lag-and-integrator circuit with $A > \infty$ (if mathematicians will allow the statement), meaning that the amplifier gain at zero frequency, $-A$, has gone positive, since $A = K(1-K)$, and that the circuit is working in the region above the diagonal in Fig. 9, Part 5. This further emphasises the regenerative nature of the situation when $K > 1$.

Use of Sallen-and-Key circuit with K > 1

When $K = 1$, $T_2/T_1 = q^2$. Hence when $R_1 = R_2$, $C_2/C_1 = 4q^2$. This may give an inconveniently large value for C_2. By using $K > 1$ a lower value for the ratio T_2/T_1, and hence of C_2/C_1, is needed for a given q.

Let $C_1 = C/x$, and $C_2 = xC$. Then $T_1 = CR/x$, $T_2 = xb(1-b)CR$, and substitution in equn. (6) gives

$$\frac{1}{q} = \frac{1}{x}\left(\frac{1}{b(1-b)}\right)^{\frac{1}{2}} + x(1-K)\left(\frac{1-b}{b}\right)^{\frac{1}{2}}, \qquad (11)$$

which can be rearranged to give K in terms of x, q, and b. Thus, for example, the circuit may be designed for $C_2 = C_1$, but at the cost of providing components (both Cs and Rs) of sufficient accuracy in initial selection and in long-term stability to meet the increased sensitivity to errors in component values (Fig. 9, Part 4), which can be interpreted as the result of balancing negative and positive resistance.

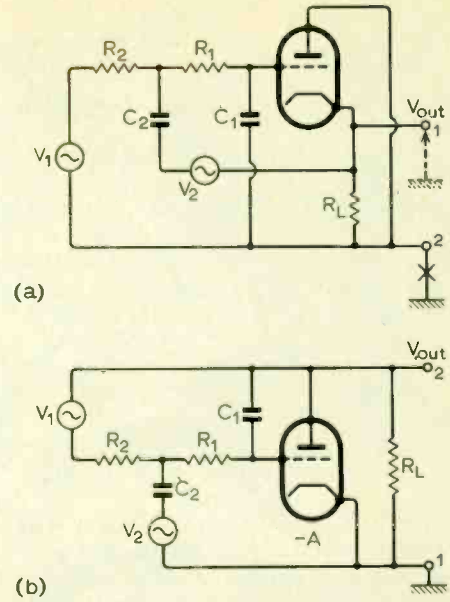


Fig. 4. By changing only the earth point, a Sallen-and-Key l.p. filter is shown to be a lag-and-integrator loop. Also, as the alternative input, V_2, has one side earthed, the circuit is now suitable for use as a 1st-order band-pass filter.

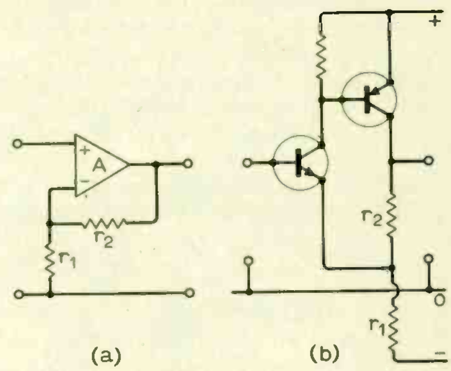


Fig. 5. Feedback less than 100%.

Lead-lag network with resistive loading

The network in the feedback path (Fig. 1) is as shown in Part 3, Table 1, diagram (a). As the ratio C_2/C_1 is increased, $k \to 1$. Hence, when $K = 1$, the loop gain at ω_c also tends to unity, (i.e., $kK \to 1$), and $q \to \infty$ (theoretically without limit) as shown by the diagonal straight line in Fig. 9 of Part 5, q being proportional to $\sqrt{(C_2/C_1)}$.* Up to this limit the active circuit behaves like a passive circuit: no matter what the component values the circuit cannot become unstable (oscillate), and errors in component values are not magnified.

When the network is loaded by resistance R_3 as shown in Fig. 6, $k \nrightarrow R_3/(R_3 + R_1)$, and the limiting case

* It is interesting to notice that increasing C_2/C_1 reduces q_0, the Q factor of the passive network. However, over the useful working region (i.e., to the left of the points of maximum Q) and always when $K > 1$, the increase in k dominates.

is therefore reached when $K = (R_3 + R_1)/R_3$. This may then be considered as a practical maximum value for K, since in general magnification of errors is to be avoided. The presence of R_3 also alters ω_c, and design equations are given in the appendix. This compensation for resistance loading by increasing K will be most useful when the resistances are effectively accurate and stable, and the ratio k is therefore accurately known. If R_3 is the input resistance of the amplifier, it may be subject to considerable uncertainty. It is then desirable that $R_3 \gg R_1$ (and $\gg R_2$), so that if compensation is attempted K will be only slightly > 1 (Fig. 7).

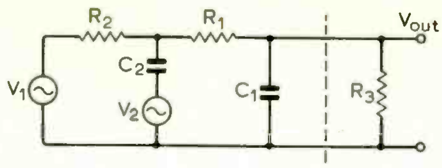
High-pass filters

Any low-pass filter can in principle be transformed into a high-pass filter by substituting $1/pT$ for pT; which means changing a lag into a lead, an integrator into a differentiator, and so on. Operating thus on equn. (4) of Part 5 gives

$$\mu = \frac{pT/q}{1 + pT/q} \cdot pqT \qquad (12)$$

and the schematic shown in Fig. 8. The transformation does not necessarily yield a practical filter however. Fig. 9 is formally the h.-p. counterpart of Fig. 13, Part 5, and if checked by conventional linear circuit analysis gives the expected h.-p. transfer function. As it stands, however, it is unlikely to give a satisfactory performance. At high frequencies it is a shunt feedback system with ratio arms C_1 and C_1'. As the impedances of these fall indefinitely with increasing frequency, and as the response is required to remain level, indefinitely increasing current is called for. An upper limit to these currents can be set by padding out C_1 and C_1' with r and r' inserted at the points X, making $C_1'r' = C_1r$. The presence of these resistors must however to some extent reduce both loop gain and loop phase shift in the region of ω_c, and the circuit is now better treated as a two-lead loop, time constants C_1r and C_2R_2, with negative gain (R_1/r if $A \to \infty$), to which the formulae for two lags and negative gain derived in Part 4 can easily be adapted.

The theoretical schematic of Fig. 8 does not show the same difficulty. At high frequencies (well above ω_c) $V_{out} \to V_{in}$, and the "error" $(V_{in} - V_{out}) \to 0$. There is therefore no call for indefinitely increasing current through C_1 with increasing ω; and the same is true for the series-feedback arrangements shown in Fig. 10. Fig. 10(a) shows the functional schematic of a straight-forward circuit with no buffer between the lead and the differentiator; c.f. Fig. 15, Part 5. The design values given are for the ideal case $A \to \infty$. Reversing the procedure shown in Fig. 4, we redraw the circuit with change of earth point and obtain the Sallen-and-Key high-pass circuit shown in Fig. 10(b). The only serious doubt the



$$T_2 = \frac{C_2R_2R_1}{R_1+R_2}, \quad T_1^* = k_1C_1(R_1+R_2)$$

$$k_2 = \frac{R_3}{R_1+R_3}, \quad k_1 = \frac{R_3}{R_1+R_2+R_3}$$

Fig. 6. CR network with resistance loading.

designer should have about these circuits is that in theory the amplifier should have a level response up to infinite frequency. As, however, it can be of the voltage-follower type, and as high internal gain is of importance only in the vicinity of ω_c, it will generally not be difficult to give the amplifier a satisfactory performance up to the highest intended signal frequency. It may, indeed, be thought desirable in these and other active high-pass systems, especially when the internal gain is high, to define the final high-frequency cutoff (with added components) rather than leave it to the chance values of stray capacitances.

For finite values of A

$$\frac{1}{q} = \left(\frac{T_2'}{T_1'}\right)^{\frac{1}{2}} + \frac{1}{b(A+1)}\left(\frac{T_1'}{T_2'}\right)^{\frac{1}{2}} \qquad (13)$$

The notation is in conformity with Part 3, Fig. 8 and equns. (28) to (31), and the primes serve to draw attention to the inversion of the positions of the suffixes compared with the low-pass case, equn. (8). For $K > 1$ the appropriate substitutions can be made in the low-pass results.

Input impedance

For low q (say $\leqslant 1$) the input impedance of a Sallen-and-Key filter is not very different from that of the network when passive. At higher values of q, because T_2/T_1 or T_1'/T_2' become $\gg 1$, at the resonant frequency the voltage across the element behind the input terminal is equal to q times the input voltage approximately, and it is necessary to take account of the relatively heavy current that will flow if the filter itself and the preceding circuit are to operate satisfactorily.

Notch factors

A notch filter with a symmetrical amplitude vs. frequency response may be used to reject a particular frequency, or be combined with others to form a broader band-stop filter. One with an asymmetrical response may be used as a section of a higher-order filter (e.g., Fig. 1 of Part 1) to give a sharper transition from pass band to stop band. In either case the notch is associated with a quadratic factor with a numerator zero.

Passive CR notch networks, with and without buffer amplifiers, have been

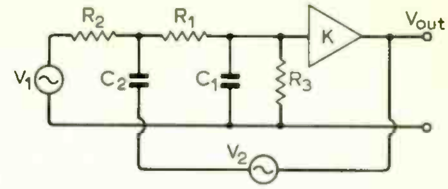
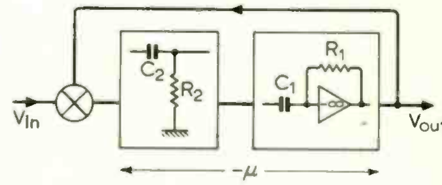


Fig. 7. Resistance-loaded network in active filter.



$$T_2' = C_2R_2 = \frac{T}{q}, \quad T_1' = C_1R_1 = qT$$

$$\frac{V_{out}}{V_{in}} = -\frac{p^2T_1'T_2'}{1+pT_2'+p^2T_1'T_2'} \qquad (A = \infty)$$

Fig. 8. Lead-and-differentiator loop as h.p. filter.

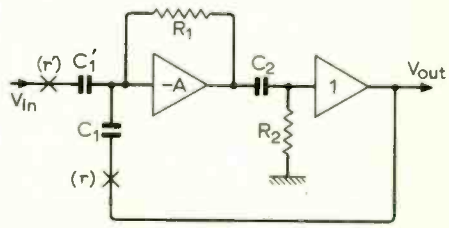


Fig. 9. Practical difficulty in high-pass circuit obtained by direct transformation of low-pass circuit (Part 5, Fig. 13).

described in Part 3. For such networks $q \ngtr \frac{1}{2}$; and Fig. 11(a) shows an example which gives a symmetrical notch,

$$\frac{V_{out}}{V_{in}} = \frac{1 + p^2T_1T_2}{1 + p(T_1 + T_2/b) + p^2T_1T_2}, \qquad (14)$$

with a zero at $\omega_\infty = 1/(T_1T_2)^{\frac{1}{2}}$, if the necessary equal-time-constant condition is met, $T_3 = T_2$; i.e.,

$$C_3R_3 = C_2R_1R_2/(R_1 + R_2) \qquad (15)$$

For $q > \frac{1}{2}$ the circuit can be made active (i.e., feedback can be applied) as shown in Fig. 11(b). The part of the circuit above and to the right of the dotted line through X_1 is the standard Sallen-and-Key l.p. circuit (Fig. 1), if the assumption is made that the output impedance of the buffer amplifier (1) is negligible; while the circuit to the left of the dotted line through X_2 is the circuit of Fig. 11(a), unaltered if the assumption is made that the output impedance of the amplifier (K) is also effectively zero. There must therefore be zero transmission at the same frequency as for equn. (14); while signals once injected into the upper part of the circuit, whether through R_2 or through C_1, are subjected to the q of this active part of the circuit. The complete transfer function is, therefore,

$$\frac{V_{out}}{V_{in}} = \frac{1 + p^2T^2}{1 + pT/q + p^2T^2} \qquad (16)$$

where $T^2 = T_1T_2$, and q is given by equn. (6). Preferably the amplifier K is a high-gain amplifier with 100% feedback. Then, as before, $K = A/(A+1)$, and q is given by equn. (8).

For an asymmetrical notch, low-pass type, the numerator becomes $(1 + a'p^2T^2)$, where $a' < 1$, and

$$\omega_\infty = 1/\sqrt{(a'T^2)} = \omega_0/\sqrt{a'} \qquad (17)$$

(ω_∞ is the frequency of the notch, ω_0 the undamped natural frequency of the system.) The required attenuation in the high-pass path is easily added by connecting the buffer amplifier 1 to a tap on R_3; i.e., the network in box B_1 is replaced by the network shown in Fig. 11(d), which has the transfer function $a'pC_3R_3/(1 + pC_3R_3)$. $T_3 = C_3R_3$ must of course still $= T_2$, equn. (15). For an asymmetrical notch of high-pass type, attenuation can be introduced into the low-pass path as in Fig. 19 of Part 3, so that, as for the passive network,

$$\omega_\infty = \sqrt{a}/T = \omega_0\sqrt{a} \qquad (18)$$

Fig. 11(b) is the standard Sallen-and-Key l.p. filter with an added h.p. path. A notch can just as easily be obtained by taking a standard Sallen-and-Key h.p. filter and adding a l.p. path, in other words by starting from Fig. 15 of Part 3, and turning the lower tee into an active filter. The result is shown in Fig. 11(c). As (theoretically) the gains at zero frequency and at infinite frequency are equal, the response is a symmetrical notch. Fig. 11(e) shows attenuation added into box B_2 of Fig. 11(c) (i.e., into the low-pass path) to give asymmetrical notch response, high-pass type. This arrangement may be slightly preferable to that described in the previous paragraph, as high-frequency signals need to pass through only one amplifier.

It is not essential to have a buffer amplifier in the added parallel path. The networks of Fig. 22 of Part 3 can be turned into active filters (e.g., Fig. 12) and the transfer functions are easily derived by making use of those for the passive networks. It is found, however, that for $K = 1$, $q = b'(T_2/T_1)^{\frac{1}{2}}$ or $q = b(T_1/T_2)^{\frac{1}{2}}$. This results in a greater spread of component values, since b' and b are <1 (often $\frac{1}{2}$). Also q_{max} is smaller for a given internal gain A when $K = 1$ nominally. It seems likely, therefore, that the circuits with the buffer amplifiers will usually be preferred.

In the filters with a buffer amplifier, q is a function of the active part of the circuit only, and, as in the simple l.p. and h.p. filters, depends on the ratio of two time constants (T_1 and T_2) and on the amplifier gain K. T_3 is isolated from the active part of the circuit, and so errors in T_3 do not affect q, although they do affect the accuracy of the required match ($T_3 = T_2$) and hence the depth of the notch. If the gain of the buffer amplifier (1) is appreciably $>$ or <1, ω_∞ is moved accordingly, equns. (17)

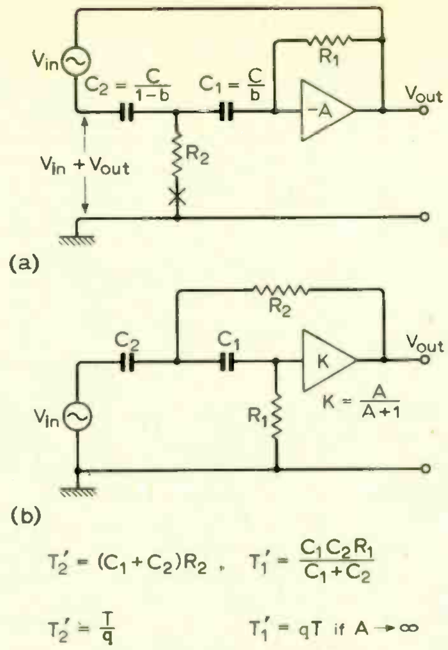


Fig. 10. (a) Lead-and-differentiator loop with series feedback; (b) the same converted by change of earth point to Sallen-and-Key h.p. filter.

and (18), but its gain affects neither q nor the depth of the notch (as long as its output impedance is effectively zero). So in this sense its internal gain is not a critical factor. And in the notch filters without a buffer amplifier, although T_3 cannot vary independently, still q does not depend critically on the balance of components or of time constants, at least for $K \leqslant 1$. This contrasts with the behaviour of some rather similar-looking circuits based on the CR parallel-tee network, which can give higher values of q for a given value of the internal gain, A, when $K = 1$ nominally, and which will be the subject of a later article.

Simple bandpass (tuned-circuit) response

As shown at the beginning of this article, Fig. 1(b) and equn. (1), the standard Sallen-and-Key l.p. filter can be arranged to give tuned-circuit (1st-order band-pass) response by injecting the signal voltage in series with C_2; and, as shown in Fig. 4, for the case $K = A/(A+1)$, (i.e., $K \leqslant 1$), by moving the earth point a more convenient arrangement with one side of V_2 earthed is obtained. Similarly the h.p. filter, Fig. 10, is converted to band-pass by injecting the input at the point X. The strange appearance of the circuits is partly remedied by a change of layout as shown in Figs. 13(a) and 14(a), which show the circuits as having feedback networks of familiar form (e.g., Fig. 3, Part 1), only the input connections being unusual.

Because of the limitation

$$q_{max} = \tfrac{1}{2}\sqrt{b(A+1)} \text{ or } \tfrac{1}{2}\sqrt{b'(A+1)}$$

the circuits are likely to be of limited application; for band-pass filters usually require higher Q factors than low-pass or

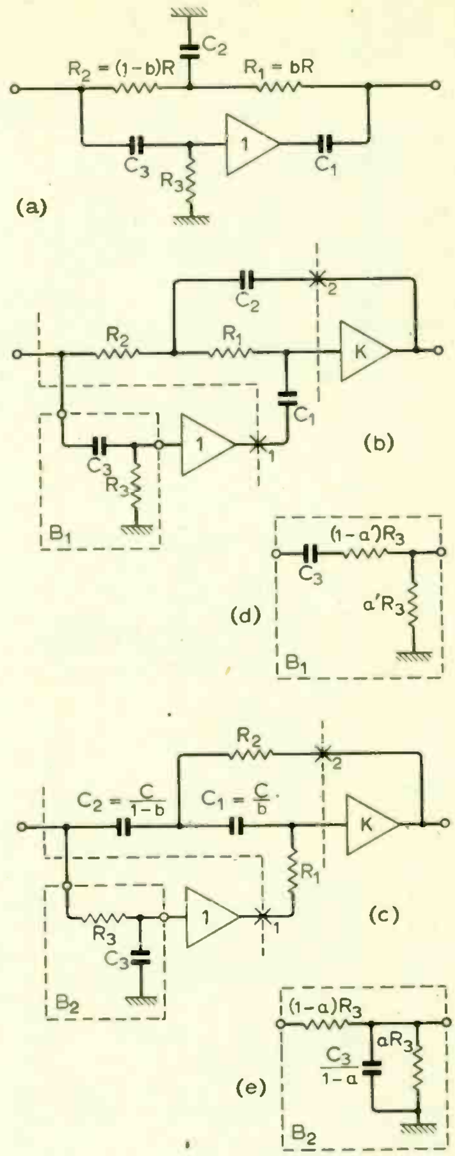


Fig. 11. Modifications for obtaining a notch (or zero): (a) Effectively passive symmetrical notch filter with buffer amplifier in h.p. path; (b) the same made active; (c) similar circuit with buffer in the l.p. path; (d) a method of putting attenuation in the h.p. path of (b); (e) in the l.p. path of (c).

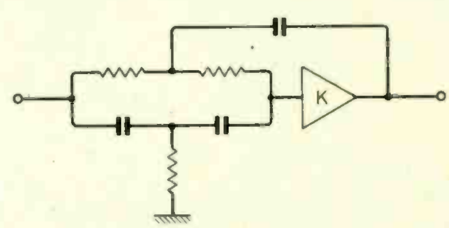


Fig. 12. Notch filter without buffer.

high-pass. For values of q well below q_{max}, however, the circuits are interesting in being fully "designable" while using the minimum possible number of components, one amplifier, two capacitors, and two resistors. This very economy, however, makes the circuits unaccommodating; e.g. the gain at resonance which for $K = 1$ is equal to q^2/b or q^2/b' (i.e., $2q^2$ when b and $b' = \frac{1}{2}$) cannot be varied independently of q;

and to overcome this inflexibility additional components must be added.

An *ab initio* analysis of the circuits, for $A = \infty$, $K = 1$, could be made as follows: (a) write down the current flow caused by V_2, assuming both the input of the amplifier (the virtual earth) and the output are shorted to ground; (b) write down the current flow caused by V_{out}, assuming that both the virtual earth and V_2 are shorted to ground; (c) set the sum of the currents converging on the virtual earth to zero.

The useful part of the current flow (a), i.e. the equivalent exciting current, is the current through R_1 (in Fig. 13) and through C_1 (in Fig. 14), i.e.

$$I_{equiv} = \frac{V_2 pT_2}{R_1(1 + pT_2)} \quad (19)$$

and

$$I_{equiv} = \frac{V_2 p_1 C_1}{1 + pT_2'} \quad (20)$$

where T_2 is the time constant given by C_2 in combination with R_1 and R_2 in parallel (Fig. 13), and T_2' the time constant given by R_2 in combination with C_1 and C_2 in parallel (Fig. 14).

These equations, as could be forseen, represent the current a voltage source would drive through a series CR branch; and so the same response will be obtained if the source V_2 is replaced by the source V_2'' feeding in through a branch C_3, R_3, of time constant as specified, Figs. 13(c), 14(c). For the magnitude (gain) to be the same, R_3 should equal R_1, or C_3 should equal C_1, for the two cases respectively. But the advantage of having the added branch is that now the gain can be varied independently by varying the impedance of the branch while keeping the product C_3R_3 constant.

Alternatively the response to an input V_2' may be calculated. Thus, for Fig. 13,

$$\frac{V_{out}}{V_2'} = -\frac{R_1 + R_2}{R_3} \cdot \frac{1 + qpT}{1 + pT/q + p^2T^2}; \quad (21)$$

whence by equating currents the response to V_2'' can be obtained,

$$\frac{V_{out}}{V_2''} = -\frac{R_1 + R_2}{R_3} \cdot \frac{qpT}{1 + pT/q + p^2T^2} \quad (22)$$

if $C_3R_3 = qT = T_2 = C_2R_1R_2/(R_1 + R_2)$.

By the same type of argument it is easily shown, Fig. 13(d), that low-pass response may be obtained by feeding in a signal V_2''' through a low-pass (simple-lag) tee network, again of the same time constant, $T_2 = qT$.

From the other circuit similar derivations can be made as indicated in Fig. 14. Here it is found that

$$\frac{V_{out}}{V_2'} = -\frac{R_1}{R_3} \cdot \frac{1 + pT/q}{1 + pT/q + p^2T^2} \quad (23)$$

and consequently that C_3R_3 should now equal $T/q = T_2' = (C_1 + C_2)R_2$.

Although all these derived circuits are extravagent in the number of components used, they can be a convenient practical choice. The extra components cause some reduction in q_{max}, but usually the effect is slight. Component values for C_3R_3 are not critical, since the input branch is effectively isolated from the resonant feedback loop by the virtual earth and has almost no effect on q.

Appendix

The transfer function giving V_{out}/V_2 for Fig. 6 is readily obtained from equn. (1) by substituting the impedance of the parallel combination of R_3 and C_1, i.e. $R_3/(1 + pC_1R_3)$, for $1/pC_1$; and by making the following convenient substitutions:

$$k_1 = R_3/(R_1 + R_2 + R_3),$$

$$k_2 = R_3/(R_1 + R_3),$$

$$T_1^* = k_1T_1,$$

i.e., T_1^* is the CR product formed from C_1 and $(R_1 + R_2)$ in parallel with R_3. [Note: $k_1/k_2 = k_1(1 - b) + b$]. Thus it is found that

$$\frac{V_{out}}{V_2} = \frac{k_1pT_2/b}{1 + p\left(T_1^* + \dfrac{T_2k_1}{bk_2}\right) + p^2T_1^*T_2} \quad (24)$$

From this, proceeding as before, equns. (1) to (4), the l.p. transfer functon for the active circuit, Fig. 7, is obtained as

$$\frac{V_{out}}{V_1} = \frac{k_1K}{1 + pT/q + p^2T^2}, \quad (25)$$

where

$$T^2 = T_1^*T_2, \quad (26)$$

$$1/q = (T_1^*/T_2)^{1/2} + (k_1/k_2)(1 - k_2K)(T_2/T_1^*)^{1/2}. \quad (27)$$

In the special case $K = 1/k_2$, $1/q = (T_1^*/T_2)^{1/2}$ and $T_1^* = T/q$, $T_2 = qT$, which have the ideal form of the corresponding equations for a simple LCR passive prototype. Thus the sensitivity to errors in capacitor values is the same as that of the circuit with an unloaded network, although, since $K > 1$, there is additional sensitivity to errors in the values of the resistors that determine K and k_2.

Corrections to Parts 3 and 4

In Part 3, October issue, in the caption to Fig. 16 CT_2 was printed instead of CR_2.

In Part 4, November issue, the following have been noticed. In Fig. 2, in the box representing the passive network, only the denominator of the transfer function appears. This should read 1/(the expression printed). In Fig. 5(a), 1 + has been omitted from the denominator of the transfer function in the box representing the passive network; and in the last full column (p. 525) references to Figs. 10(a) and 10(b) should read 11(a) and 11(b) respectively.

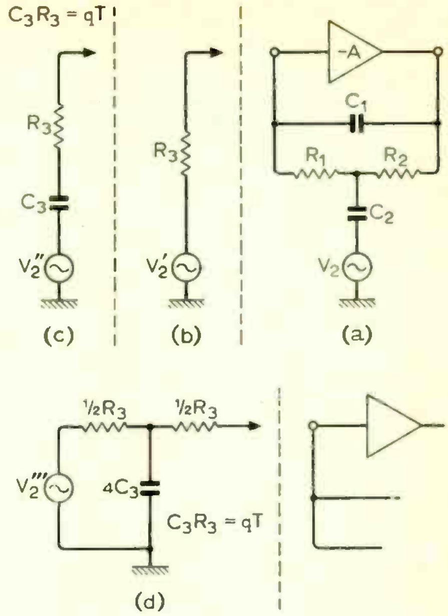


Fig. 13. Derivation of band-pass filter and an alternative form of low-pass filter from the standard l.p. filter (Fig. 4).

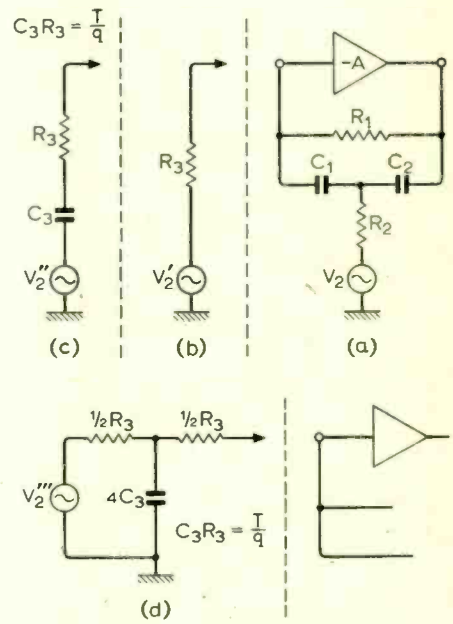


Fig. 14. Similar derivations from the standard h.p. filter (Fig. 10).

Personalities

Professor C. W. Oatley, O.B.E., F.R.S., professor of electrical engineering in the University of Cambridge, has been awarded one of the Royal Society's three Royal Medals for 1969/70 "for his distinguished work in the wartime development of radar and latterly for the design and development of a highly successful scanning electron microscope." Professor Oatley has occupied the chair of electrical engineering at Cambridge since 1960. He was in charge of basic work on radar transmitters and receivers at the Government Radar Research & Development Establishment during the war and from 1945 until receiving his professorship was lecturer in electrical engineering at the University.

The University of Edinburgh has appointed **P. L. Kirby,** D.Sc., F.Inst.P., who is research director of Welwyn Electric Ltd, of Bedlington, Northumberland, as its second visiting industrial professor in the newly established Microelectronics Liaison Unit within the School of Engineering Science. Dr. Kirby graduated from Durham University during the war and after two years working on radar systems at T.R.E., Malvern, returned to the North East where he worked on the physical properties of glasses. During this period in industry he took the further degrees of M.Sc., and D.Sc. from Durham and then in 1956 moved to Welwyn Electric Ltd. Professor Kirby has maintained a personal interest in the measurement and interpretation of noise and non-linearity effects in resistive materials.

Peggy Lilian Hodges, head of Guided Weapon Simulation and System Analysis at the Stanmore Laboratories of GEC-AEI (Electronics), has been elected to the Fellowship of the Royal Aeronautical Society in recognition of the contribution she has made to avionic and guided weapon technology. Miss Hodges was born in 1921 and educated at Westcliff High School, Essex, and Girton College, Cambridge. She joined GEC-AEI (Electronics) in 1950, and her work at Stanmore has been centred largely on the performance of guided weapons. She has worked on many projects, notably Seaslug and Sea Dart, with a particular interest in weapon simulation techniques. Miss Hodges is a senior vice-president of the Women's Engineering Society.

Charles Kao, B.Sc. (Eng.), Ph.D., M.I.E.E., has been appointed an honorary senior research fellow at Queen Mary College, University of London. This is the second such appointment from Standard Telecommunication Laboratories in recent months with a view to bringing industrial experience to University affairs. From time to time Dr. Kao will lecture on his specialist subjects including topics in optical communications, coherent wave optics, and electromagnetic problems. Dr. Kao, who is 36, has been with S.T.L. since 1961, where latterly he has been mainly concerned with problems associated with the transmission of coherent light down optical waveguides for future telecommunication systems.

Alan Hall has joined Oxley Developments Company, of Ulverston, Lancs, as promotional sales manager. He was until recently in the electronic component division of Johnson Matthey, prior to which he was with Muirhead. Mr. Hall operates an amateur radio station with the call G3UWA.

Alan Hall

John L. Carroll, who joined Data Recognition Ltd in 1966 as general manager and has been responsible for the development of their current range of optical document readers, has been appointed technical director. Prior to joining Data Recognition, Mr. Carroll was with English Electric Computers where he was responsible for the development of document handling peripheral equipment; and before that he worked for Solartron on the development of character recognition equipment.

G. Ross Watson appointed by the Video Systems Division of Bell & Howell as international marketing manager, was until recently sales engineer responsible for marketing television camera tubes with the English Electric Valve Company. For three years from 1958 Mr. Watson, who is 44, was manager of a mobile television unit frequently used to demonstrate the value of closed-circuit colour TV at surgical operations.

Peter Smitham who joined ITT Electronic Services, Harlow, Essex, in July 1967 has been appointed manager. He was previously materials manager. He studied at University College Swansea and spent a post-graduate year at Salford University.

William J. Charnley, appointed deputy controller of guided weapons in the Ministry of Technology, was educated at Oulton High School, Liverpool, and at Liverpool University where he obtained a first class honours degree in engineering. Mr. Charnley, who is 47, joined the Civil Service in 1943 at the Royal Aircraft Establishment, Farnborough. He was appointed superintendent of the Blind Landing Experimental Unit in 1955. Six years ago he became head of the Instruments and Electrical Engineering Department at R.A.E. and two years later was appointed head of the Weapons Department. Since 1968 he has been head of the Establishment's Research Planning Division where he is succeeded by **Harold G. Robinson,** O.B.E., who has been head of the Avionics Department since 1965. Mr. Robinson, who is 45, was educated at H.M. Dockyard School, Portsmouth, where he was awarded a Whitworth Scholarship to Imperial College, London University. He obtained a 1st class honours degree in electrical engineering, and after joining the Civil Service at the R.A.E. in 1948 continued his post-graduate studies during 1951-52 at the Californian Institute of Technology. In 1955 he took charge of the Black Knight research rocket project. From 1960 until 1965 he was in charge of the satellite launcher division at Farnborough.

Tudor Jones, M.I.E.E., aged 42, has joined Cambion Electronic Products Ltd, manufacturers of electronic components, as sales manager. He joins Cambion from the English Electric Co., Stafford, where he was manager of the Production Systems Department.

Peter L. Mothersole, F.I.E.R.E., M.I.E.E., has joined Pye T.V.T. Ltd, Weybridge, as engineering manager of the Audio & Vision Division. Mr. Mothersole, who is 40, has been with the Mullard

Peter Mothersole

Research Laboratories since 1953, where he was for some time leader of the television receiver group. During his National Service he was a radar theory instructor at R.A.F. Yatesbury and then spent a year with E. K. Cole Ltd at Malmesbury as a design engineer on airborne radar equipment.

Paul Spring, who joined Grundig (Great Britain) Ltd on its formation in 1952, has been appointed managing director. Mr. Spring has successively been chief engineer, general works manager and, since 1964, technical director.

Geoffrey E. Beck, B.Sc., F.I.E.E., for the past two years chief engineer of Marconi's Electronics Group is appointed technical manager of its Aeronautical Division, based at Basildon, Essex. Mr. Beck, who is 53, graduated at Birmingham University in 1938 and joined the Marconi Research Division, where he worked on the design of naval radar equipment thoughout the war. In 1949, Mr. Beck began his long association with the pioneering work into the development of Doppler navigation equipment, which provides pilots with continuous positional information without the use of ground-based aids. In 1962, Geoffrey Beck and Mervyn Morgan, who were jointly responsible for this work, were awarded the Johnston Memorial Trophy by the Guild of Air Pilots and Air Navigators in recognition of their service to aerial navigation. From 1965 to 67, Mr. Beck was manager of the group responsible for the development of the television guidance system for the Martel guided missile. He is vice-president of the Institute of Navigation.

Progress in Tape-recording Techniques

by Sidney Feldman

Exhibits at the Audio Engineering Society's 37th Convention, held in New York City in October, were predominantly of interest to recording studio engineers. Several 8-track one-inch and 16-track two-inch studio recorders were on operational display. Two machines (Gauss and Magnetic Recording Systems) employed d.c. capstan-drive systems, with the motor-speed controlled precisely by a magnetic tachometer referred to a high stability oscillator. Thus the recorder is not affected by power line frequency variations. The Magnetic Recording machine has a switch-selected speed-range of 32 to 1, permitting operation from $1\frac{7}{8}$ i.p.s. to 60 i.p.s., and also allows any intermediate speed to be obtained using an external variable-frequency source. Fig.1 shows the basic servo-system employed.

In the Gauss recorder, external synchronization is possible for variable-speed operation, with possible pitch changes of ±75%. This tape machine utilizes the "focused gap" system of recording, which was marketed, under licence, by Fairchild Recording several years ago, in a series of tape recorders. The bias frequency is approximately 1MHz, and specifications call for a signal-to-noise ratio of 70dB, record input to reproduced output, measured with ASA curve A; peak record level set for 1% distortion on 3M Company 201 tape, at 15 i.p.s.

Of the high-speed tape duplication equipment, Gauss utilizes an endless-loop tape bin, "focused-gap" head, and a bias frequency of 10MHz. Duplication takes place at speeds to 240 i.p.s. Running from a 1200ft master tape at the highest speed, this system can produce 55 copies/hour/slave, utilizing the "stagger loading" system at the slaves. These copies would be at $1\frac{7}{8}$ i.p.s. The tape would then have to be loaded into the appropriate cassette or cartridge. Console designers are now using, mainly, operational amplifiers in their modules. The modules are completely wired by the manufacturer, saving labour and inter-wiring when a system is built-up. These console "building-blocks" are usually strips 1.5in wide and about 14in long, and they provide functions of equalization, reverberation level control, main-channel level control, input attenuator, and microphone/line input switching. A typical module will accept microphone level at the input and provide up to +24dBm output with less than 0.5% t.h.d. from 20Hz to 20kHz.

The large recording consoles in use today with loss-less mixing, are only possible using operational amplifiers. A typical mixing circuit, as shown by Melcor (Fig. 2), provides 114dB of isolation between inputs at 20kHZ, rising to 134dB at 1kHz. Distortion is 0.25% from 20Hz to 20kHz, at full output of +20dBm. Gain can be adjusted to a maximum of 10dB.

Most tape recorders for the professional market are using transistors for switching functions, and the Quad-Eight Company even have a logic system for track switching on their large console designs. This logic switching can also be interlocked with the tape recorder and the monitoring system, so that operating one button will switch all functions simultaneously.

Distortion analyser

Crown International have developed an i.m. distortion analyser to test, on a production basis, the Crown DC-300 dual-channel amplifier. Typical i.m. distortion, per channel, (60Hz-7kHz, mixed 4:1) is below 0.05% from 0.01 watt to 150 watts r.m.s. into 8Ω. The analyser permits rapid measurements of i.m. distortion over a wide range of input levels and power ratings. Active Butterworth filters replace conventional hum-sensitive *LC* filters. The residual distortion in the analyser itself is typically 0.003%. Ganged input and output controls are employed to facilitate production line testing of amplifiers and other equipment.

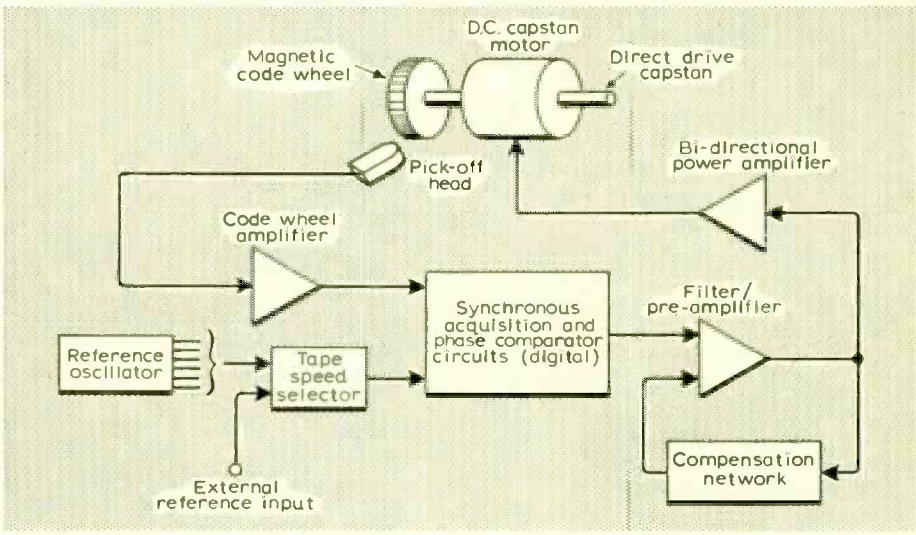


Fig. 1. Speed control system employing magnetic tachometer.

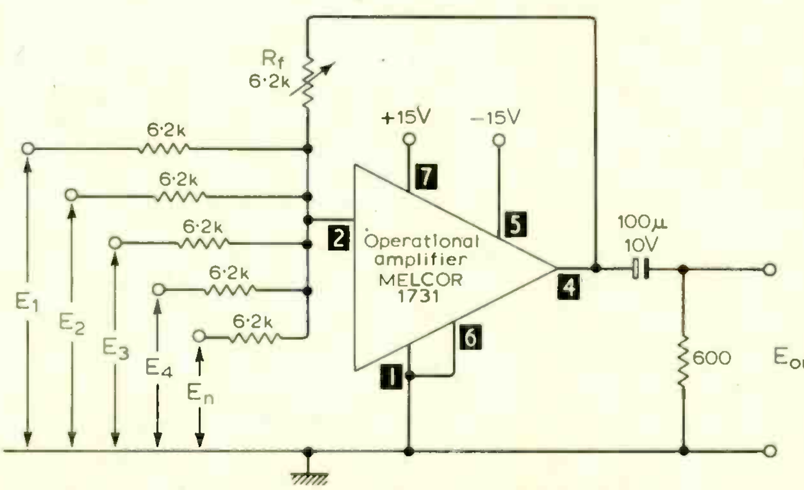


Fig. 2. Mixer using operational amplifier.

World of Amateur Radio

Licences and "pirates"

Of every five new British amateur licences now being issued, rather more than three are for Class B operation on v.h.f. telephony only. The licence statistics to the end of October show that in the previous six months there was an increase of 311 Class B licences to a total of 1841, compared with an increase of 198 Class A licences (permitting h.f. operation and requiring the passing of a Morse test) to a total of 13,373. Taking into account the 180 amateur television licences British amateurs now total nearly 15,400.

That there is still an appreciable number of people who attempt to operate in the amateur bands without the formality of a licence is shown by the fact that, in the first nine months of 1969, the Post Office successfully prosecuted more than 70 persons and warned 50 others for offences involving wireless transmitting apparatus being used contrary to Section 1 of the Wireless Telegraphy Act. The fines imposed on these "pirate" stations ranged up to about £100 and the penalties often included forfeiture of the apparatus. The Post Office has indicated that some of the illicit transmissions are regarded as representing a potential hazard to safety of life; they are equally unpopular with licensed amateurs who have sometimes been subjected to deliberate interference and embarrassed by such tricks as the tape recording of genuine amateur "contacts" which are then replayed on transmissions outside the limits of the amateur bands. The Post Office welcomes information which would help in tracing and apprehending the pirates.

Good tropospheric "openings"

During the spell of pronounced tropospheric propagation in mid-October—conditions which brought many complaints of co-channel interference to broadcasting organizations—large numbers of amateur v.h.f. contacts were made between stations in the U.K. and many countries of Western Europe. The contacts extended from Sweden and Finland to Austria and Switzerland as well as the almost routine links with France, Holland and West Germany. While most of the contacts were made in the 144-MHz (two-metre) band, the conditions extended also to the 432-MHz (70 cm) band; many of the contacts exceeded 1000 miles. Some amateurs believe that the "tropo" conditions of the 1969 Indian summer were among the most pronounced yet recorded. Peter Blair, G3LTF, of Chelmsford, has raised his total of countries worked on 144 MHz to 28 and on 432 MHz to 19. From January 1st the new voluntary divisions of the 144-MHz band are: 144.0—144.5 telegraphy only; 144.15—144.5 south-west region; 144.5—145.1 south-east region; 145.1—145.5 midlands; 145.5—145.95 north, Scotland and Northern Ireland; and 145.95—146 beacon transmissions.

R.S.G.B. president for 1970

Dr. John Saxton, director of the Science Research Council's Radio and Space Research Station (Slough) and this year's chairman of the I.E.E. Electronics Division, is to be installed as the 36th president of the Radio Society of Great Britain during the course of a social evening at the Bonnington Hotel, London, on Friday, January 16th. Dr. Saxton, although not himself the holder of an amateur licence, has a keen interest in the relationship between meteorology and radio propagation, and for a number of years has attended many amateur v.h.f. functions.

It is clear from the latest Society accounts that the 1970 Council, despite the recruitment in recent years of several thousands of additional members, faces problems of the type which are seriously affecting many national and local societies. In each of the past four yars expenditure has exceeded income: to a total in the four years of some £8500. Fortunately, the Society has substantial reserves but nevertheless it faces acutely the paradox that even with the present record membership, costs are still rising faster than revenue.

In Brief: There has been a good response from British amateurs to a proposal —"Project Trident"—to design and build in the U.K. an amateur radio communications satellite capable of receiving on the 144-MHz band and retransmitting the signals on the 432-MHz band; it is recognized that such a project will take a considerable time to complete . . . It is now hoped that the Australian-built amateur satellite "Australis—Oscar 5" will be launched during December or early January on the Thor-Delta rocket used to put a Tiros weather satellite into orbit; Australis is expected to radiate on 144.050MHz and 29.450MHz for a number of weeks . . . The R.S.G.B. 1.8 MHz Affiliated Societies' Contest is due to be held on January 10th and 11th between 18.00 and 22.00 G.M.T. each day . . . This season's 1.8MHz "Transatlantic Tests" will be continued between 05.00 and 07.30 G.M.T. on December 28th, January 11th and February 1st and 15th . . . A Boy Scouts station on the Caribbean Island of Anguilla, with the callsign VP2EQ, is being operated in the 14-MHz band . . . Indian stations have recently been using the special prefix VU0 instead of VU2 as part of the Ghandi centenary celebrations . . . Mike Matthews, G3JFF, is operating as a maritime mobile station on board the Far East flagship H.M.S. *London* and is expected to visit many Far East and Pacific areas during the next 15 months. . . . The Royal Naval Amateur Radio Society, with the callsign G3BZU, transmits a monthly Morse proficiency test at 19.00 G.M.T. on the first Tuesday of each month on 1.875MHz for practice runs and 3.520 MHz for speed proficiency tests.

PAT HAWKER, G3VA

Since the war, amateur radio in Japan has developed greatly. Station of Yoshio Sameshima, JA2CLI, has many 1.8MHz ("Top Band") achievements to its credit; contacts include the U.S., Hawaii, Canada and Australia (photo. courtesy of Stewart Perry W1BB).

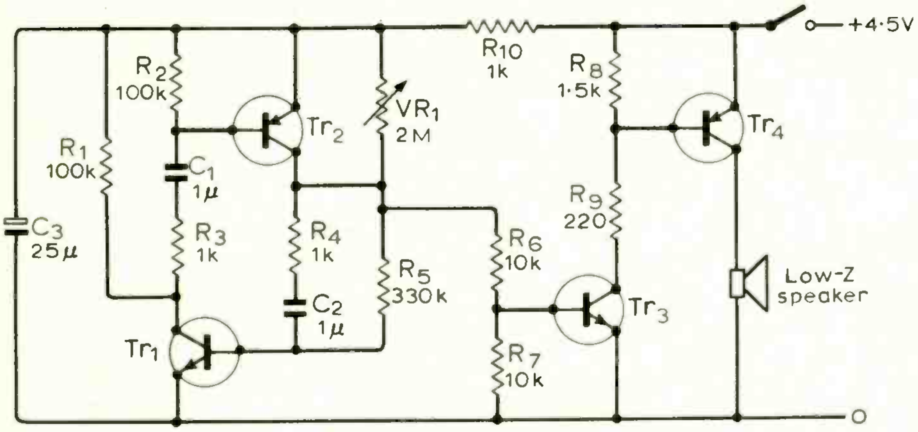
Electronic Metronome

An efficient circuit giving a speed range of 30 to 240 beats per minute

by D. T. Smith

The timing pulses are generated by a complementary-pair form of multivibrator Tr_1, Tr_2. Both transistors conduct or are cut off together and the conduction time can be made a very small part of each cycle. The conduction time (about 10ms) is used to generate the "tick" and the off time (0.25 to 2s) the interval between ticks. This form of multivibrator is useful in many applications where short pulses, relative to their separation, are required. Low frequencies can be obtained with relatively low capacitor values, and a good range of frequencies obtained by varying a single resistor.

As this form of multivibrator may be unfamiliar to some readers, its operating cycle is described. During the conduction period the base of Tr_1 is forward biased and therefore held near zero volts, while Tr_2 is conducting hard and charging C_2 via R_4 towards +4.5V. The conduction period of Tr_2 is limited by the time C_1 can supply enough base current to drive Tr_2. This time is set primarily by C_1 and R_3. When Tr_2 is cut off R_6 and R_7 pull the collector of Tr_2 down to zero so that the charge on C_2 gives a negative voltage on the base of Tr_1. Tr_1 is thus cut off, and no base current flows. The off time is that taken for VR_1 and R_5 to discharge C_2 and then generate a forward bias at the base of Tr_1 to start conduction. As current starts to flow in Tr_1 it feeds current via R_3 and C_1 to the base of Tr_2 which in turn feeds current via R_4 and C_2 to the base of Tr_1 and so closes a regenerative feedback loop. Both transistors are switched hard on, and the cycle is repeated.



Complete circuit of metronome.

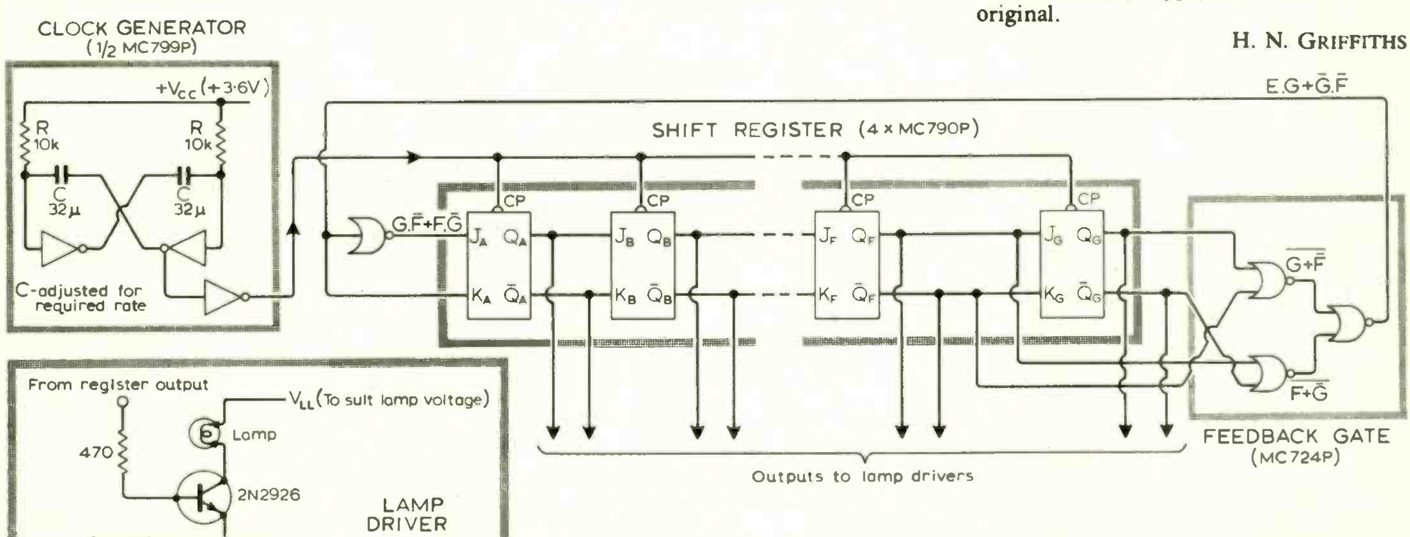
There is no point in having a good quality amplifier to drive the loudspeaker, so a simple two-stage amplifier Tr_3 and Tr_4 is used. This is direct coupled with both transistors cut off when the multivibrator transistors are off, and both conducting hard when the multivibrator transistors are conducting. Any medium- or high-gain silicon planar transistors can be used for Tr_1, Tr_2 and Tr_3. A medium or high power germanium p-n-p transistor capable of switching about 1A—AC128, OC83, OC25 etc.—can be used for Tr_4.

There are no special precautions necessary in wiring the circuit, and Veroboard is convenient to use. C_2 should be a paper or polyester type and not electrolytic, as variations of capacitance with age or leakage would upset the calibration. The circuit with loudspeaker and battery are fitted in a suitable box. A low value variable resistor, say 25 Ω may be included in series with the speaker to act as a volume control.

A Digital Christmas Tree

Using a large number of many coloured lamps switched in pseudo-random sequence, an elegant and fascinating twinkling effect is produced which can be exploited by arranging the lamps around a Christmas tree. In the prototype a 7-stage shift register is used to generate the 'M' sequence, an exclusive OR gate being used to provide feedback to the input from stages 6 and 7. The length of the sequence is 127 clock periods (2^7-1). It is arranged that fourteen lamps are controlled by transistor switches from the shift register stages (7 from the Q and 7 from the $\bar{Q}$ outputs). Transistors can, of course, replace the micrologic elements in the sequence generator. Small pea lamp bulbs (model railway type) are used in the original.

H. N. GRIFFITHS



Layout for pseudo-random generator.

D.C. Bias in Push-Pull Power Amplifiers

A feedback amplifier controls the working point of a directly coupled driver and output pair

by R. A. Smith

A bias circuit, conventional to many amplifiers, and consisting of d.c. feedback from the collector to the base of the driver transistor, is shown in Fig. 1. A typical practical arrangement is given in Fig. 2. However, the circuit is very sensitive to changes in the current gain of the driver transistor, and hence R_f must be adjusted for the particular driver transistor used.

Since the prices of suitable transistors are now very low, extra low-current transistors in a circuit present no problem. Hence a transistor can be used whose sole purpose is to stabilize the d.c. level of the output. The requirements of this transistor are:—

(i) High output impedance, so as not to shunt the a.c. signal at the base of the driver transistor.

(ii) A positive current gain to ensure that the d.c. feedback is negative. (The driver transistor changes the sign of the signal).

Its input impedance is not important since it is to be driven through a filter from the low-impedance output of the voltage amplifier, which is capable of supplying large currents; i.e., its loading effect on the amplifier output will be negligible even if the extra transistor has a low input impedance.

In order to satisfy (i), the collector of the stabilizer transistor must be connected to the driver's base; in order to satisfy (ii) a common base circuit must be used. For such a transistor to conduct at all, it must be of opposite polarity to the driver transistor. Also, the a.c. level of the output must be filtered from the d.c. to prevent excessive a.c. feedback. Using a simple *RC* circuit for this, we obtain the arrangement shown in Fig. 3.

R_2 must be chosen so that the potential across it is small compared with the supply voltage. The current passing through this resistor is approximately the base current of the driver transistor, i.e. $1/\beta$ multiplied by driver transistor collector current which is approximately $V/2R_L\beta$.

Thus $V \gg V_{R2} = iR_2 = R_2V/2R_L\beta$

$2R_L\beta/R_2 \gg 1$ and $R_2 \ll 2R_L\beta_{min}$ in the worst case.

With R_L as $2\text{k}\Omega$, $\beta_{min} = 20$ and a factor 20 for "$\ll$", this gives $R_2 = 4\text{k}\Omega$.

The R_2C time constant must be long compared with the lowest frequencies being used.

Fig. 4 shows a circuit used as an a.f. power amplifier. The values given are for a 3Ω speaker and 25-V power supply.

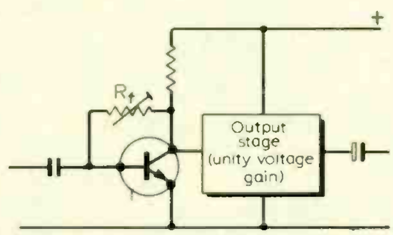


Fig. 1. Arrangement where driver stage Tr_1 controls d.c. level of output pair.

High output impedance amplifier

With high output impedance amplifiers we are trying to drive a current in a load irrespective of the potential across it. In an inductive load, for example, the potential may vary considerably depending on the waveform of the input. For the output to be at high impedance, the drive should be from the collectors of the

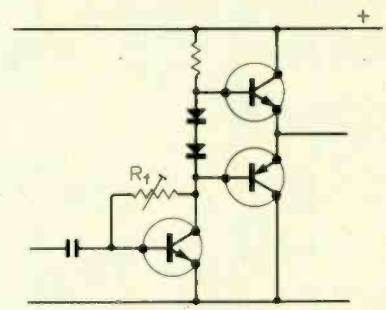


Fig. 2. Typical low-to-medium power output stage.

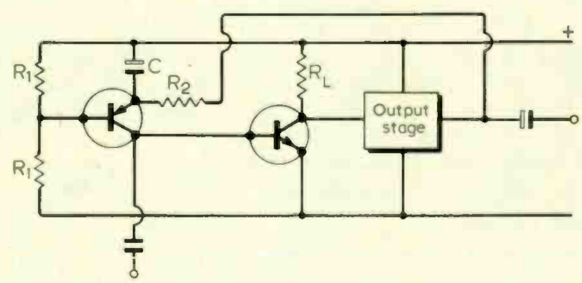


Fig. 3. Use of common-base stage to control d.c. level of amplifier output.

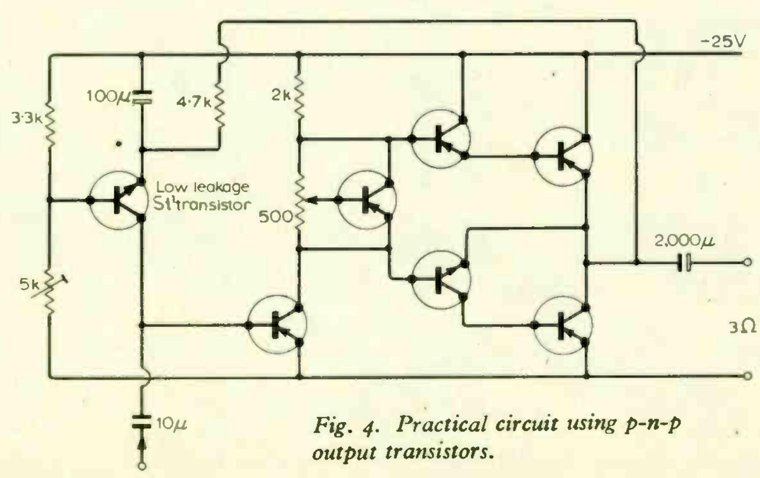


Fig. 4. Practical circuit using p-n-p output transistors.

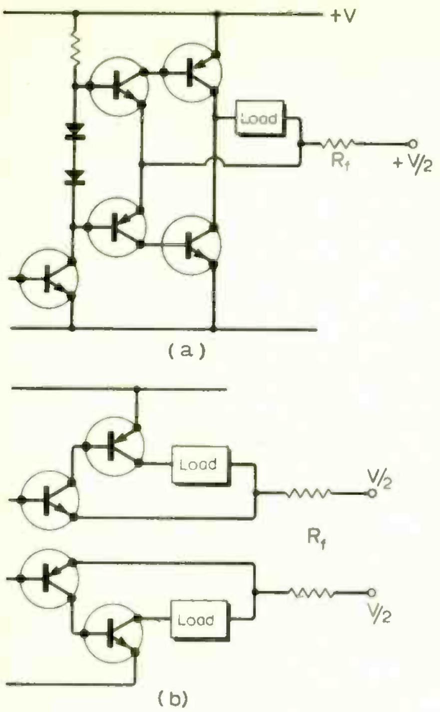


Fig. 5. High output impedance power stage. (a) Actual configuration, (b) Convenient bisection for analysis.

transistors, since the currents in these are the least sensitive to variations of potentials across them.

To apply feedback, the current in the load is passed through a resistor in series with the load, as shown in Figs. 5(a) and 5(b), and hence converted into a voltage which is compared with the input voltage to the amplifier at the emitter-base junctions of one of the driver transistors, depending upon which half of the circuit is conducting.

As will be seen from Fig. 5(b) each part, upper and lower, is an emitter follower across R_f; however, the largest part of the current in R_f comes from the collector of the output transistors (high impedance). There is also a small current in R_f which flows in the emitter of whichever driver transistor is conducting and this current is approximately the same as the collector current, i.e. $1/\beta$ times the current through the load in series with R_f.

R_f should be chosen so that the maximum current in the load (and hence also in R_f) produces a voltage across R_f of, say, a tenth of the power supply voltage. In this case, there is a maximum potential swing of approximately $\pm 0{\cdot}4$ of the supply voltage across the load, and the back e.m.f. of an inductive load must not exceed this value if the amplifier is to work in its linear region.

The bias circuit described above can be incorporated in the circuit as shown in Fig. 6.

In a practical circuit, the standing current in the output transistors can become intolerably large if bias resistors are not included as shown in Fig. 7. Resistors R_A reduce the quiescent current of the driver transistors and resistors R_B bleed much of the remaining driver transistors' current to the supply rails rather than through the bases of the power transistors. Values shown are for an amplifier driving 0·25A into an inductive load; it was for driving the scan coils of a magnetically deflected c.r.o.

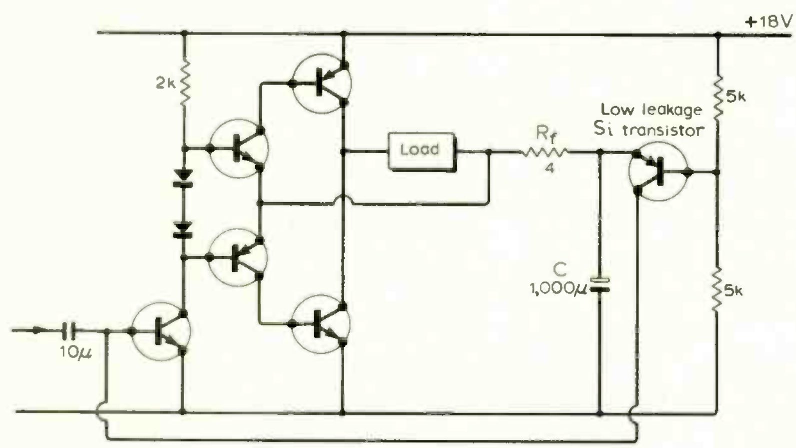


Fig. 6. Application of bias transistor to circuit of Fig. 5.

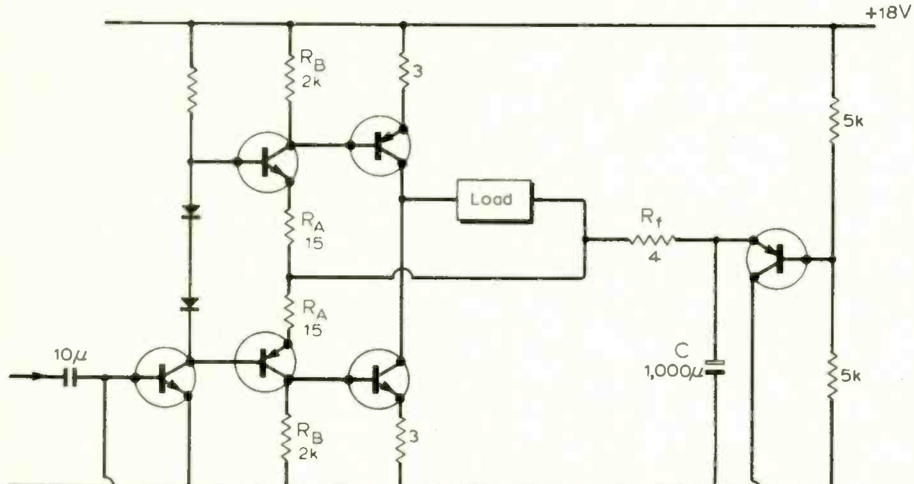


Fig. 7. Modification of the previous circuit to limit standing current in the output stage.

More Announcements

(see also p.19)

Hewlett-Packard Ltd have installed a £20,000 **patient monitoring system** at Walsgrave General Hospital, Coventry. The system includes a cardiac catheterization unit, bedside monitors for coronary care, defibrillator trolleys and two nurse's central stations.

Pye Telecommunications Ltd, has received contracts worth £575,000 for **radio telephone equipment** to be supplied to Government departments. The orders include u.h.f. fixed and mobile f.m. equipment for airports, v.h.f. motorcycle and personal transmitter/receivers, and v.h.f., h.f. and m.f. marine transmitter/receivers.

STC Mobile Radio Telephones Ltd has been awarded a contract valued at approximately £700,000 by the Home Office for the supply of several thousand mobile a.m. **radio telephones for police use.**

Plessey Electronics Group has received an order from the North of Scotland Hydro-Electric Board for the supply of **radio relay equipment.** Operating in the 1500MHz band, the equipment will link the Board's head office in Edinburgh with its main control room at Port-na-Craig, Pitlochry, and communications centres at Burghmuir, Perth and Tealing near Dundee.

A telecommunications project. A contract worth £1.4M has been awarded to S.T.C. by the Ministry of Posts, Telegraphs and Telephones of Kuwait for the provision of a number of broadband microwave and coaxial cable links from Basra, Iraq, into the telecommunications centre at Kuwait City.

Microwave Associates Ltd, have announced an agreement whereby they will provide a complete marketing service for the products of Microwave Semiconductor Corporation, Somerset, New Jersey, U.S.A.

Electron microscopes worth more than $ ½M have been ordered from AEI Scientific Apparatus Ltd for the United States and Canada. These orders have been placed by Picker Nuclear, the company's associates in the United States.

1970 U.K. Conferences and Exhibitions

Further details are obtainable from the addresses in parentheses

LONDON

Jan. 19–23 Bloomsbury Centre Hotel
American Data Communications Equipment
(U.S. Embassy, Grosvenor Sq., London W1A 1AE)

Mar. 2–5 Alexandra Palace
Physics Exhibition
(I.P.P.S., 47 Belgrave Sq., London S.W.1)

Mar. 10–12 Camden Town Hall
Sound '70 International
(Association of Public Address Engineers, 394 Northolt Rd., South Harrow, Middx.)

Mar. 17–19 Savoy Place
Electrical Methods of Machining, Forming and Coating
(I.E.E., Savoy Pl., London W.C.2)

Apr. 8–15 Earls Court
Electrex '70
(Electrical Engineers A.S.E.E. Exhibition, Museum St., London W.C.1)

Apr. 13–16 University College
Atomic and Molecular Physics
(I.P.P.S., 47 Belgrave Sq., London S.W.1)

Apr. 23–26 Skyway Hotel
High Fidelity Exhibition
(Federation of British Audio, 49 Russell Sq., London W.C.1)

Apr. 28 & 29 Royal Garden Hotel
Microelectronics Conference
(Business Conferences & Exhibitions, Mercury House, Waterloo Rd., London S.E.1)

May 4–7 Royal Festival Hall
London Engineering Congress (LECO 70)
(Council of Engineering Institutions, 2 Little Smith St., London S.W.1)

May 5–15 Earls Court
Mechanical Handling Exhibition
(Iliffe Exhibitions, Dorset House, Stamford St., London S.E.1)

May 11–13 Middlesex Hosp. Med. School
Television Measuring Techniques
(I.E.R.E., 8-9 Bedford Sq., London W.C.1)

May 11–16 Olympia
Instruments, Electronics & Automation Show
(Industrial Exhibitions, 9 Argyll St., London W.1)

May 19–21 Savoy Place
Signal Processing Methods for Radio Telephony
(I.E.E., Savoy Pl., London W.C.2)

June 9–11 Savoy Place
Electrical Interference in Instrumentation
(I.E.E., Savoy Pl., London W.C.2)

July 13–17 Olympia
Ships' Gear International Show
(Brintex Exhibitions, 3 Clements Inn, London W.C.2)

Sept. 7–11 Grosvenor House
International Broadcasting Convention
(International Broadcasting Convention, Savoy Pl., London W.C.2)

Sept. 15–18 Olympia
Bio-Medical Engineering Exhibition
(U.T.P. Exhibitions, 36-37 Furnival St., London E.C.4)

Sept. 15–18 Savoy Place
Electrical Discharges in Gas
(I.E.E., Savoy Pl., London W.C.2)

Sept. 29–Oct. 2 Savoy Place
Trunk Telecommunications by Guided Waves
(I.E.E., Savoy Pl., London W.C.2)

Oct. 15–21 Olympia
Audio Festival & Fair
(International Audio Festivals and Fairs, 42 Manchester St., London W.1)

BANGOR

July 6–10 University College
Microwave Spectroscopy
(I.P.P.S., 47 Belgrave Sq., London S.W.1)

BIRMINGHAM

Apr. 14–16 The University
Automatic Test Systems
(I.E.R.E., 8-9 Bedford Sq., London W.C.1)

BRIGHTON

Mar. 2–6 Exhibition Halls
Engineering Design Show
(Business Conferences & Exhibitions, Mercury House, Waterloo Rd., London S.E.1)

CAMBRIDGE

Mar. 19–22 Churchill College
Television Tomorrow
(Royal Television Society, 166 Shaftesbury Ave., London W.C.2)

CRANFIELD

Mar. 23–26 College of Aeronautics
Aerospace Instrumentation Symposium
(N. O. Matthews, Dept. of Flight, College of Aeronautics, Cranfield, Beds.)

EDINBURGH

Mar. 17–20 The University
Management and Economics in the Electronics Industry
(D. J. T. Williams, Ferranti Ltd., Ferry Rd., Edinburgh 5)

HARWELL

Apr. 2–3 A.E.R.E.
High Voltage Electron Microscopy
(I.P.P.S., 47 Belgrave Sq., London S.W.1)

MANCHESTER

Jan. 6–8 The University
Solid State Physics
(I.P.P.S., 47 Belgrave Sq., London S.W.1)

Feb. 23–27 Belle Vue
Labex Northern
(U.T.P. Exhibitions, 36-37 Furnival St., London E.C.4)

May 19–22 Belle Vue
Industrial Training Exhibition & Symposium
(John Clarke (P.R.) Ltd., St. James House, 44 Brazennose St., Manchester 2)

OXFORD

Apr. 6–11 The University
Biological Engineering Conference
(J. Gasking, Dept. of Pharmacology, St. Bartholomews Hospital Medical School, Charterhouse Sq., London E.C.1)

Sept. 14–16 The University
Photo-electron Spectroscopy
(I.P.P.S., 47 Belgrave Sq., London S.W.1)

READING

Apr. 6–8 The University
Thin Films Conference
(I.P.P.S., 47 Belgrave Sq., London S.W.1)

Apr. 15–17 The University
Defects in Semiconductors
(I.P.P.S., 47 Belgrave Sq., London S.W.1)

TEDDINGTON

Feb. 25–26 N.P.L.
Trends in Diffusion Conference
(I.P.P.S., 47 Belgrave Sq., London S.W.1)

UXBRIDGE

Apr. 14–16 Brunel University
Computer Graphics International Symposium
(R. Elliot Green, Brunel University, Uxbridge, Middx.)

Overseas

JANUARY-APRIL

Jan. 14–16 Honolulu
System Sciences Conference
(Dr. R. H. Jones, 2565 The Mall, University of Hawaii, Honolulu, Hawaii 96822)

Jan. 20 & 21 Chicago
Soldering Technology Seminar
(W. R. Dunbar, Grover M. Hermann Hall, Illinois Inst. of Technology, 3241 S. Federal St., Chicago, Illinois 60616)

Feb. 6–11 Paris
Audiovisual Techniques, Electroacoustics & Electronics Show
(Fed. Nat. des Ind. Electroniques, 16 rue de Presles, Paris 15)

Feb. 16–19 Tampa Fla.
Computer-Aided Circuit Optimization
(Dr. G. W. Zobrist, Dept. of Elect. Eng., University of South Florida, Tampa, Florida 33620)

Feb. 18–20 Philadelphia
Solid-State Circuits Conference
(I.E.E.E., 345 E. 47th St., New York, N.Y. 10017)

Feb. 24–Mar. 5 Tampa, Fla.
Applied Communication Systems Analysis
(Dr. G. W. Zobrist, Dept. of Elect. Eng., University of S. Florida, Tampa, Fla. 33620)

Mar. 5–10 Paris
Audio Festival
(Fed. Nat. des Ind. Electroniques, 16 rue de Presles, Paris 15)

Mar. 11–13 Washington
Scintillation and Semiconductor Counter Symposium
(Louis Costrell, Radiation Physics Inst. Section, N.B.S., Washington, D.C. 20234)

Mar. 18–21 Nairobi
Electro 70 Show
(Electronics Institution of East Africa, P.O. Box 9690, Nairobi, Kenya)

Apr. 3–8 Paris
Electronic Components Show
(Fed. Nat. des Ind. Electroniques, 16 rue de Presles, Paris 15)

Apr. 6–10 Paris
Advanced Microelectronics Conference
(Fed. Nat. des Ind. Electroniques, 16 rue de Presles, Paris 15)

Apr. 14–17 Washington
Geoscience Electronics Symposium
(I.E.E.E., 345 East 47th St., New York, N.Y. 10017)

Apr. 21–24 Budapest
Microwave Communication Colloquium
(Microcoll—TechnicaHáza Budapest, V. Szabadsag tér 17, Hungary)

Apr. 27–29 Atlantic City
Frequency Control Symposium
(Electronic Components Lab., U.S. Army Electronics Command, Fort Monmouth, New Jersey 07703)

New Products

General Purpose Audio Amplifier

The Elcom GPA general purpose amplifier module—available in two different supply voltage versions—is a low-power high-quality amplifier intended for rack mounting and capable of driving a speaker to 4W mean power. Output is unbalanced, but an external transformer is available for balanced loads. Power supplies required are 50V for the GPA50 and 24V for the GPA24. The a.c. coupled output has an impedance of 7.5 Ω (GPA24) and 15 Ω (GPA50). The transformer coupled output has an impedance of 3 Ω, 7.5 Ω and 15 Ω for both voltage versions. At 4W output, sensitivity is quoted as 20dBm maximum, noise level 100dB, and distortion 0.3% (GPA24) and 0.1% (GPA50). Frequency response from 30Hz to 20kHz is within ±1dB, and the amplifier is provided with remote or local gain control facilities. Elcom (Northampton) Ltd, Weedon Road Industrial Estate, Northampton.
WW 310 for further details.

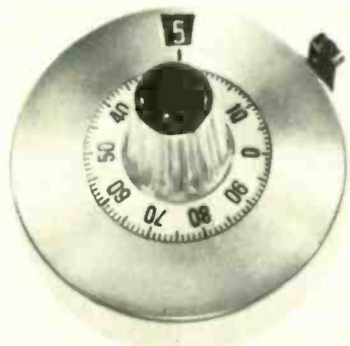
Auto-range Digital Voltmeter

The SM 212/C digital voltmeter from S.E. Laboratories is designed specifically for data logging and the automatic testing of equipment systems. Selecting "auto" on

the front panel gives complete automatic continuous monitoring over the full range of the instrument (from 10 μV to 1kV). The instrument up-ranges at a reading of 9,000 and down-ranges at a reading of 800. All control switches are front-mounted push-buttons. As well as having automatic selection, the instrument's ranges can be selected manually by five push-buttons, and remote ranging for external programming via the B.C.D. output socket. Maximum resolution is 10 μV, input impedance >1000M Ω on direct ranges, and accuracy ±0.01%. Reading rate is 25 per sec. synchronized to mains frequency. Series-mode rejection is >60dB without filter, and common-mode rejection >140dB. S.E. Laboratories (Engineering) Ltd, North Feltham Trading Estate, Feltham, Middx.
WW 315 for further details.

Turns-counting Dial

R. C. Knight Ltd introduce a range of turns-counting dials for use with multi-turn potentiometers. The model 33-30 illustrated can be used on 10-, 20-, or 30-turn potentiometers. Mating with the potentiometer shaft is accom-



plished using a tapered collet arrangement. Small quantities of up to 100 off are available from stock and prices range from 41s 9d to 47s 3d each, depending on the quantity ordered. R. C. Knight Ltd, 20 Solent Avenue, Lymington, Hants.
WW 336 for further details

Constant-current Power Sources

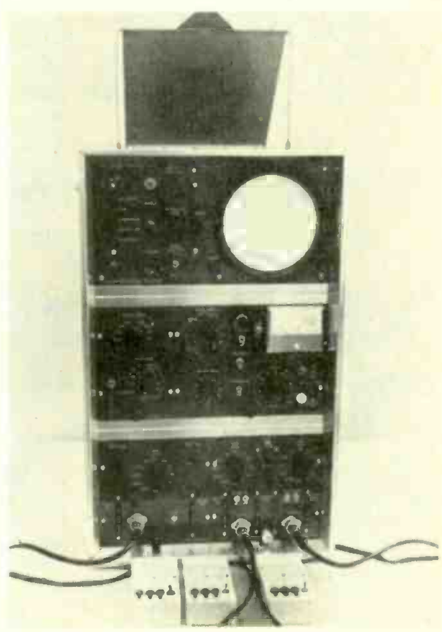
Direct currents as small as 1 μA and as large as 500mA are supplied with extreme accuracy by two constant-current power sources—models 6177B and 6181B—from Hewlett-Packard. Current regulation is such that the output current changes less than 25 p.p.m. (±5 p.p.m. of range setting) with a load change that swings the output voltage from zero to maximum. Current-setting and voltage-limiting controls are independent and can be preset before the load is connected. Maximum output for Model 6177B is 500mA, with voltage limiting continuously adjustable between 0 and 50V. Model 6181B has a maximum output of 250mA with 0-100V limiting. Current output is selected with high resolution (0.2% of range) by a 10-turn control and 3-position ×10 range switch. Either of the floating output terminals may be grounded to provide current of either polarity. For systems use, these instruments can be programmed by either external voltage or resistance changes. Extremely high output impedance is maintained without use of reactive elements, resulting in fast programming speed: 500 s from 0 to 99% of programmed output. Hewlett-Packard Ltd, 224 Bath Road, Slough, Bucks.
WW 316 for further details

Light-emitting Diode

The MV50 from Monsanto, is a diffused planar gallium arsenide phosphide light-emitting diode which peaks at 6,500Å. It can be used in place of incandescent lamps as small as the T3/4 size. The life-time of the unit is said to approach 100 years. Light output is 750ft lamberts with a forward current of only 20mA. Turn-on time is 1ns. The MV50 is available in the U.K. from Semiconductor Specialists Inc, Airpark House, 127 Station Road, West Drayton, Middx.
WW 330 for further details

Electromyograph

Isleworth Electronics have developed an electromyograph suitable for use in clinical medicine practice. The type 7 Electromyograph is a solid-state design, with plug-in units. Four plug-in positions are provided: two amplifiers, a timebase and a stimulator. Two types of amplifier are available—a single channel and double channel. With various combinations, between two and four signals may be displayed simultaneously on the cathode-ray tube. Each channel carries its own built-in calibration signal. Comprehensive camera recording facilities are

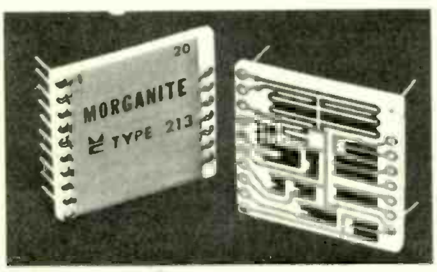


provided by a second cathode-ray tube at the rear of the instrument. The remote cable-operated camera shutter is synchronized electrically with the machine. Five modes of operation are possible: single sweep, continuous, superimpose, scan, and autograph. All modes are electrically interlocked to prevent overlapping exposure. Film wind-on after each exposure is automatic. Outputs are provided for data recorder, external loudspeaker (to supplement the unit's own internal sound channel), and trigger pulses to synchronize peripheral equipment. Isleworth Electronics, Frederick Street, Waddesdon, Bucks.

WW 320 for further details.

Binary Ladder Networks

Morganite Resistors have produced two binary ladder networks. Model 215 is an eight-bit high-speed ladder with a standard resistance of 10kΩ in the binary R-2R configuration. Settling time is less than 100ns with a maximum output voltage ratio error of +0.25 bit over the temperature range −55 to +125°C. Three application resistors, ratioed to the ladder, are also included for bipolar operation and ampli-



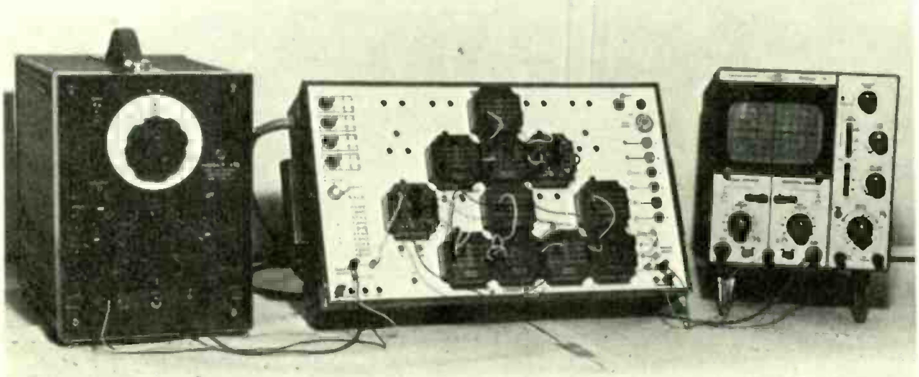
fier summation. Model 213 is a 10-bit binary resistor array designed to be compatible with the Fairchild μA 722 current source for D/A and A/D applications. Resistance values correspond directly with those specified on the A 722 data sheet. The resistance temperature coefficient is 0 to −200 p.p.m./°C with resistance tolerance of ±2% over the temperature range −20 to +85°C. Morganite Resistors Ltd, Bede Industrial Estate, Jarrow, Co. Durham.

WW 334 for further details.

Analogue Computer Teaching System

Analogikit is a system which combines digital and analogue techniques and is intended for the designer, technician and university graduate. The equipment includes operational amplifiers, feedback, summing, scaling and initial condition elements. An introductory handbook explains the arithmetical aspects of summing, scaling and integration with simple illustrative experiments leading to the construction of differential equations with practical examples of simulated systems. An advanced book deals with the mathematical aspects for degree course students. A complete teaching kit for analogue work, including a mounting deck with power supplies, costs £165 in the U.K. Feedback Ltd, Park Road, Crowborough, Sussex.

WW 308 for further details.



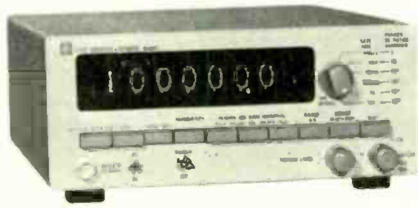
Automatic Counter

All models in the Dana series 8100 automatic counters measure frequencies from 0.05Hz to 50 MHz (d.c. coupled) and 5Hz to 50MHz (a.c. coupled), but models 8120, 8130, 8124 and 8134 have an additional a.c. coupled range from 10 MHz to 500MHz. Models 8110, 8130, 8114, 8134 have a facility for time interval measurement in the range 0.1 s to 10s (up to 100s as an option). When using one of these automatic counters, all that is necessary is to connect the input signal, and set an input voltage range switch to PRESET. The remainder of the measurement process is then controlled by computer logic. Automatic resolution during the reading time is effected, and decimal points and units are automatically indicated. In one second, reading accuracy approaches $\pm 2 \times 10^{-7}$. It is claimed the accuracy of the 8100 is better without operator adjustment than that of a manually controlled counter which requires function selection and period-to-frequency calculation. Dana Electronics Ltd, Bilton Way, Dallow Road, Luton, Bedfordshire.

WW 305 for further details.

32-MHz Counter

The GR 1192 counter measures time intervals, frequency and period from d.c. to 32MHz to a resolution of 0.1 μs, and frequency ratio. If the 1157-B scaler is used, the frequency range can be extended to

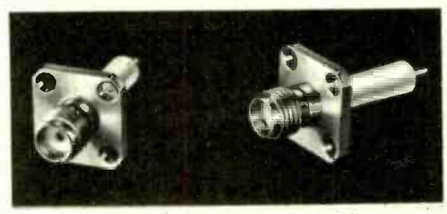


500MHz. Models are available with 5, 6 or 7 digit presentation. When measuring frequency from d.c. to 32MHz, the counting gate times are 100μs to 10s, and Hz, kHz and MHz can be displayed with positioned decimal point. Accuracy is ±1 count ± time base accuracy. The stability of the 10MHz time base is less than ±2 parts in 10^{-6} per month. Measurement of period is limited by the digit presentation and is up to 100s, 10s and 1s in the 7-, 6- and 5-digit models, respectively. Single and multiple periods up to 10^5 are covered, and time periods can be displayed in ms, μs and ns with positioned decimal point. The ratio of two frequencies, A and B, can be measured from 1 to 10^5. Frequency A from d.c. to 32MHz is measured over 1 to 10^5 periods of frequency B, 50Hz to 10MHz. Trigger error in time measurements is defined at ±0.3% of one period divided by the number of periods averaged for a 40dB input signal-to-noise ratio, and assumes no noise internal to the counter. For input signals of extremely high signal-to-noise ratio, the trigger error in μs is less than 0.0003 divided by the signal slope in V/μs. Price of the three models is £326 (5 digit); £382 (6 digit) and £437 (7 digit). General Radio Company (U.K.) Ltd, Bourne End, Buckinghamshire.

WW 303 for further details.

3mm Jack Receptacle

Sealectro have developed a 3mm s.r.m. series jack receptacle which prevents r.f. radiation. Designated part number



50-645-4520-31, the receptacle is constructed of gold plated stainless steel, Teflon, and gold-plated beryllium copper. It meets all requirements of MIL-C-39012 regarding contact and dielectric torque and captivation. R. F. Components Division, Sealectro Ltd, Walton Road, Farlington, Portsmouth, PO6 1TB.

WW 317 for further details.

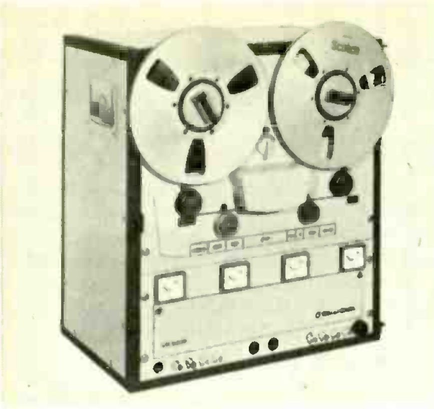
DC/DC Converters

A range of d.c./d.c. converters for changing an available low d.c. voltage (between six and sixty volts in multiples of six volts) to a much higher d.c. voltage is available from Plessey. General use of the component is in transistor instruments incorporating a cathode-ray tube for display purposes. Normal voltages up to 8kV with power up to 0.5W are available in the unit size of 12.7 × 5.1 × 3.8cm, and ranging up to 10kV and 2W in a unit measuring 13.4 × 5.9 × 4.5cm. Plessey Wound Components Division, Titchfield, Hants.

WW 321 for further details.

Portable Instrumentation Recorder

A portable instrumentation magnetic tape recorder, especially designed for use by non-skilled personnel, has been introduced by Bell & Howell. Suitable for a wide range of industrial and research applications, the VR-3200 is available in both 4-track and 6-track versions with speed ranges of $1\frac{7}{8}$ to 15 i.p.s. and $3\frac{3}{4}$ to 30 i.p.s. respec-



tively. Both versions use ¼in tape on a 10½in diameter standard N.A.B. spool. F.M. circuitry gives a frequency response of d.c. – 10kHz at 30 i.p.s. with a signal-noise ratio of 44dB. Recording and playback are possible at any speed, the correct centre frequency and filter being automatically selected from the tape transport speed selection switch. Peak detection monitor meters are fitted which enable the correct modulation to be adapted for any input signal level in the range 100mV to 30V. A test facility is incorporated to allow setting up without running tape. Operation is from 230V a.c. (50Hz). A remote control unit is available as an optional extra. Price from £1,456. Bell & Howell Ltd, Consolidated Electrodynamics Division, Lennox Road, Basingstoke, Hants.
WW 325 for further details.

Marine Communications Receiver

Marine general-purpose/s.s.b. communications receiver type R551, from Redifon, is designed to meet the British Post Office specification and international requirements for a ship's main and s.s.b. receiver. All-solid-state it provides unbroken frequency coverage from 60kHz to 30MHz. It incorporates a frequency synthesizer as well as continuously variable of "free" tuning.

Frequency of the basic receiver is set on three in-line direct-reading decade dials which select the digits for MHz tens, MHz units and kHz hundreds (e.g. 27.2MHz). The tuning process is then completed by a continuously variable control which sweeps a range 100kHz wide. This control is geared to a counter in the same line as the decade dials to give a direct read-out of frequency down to 100Hz (e.g. 27.2796MHz, or 27,279.6kHz). Complete frequency synthesis, using the ARU11, provides the additional decades to enable operators to select precisely the digits for kHz tens, kHz units, and Hz hundreds. This permits immediate direct setting of known frequencies down to increments of 0.1kHz, with instant switch selection of free tuning or of complete synthesis. Another feature is a dynamic range of over 120dB. This accommodates a correspondingly wide variation in levels of input signals. The use of two inter-coupled a.g.c. systems enables the R551 to receive wanted signals at sensibly constant level despite adjacent unwanted signals. A high degree of front-end protection, independent of whether the receiver is switched on or off, permits the R551 to be installed and operated in close proximity to high-power transmitters. Redifon Ltd, Broomhill Road, London S.W.18.
WW 312 for further details.

S.S.B. Manpack

The TRA.6929 Minical s.s.b. manpack from Racal-BCC has a power output of 1W p.e.p. and six operating channels covering frequencies from 2 to 7MHz or 2.6 to 9MHz. Complete with batteries, handset, aerial and haversack, the manpack measures 190 × 76 × 210 mm and weighs 3.6 kg.

Intended for military use, Minical has been specifically designed for simplicity of operation with a minimum number of controls. Changing channel takes only a few seconds, and it is claimed that unskilled operators are able to use it after a few minutes instruction. Tuning is effected with the aid of an internal noise generator. By this means, the possibility of radiation during tuning is avoided. The manpack operates from either U2/D type dry cells or rechargeable NiCad cells. If required, a vehicle 12V supply can be used to power the manpack or for recharging the NiCad cells. Racal-BCC Ltd, Western Road, Bracknell, Berkshire.
WW301 for further details

R.F./U.H.F. Millivoltmeters

Millivac r.f. millivoltmeters types MV-828A and MV-928A are solid-state instruments with full-scale ranges from 1mV to 3V, extended to 300V by a capacitative divider. Frequency range is 10kHz to 1,200MHz. Both instruments operate on 115/230V, 50-450Hz supplies, whilst the MV-928A also operates on internal nickel-cadmium batteries and has a built-in battery charger. Features of the instruments include temperature-compensated probe with replacement diode cartridge and recorder output. Avail-

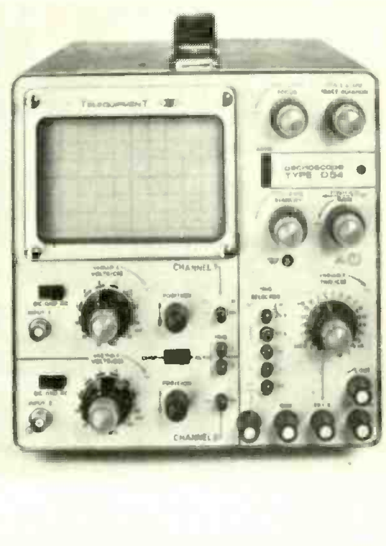
able through Millivac's U.K. agents, Lyons Instruments Ltd, Hoddesdon, Herts, the MV-828A is priced at £337 10s and the MV-928A at £387 10s. (Duty free).
WW 326 for further details.

Integral-cycle Zero-voltage Switch

The CA3059 integral-cycle zero-voltage switch is contained within a 14-lead dual in-line plastic package and operates direct from the a.c. line. This RCA device is capable of driving triac gates directly, and by providing a triac gating signal at zero-voltage crossings minimizes r.f. interference. A fail-safe circuit is incorporated to guard against an accidentally opened or shorted sensor, and an optional output control is available. Electrical characteristics include; d.c. gate-trigger current of 40mA for V_{GT} of 3V and R_{GT} of 70 Ω, gate-trigger pulse width of 80 μs before and after 'O' for $C_X = 0$; a gate-trigger pulse width of 20μs before 'O' and 170μs after 'O' for C_x of 0.015μF; an on-off accuracy of 1% and 3% for sensors of 5kΩ and 100kΩ, respectively. RCA Ltd, Sunbury-on-Thames, Middlesex.
WW 309 for further details.

Dual-trace 10-MHz Oscilloscope

The D54 is a solid-state-circuit oscilloscope. Intended for general purpose laboratory and production line testing applications the Telequipment D54 solid-state oscilloscope has a vertical amplifier bandwidth of d.c. to 10 MHz within –3dB when d.c. coupled,



and 2Hz to 10MHz within −3dB when a.c. coupled. A 12-position frequency compensated input attenuator calibrated direct in V/cm can be set for sensitivities of 10mV/cm to 50V/cm in a 1-2-5 sequence. The range of timebase sweep speeds is 200ns/cm to 2s/cm covered in 22 calibrated steps. A variable uncalibrated control provides continuous overlap between steps and reduces slowest sweep speed to approximately 5s/cm. The D54 can be operated in the following four modes: channel 1 only; channel 2 only; alternate during which the input to the vertical output amplifier is synchronously switched between channel 1 and channel 2 during flyback; and chopped during which the input to the vertical output amplifier is continuously switched between channel 1 and channel 2 at approximately 100kHz. Telequipment Ltd, 313 Chase Road, Southgate, London N.14.

WW 302 for further details.

Over-voltage Protection Unit

New from ITT is an over-voltage protection unit designed to give semiconductor devices protection against voltage surges of 1 µs or greater duration. The unit employs a reference amplifier and variable potential divider to sense applied voltage. The trip point is continuously variable between 4.5 and 60V, with resolution better than 0.1V. An excess voltage triggers a crowbar

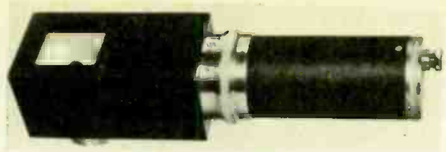
s.c.r. across the supply. In the event of a fault the unit will handle 500A peak—250A mean half cycle. Provision is made for limiting the surge current to lower values if desired. Connected across the two supply terminals, the unit takes less than 10mA drain at all voltages. The unit is compact—approximately 65 × 40 × 50mm. Access to the voltage adjustment potentiometer is through a hole adjacent to the terminals. The unit will operate in an ambient temperature range from −40° to +65°C. ITT Components Group Europe, Rectifier Product Division, Edinburgh Way, Harlow, Essex.

WW 319 for further details.

Colour Monitor Calibrator

The Grafikon calibrator is a hand-held optical instrument that enables the white point of a colour monitor or receiver to be visually set. The instrument is offered up to the tube face and the monitor controls are adjusted to make the colour picture match the instrument's reference colour. The comparison between the monitor and the reference is seen in a Lummer Brodhun photometer cube. The reference colour is obtained from a tungsten halogen lamp and glass filter and is diffused to form a very even reference field. The lamp current is electronically stabilized to ensure that its colour is the same each time it is switched on while the tungsten halogen cycle in the lamp maintains its long-term colour stability. A mechanical iris is incorporated to adjust the brightness of the reference field to any grey scale step. This ensures that the reference colour remains the same for all values of brightness. Grafikon Engineers Ltd, 75 South Western Road, Twickenham, Middx.

WW 331 for further details.



Transportable Insulation Tester

Miles Hivolt offer a transportable insulation test set for measuring leakage currents down to 0.01 A at up to 30kV d.c. It can be driven from the mains or from rechargeable 24V batteries which give four hours' use at full load, the equivalent of many days' normal use. Mains input is 100-125V or 200-250V at 45-66Hz. The output voltage is available in two ranges 0.5-5kV and 3-30kV. The output voltage is measured at two ranges 5kV and 30kV with full-scale deflections. Maximum output current is 200 A at full voltage with higher currents at lower voltages. The equipment weighs 11.5kg with either battery or mains power unit fitted. Miles Hivolt Ltd, Riverbank Works, Old Shoreham Road, Shoreham-by-Sea, Sussex.

WW 313 for further details.

40-MHz Counter/Timer

A solid-state 40-MHz counter/timer, the TF2414A, with 10mV sensitivity is available from Marconi Instruments. Advantages include time interval measurement down to 1 µs, period and multi-period measurement, 1M ' input impedance and display memory. Direct frequency measurement is provided up to 40MHz. A special version TF2414A/2M is designed for use with the M.I. frequency converters (TF2400 series) which extend the frequency range up to 500MHz. Another version, TF2414A/1 provides a printer output facility supplying a 1-2-4-8 b.c.d. output code for each digit displayed. Stability and accuracy are determined by an oven-controlled crystal oscillator. Circuits incorporate discrete and integrated silicon semiconductors on plug-in printed boards. The display memory maintains the readout while the count is in progress, thus giving a continuous coherent readout. The crystal oscillator has stability of typically 1×10^{-6} over three months and temperature co-efficient of $\pm 5 \times 10^{-7}$ per °C. A standard frequency output is available from the internal reference oscillator through a front panel socket over a range from 0.1Hz to 1MHz (selected by the range switch). Price £298 f.o.b. U.K. Marconi Instruments Ltd, Longacres, St. Albans, Herts.

WW 311 for further details.

Add-on Transmitter Amplifier

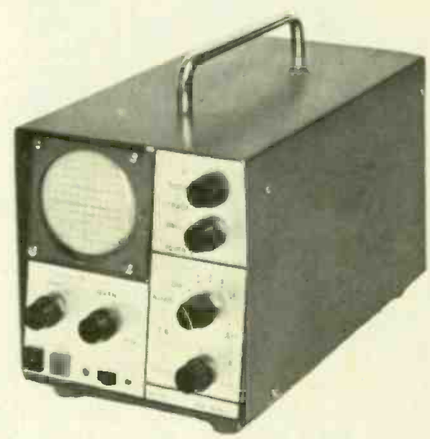
A wideband untuned solid-state linear transmitting amplifier covering the frequency range 2-30MHz, intended as an add-on unit to a low-power transmitter/receiver such as a packset, has been developed by The M.E.L. Equipment Company Ltd. It has an output of 100W p.e.p. and is designed for a transmitter, the

output of which is not less than 5W p.e.p. It operates from d.c. supplies of 10-30V without need for voltage adjustment. The power supply is self-contained, and provides a supplementary output of 20W at 24V d.c. for the associated packset. It is sealed, operable at ambient temperatures from −15°C to +55°C and meets the durability requirements of DEF 133 (L3). Designated type BA.1013/01 the amplifier measures 310mm wide by 300mm deep by 116mm high. The M.E.L. Equipment Company Ltd, Manor Royal, Crawley, Sussex.

WW 335 for further details.

Educational oscilloscope

An oscilloscope, Mitre type EA0699-1, intended for use in schools, in service workshops and in other equipment as a built-in monitor, has a Y bandwidth of d.c.

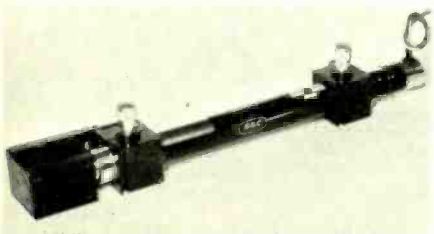


to 100kHz. The instrument costs £24. 10s. (discount for schools) and features a Y sensitivity of approximately 100mV/cm at maximum gain with full Y shift. The timebase range covers approximately 100ms/cm to 10µs/cm and is automatically synchronized. The X input required is 1V/cm with full X shift when the timebase is switched off. Flyback suppression and access to Y plates

are also featured. Power supply required is 25W at 200 to 250V, 50 to 60Hz. Mitre Electronic Products, 22 Powis Terrace, London W.11.
WW 304 for further details.

Broad-band Travelling-wave Amplifier

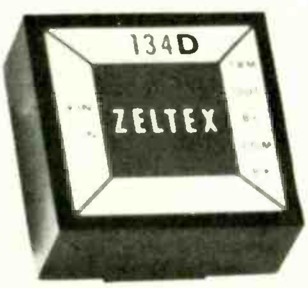
The TWS23 travelling-wave amplifier from the M-O Valve Company has an output of greater than 10W flat to better than 3dB and at a gain of at least 26dB in the frequency range 2.0 to 4.0GHz, whilst, by adjusting helix voltages, it is possible to



obtain power outputs of over 20 watts at spot frequencies. The tube is packed in a permanent magnet focusing mount, and r.f. coupling is by means of a type N 50 connector. Cooling may be by either conduction or convection, according to specification. The M-O Valve Co. Ltd, Brook Green Works, London W.6.
WW 322 for further details.

F.E.T—input Op. Amp.

Advance Industrial Electronics have available a low-cost general purpose Zeltex operational amplifier, Model 134D which can be used in differential, inverting and non-inverting circuits. Typical voltage drift is 50 μV/°C. Typical input bias current is 50pA. Initial offset voltage can be adjusted to zero with an external potentiometer. The unit is short-circuit proof to ground The amplifier housed in a



plastic/epoxy case can be mounted directly on a p.c. board or plugged into a mating connector. Specification includes an output of $\pm$V at 4mA, a d.c. gain of 50,000, and a gain/bandwidth product of 1.3 MHz. Frequency at full output is 100kHz. The slew rate is 6V/ s and operating temperature -25 to $+85$°C. Price is £8 5s. Advance Institute Electronics, Raynham Road, Bishops Stortford, Herts.
WW 333 for further details

V.L.F. Third-octave Analyser

AIM Electronics have announced a third-octave frequency analyser (TOF 260A) with a frequency range extending from 0.5Hz up to 100kHz and covering any eight octaves in this frequency range. The octaves covered are pre-set to customer requirements. The unit consists of twenty-four filters, each covering one-third of an octave, designed in accordance with BS2475:1964 (which recommends centre frequencies and equivalent bandwidth of the filter elements). Each filter may be attenuated by 0-100% by adjustment of a ten-turn calibrated potentiometer. The outputs from all the filters are combined at the output socket. Thus any combination of filters may be selected by adjustment of the attenuators. Typical applications include extraction of third-octave information from unknown waveforms and simulating the characteristic noise of any low-frequency excitation (e.g. vibrations) by selective filtering of white noise. Price £600. AIM Electronics Ltd, Bar Hill, Cambridge, CB3 8EZ.
WW 323 for further details.

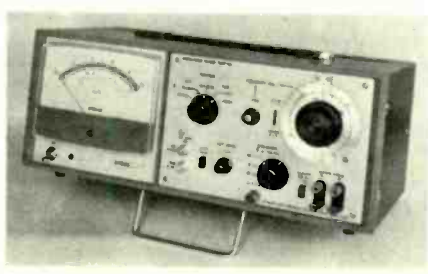
Transistor Amplifier for 1–2 GHz

Electro/Data Inc. have developed a broad-band transistor amplifier for the range 1 to 2 GHz. The new amplifier, designated Model A-12, has a 15dB gain response from 1 to 2 GHz with greater than 10dB of gain from 700 MHz to 2.2 GHz. The

amplifier's noise figure is 6dB typical with a maximum value of 8dB. It has miniature 50 Ω input and output connectors and a shielded d.c. bias input. A single, negative 12V, 14mA source is required for biasing. Two or more units can be cascaded to provide increased gain, with minor changes in passband ripple and bandwidth. The amplifier has linear gain for output signals up to -10dBm. Electro/Data Inc., 1621 Jupiter Road, Garland, Texas 75040, U.S.A.
WW 314 for further details.

Modulation Meter

Type 785 modulation meter from Dymar is a solid-state instrument for the measurement of the depth of modulation in a.m. transmitters or the frequency deviation in the case of f.m. transmitters. It is specifically designed for narrow deviation transmitters in mobile and portable v.h.f. radiotelephones, the most sensitive deviation range being 3kHz f.s.d. The frequency range covered is 30-480 MHz and the sensitivity over the whole of this range is better than 2.5mV in 50 (-40dBm) which permits loose coupling to the transmitter under test. The residual f.m. noise of the local oscillator is typically -44dB below 3kHz deviation with



the a.f. "voice" filter switched in. Auxiliary outputs are provided at the i.f. (500kHz) and the demodulation audio frequency. This permits viewing of the modulation waveforms on an oscilloscope or applying it to distortion analyzers. Price £240. Dymar Electronics Ltd, Colonial Way, Radlett Road, Watford, Herts.
WW 327 for further details.

Analogue Switches

A range of m.o.s.a.i.c. analogue switches, the ML150 series, has been introduced by Plessey. The switches, with full gate-control isolation and gate-oxide protection, are available in 6-way multiplexer, dual sample/hold and 3-bit digital-to-analogue configurations. The MP130 series provide matching drive circuits for ML150. The large negative output voltage swings of these circuits (30V) are particularly suited to driving m.o.s. analogue switches. Plessey Microelectronics, Cheney Manor, Swindon, Wilts.
WW 324 for further details.

Continuous Tape-Transport System

A continuous magnetic tape-transport system—MTD 10500—is announced by Recording Designs Ltd. The system comprises three basic models, write only, read only and write/read. Each has variants to suit a range of requirements. The same tape-transport technique is used for each with modular electronics to give particular system characteristics. Seven- and nine-track versions are available each with bi-directional transport speeds from 4 to 37.5 i.p.s. as standard, and an optional speed-range of between 1 and 75 i.p.s., if required. Slew-mode speed (for high-speed inter-block gap detection) is 120 i.p.s. Start and stop speed times are less than 20ms in the standard speed range. Recording densities of 200, 556 and 800 b.p.i. are available. Recording Designs Ltd, Blackwater Station Estate, Camberley, Surrey.
WW 332 for futher details.

Low-pass Active Filters

Lionmount are manufacturing low-pass active filters which can be varied continuously throughout the passband. Two types are available; one of which covers the range 1 to 10kHz in one band; the other covering the frequency range 1Hz-10kHz in four switched bands. The designs are based on

9th order Butterworth or Chebychev configuration and can realize 80dB/decade attenuation at cut off. The filters will accept an input voltage of $\pm$10V peak and may be loaded with a minimum of 2,000 Ω. Lionmount & Co. Ltd, Bellevue Road, New Southgate, London N.11.
WW 318 for further details.

January Meetings

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

LONDON

6th. I.E.E. "Marketing and the component engineer" by R. H. W. Burkett at 17.30 at Savoy Pl., W.C.2.

6th. I.E.R.E.—Discussion on "The Haslegrave report on technician courses and examinations" at 18.00 at the London School of Hygiene and Tropical Medicine, Keppel St., W.C.1.

7th. R. Soc.—Juvenile lecture "Television at school" by Dr. R. C. G. Williams at 14.30 at John Adam St., W.C.2.

7th. I.E.R.E.—"Positional transducers and precision electronic measurements" by P, C. F. Wolfendale at 18.00 at 9 Bedford Sq., W.C.1.

9th. I.E.E. "Tellegen's Theorem: an unusual theorem of wide circuit application" by Dr. R. Spence at 17.30 at Savoy Pl., W.C.2.

12th. I.E.E.—"Phasor diagrams". Discussion led by M. G. Scroggie at 17.30 at Savoy Pl., W.C.2.

13th. I.E.E.—Discussion on "Prospects for ultra-high-frequency f.e.ts" at 17.30 at Savoy Pl., W.C.2.

13th. I.E.R.E./I.E.E.—"Physiology for engineers—control of circulation" by Dr. I. Gabe at 18.00 at St. Bartholomew's Hospital Medical Coll., E.C.1.

14th. I.E.E.—"Changing relations between science and technology and their effect on international co-operation" by Dr. A. P. Speiser at 17.30 at Savoy Pl., W.C.2.

14th. I.E.R.E.—"U.H.F. television transposer equipment" by W. L. Gregory at 18.00 at 9 Bedford Sq., W.C.1.

20th. I.E.E.—"The British Calibration Service" by H. E. Barnett at 17.30 at Savoy Pl., W.C.2.

20th. I. Electronics.—"Power semiconductor electronics" by R. G. Dancy at 18.30 at the London School of Hygiene, Keppel St., W.C.1.

21st. S.E.R.T.—"The new I.V.C. colour video tape recorder" by R. A. Calaz at 19.00 at London School of Hygiene, Keppel St., W.C.1.

22nd. I.E.E.—"Devices using tunnelling super-currents" by Dr. B. D. Josephson at 17.30 at Savoy Pl., W.C.2.

23rd. Brit. Acous. Soc.—Symposium on "Electroacoustics in air and water" at 10.00 at 1 Birdcage Walk, S.W.1.

26th. I.E.E.—"Satellite television distribution" by A. K. Jeffris, D. G. Pope and P. C. Gilbert at 17.30 at Savoy Pl., W.C.2.

28th. I.E.R.E.—Colloquium on "Systems engineering and its educational impact" at 18.00 at 9 Bedford Sq., W.C.1.

30th. I.E.E.—"Radar ecnoes from clear air in relation to refracting-index variations in the troposphere" by J. A. Lane at 17.30 at Savoy Pl., W.C.2.

BELFAST

21st. I.E.R.E.—"Air traffic control" by David Evans at 18.30 at Ashby Institute, Queens University, Stranmillis Road.

BIRMINGHAM

26th. I.E.E./I.P.O.E.—"Operational experience with p.c.m. systems" by D. Cleobury at 18.00 at M.E.B., Summer Lane.

BOLTON

12th. I.E.E.T.E.—"The origins of electrical communications" by J. Dalton at 19.30 at Institute of Technology, Deane Rd.

BRISTOL

15th. I.E.R.E./R.Ae.S./I.E.E.—"B.A.C. satellites" by G. Crowder at 19.00 at Filton House Conference Room, Filton.

CAMBRIDGE

29th. I.E.R.E./I.E.E.—"Tuning of gunn effect oscillators" by P. W. Crane at 18.30 at University Engineering Laboratories, Trumpington Street.

CARDIFF

14th. I.E.R.E.—"Electronics for process control instrumentation" by J. Seers at 18.30 at University of Wales Institute of Science and Technology.

16th. S.E.R.T.—"Educational use of C.C.TV" by T. Evans at 19.30 at College of Further Education, Cyncoed.

22nd. R.T.S.—"Television transmission equipment in education" by W. D. Kemp at 19.00 at B.B.C., Llandaff.

CHATHAM

15th. I.E.R.E.—"The engineer in management" by F. Oakes at 19.00 at Medway College of Technology.

CHELMSFORD

19th. I.E.R.E./I.E.E.—"Radar ornithology" by Dr. E. Eastwood at 18.30 at the Civic Centre, Duke Street.

EDINBURGH

7th, I.E.R.E.—"Pulse code modulation for point-to-point music transmission" by E. Rout at 19.00 at Napier College of Science and Technology, Colinton Road.

20th. I.E.E.—"The electronics industry in Scotland—past, present & future" by I. MacDonald at 18.00 at the Carlton Hotel.

FARNBOROUGH

22nd. I.E.E./I.E.R.E.—"Speech and vocoders" by L. C. Kelly at 19.00 at the Technical College.

GLASGOW

8th. I.E.R.E.—"Pulse code modulation for point-to-point music transmission" by E. Rout at 19.00 at the Institution of Engineers and Shipbuilders, 183 Bath St., C.2.

LEEDS

6th. I.E.E.—"The automatic landing of aircraft" by S. A. W. Jolliffe at 18.30 at the University.

LEICESTER

20th. I.E.R.E.—"Static inverters and their applications" by E. W. Porter and R. J. Green at 18.30 at the University.

29th. I.E.E.—"The latest techniques in computer-aided electronic design" by E. Wolfendale at 18.30 at the City Polytechnic.

LIVERPOOL

5th. I.E.E.—"Communications for people at work and at play" by D. G. Holloway at 18.30 at the University.

7th. I.E.E. (Grads.)—"Low and medium frequency noise in transistors" by Dr. K. F. Knott at 18.30 at M.A.N.W.E.B. Elec. Indus. Development Centre.

19th. I.E.E.—"Electronics in automobiles" by W. G. Hill at 18.30 at the University.

22nd. I.E.E. (Grads.)—"Developments in radio control" by J. R. Francis and R. T. King at 18.30 at M.A.N.W.E.B. Elec. Indus. Development Centre.

29th. I.E.E.—Faraday Lecture "People, communications and engineering" by J. H. H. Merriman at 10.15 and 14.30 (students) and 18.45 (public) at the Philharmonic Hall.

MANCHESTER

7th. I.E.E./I.E.R.E.—"On the future of world communications" by Prof. C. Cherry at 18.15 at U.M.I.S.T.

28th. I.E.E. (Grads.)—"Radio interference from high-voltage transmission line conductors" by M. G. Faulkner at 18.45 at U.M.I.S.T.

NEWCASTLE-UPON-TYNE

7th. S.E.R.T.—"Tandberg audio" by A. W. Dakin at 19.30 at Charles Trevelyan Technical College, Maple Terrace.

14th. I.E.R.E.—"Electronic telephone exchanges" by V. E. Mann at 18.00 at Dept. of Physics and Physical Electronics, Rutherford Coll., Ellison Pl.

14th. I.E.E.T.E.—"Decca navigational system" by A. Brooker-Carey at 19.30 at Rutherford College of Technology, Ellison Place.

26th. I.E.E.—"The application of electronic engineering to road safety" by D. G. W. Mace and S. Penoyre at 18.30 at the Polytechnic.

NEWPORT

21st. I.E.E.T.E.—"Change to metric" by G. Esplin at 19.30 at College of Technology, Allt-Yr-Yn Avenue.

NOTTINGHAM

13th. I.E.E.—Faraday Lecture "People, communciations and engineering" by J. H. H. Merriman at 14.30 (students) and 19.15 (public) at Albert Hall.

OXFORD

14th. I.E.E.—"Tomorrow's world—use of satellites for communication" by W. J. Bray at 19.00 at College of Technology, Headington.

PRESTON

14th. I.E.E.—"Metrication" by T. C. Campbell at 19.30 at Yorella Restaurant.

READING

22nd. I.E.R.E.—"M.O.S. devices in l.s.i." by G. E. Stevenson at 19.30 at J. J. Thomson Physical Laboratory, the University, Whiteknights Park.

RUGBY

20th. I.E.E. (Grads.)—"Brain cell to microcircuit (pattern recognition)" by Dr. I. Aleksander at 18.15 at the College of Engineering Technology.

SOUTHAMPTON

27th. S.E.R.T.—"Field effect transistors" by G. A. allcock at 19.30 at the College of Technology, East Park Terrace.

28th. I.E.R.E.—"Electronic character recognition" by R. H. Britt at 18.30 at the Lanchester Theatre, University.

STEVENAGE

12th. I.E.E.—"Current electronic developments in the deep sea fishing industry" by P. J. Hearn at 19.30 at the College of Further Education.

STOKE-ON-TRENT

15th. I.E.E.—Faraday Lecture "People, communications and engineering" by J. H. H. Merriman at 14.30 (students) and 19.30 (public) at Victoria Hall, Hanley.

SUNDERLAND

22nd. I.E.E. (Grads.)—"Pulse code modulation" by J. Hutton at 18.30 at the Polytechnic.

WEYMOUTH

29th. I.E.E.—"Applications of integrated circuits" at 18.30 at South dorset Technical College.

WOLVERHAMPTON

7th. I.Prod.E./I.Mech.E.—"C.E.I. as a professional union" by K. M. Platt at 19.15 at Stafford College of Technology, Beacon Side.

Test Your Knowledge

*Series devised by L. Ibbotson**, *B.Sc., A.Inst.P., M.I.E.E., M.I.E.R.E.*

20. Colour

In all the questions it is assumed that the viewer has normal colour vision.

1. Select from the colours quoted below the one which does not appear in the spectrum of white light:
   (a) orange
   (b) yellow
   (c) purple
   (d) violet.

2. From the spectral colours below select the one which is associated with the highest frequency of radiation:
   (a) red
   (b) blue
   (c) green
   (d) blue-green.

3. Three light sources of the same area give monochromatic radiation of colours red, green and blue respectively, and have equal luminosity (appear equally bright). The intensity of radiation:
   (a) is the same for all three
   (b) is least for the red
   (c) is least for the green
   (d) is least for the blue.

4. Evidence suggests that the human brain distinguishes between different colours by the relative stimulation of optical receptors having different frequency responses, in the eye. The theory is that:
   (a) each "cone" in the retina has a frequency response curve which is slightly different from all the others
   (b) a separate type of receptor responds to each spectral colour
   (c) only three distinct frequency-response characteristics are involved
   (d) only two distinct frequency-response characteristics are involved

5. Monochromatic light of wavelength 580mμ is seen as yellow. It therefore follows that any light entering the eye which appears to have the same hue:
   (a) must consist of monochromatic light of wavelength 580mμ
   (b) may contain many frequencies, but must have maximum energy flux at 580mμ
   (c) must contain some energy at wavelength 580mμ, but not necessarily have maximum energy flux at this wavelength
   (d) need not contain any energy at 580mμ wavelength

6. True white light is:
   (a) light with equal energy at all frequencies in the visible range
   (b) light with a spectral distribution the same as that emitted by the sun
   (c) the light emitted by a "black body" at a temperature of 5200°K
   (d) an inexact concept which is defined differently in different circumstances.

7. A single monochromatic light can be rendered colourless (giving the sensation of white) by the addition of a suitable quantity of another monochromatic light:
   (a) whatever the colour of the original light
   (b) unless the original light is in the red region of the spectrum
   (c) unless the original light is in the green region of the spectrum
   (d) unless the original light is in the blue region of the spectrum.

8. White light falls on an object which absorbs in the blue, but reflects other frequencies. The colour of the object will be seen to be:
   (a) yellow
   (b) green
   (c) red
   (d) purple.

9. Monochromatic yellow light from a sodium lamp falls on an orange (fruit). The colour of the orange when viewed in this light will be:
   (a) very pale orange
   (b) low intensity orange
   (c) yellow
   (d) black.

10. If white light is added to light of any given colour the result is:
   (a) a change in hue, but no change in saturation of the colour
   (b) a change in saturation, but no change in hue
   (c) a change in both hue and saturation
   (d) if the original light was monochromatic a change of saturation only, otherwise a change of both hue and saturation.

11. A particular green light has a radiant flux density of 1 watt per square metre. To this light is now added 1 watt per square meter of pure violet light. The effect will be:
   (a) a considerable change in colour, but little change in luminance
   (b) a large increase in luminance, but little change in colour
   (c) little change in either colour or luminance
   (d) a large change in both colour and luminance.

12. Discounting luminance information, the colour of a light can be specified entirely using:
   (a) one variable
   (b) two variables
   (c) three variables
   (d) seven variables.

13. If three colours are located on the chromaticity diagram, then mixtures of varying (positive) quantities of light of these three colours will produce only:
   (a) all colours within the spectral locus (all realisable colours)
   (b) all colours inside the triangle having the given three colours at the corners
   (c) all colours outside the triangle having the given three colours at the corners
   (d) all colours on straight lines joining the three given colours.

14. By mixing, in appropriate quantities, fully saturated red, green and blue light it is possible to produce light:
   (a) of all colours (all hues and saturations)
   (b) of every hue, but not all saturations
   (c) over a restricted range of hues, but with all saturations in that range
   (d) over a restricted range of both hues and saturations.

15. If ideal phosphors could be developed which produced monochromatic red (700mμ), green (520mμ) and blue (450mμ) light, these could be used, with advantage, at the output of a colour television system. The camera filters at the input of the system would require:
   (a) to pass bands of frequencies, as narrow as possible, at the quoted wavelengths
   (b) to have broad overlapping frequency transmission characteristics with maximum transmissions at the quoted wavelength values
   (c) to have pass-bands which met but did not overlap, so as to divide the visible spectrum into three bands centred on the three quoted wavelengths
   (d) to have pass-bands between the quoted wavelength values.

Answers and comments, page 47

*West Ham College of Technology, London E.15.

Literature Received

"Gramophone-record reproduction: development, performance and potential of the stereophonic pickup" is the title of an article reprinted from *Proceedings I.E.E.*, Vol. 116, No. 8, August 1969, which is available from Shure Electronics Ltd, 84 Blackfriars Road, London S.E.1 .... **WW434**

Photain Controls Ltd, Radalls Road, Leatherhead, Surrey, have produced a leaflet which describes their range of photocell lamp modules intended for use in automatic gain control circuits, stepless speed control for motors and modulation circuits, etc **WW435**

The eight digital electronic counters in the Dana series 8100 range of automatic counters are described in a brochure from Dana Electronics Ltd, Bilton Way, Dallow Road, Luton, Bedfordshire **WW436**

The new 7000-series of oscilloscopes from Tektronix, which includes two oscilloscope main-frames with a choice of six vertical amplifiers, four timebase units and three sampling units, are described in a booklet which may be obtained from Tektronix UK Ltd, Beaverton House, Harpenden, Herts **WW437**

We have received the following publications from Marconi Instruments Ltd, Longacres, St. Albans, Herts.

Catalogue 1969–70. A very large catalogue which lists a vast range of electronic measuring equipment **WW438**

"MI Bargain Buys". This month's special offers **WW439**

ACTIVE DEVICES

"The use of Coaxial-Package Transistors in Microstripline Circuits" is the title of Application Note AN-4025 which has been published by RCA Electronic Components, Harrison, New Jersey 07029, U.S.A. **WW401**

Dickson Electronic Corp's field-effect and bipolar transistors in l.i.d. chip assemblies are described in a 19-page brochure which may be obtained from Dage (Great Britain) Ltd, 1 Penn Place, Rickmansworth, Herts. **WW403**

"Semiconductor Summary 1969/70" is the title of a short-form catalogue available from ITT Electronic Services, Standard Telephones and Cables Ltd, Edinburgh Way, Harlow, Essex. **WW404**

Ferranti Ltd., Gem Mill, Chadderton, Oldham, Lancs, have produced some additions for their Microspot c.r.t. manual. This includes a contents sheet and provisional data on the types 1B/97, 12H/40, 14/08, 16A/19, 16A/40, 21B/10 cathode-ray tubes, the DY605 electronic display equipment and the PD5002 solid-state light source. **WW405**

The semiconductor products of SGS (UK) Ltd, Planar House, Walton Street, Aylesbury, Bucks, are listed in two catalogues which are available price 21s each.
Consumer devices. Professional discrete devices

PASSIVE COMPONENTS

Airpax Electronics, of Cambridge, Maryland 21613, U.S.A., have produced the following two leaflets.

"The Choice of Protection" discusses the use of mechanical methods of protecting electrical and electronic circuits from the effects of short circuits **WW411**

A catalogue listing semiconductor fuses **WW412**

A new edition of the Amphenol catalogue describing miniature circular connectors has just been released. It is available from Amphenol Ltd, Thanet Way, Whitstable, Kent **WW413**

Programming systems produced by Oxley Developments Co., Priory Park, Ulverston, Lancs, are the subject of a new catalogue **WW414**

"Professional Communications Antenna Systems" is the title of a catalogue available from Antenna Specialists UK Ltd, 1 Euston Road, London N.W.1 .... **WW415**

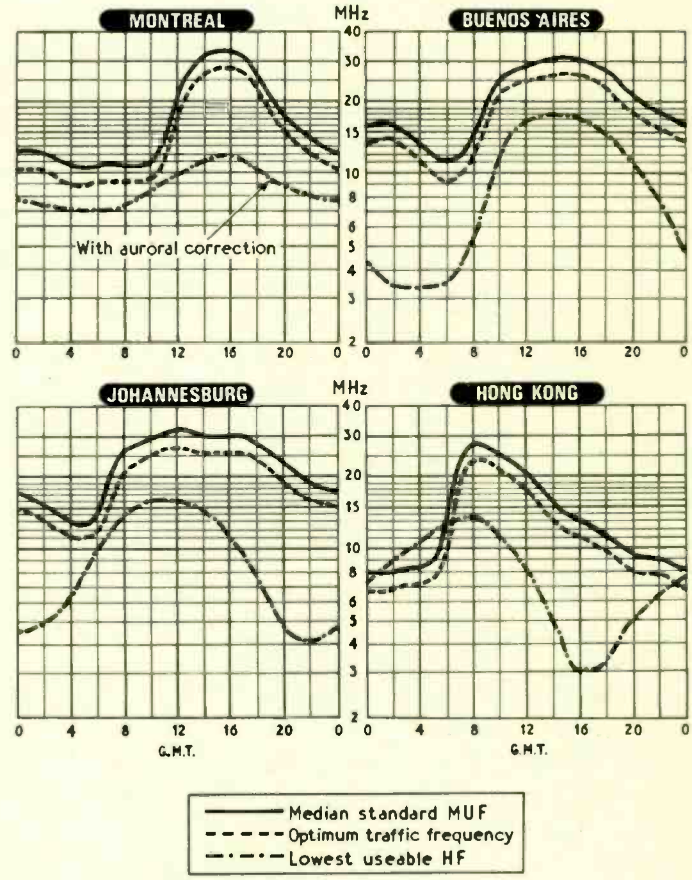
Full details of a range of edge connectors are given in the well illustrated catalogue "Metal Plate Connector Guide", available from Elco Corporation, Willow Grove, Pa. 19090, U.S.A. **WW416**

An article entitled "Understanding Thermocouples" that originally appeared in our sister journal *Instrument and Control Engineering* has now been reprinted and is available from IPC Business Press (Sundry Sales Department), 161–166 Fleet Street, London E.C.4. Price 6s 9d, including postage.

EQUIPMENT

An effects generator which can be used to produce sound effects for radio and TV programme inserts, and public address announcements is described in a leaflet from the manufacturers Mellotronics Ltd, 28–30 Market Place, London W.1 .... **WW433**

H.F. Predictions—January



Winter season conditions will continue with a large differential between day and night frequencies except on some routes which show a secondary peak a few hours before dawn. At sunrise and sunset, therefore, the rate of change of MUF is at its greatest and it becomes difficult to maintain satisfactory communication over these periods. On shorter routes, generally less than 2000 km, the daytime MUFs in winter may be lower than in summer when propagation is via the E layer.

The LUFs shown were calculated by Cable and Wireless Ltd for reception in the United Kingdom of point-to-point telegraph services. For other services the curves would be displaced vertically, the exact amount depending on service and equipment parameters.

Answers to "Test Your Knowledge"

Questions on page 45

1. (*c*) No single monochromatic radiation produces the sensation purple; it requires a mixture from the two ends of the spectrum. If monochromatic red light of wavelength 700 mμ and monochromatic violet of wavelength 400 mμ (the normally accepted ends of the spectrum) are mixed in various proportions, then the range of "pure" purples is produced.

2. (*b*)

3. (*c*) Since the eye is most sensitive to light in the green part of the spectrum, far less energy-flux density is required to produce a given luminance of green light than is required for the same luminance of red or blue. Note that the term "monochromatic" is used to describe radiation of one single wavelength (or, in practice, since this is impossible, over a very narrow band) even though in the present context it may seem inappropriate.

4. (*c*) The details of the mechanism are still not known.

5. (*d*) Suitable quantities of light of other wavelengths can produce a similar stimulus in the colour receptors. If spectral green and red are used the result will have the same saturation as well as the same hue.

6. (*d*) The lights described in (*a*), (*b*) and (*c*) are all forms of white light, although their spectral energy distributions are somewhat different. The standard of white used in television is the colour of a light produced by a particular combination of a tungsten lamp and a filter, known as "standard illuminant C".

7. (*c*) The complementary of green is purple, which is non-spectral.

8. (*a*) Yellow is the complementary of blue, so that removing blue from white leaves yellow.

9. (*c*) The orange, like most natural coloured objects, reflects light over a range of wavelengths, so that its colour, when illuminated by white light, is determined by the total effect of these on the eye. Since the orange is here illuminated with pure yellow it can only reflect yellow.

10. (*b*) This, and most other properties of colour, are well illustrated by the chromaticity diagram.

11. (*a*) Although wavelengths at the blue end of the spectrum contribute very little to the brightness of a light they have a very significant effect on its colour.

12. (*b*) These can be dominant wavelength and purity, or chromaticity co-ordinates (as in the chromaticity diagram). This is why colour information in colour television can be carried by two signals.

13. (*b*)

14. (*b*) Reference to the chromaticity diagram shows that no triangle with its corners on realisable colours, even on the spectral locus, can include the whole diagram.

15. (*b*) The total transmission characteristics for each of the three colour channels in the camera would require to be such that any incident radiation would produce relative responses in the three channels equal to the relative outputs from the three phosphors at the receiver required to produce its colour as nearly as possible.

Real & Imaginary

by Vector

"Yellow, and black, and pale and hectic red,"

As I write, the persuaders have just begun their honeyed blandishments in the Press, on sound radio and on television.

Like those purposeful citizens who make a crust by robbing strongrooms, the colour vendors use an oblique approach. Just as cracksmen traditionally begin operations in the cellars of the house next door to the bank, so do our persuaders tunnel into your private strongroom at your weakest point, namely the Little Woman and to some extent the kids, because these, as a generalization, look at the box a lot more than you do.

At present several of the channels are hard at it, backed by powerful newspaper and magazine campaigns—'it' in this case being the task of making you feel a second-class citizen if you are still viewing in unnatural monochrome.

Every day now, and far into the night, the B.B.C. and I.T.A. are firing continual salvoes extolling the merits of colour. What does astonish me is that, at the time of writing, I haven't seen any advertisment emanating from a radio manufacturer on any of the channels.

Should any reader be reaching for his pen to remind me that the I.T.A. is the only organization permitted to carry advertising, stay your hand. While it is true that the B.B.C. does not lend itself to the sordid business of raking in money in return for advertising time, there are other, and more gentlemanly, ways of going about it, as any press relations officer worth his salt could tell you.

One such is for the would-be advertiser to latch on to some national sport or cult. One of your first acts is to present a handsome trophy which has the name of your product indissolubly attached to it; all you have to do then is to sit back and wait for the event to be televised.

Another method is to plaster the railings of the more dynamic association football clubs with advertisements of your product. Try as he may, the cameraman will have to have the railings in the picture for a good deal of the time and so, given a little luck, you have a free plug both on B.B.C. and I.T.A. for about nine months in any given year.

I see the B.B.C. is making a platform of 'natural television'. They did something similar some years ago in a drive to popularize the v.h.f. sound service. 'High quality' was the torch carried then, but this was soon extinguished by the radio manufacturers, who shoved cheese-pared circuits into a small box, together with a tinpot loudspeaker, and tried to sell it as hi-fi.

And what *is* natural television, pray? If the term means anything it signifies that, colour-wise, the picture on the home screen is identical with the scene in the studio. That being so, I must say that I'm surprised that the B.B.C's technical boys have allowed their advertising colleagues to get away with it. For, given an additive system with all its registration problems, the inclusion of band-saving techniques, and colour filters with transmission characteristics which only approximate to those of the home receiver's phosphors, then even the best colour monitors will not stand comparison with the actual scene.

It's a pity to have selected such a sales story because it looks as if the experience of v.h.f. sound is going to be repeated with colour television, if the criminally maladjusted receivers to be seen all too often in dealers' showrooms are anything to go by.

The public will swallow it of course for the same reason that, in 1922, it subscribed to the belief that an unbiased three-valve receiver feeding a 'sugar-loaf' horn loudspeaker was giving perfect quality. They believed it because the only standard of comparison was the acoustic gramophone and the quality of the 'wireless' was, in its day, marginally better than that. By the same token, today's standard of comparison with a colour set is the monochrome receiver and therefore any colour, however unreal, is better than no colour at all. Provided that the sky is some shade of blue and the grass approximates to green, who cares about fidelity? Electronics engineers, certainly, and artists, perhaps, but precious few else. So there was really no need for the B.B.C. to oversell on fidelity.

Sticking my neck into the prophet's noose, my guess is that colour television will take several years to become the norm in the average home and that not a few manufacturers will catch colds in the process.

What, I wonder, would happen if someone came up with a colour system that was miles ahead of PAL? If there is any such lone inventor reading this, I would advise him that he is most unlikely to see his brain-child come into general use. For, with about £150M already invested in the present system, nobody is going to look kindly upon an invention that sets everyone back to square one.

What are the prospects of such a happening? Who knows? What would it be like, this super system? This also is anybody's guess. Almost certainly, I would think, it would embody a subtractive colour system. It would also employ a translating interface which is much more in accord with the human eye-brain complex than is today's television camera.

Our present system is a hangover from Clerk Maxwell, who was the first to show that three black-and-white transparencies can, under certain conditions, provide a picture in full colour. This is an application of the Young-Helmholtz trichromatic theory which is generally believed to form the basis of human colour vision in spite of some anomalies which cannot easily be explained away. No one, for instance, has positively identified three types of cone structure in the eye, one red-detecting, one green and one blue; all the cones seem pretty much the same. Then, a few years ago Dr. Edwin ("Polaroid") Land demonstrated that two colours, or even one red light and one white, can interact to provide a gamut of colour. Even two monochromatic light sources will produce a wide variety of diluted colours. (This in fact was no new discovery; colour film processes, using two colours only, have been patented since the turn of the century.)

There is a growing awareness of the extreme complexity of the human eye and it is possible that further discoveries in this area may provide the electronics industry with important new thinking about television. We are moving away from comfortable concepts where, for instance, 500 mμ always equates with green light to quicksands where a body radiating at 500mμ appears to the eye as brilliant red. (Yes, I know it sounds daft but it can be done by interfering with the signals which trigger the brain into registering colour.) These coded signals are the core of the matter; if only the code could be broken, all sorts of possibilities exist. It might even be feasible to dispense with conventional displays and, instead, feed signals to the area behind the retina.

This sounds crackpot until we come to terms with the thought that colour sensations needn't derive from incident light-frequency radiation. The coded signals to the brain can be affected in various ways; by mechanical vibration; by the application of external voltages or currents or by hallucinatory drugs. In the last-mentioned case manifestations occur which have every semblance of three-dimensional reality. Given an exact control of the input signals, what might not be possible? Even a degree of sight to the blind seems to be feasible.

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WW—006 FOR FURTHER DETAILS

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JR-310

SSB COMMUNICATIONS RECEIVER

∗ High-stability VFO of 2 FET's and 2 transistors and easily handles QSO's for hours. ∗ Precision double gear dial—a TRIO innovation —with linear frequency variable capacitor. Possible to get finer reading 1KHz. One dial rotation covers 25KHz, makes SSB demodulation easier. ∗ Frequency range covers entire amateur band from 3.5MHz to 29.7MHz. One-touch selection system switches bands. WWV reception of 15MHz possible. ∗ MHz band circuit structure patterned on Collins type double conversion system so first oscillation is by crystal control, second local oscillation by VFO.

SPECIFICATIONS OF JR-310

∗ FREQUENCY RANGE: 3.5-29.7MHz (7 Bands)
∗ SENSITIVITY: 1μV (at 10dB S/N)
∗ IMAGE RATIO: More than 50dB
∗ FREQUENCY STABILITY: ±2KHz in 1–60min. after switching on, subsequently within 100Hz per 30min.
∗ Dimensions: 13"(W), 7-3/32"(H), 12-3/16"(D).

Model SP-5D
COMMUNICATION SPEAKER

∗ Communications Speaker which has been designed for use with the 9R-59DE.
∗ Dimensions: 3-9/16"(W), 7-1/8"(H), 5-3/16"(D).

Model 9R-59DE
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WW—007 FOR FURTHER DETAILS

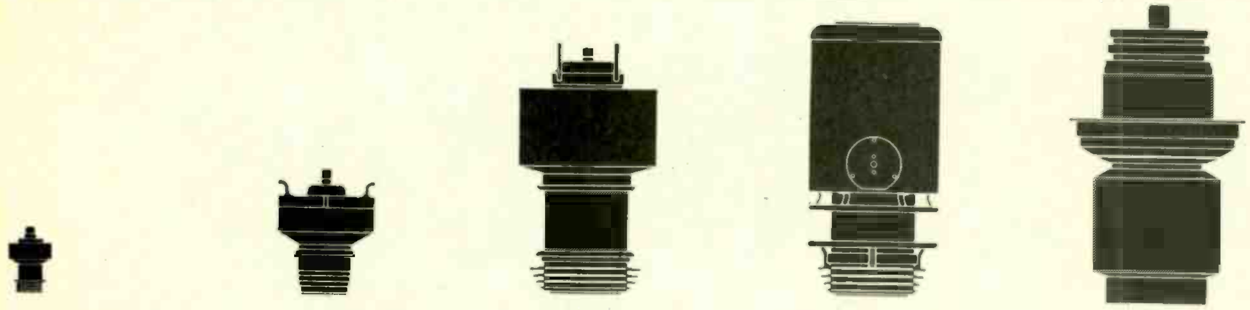
If you need power tetrodes at the right price look at this EEV range

Forced-air Cooled

Type	Service type	Anode dissipation max. (kW)	Output power (kW)	Anode voltage max. (kv)	Frequency (MHz)	Filament ratings (V)	Filament ratings (A)
4CX1000A 4CX1000K	—	1.0	3.2	3.0	110	6.0	9.0
4CX1500B	—	1.5	2.7	3.0	30	6.0	9.0
4CX5000A	CV8295	5.0	16.0	7.5	30/110	7.5	75
4CX10,000D	CV6184	10.0	16.0	7.5	30/110	7.5	75
4CX35,000C	—	35.0	82.0	20.0	30	10	300
CR192A (6166A)	CV8244	10.0	9.0	6.9	60/220	5.0	175

Vapour Cooled

Type	Anode dissipation max. (kW)	Output power (kW)	Anode voltage max. (kv)	Frequency (MHz)	Filament ratings (V)	Filament ratings (A)	Boiler unit
CY1170J	60	82	15	30	10	300	Integral
CY1172 (RS 2002V)	150	220	15	30	21	350	CY4120



4CX1000K
For audio or linear single sideband amplifiers. 4CX1000K has a solid disc screen contact to permit use up to 400MHz.

4CX10,000D
For audio, linear, single sideband or screen modulated r.f. amplifiers.

4CX35,000C
For audio amplifiers, r.f. linear amplifiers or Class C amplifiers or oscillators.

CY1170J **CY1172**
For audio amplifiers, r.f. linear amplifiers or Class C amplifiers or oscillators. Both types have a coaxial metal-ceramic envelope. A range of glass envelope types is also available.

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Chelmsford Essex England Telephone: 61777
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WW39

AP 358

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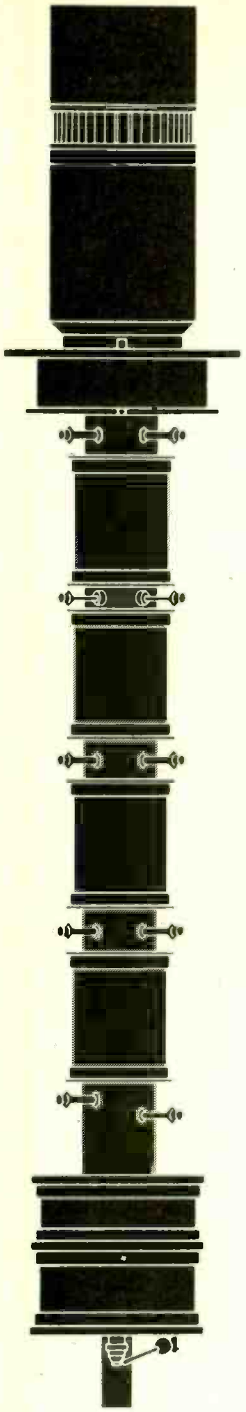
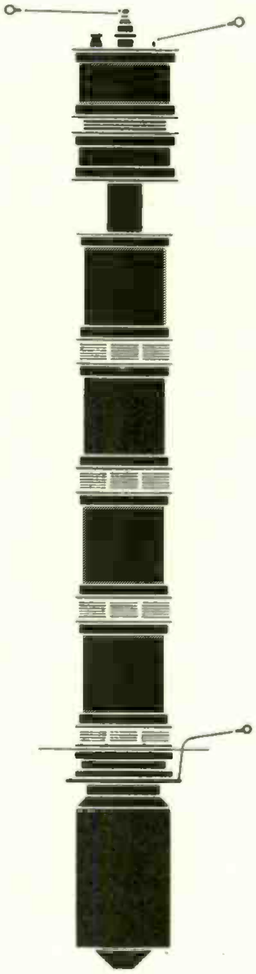
WW—009 FOR FURTHER DETAILS





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PVC/steel for sides, top and bottom =	Rigidity, low cost and ease of assembly.
3 heights of case, 4 widths, 2 depths =	24 cases with screws on top and 24 cases with screws on side, that's 48 cases.
Low cost =	Prices include chassis.
Modern design =	Metal work on front and back and chassis is made easier by aluminium, with PVC steel cladding for strength.
Good delivery =	Believed to be the first off the shelf range of all PVC coated material cases.
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Economy of size, 24 sizes, 48 shapes =	70 cubic inches to 2200 cubic inches for convenient sizing or layout, no wasted space.
Genuine modular design =	Cases may be mounted together as height includes feet.
Stainless steel screws used throughout =	Modern Pozidrive screws for good appearance and ease of use. Screwdriver cannot slip.
6 chassis sizes and many chassis positions on ½" centres =	Easier planning and 1 to 4 or more chassis can easily be used.

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D	9	3	6.5	46/6	45/6	44/6	4/6
E	9	7	6.5	49/6	48/6	47/6	4/6
F	9	10	6.5	58/6	57/6	56/6	4/6
G	13	3	6.5	49/6	48/6	47/6	4/6
H	13	7	6.5	58/6	57/6	56/6	4/6
I	13	10	6.5	69/6	68/6	67/6	6/–
J	18	3	6.5	58/6	57/6	56/6	4/6
K	18	7	6.5	79/6	77/6	76/6	6/–
L	18	10	6.5	106/–	104/–	103/–	6/–
M	4.5	3	13	36/6	35/6	34/6	4/6
N	4.5	7	13	49/6	48/6	47/6	4/6
O	4.5	10	13	69/6	68/6	67/6	6/-
P	9	3	13	49/6	48/6	47/6	4/6
Q	9	7	13	69/6	68/6	67/6	6/–
R	9	10	13	79/6	77/6	76/6	6/–
S	13	3	13	58/6	57/6	56/6	6/–
T	13	7	13	79/6	77/6	76/6	6/–
U	13	10	13	99/6	98/–	97/–	7/6
V	18	3	13	79/6	77/6	76/6	6/–
W	18	7	13	106/–	104/–	103/–	7/6
X	18	10	13	129/6	127/6	126/–	7/6
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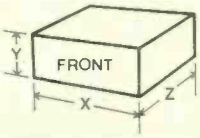
For other West Hyde products please see previous advertisements



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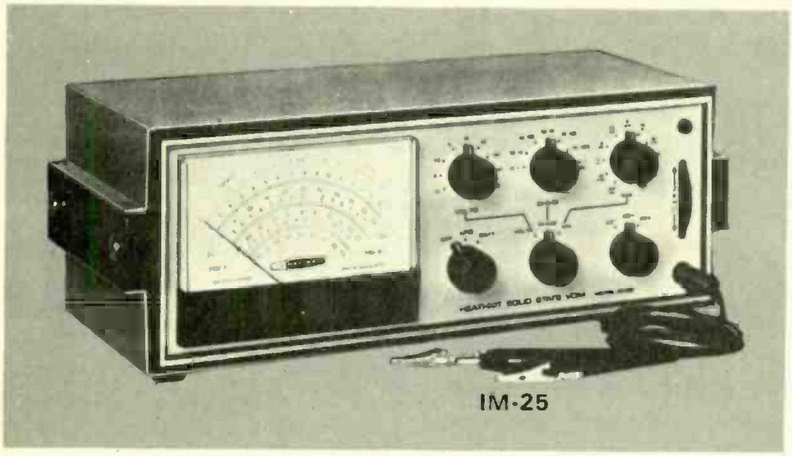

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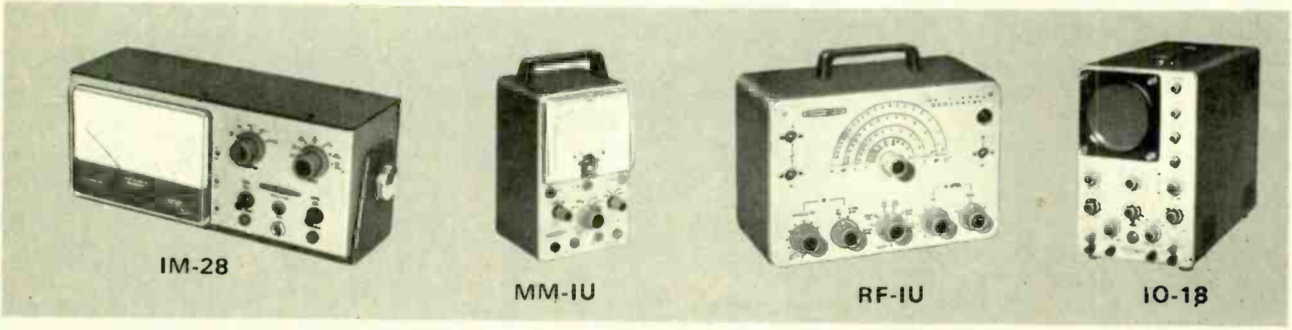
IM-28 MM-IU RF-IU IO-18

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MODEL 2000
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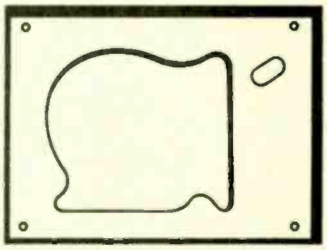
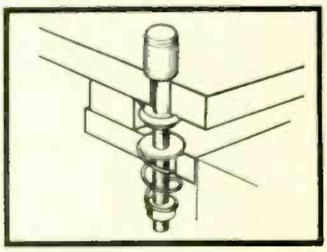
The SME model 2000 plinth system is more than a handsome and convenient housing for your turntable and SME precision pick-up arm. It meets the mechanical requirements under which the best performance will be obtained. High-quality workmanship is combined with ease of assembly. The basic unit is finished in selected veneers of teak, straight-grained walnut, or rosewood. A one-piece hinged lid in heavy acrylic is reinforced with a polished stainless-steel trim.



Motor boards in matching veneers are ready cut and drilled for screwdriver assembly with the appropriate pick-up arm and turntable. An uncut board is also available.



Four-point spring suspension adjustable for height and damping protects the motor board from acoustic feedback and external vibration.

SME

Write for details to: **SME LIMITED · STEYNING · SUSSEX · ENGLAND**

Tektronix Type 556

DC-to-50 MHz, dual-beam, sweep-delay oscilloscope

The Type 556 and rack-mount Type R556 use any combination of Tektronix letter or 1-series plug-ins

The UPPER BEAM can display a signal from either *left* or *right* plug-in; with either Time Base A, Time Base B, or external signals; triggered from a composite vertical signal, plug-in single channel signal (with 1A1 or 1A2), external, or line.

The LOWER BEAM can display a signal from the *right* plug-in; with either Time Base B or external signals; triggered from a composite vertical signal, plug-in single channel signal (with 1A1 or 1A2), external, or line.

Independent Vertical Systems use Type 1A1 or 1A2 Plug-in Units for 50 MHz operation; also accept any other 1-series or letter-series plug-in units.

Independent Sweep Systems provide 24 calibrated steps from 0.1 µs/cm to 5s/cm; the X10 Magnifier extends the fastest sweep rates to 10ns/cm.

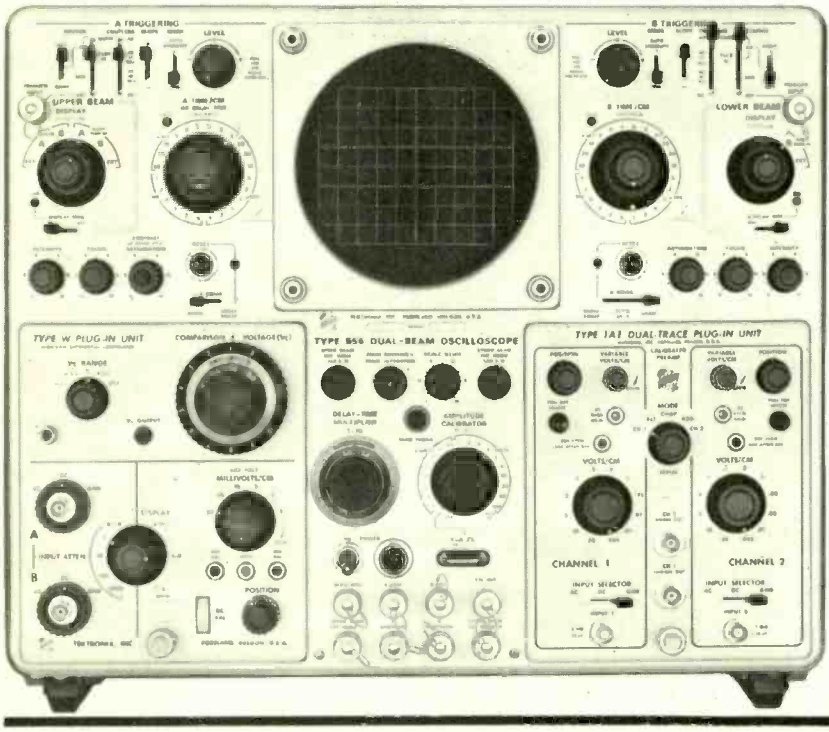
Calibrated Sweep Delay extends continuously from 0.1 microsecond to 50 seconds.

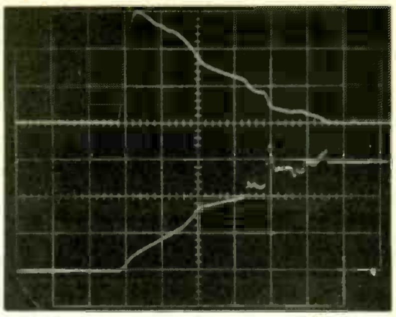
Signal-Sweep Operation enables one-shot displays of normal or *delayed* sweeps.

Independent Triggering Systems provide stable displays to beyond 50MHz. Either input signal can be used to trigger either or both time-bases.

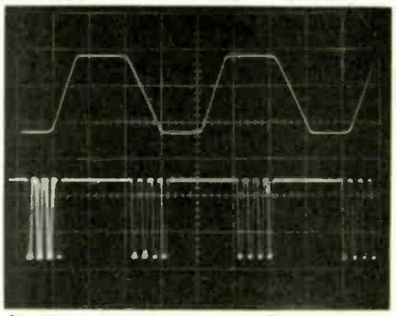
New Dual-Beam CRT (with illuminated internal graticule) provides "zero-parallax" viewing of small spot size and uniform focus over the 8cm by 10cm display area. Each beam has 6cm vertical scan, with overlap scan of 4cm by 10cm.

EMI (RFI) Suppression — meets interference specifications of MIL-I-6181D over these frequency ranges: 150kHz to 1GHz — Radiated (with CRT mesh filter installed), and 150kHz to 25MHz — Conducted (power line).





Simultaneous Single-shot Displays. Current versus voltage display of a 0.75 ampere, fast-blow fuse during destructive overload. Both beams are driven by B Time-Base at 50 µs/cm which is delayed by pre-triggered A Time-Base to provide base reference lines before and after the event. The upper beam shows the current waveform at 30A/cm while the lower beam shows the corresponding voltage across the fuse at 100V/cm.



Single-input Dual-beam Displays. Upper beam shows bursts of 2.5MHz pulses on Time Base A with time variation between bursts. This shows up as increasing time-jitter between the first and successive bursts. The lower beam shows B Sweep (0.1 µs/cm) delayed by A Sweep and triggered on the second pulse of the last burst to provide a jitter-free expanded display of the A Sweep intensified zone. The use of only one probe and one plug-in input simplifies signal connection and provides minimum loading on the source.

Plug-in units shown

Type 1A1 Dual-trace Unit
(Dual-Trace—50mV/cm at DC-to-50 MHz, 5mV/cm at DC-to-28 MHz. Single-Trace—500µV/cm at 2Hz-to-15 MHz. 5 Display Modes—Channel 1, Channel 2, Alternate, Chopped, Added Algebraically. Front-panel signal output.)

Type W Differential Comparator Unit
(*Conventional Preamplifier*—50mV/cm at DC-to-23MHz to 1mV/cm at DC-to-8MHz. Decade Input Attenuator to X1000. *Differential Input Preamplifier*—CMRR of 20,000 to 1, DC-to-20kHz. Max Peak Input of ±15V, X1 Attenuation. *Calibrated Differential Comparator*—Vc Supply of 0 to ±11V. Accuracy of ±0.15% of output ±0.05% FS.)

Price without plug-in units—£1,560

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WW—016 FOR FURTHER DETAILS

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POWER

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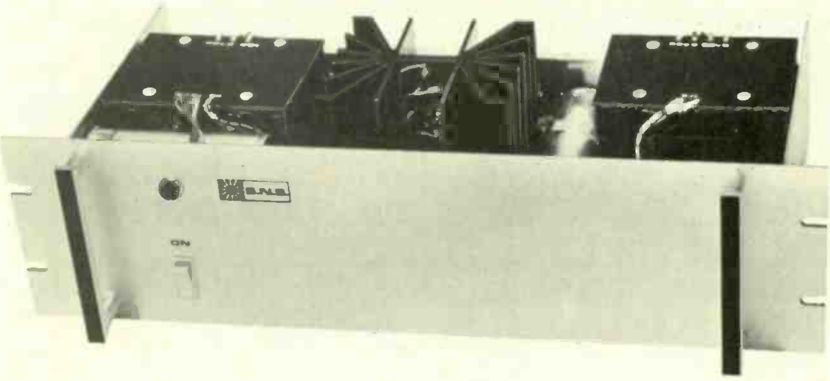

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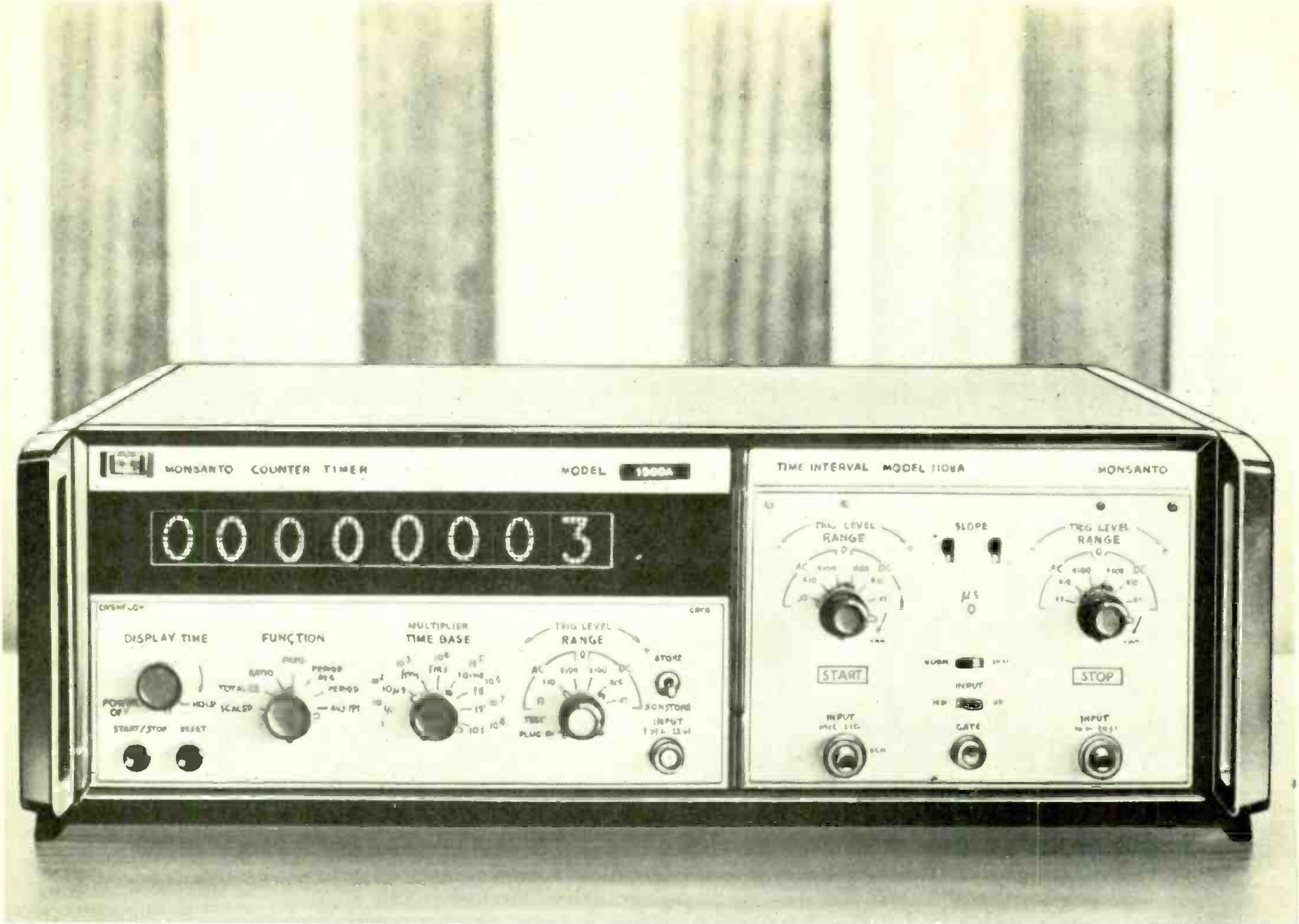

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Switched Capacitor Boxes
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Cat. Ref.	Range
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C.100	0 to 100 mfd. in 1 mfd. steps.
C.140	0 to 140 mfd. in 1 mfd. steps.

All instruments calibrated in absolute units so that no correction has to be made for strays.

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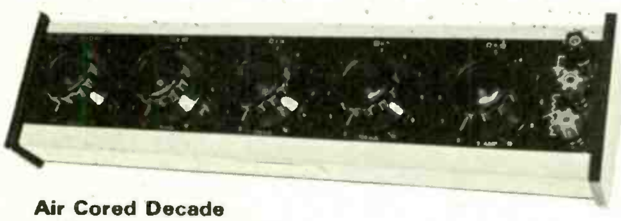
Average Accuracy 0.1%. Residual resistance: 4 Decade – 12 milliohms. 5 Decade – 15 milliohms.

Decade	x 100,000 ohms	x 10,000 ohms	x 1,000 ohms	x 100 ohms	x 10 ohms	x 1 ohm	0.1 ohm
Max. Cont. Current	3 mA	7 mA	20 mA	70 mA	200 mA	700 mA	1A
Short time current rating	3.2 mA	10 mA	32 mA	100 mA	320 mA	1 A	1 A

Precision Metal film decade resistance box suitable for use both on d.c. and at high frequencies. Accuracy actually improves with use and age.

5 Decade	Cat. Ref. R7	1,111,100 Ω by 10 Ω steps	
	Cat. Ref. R9	111,110 Ω by 1 Ω steps	
	Cat. Ref. R10	11,111 Ω by 0.1 Ω steps	
4 Decade	Cat. Ref. R5	111,100 by 10 Ω steps	
	Cat. Ref. R4	11,110 by 1 Ω steps	
	Cat. Ref. R3	1,111 by 0.1 Ω steps	



Air Cored Decade Inductor Accuracy ±5%
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2 decade model Cat. Ref. L2 1 mH to 100 mH
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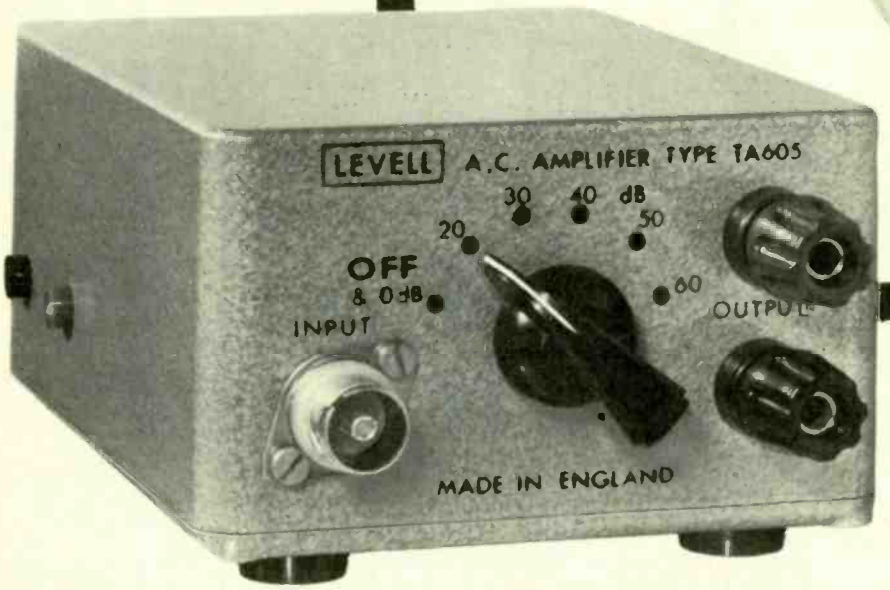
The TA401 is similar to the TA601 (as illustrated)



TA605 ACTUAL SIZE

SPECIFICATIONS

	TYPE TA401	*TYPE TA601*	*TYPE TA605*
GAIN	40dB ±0.1dB	60dB ±0.1dB	20, 30, 40, 50 and 60dB ±0.2dB.
BANDWIDTH ±3dB	1 Hz-3MHz	3Hz-1.2MHz	20-40dB, 1Hz-3MHz; 50dB, 2Hz-2MHz; 60dB, 4Hz-1.5MHz.
BANDWIDTH ±0.3dB	4Hz-1MHz	10Hz-300kHz	20-40dB, 4Hz-1MHz; 60dB, 10Hz-300kHz.
INPUT IMPEDANCE	>5MΩ, <40pF from 100Hz to 1MHz	>IMΩ, <50pF from 100Hz to 300kHz	>5MΩ, <40pF from 100Hz to 300kHz.
INPUT NOISE	<15 μV, zero source; <50 μV, 100k Ω source	<15 μV, zero source; <40 μV, 100k Ω source	As TA401 and TA601 at 40dB and 60dB.
POWER SUPPLY	PP3 battery, life 100 hours		PP9 battery, life 1,000 hours, or A.C. Power Unit.
AVAILABLE OUTPUT	IV up to IMHz, 300mV at 3MHz, into load of 100kΩ and 50pF		1.5V up to 2MHz, IV at 3MHz, into 100kΩ and 50pF.
OUTPUT IMPEDANCE	100 Ω in series with 6.4 μF		
SIZE AND WEIGHT	3" x 1¾" x 1¼" 7 oz.		2½" x 4" x 5½" 2¼ lb.
PRICE with Battery and input lead	£17.0.0	£17.0.0	£27.0.0 (Optional A.C. Power Unit £7.10.0 extra).

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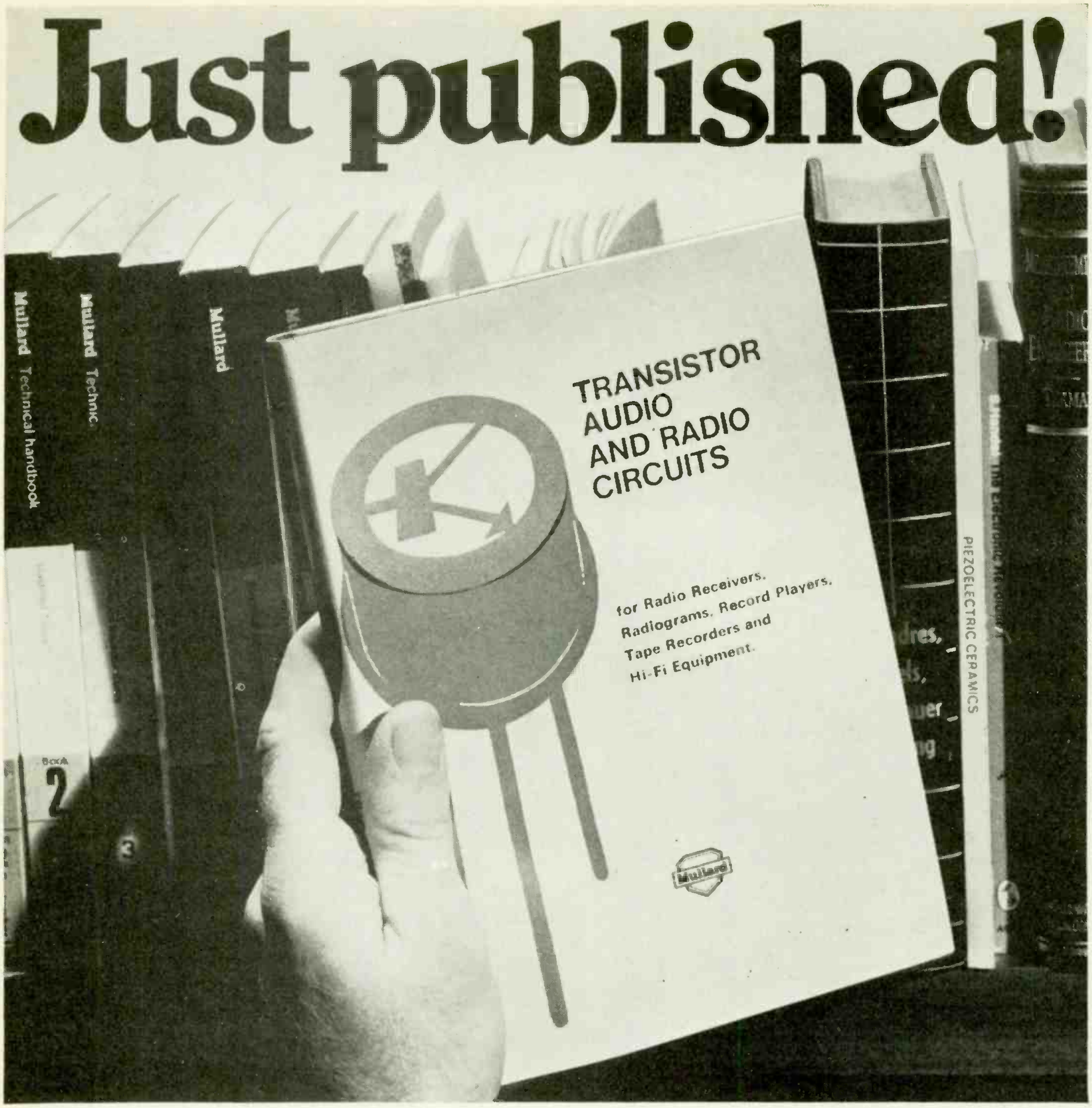

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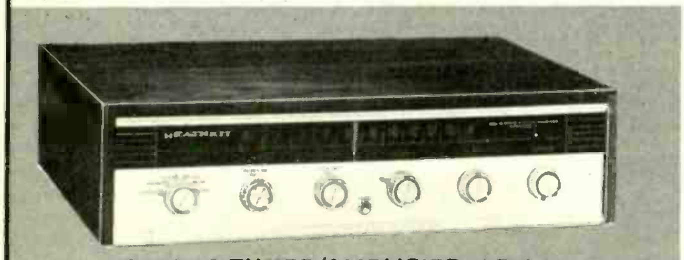
STEREO 'COMPACT' AD-27

Are you a do-it-yourself man? Would you like to own a first-class Hi-fi outfit at a do-it-yourself price? The wide range of world-famous Heathkit products offers something for everyone.

STEREO 'COMPACTS'

The newest additions to the Heathkit range are two "stereo compacts". The AD-27, pictured left includes a turntable unit with a Shure magnetic cartridge, an FM stereo tuner and a 30 watt stereo amplifier. The whole is built into an attractive compact teak or walnut veneered cabinet – all for a kit price of only £82! The AD-17 compact is similar but does not have the FM radio facility and uses a simpler but still attractive cabinet. This kit only costs £54.



STEREO TUNER/AMPLIFIER, AR-14

STEREO TUNER AMPLIFIERS

If you need a Tuner-Amplifier, we can offer models to suit any pocket. Pictured on the left is the very popular Heathkit AR-14. This is a solid-state stereo Tuner-Amplifier with a sensitive FM tuner, a built-in stereo decoder and a 30 watt stereo amplifier (15 watts I.H.F.M. per channel). It is wonderful value at a kit price of £54.

STEREO TUNER TFM-15

STEREO AMPLIFIER, TSA-12

STEREO 'SEPARATES'

If your preference is "separates", or perhaps you want just a stereo amplifier without a tuner, again Heathkit offers a selection. Typical is the TSA-12 stereo amplifier, illustrated. This is a solid state stereo amplifier (15 watts I.H.F.M. per channel) at a kit price of only £32 16 0. We have radio tuners to match either for FM reception only, or for FM and Long and Medium wave. The Stereo Tuner, model TFM-15 costs only £28 14 0 in kit form.

LOUDSPEAKER SYSTEMS

All the units described above can be used with any good hi-fi loudspeakers. To cover this need, the Heathkit range includes several hi-fi loudspeaker kits. The Berkeley kit features a 12 in. bass loudspeaker and a 4 in. high-frequency unit, a ready finished teak or walnut veneered cabinet, and the kit price is only £21 4 0. The 'Avon' mini kit is only £13 8 0.

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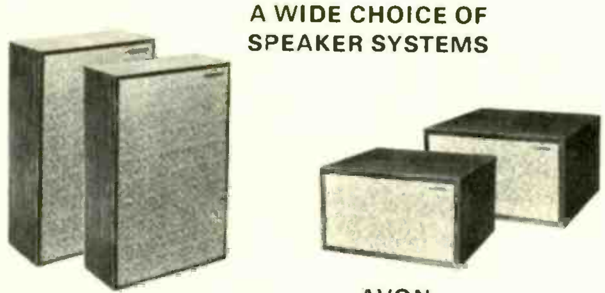

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- **HIGH QUALITY REPRODUCTION**
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- **QUICKLY SET UP**
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Specification

Power Output: 25-30 watts at 100V line.
Inputs: Two microphones 30-50Ω balanced.
Auxiliary switched gram, tape, or medium impedance microphone.
Master Gain Control, Tape Record Socket,
Bass Tone Control: + 10 db – 12 db @ 100 cps.
Treble Tone Control: + 8.5 db – 10 db @ 10 Kc/s.
Frequency Response: ± .5 db 25 c/s – 12 Kc/s.
Dimensions: Length: 3' 4". Depth: 1' 6". Height: 2' 6".
Height less legs: 1' 0".

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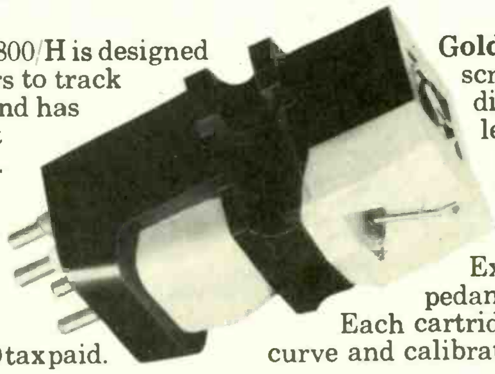

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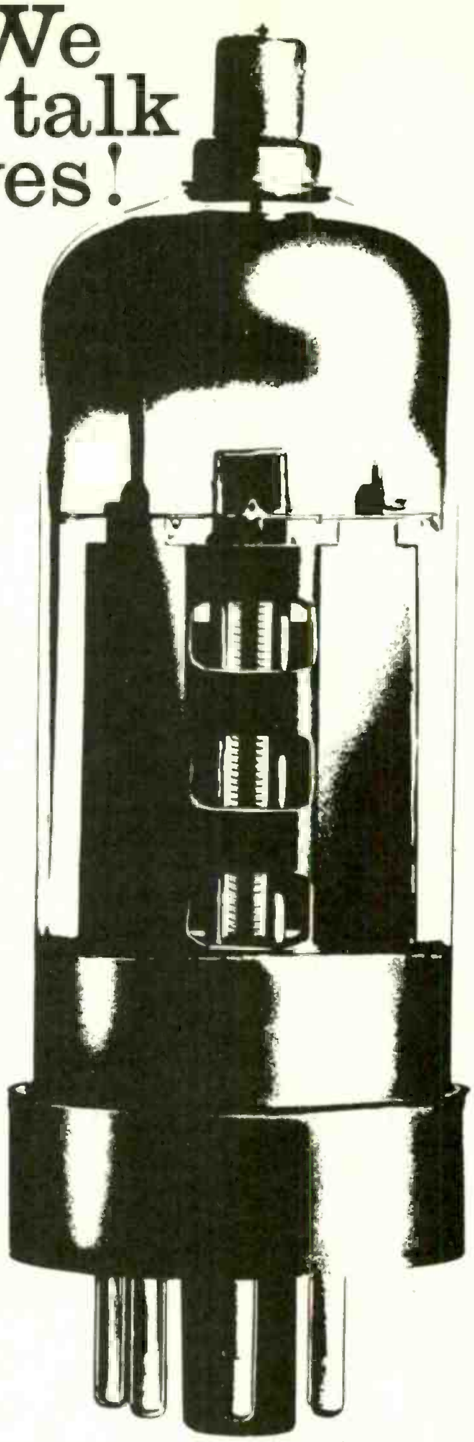

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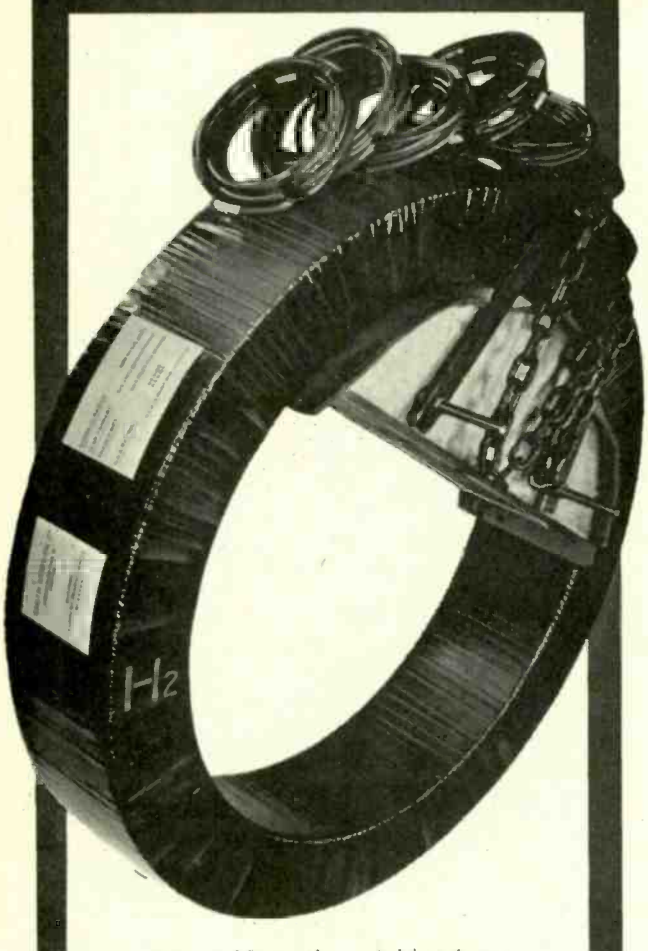

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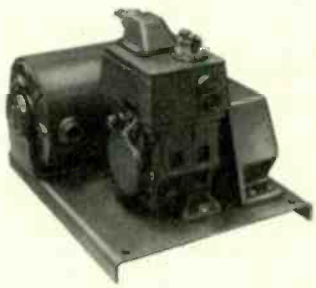

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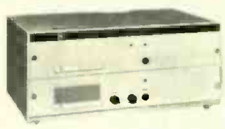
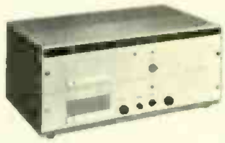


Pye VHF Radiotelephone Fixed Station

Solid-state receiver and transmitter · 10-15W R.F. output · Field-effect transistors used in receiver · Suitable for all climates · Electronic squelch · Designed to meet all relevant specifications.



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Pye 'Westminster' Remote Mounted Radiotelephone

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Pye 'Westminster' Front Mounted Radiotelephone

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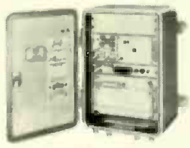

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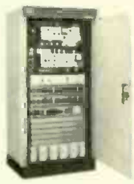

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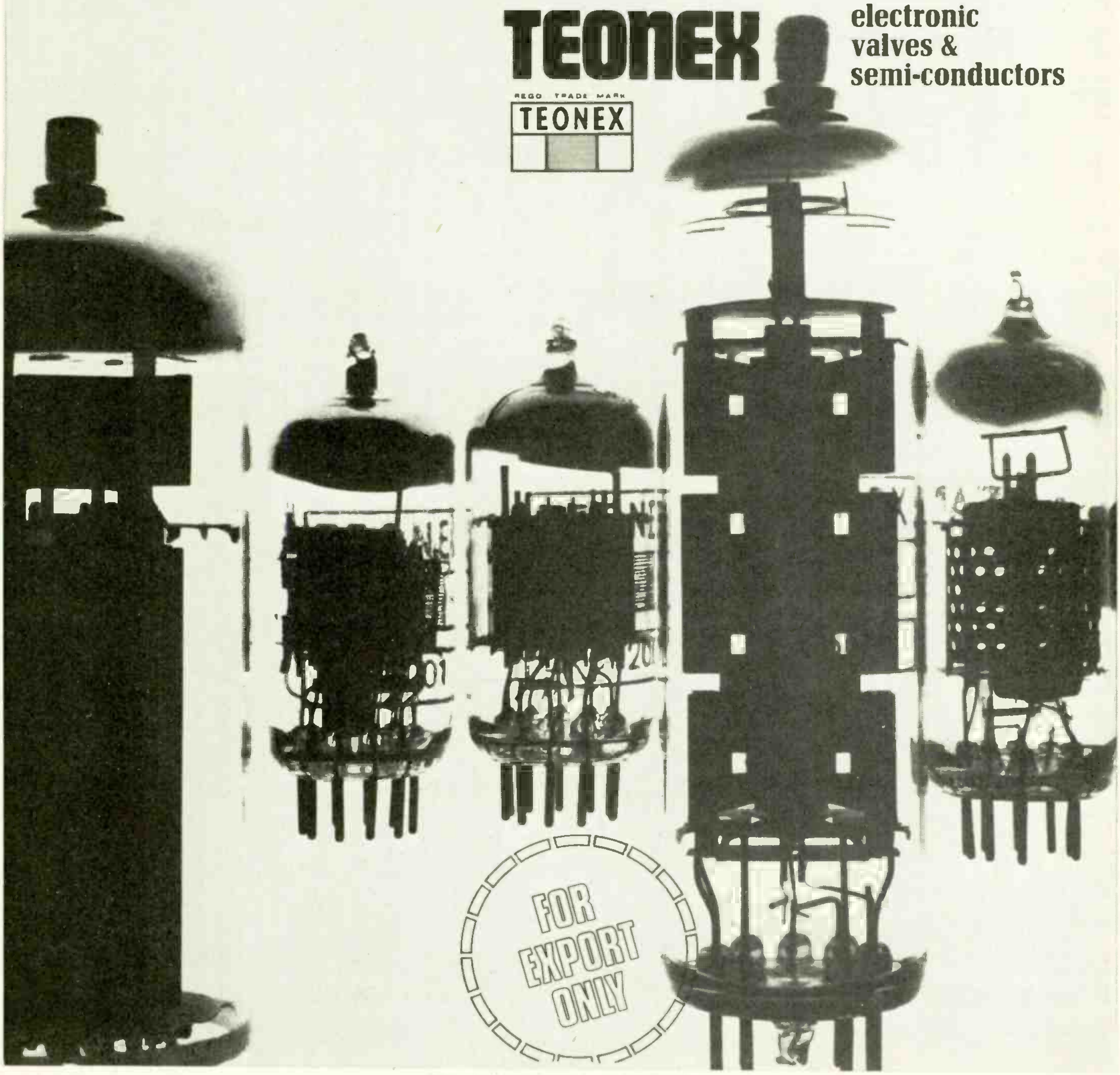

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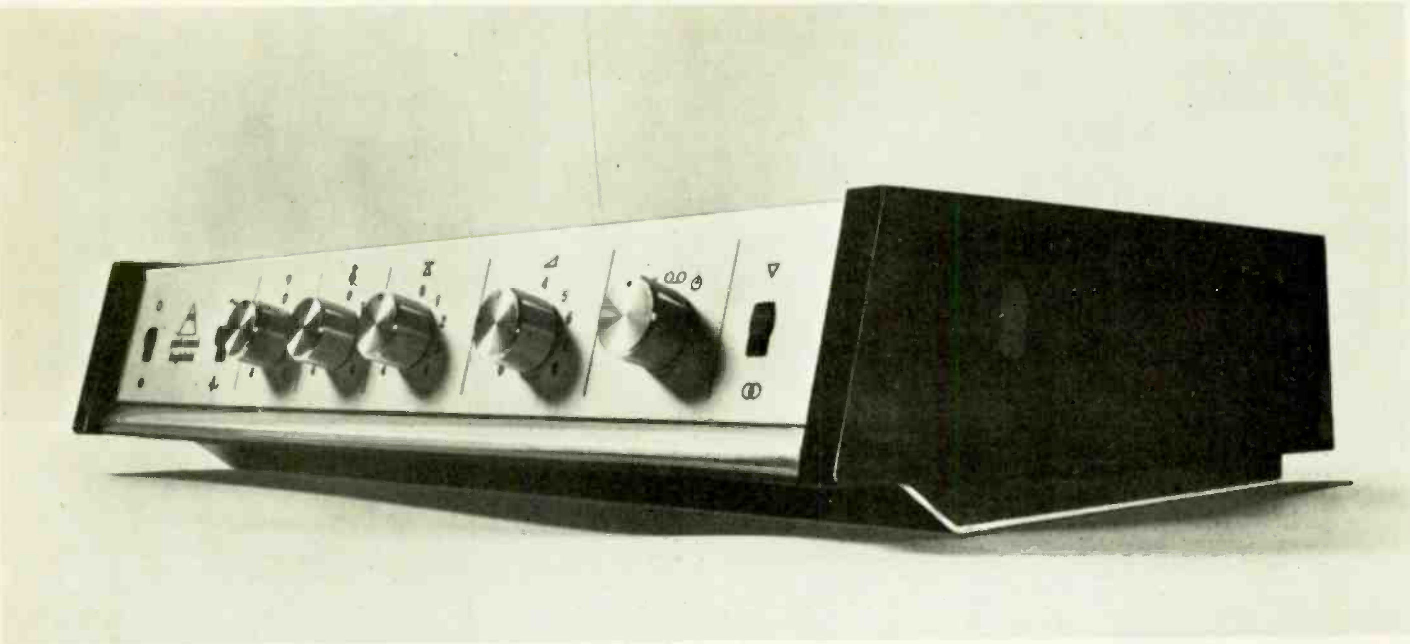
peak sound



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Using two Peak Sound PA. 12-15's, driven simultaneously at 1 KHz from 240 V. mains supply.

Output per channel: 11 watts into 15 Ω: 14 watts into 8 Ω. *(see spec. guarantee)*.

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Some notes on Bridge Measurement by WAYNE KERR

Number 6

Radio-Frequency Bridges

The first five issues in this series of notes have described some of the basic principles of low frequency bridges and also their application to the measurement of components using two, three and four terminal techniques.

Transformer Ratio Arm bridges can be designed to operate at radio frequencies up to about 250MHz where other forms of bridge based on transmission lines become practicable.

The design of a bridge required to operate at high frequencies demands careful attention to every aspect of the layout, and in particular to the series inductance introduced by connections between component parts of the bridge. Short lengths of conductor which are insignificant at low frequencies can resonate and introduce immense errors as the frequency is increased.

However, the neutral connection which is available from transformer ratio arms can be used to effectively cancel the series inductance of conductors in the following manner. If two strip connections are made to, say, a bridge standard, these are placed side by side and mounted above a plate connected to neutral. The loop current flowing in the strips will induce, in the plate, an equal and opposite current which cancels the magnetic field, thus reducing the loop inductance.

Figure 1 illustrates a practical circuit for a bridge capable of operating at frequencies up to 100MHz.

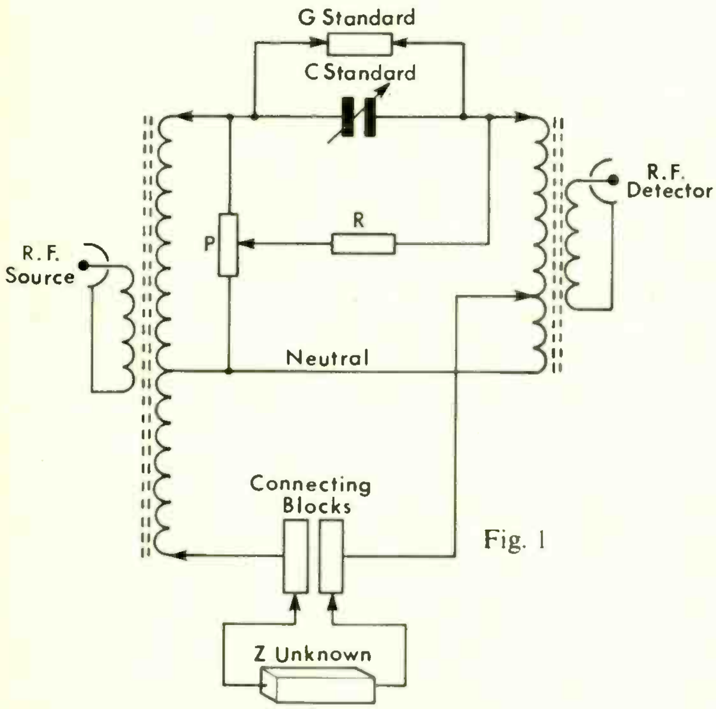

Fig. 1

The transformers are formed by winding thin silver tapes on to ferrite or ferrous dust ring cores which are mounted inside individual screening cans.

The unknown impedance is connected to the blocks shown in the diagram which represent a shunt capacitance on the unknown side of the bridge. This capacitance is balanced by the standard variable capacitor and its value is so chosen that the capacitor is half engaged when the dials are at zero. An unknown reactance can therefore be balanced either by increasing the setting of the capacitor or decreasing it in the case of an inductive reactance. This feature is of particular value when transmission lines or aerial arrays are being evaluated.

Drums of low inductance resistors forming fixed conductance standards are arranged to engage with spring contacts. A variable conductance for interpolation is formed by means of a resistor R which is fed with a voltage derived from a resistive potential divider P.

Recently, a continuously variable potential divider has been developed which enables voltage division to be effected with great precison. This device is based on the magnetic field in a single turn loop and is illustrated in Figure 2.

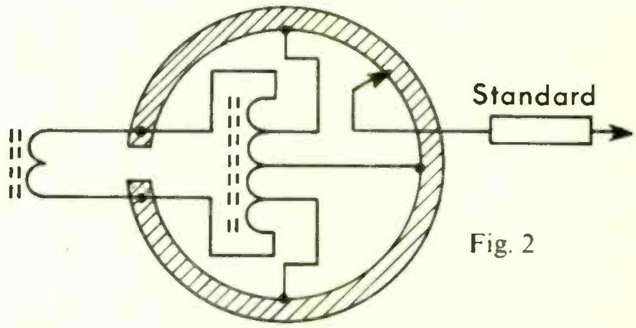

Fig. 2

The loop is connected to a winding which forms part of the left hand transformer shown in Figure 1. An auto-transformer is connected across the loop and several taps are connected to give a predetermined voltage distribution round the loop. Separate loops can be used to drive resistive and reactive standards and one interesting feature of the arrangement is its ability to create a continuously variable inductance standard. In this case an air cored toroid can be employed whose external field is so small that the presence of metal objects near the coil has no measurable effect.

Radio-frequency bridge measurements require that considerable care should be taken in setting-up the apparatus. Any leakage of power from the source to the detector which by-passes the bridge network will give errors. Furthermore, if an aerial assembly is being measured, radiation from the aerial may be picked up by a badly screened detector and subsequently cancelled by a voltage of opposite phase in the operation of the bridge which will now balance at a false point on its scales. However, with a well screened detector and with soundly constructed connecting cables coupling the source and detector to the bridge, highly accurate measurements can be performed on both active and passive assemblies.

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Date 15th September, 1969

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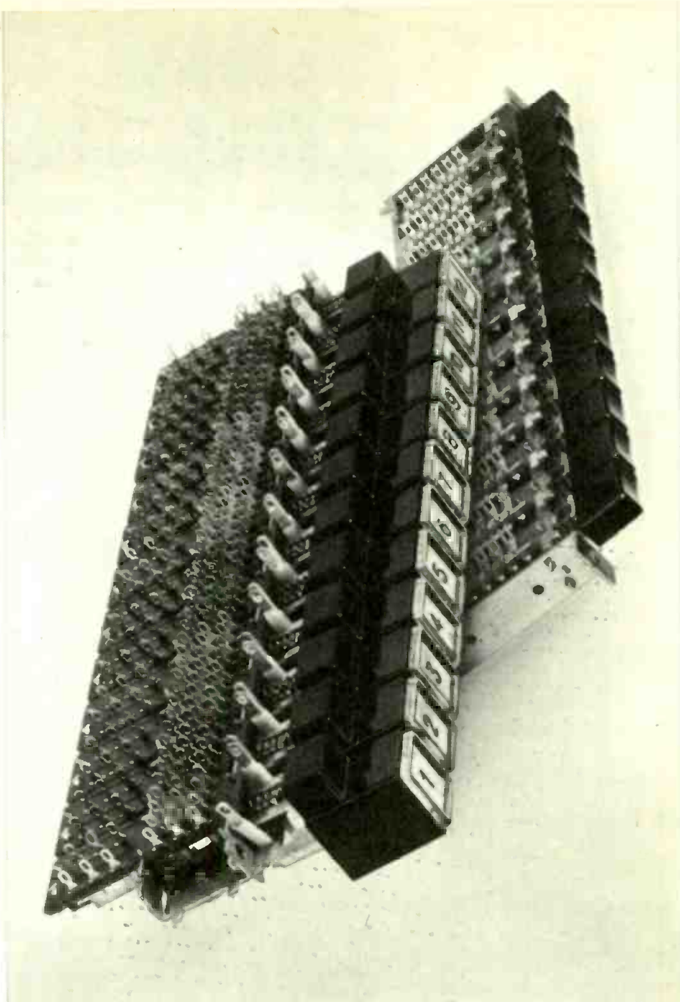

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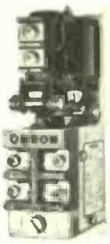

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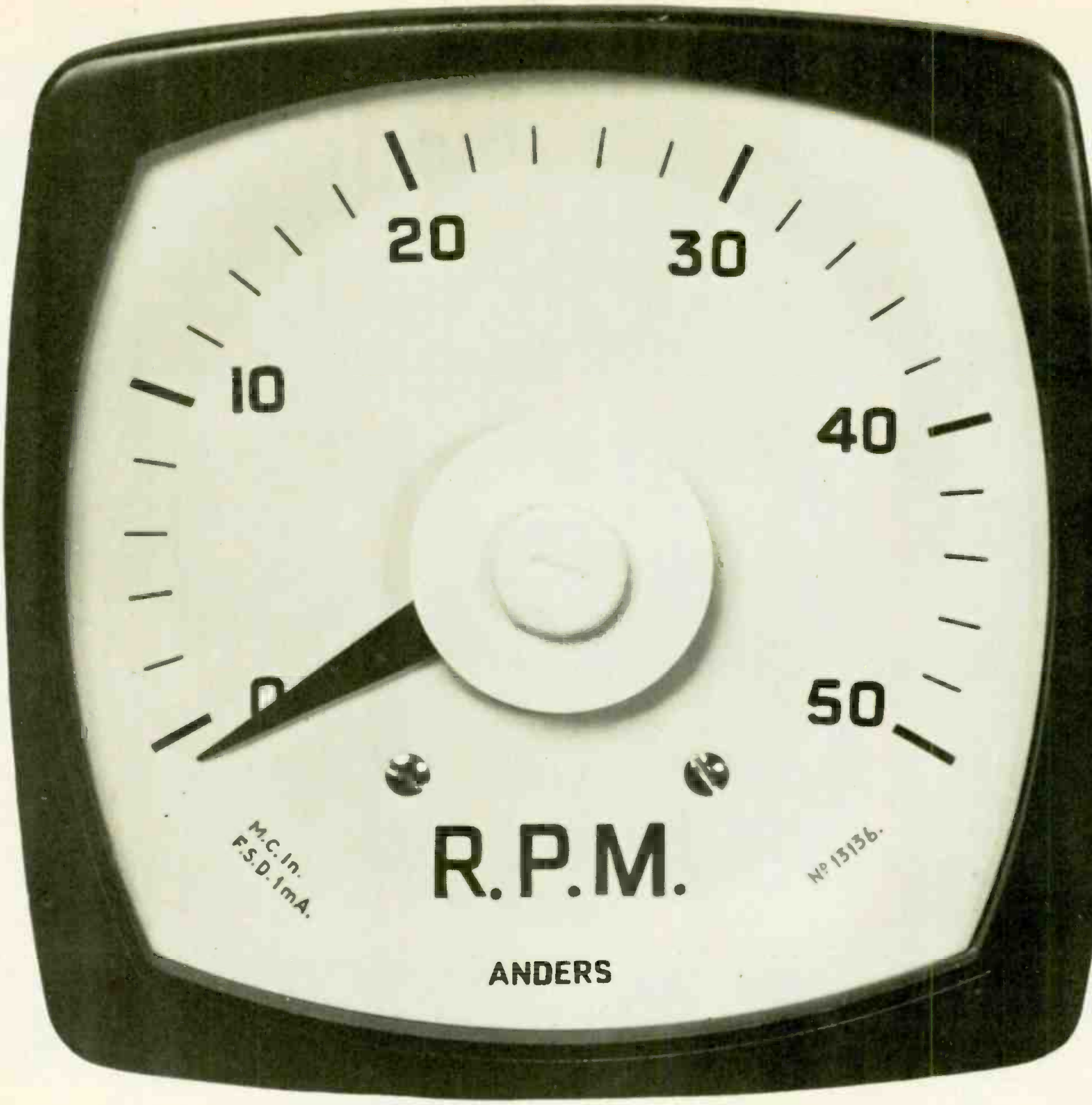

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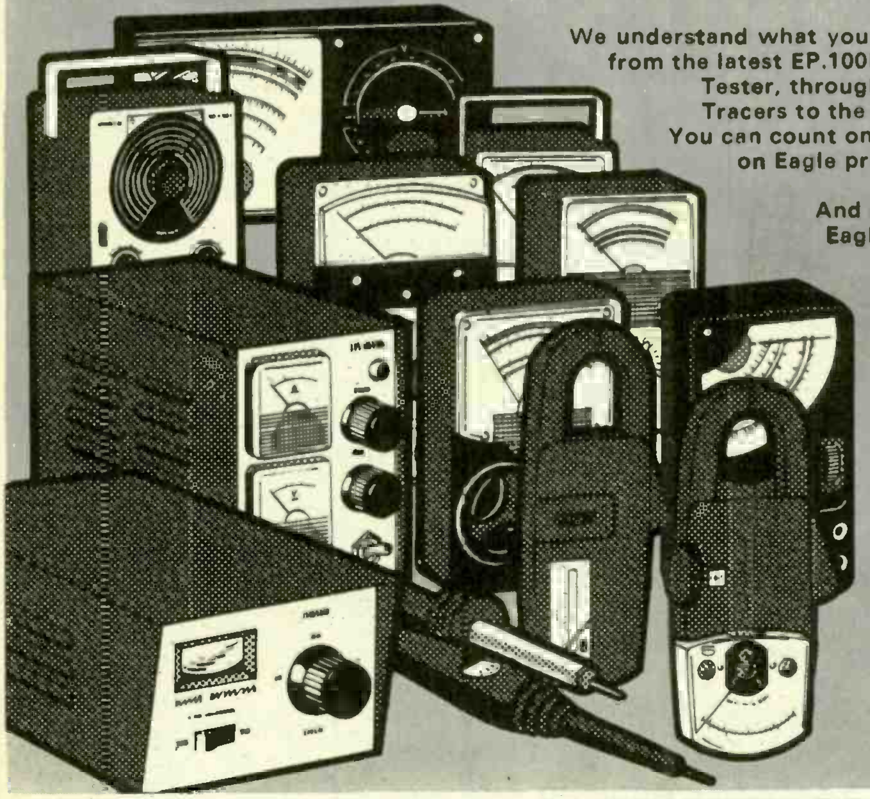

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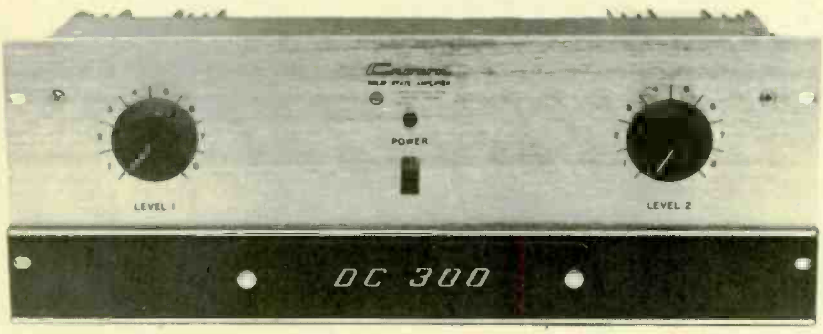

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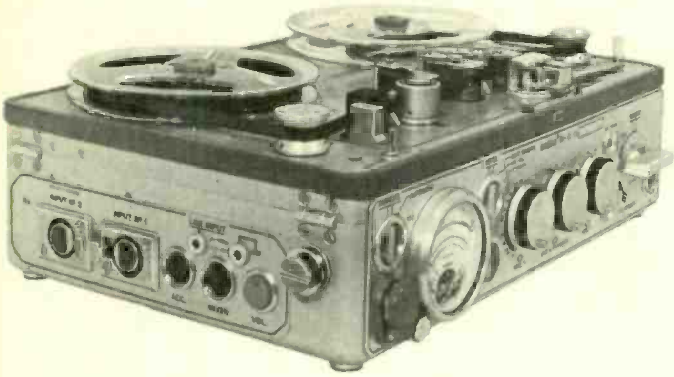

MODEL IVD Automatic/Manual, three speeds

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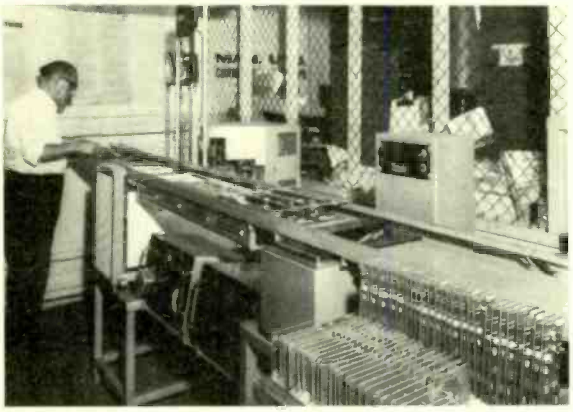

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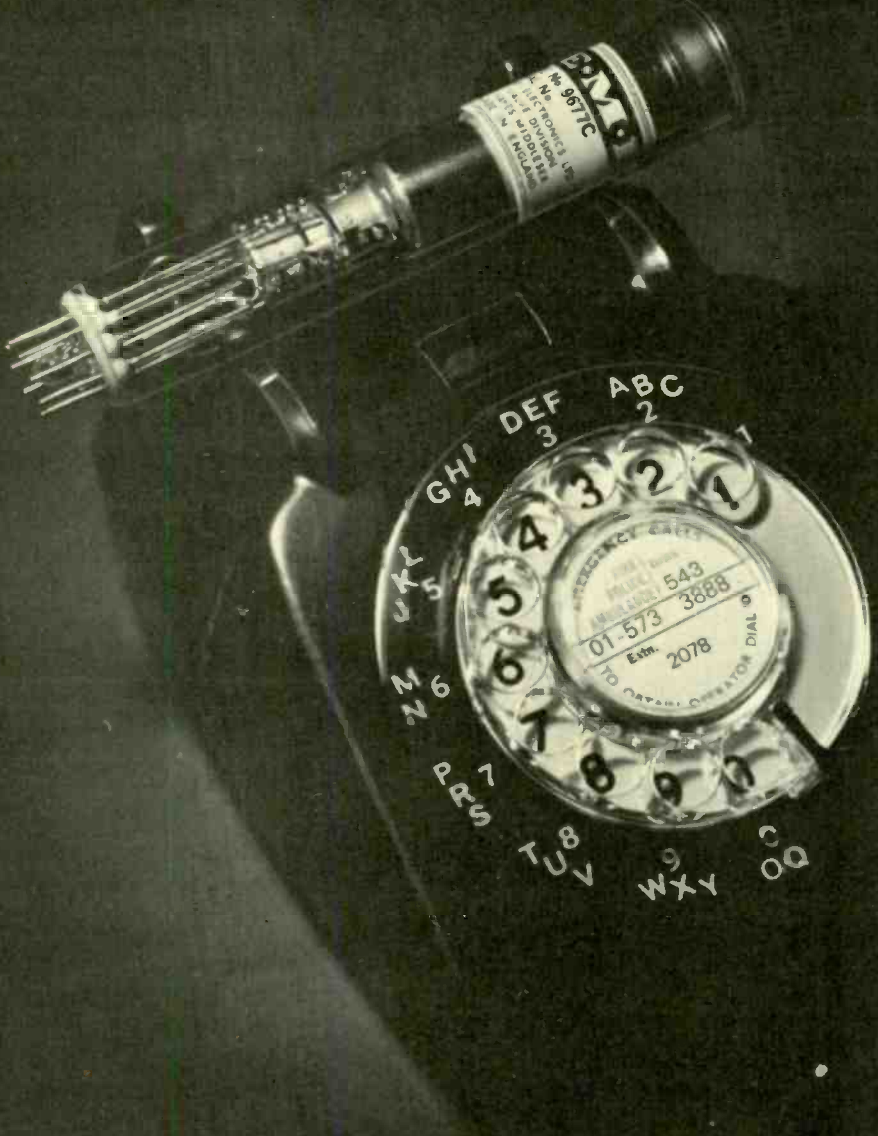
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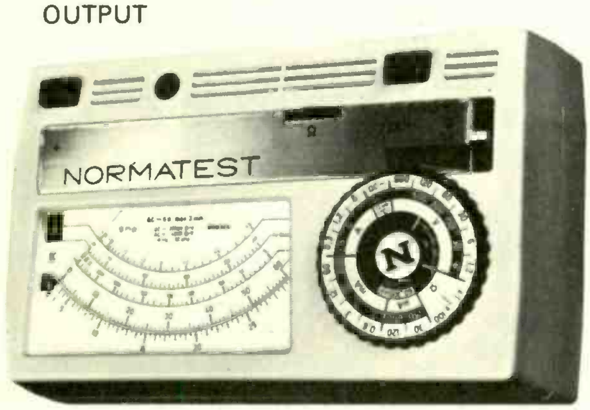

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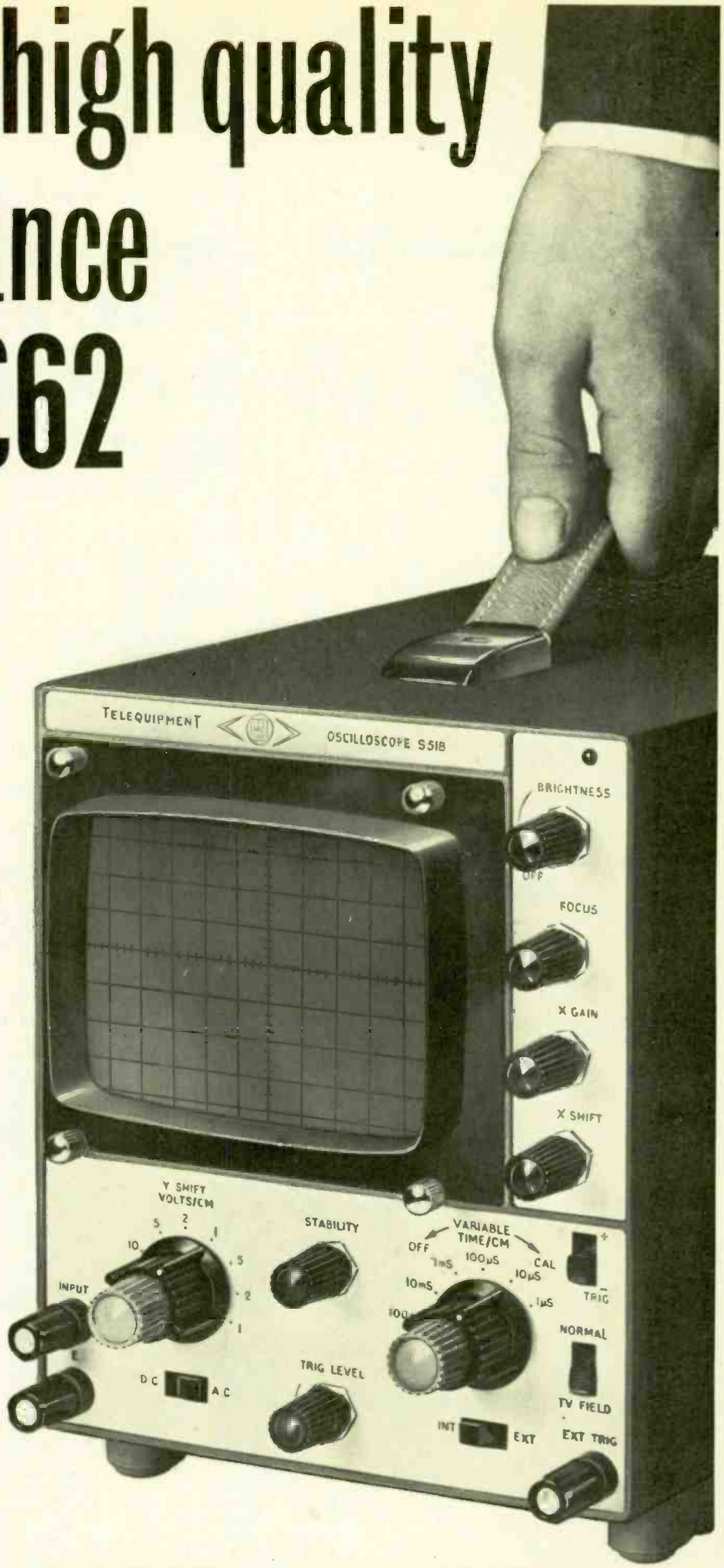

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Wireless World

Electronics, Television, Radio, Audio

Fifty-ninth year of publication

January 1970

Volume 77 Number 1411

The macrophotograph on **this month's cover** shows wires being bonded on to integrated circuits at the Mullard Southampton works. On page 6 the future of linear i.cs is discussed.

Contents

OUR NEXT ISSUE

Loudspeaker performance: Paul Klipsch, originator of the Klipsch horn, compares horns and direct radiators
Ceramic pickups and transistor pre-amplifiers: are they incompatible?
Matching: what is meant by this term?

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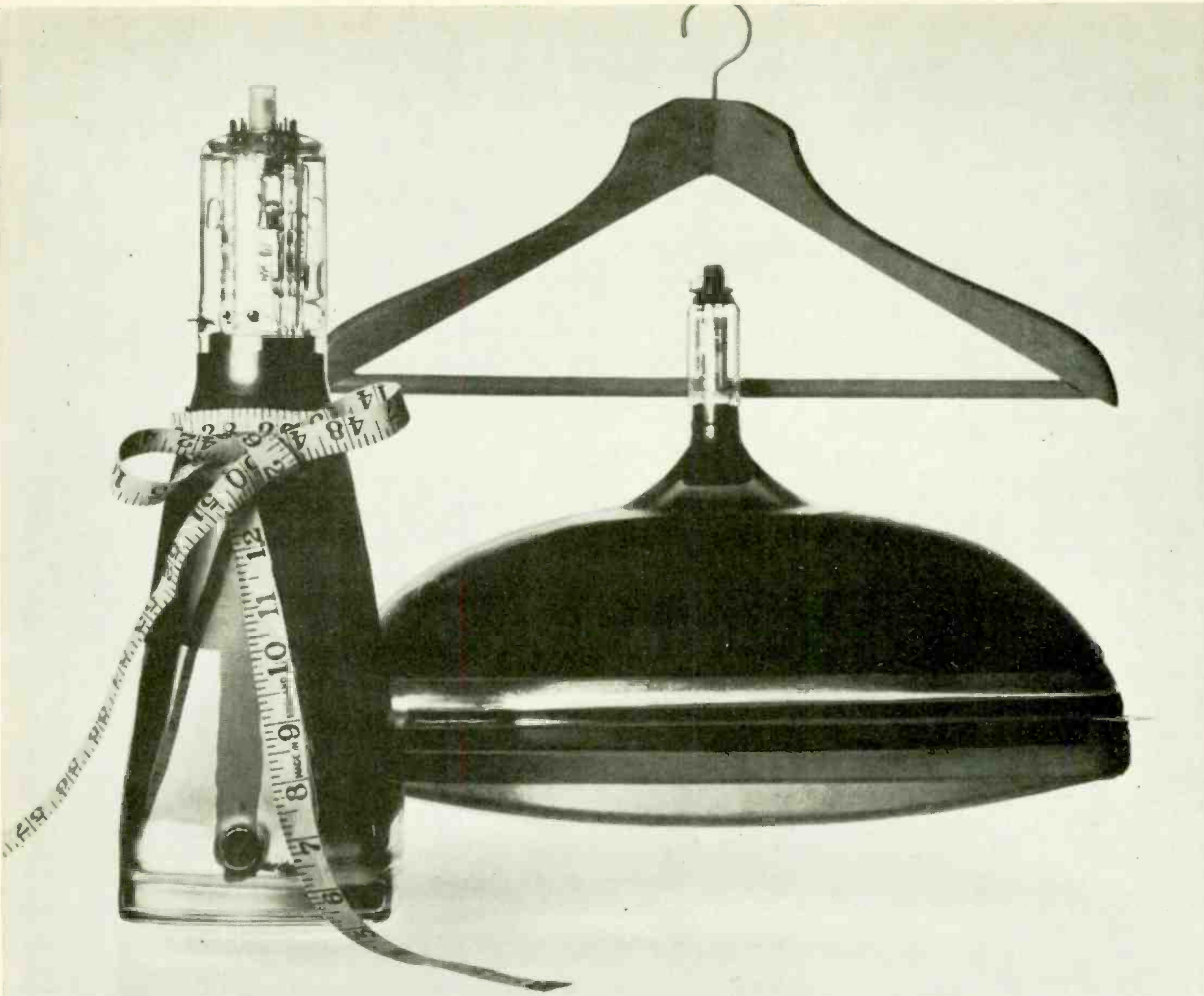

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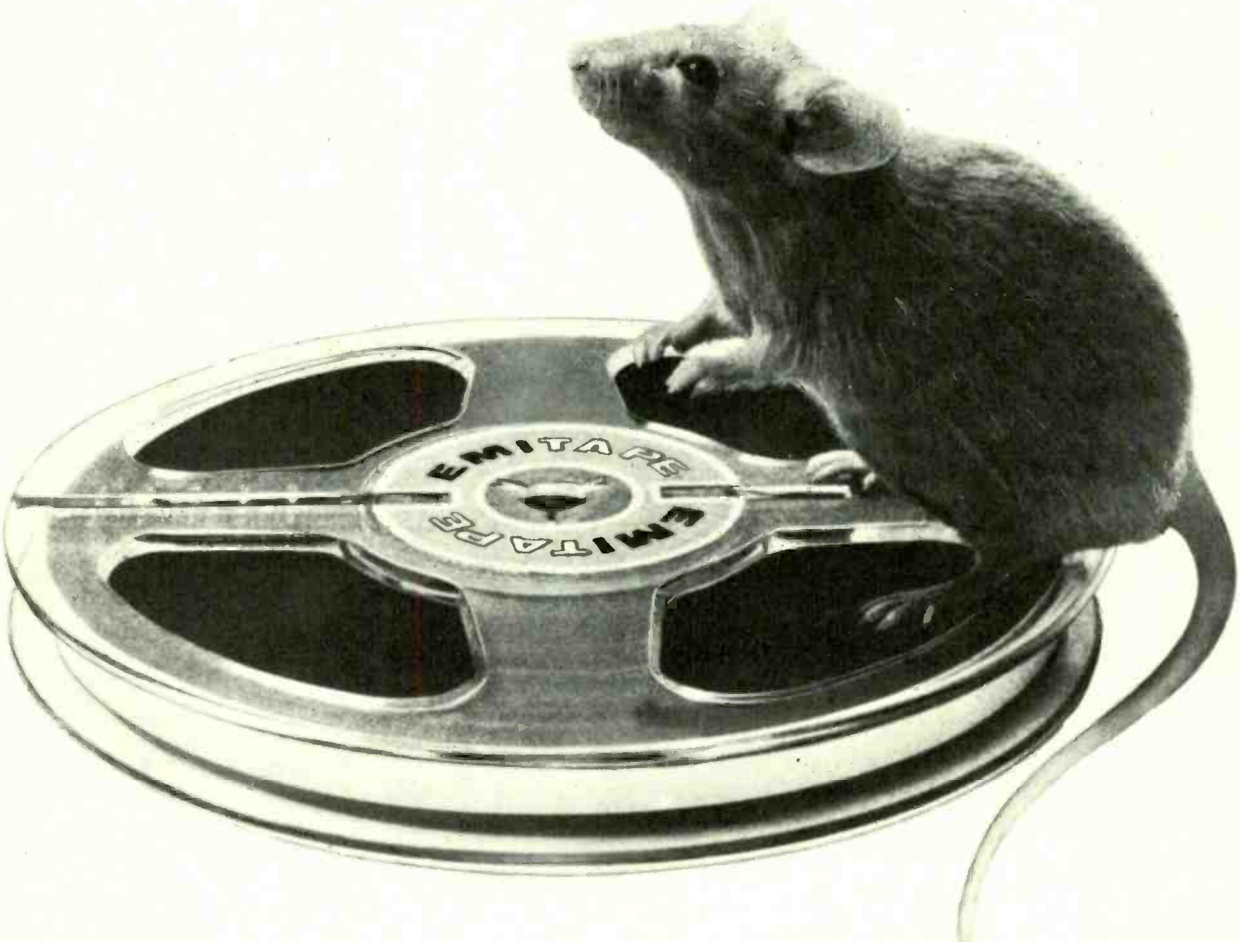
low-noise recording tape

quiet as a mouse!



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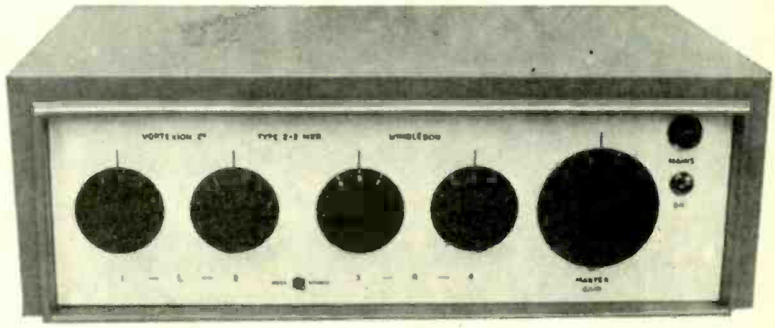
Vortexion

STEREO MIXERS

These electronic Stereo Mixers range from 2+2 to 5+5 input channels, with left and right outputs at 500 millivolts into 20K ohms up to infinity.
Separate control knobs are provided for L & R signals on each stereo channel so that a Mono/Stereo changeover switch provided can give from four to ten channels for monaural operation, in which state the L & R outputs provide identical signals.
A single knob ganged Master Volume control is fitted, plus a pilot indicator.
The units are mains powered and have the same overall dimensions as monaural mixers.



Also available Monaural Electronic Mixers:—

4 Way Monaural Mixers	3 Way Monaural Mixers with P.P.M.
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50/70 WATT ALL SILICON AMPLIFIER WITH BUILT-IN 4 WAY MIXER USING F.E.T.'s. This is a high fidelity amplifier (0.3% intermodulation distortion) using the circuit of our 100% reliable 100 Watt Amplifier (no failures to date) with its elaborate protection against short and overload, etc. To this is allied our latest development of F.E.T. Mixer amplifier, again fully protected against overload and completely free from radio breakthrough. The mixer is arranged for 3-30/60 Ω balanced line microphones, and a high impedance line or gram. input followed by bass and treble controls. Since the unit is completely free from the input rectification distortion of ordinary transistors, this unit gives that clean high quality that has tended to be lost with most solid state amplifiers.
100uV on 30/60 ohm mic. input. 100mV to 100 volts on gram/auxiliary input 100 KΩ.

CP50 AMPLIFIER. An all silicon transistor 50 watt amplifier for mains and 12 volt battery operation, charging its own battery and automatically going to battery if mains fail. Protected inputs, and overload and short circuit protected outputs for 8 ohms—15 ohms and 100 volt line. Bass and treble controls fitted. Models available with 1 gram and 2 low mic. inputs. 1 gram and 3 low mic. inputs or 4 low mic. inputs.

100 WATT ALL SILICON AMPLIFIER. A high quality amplifier with 8 ohms—15 ohms and 100 volt line output for A.C. Mains. Protection is given for short and open circuit output over driving and over temperature. Input 0.4v on 100K ohms.

200 WATT AMPLIFIER. Can deliver its full audio power at any frequency in the range of 30 c/s—20 Kc/s ± 1 db. Less than 0.2% distortion at 1 Kc/s. Can be used to drive mechanical devices for which power is over 120 watt on continuous sine wave. Input 1 m W 600 ohms. Output 100-120v or 200-240v. Additional matching transformers for other impedances are available.

30/50 WATT AMPLIFIER. With 4 mixed inputs, and bass and treble tone controls. Can deliver 50 watts of speech and music or over 30 watts on continuous sine wave. Main amplifier has a response of 30 c/s-20Kc/s ± 1db. 0.15% distortion. Outputs 4, 7.5, 15 ohms and 100 volt line. Models are available with two, three or four mixed inputs for low impedance balanced line microphones, pick-up or guitar.

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

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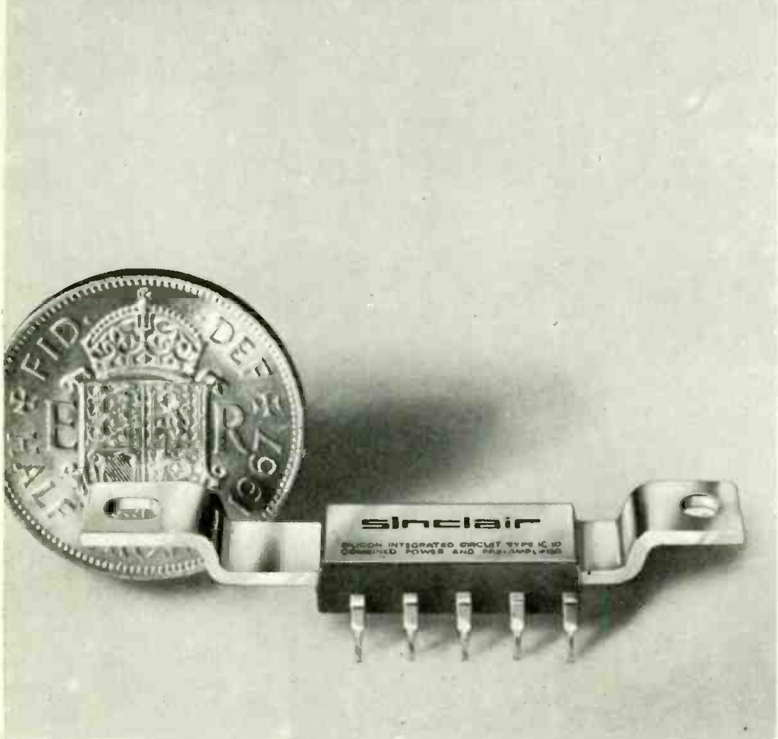
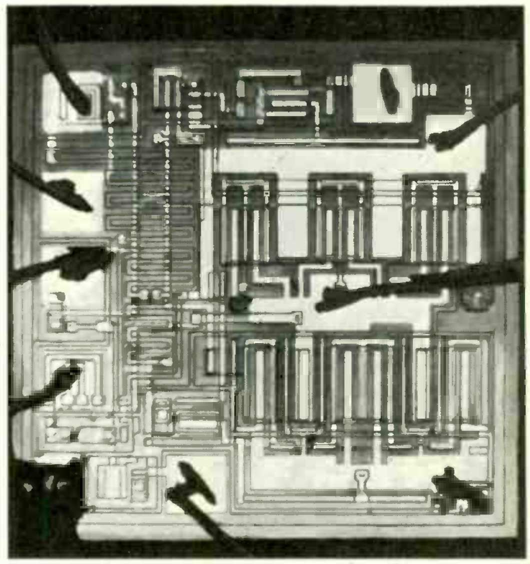
SINCLAIR IC-10



MONOLITHIC INTEGRATED CIRCUIT AMPLIFIER AND PRE-AMP



A 13 transistor circuit measuring only one twentieth of an inch square by one hundredth of an inch thick!

the world's most advanced high fidelity amplifier

The Sinclair IC-10 is the world's first monolithic integrated circuit high fidelity power amplifier and pre-amplifier. The circuit itself, a chip of silicon only a twentieth of an inch square by one hundredth of an inch thick, has 5 watts R.M.S. output (10w. peak). It contains 13 transistors (including two power types), 2 diodes, 1 zenor diode and 18 resistors, formed simultaneously in the silicon by a series of diffusions. The chip is encapsulated in a solid plastic package which holds the metal heat sink and connecting pins. This exciting device is not only more rugged and reliable than any previous amplifier, it also has considerable performance advantages. The most important are complete freedom from thermal runaway due to the close thermal coupling between the output transistors and the bias diodes and very low level of distortion.

The IC-10 is primarily intended as a full performance high fidelity power and pre-amplifier, for which application it only requires the addition of such components as tone and volume controls and a battery or mains power supply. However, it is so designed that it may be used simply in many other applications including car radios, electronic organs, servo amplifiers (it is d.c. coupled throughout), etc. Once proven, the circuits can be produced with complete uniformity which enables us to give a 5-year guarantee on each IC-10, knowing that every unit will work as perfectly as the original and do so for a lifetime.

MORE SINCLAIR DESIGNS ON PAGES FOLLOWING

■ SPECIFICATIONS

Output:	10 Watts peak, 5 Watts R.M.S. continuous
Frequency response:	5 Hz to 100 KHz ± 1dB
Total harmonic distortion:	Less than 1% at full output.
Load impedance:	3 to 15 ohms.
Power gain:	110dB (100,000,000,000 times) total.
Supply voltage:	8 to 18 volts.
Size:	1 x 0.4 x 0.2 inches.
Sensitivity:	5mV.
Input impedance:	Adjustable externally up to 2.5 M ohms.

■ CIRCUIT DESCRIPTION

The first three transistors are used in the pre-amp and the remaining 10 in the power amplifier. Class AB output is used with closely controlled quiescent current which is independent of temperature. Generous negative feedback is used round both sections and the amplifier is completely free from cross-over distortion at all supply voltages, making battery operation eminently satisfactory.

■ APPLICATIONS

Each IC-10 is sold with a very comprehensive manual giving circuit and wiring diagrams for a large number of applications in addition to high fidelity. These include stabilised power supplies, oscillators, etc. The pre-amp section can be used as an R.F. or I.F. amplifier without any additional transistors.

SINCLAIR
IC-10 *with IC-10 manual and 5-year guarantee Post free.* **59/6**

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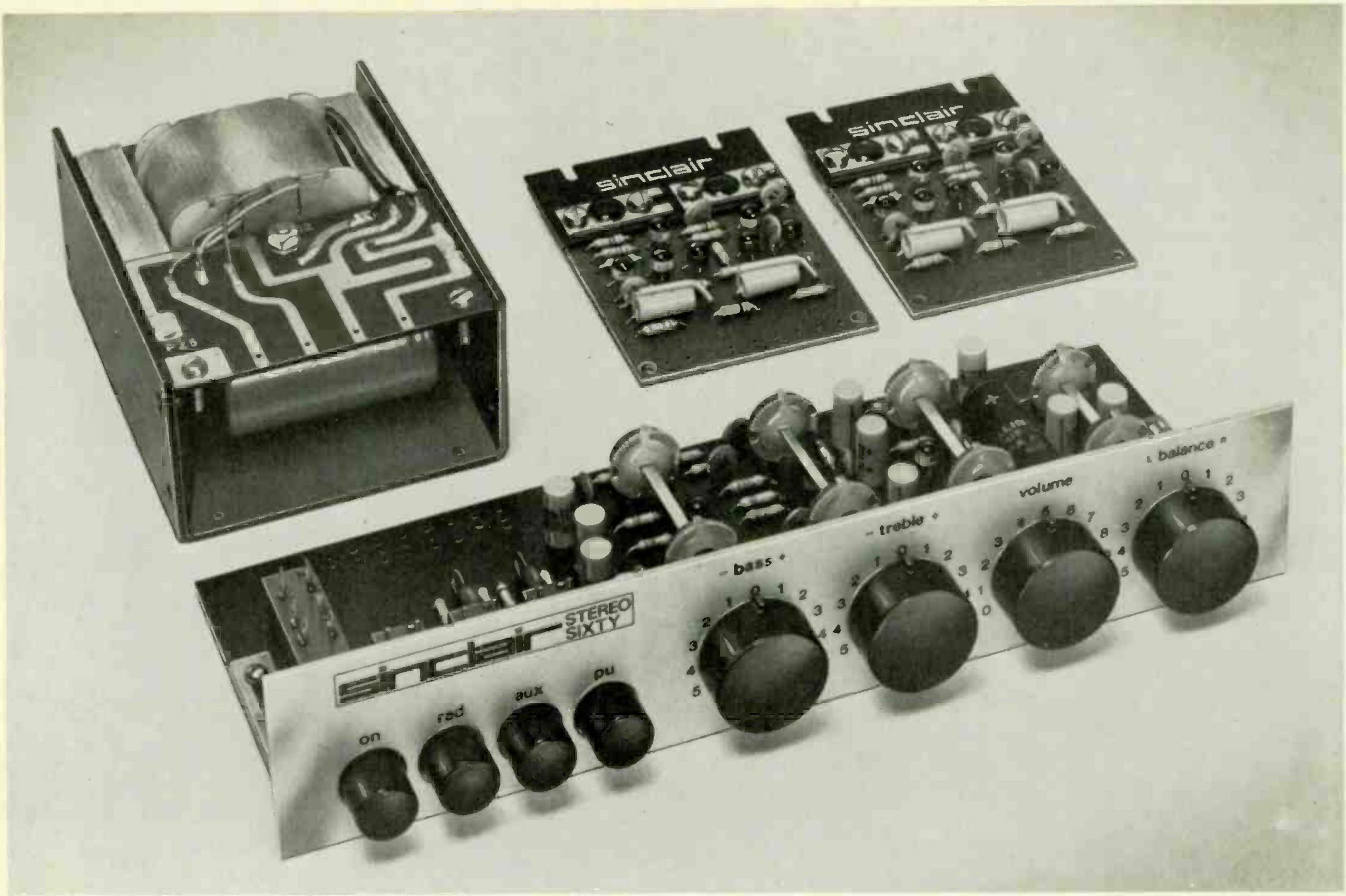
Telephone: 0223 52731



Project 60 an exciting alternative

The buyer of an amplifier today has a remarkably wide variety to choose from. It is unlikely that a purchaser would have real difficulty in finding a unit that met all his requirements, although the price might not be as low as could be wished. The only snags are that one's needs can change and that the technically correct amplifier may be physically inconvenient. If you are confident that there is an amplifier available, of the right size and price, which will meet all your needs for the forseeable future, then that is your best buy. If not, however, we can offer you another possibility which we believe to be an exciting alternative approach. That alternative is **Project 60**.

Project 60 is a range of modules which connect together simply to form a complete stereo amplifier with really excellent performance. So good, in fact, that only 2 or 3 amplifiers in the world can compare with it in overall performance.

The modules are: **1**. The Z-30 high gain power amplifier, which is an immensely flexible unit in its own right. **2**. The Stereo 60 preamplifier and control unit. **3**. The PZ.5 and PZ.6 power supplies. A complete system comprises two Z-30's, one Stereo-60 and a PZ-5 or PZ-6. The power supplies differ in that the PZ-6 is stabilised whilst the PZ-5 is not. This means that the former should be used where the highest possible continuous sine wave rating is required. In a normal domestic application there will not be a significant difference between using either power unit unless loudspeakers of very low efficiency are being used.

All you need to assemble your system is a screwdriver and a soldering iron. No technical skill or knowledge whatsoever is required and, in the unlikely event of you hitting a problem, our customer service and advice department will put the matter right promptly and willingly.

Perhaps the greatest beauty of the system is that it is not only flexible now but will remain so in the future. We shall shortly be introducing additional modules which will include a comprehensive filter unit, a stereo F.M. tuner and an even more powerful amplifier for very large systems. These and all other modules we introduce will be compatible with those shown here and may be added to your system at any time.

Project 60 modules have been carefully designed to fit into virtually every known type of plinth or cabinet and templates provided enable you to position them. Only holes have to be drilled into the wood of the plinth and any slight slips here will be covered completely by the aluminium front panel of the Stereo 60. The Project 60 manual gives all the instructions you can possibly want clearly and concisely.

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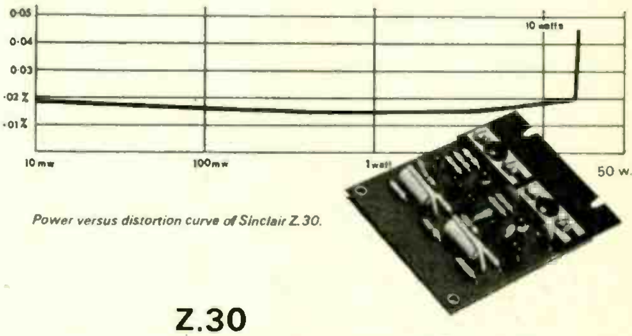
WW—073 FOR FURTHER DETAILS

Z-30 TWENTY WATT R.M.S. (40 WATT PEAK) POWER AMPLIFIER

The Z-30 is a complete power amplifier of very advanced design employing 9 silicon epitaxial planar transistors. Total harmonic distortion is incredibly low being only 0.02% at full output and all lower outputs. As far as we know, no other high fidelity amplifier made can match this specification, no matter what the price. Thus you can be utterly certain that your Project 60 system will do full justice to your other equipment however good it may be. The Z-30 is unique in that it will operate perfectly, without adjustment, from any power supply from 8 to 35 volts. It also has sufficient gain to operate directly from a crystal pickup. So in addition to its use in a high fidelity system you can use a Z-30 to advantage in your car or a battery operated gramophone for your children, for example. These, and many other applications of the Z-30, are covered in the Project 60 manual.

APPLICATIONS

High fidelity amplifier; car radio amplifier; record player fed direct from pick-up; intercom; electronic music and instruments; P.A., laboratory work, etc. Full details of these and many other applications are given in the manual supplied with your Z.30.



Power versus distortion curve of Sinclair Z.30.

SPECIFICATIONS

Power output—15 watts R.M.S. (30 watts peak) into 8 ohms using a 35 volt supply; 20 watts R.M.S. (40 watts peak) into 3 ohms using a 30 volt supply.

Output—Class AB.

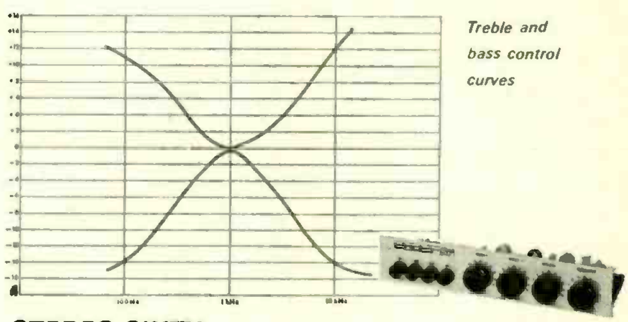
Frequency response: 30 to 300,000 Hz ± 1dB.
Signal to noise ratio: better than 70dB unweighted.
Distortion: 0.02% total harmonic distortion at full output into 8 ohms and at all lower output levels.
Size: 3½ x 2¼ x ½ inches.
Input sensitivity: 250mV into 100 Kohms.
Damping Factor: >500.
Loudspeaker impedances 3 to 15 ohms.
Power requirements: 8 to 35 V.d.c.

Z.30

Ready built, tested and guaranteed, with Z.30 manual. **89/6**

STEREO SIXTY PREAMPLIFIER AND CONTROL UNIT

The Stereo 60 is a stereo preamplifier and control unit designed for the Project 60 range but suitable for use with any high quality power amplifier. Again silicon epitaxial planar transistors are used throughout and great attention has been paid to achieving a really high signal-to-noise ratio and excellent tracking between the two channels. Input selection is by means of push buttons and accurate equalisation is provided for all the usual inputs. The tone controls are also very carefully designed and tested.



Treble and bass control curves

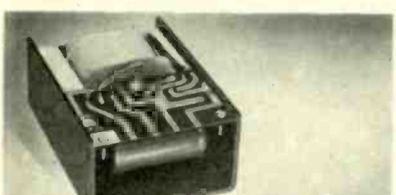
SPECIFICATIONS

- Input sensitivities—Radio—up to 3mV: Magnetic Pickup—3mV Correct within ± 1dB on R.I.A.A. curve. Ceramic Pickup—up to 3mV: Auxiliary—up to 3mV.
- Output—1 volt.
- Signal-to-noise ratio—better than 70dB.
- Channel matching—within 1dB.
- Tone Controls—TREBLE + 15 to − 15dB at 10 KHz; BASS +15 to −15dB at 100 Hz.
- Power consumption 5mA.
- Power requirement—PZ.5 or PZ.6.
- Finish—brushed aluminium front panel with black knobs.
- Mounting—on cabinet front by spindle bushes and adjustable brackets.

STEREO SIXTY

Ready built, tested and guaranteed **£9.19s.6d.**

SINCLAIR POWER SUPPLY UNITS



PZ-5 30 volts unstabilised—sufficient to drive two Z-30's and a Stereo 60 for the majority of domestic applications.

Price: £4. 19s. 6d.

PZ-6 35 volts stabilised—ideal for driving two Z-30's and a Stereo 60 when very low efficiency speakers are employed.

Price: £7. 19s. 6d.

GUARANTEE

If at any time within 3 months of purchasing Project 60 modules from us, you are dissatisfied with them, we will refund your money at once. Each module is guaranteed to work perfectly and should any defect arise in normal use we will service it at once and without any cost to you whatsoever provided that it is returned to us within 2 years of the purchase date. There will be a small charge for service thereafter.

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22 NEWMARKET ROAD, CAMBRIDGE
Telephone 0223 52731

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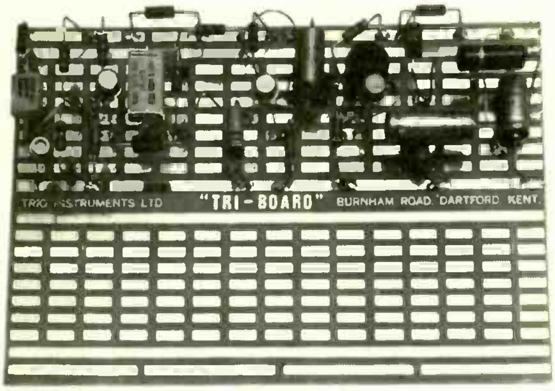
'TRI-BOARD'



The ideal "Breadboard" material for rapid construction of electronic circuits at the design and prototype stages of development programmes.

TRI-BOARD is supplied in Fibreglass which is suitable for cold punching or cutting. Board size is $7\frac{1}{2}'' \times 5\frac{3}{8}'' \times \frac{1}{16}''$ thick with 1 oz. copper
A roller tinned finish is standard.

PRICE 15/- net per board.
Quantity discounts apply:

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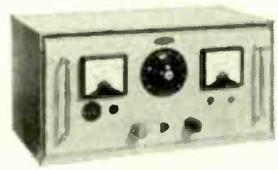
WW—077 FOR FURTHER DETAILS

SMOOTHED POWER UNITS WITH THE ACCUMULATOR PERFORMANCE.

Valradio

Type
250VRU/30/20



Versatile power units providing all the usual voltages and currents normally required for development, servicing and production testing of practically all domestic and industrial equipment, up to a loading of 600W DC or AC.

APPLICATIONS
- ★Production testing and servicing of battery operated equipment.
- ★Testing fuel pumps—DC motors—relays—windscreen wipers—car radios—and other types of battery equipment.
- ★Multiple outputs.
- ★Continuously variable DC voltage.
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FEATURES
- ★Output stabilised to accumulator performance.
- ★Very low ripple.
- ★Incorporating silicon rectifiers.
- ★All models incorporating surge current limiting.
- ★Low voltage outputs completely isolated from mains.
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Type 250VRU/30/20. Output 1, 0-30V 20A DC. Output 2, 0-60V 10A AC. Output 3, 0-250V 4A AC. Price £131-5-0. Input 200/250V 40/60 Hz. Also available for 60V, 120V, 240V outputs.

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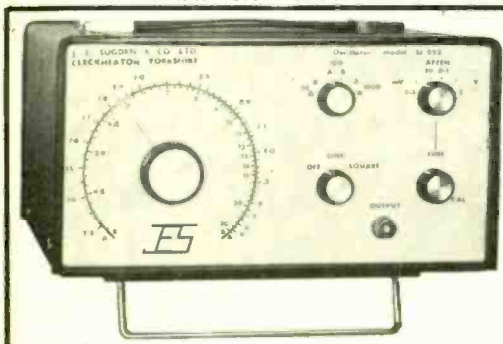
WW—078 FOR FURTHER DETAILS



JES AUDIO INSTRUMENTATION

Illustrated the Si453 Audio Oscillator

SPECIAL FEATURES:
- ★ very low distortion content—less than .05%
- ★ an output conforming to RIAA recording characteristic
- ★ battery operation for no ripple or hum loop
- ★ square wave output of fast rise time

£35.0.0

also available

Si451 Millivoltmeter
- ★ 20 ranges also with variable control permitting easy reading of **relative** frequency response

£30.0.0

Si452 Distortion Measuring Unit
- ★ low cost distortion measurement down to .01% with comprehensive facilities including L.F. cut switch, etc.

£25.0.0

J. E. SUGDEN & CO. LTD., BRADFORD ROAD, CLECKHEATON, YORKS. Tel: Cleckheaton (0WR62) 2501

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MODEL A-303TRD

SANWA MULTI TESTERS

USED THROUGHOUT THE WORLD. SANWA'S EXPERIENCE OF 30 YEARS ENSURES ACCURACY. RELIABILITY. VERSATILITY. UNSURPASSED TESTER PERFORMANCE COMES WITH EVERY SANWA.

6 Months' Guarantee. Excellent Repair Service

Model P-IB	£3 7 6		
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Cases available for all meters

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SOLE IMPORTERS IN U.K;
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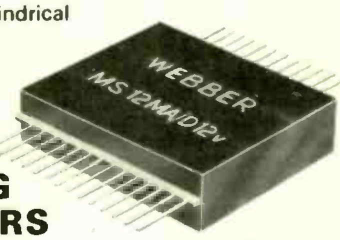
ENCAPSULATION –

low tool cost method for cylindrical coils and potting. Enquiries also for—

REED RELAYS
SOLENOIDS
COIL WINDING
TRANSFORMERS
to 8 K.V.A.



Relay module 12-way "MS" range

R. A. WEBBER LTD.
Knapps Lane, Bristol 5. 0272 657228

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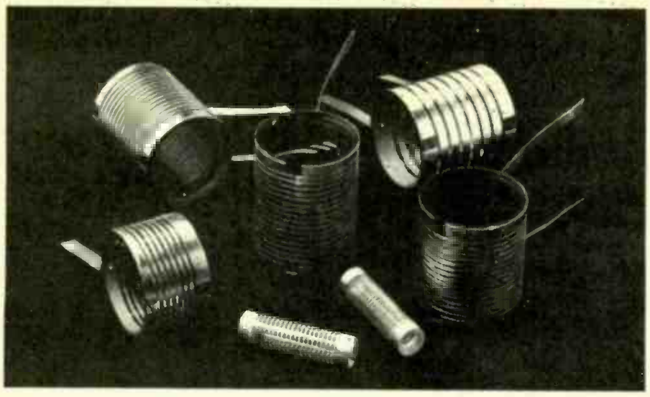

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Illustrated above are a variety of high quality examples of our work in this field.

The inductor coils are uniquely designed and feature a silver conductor fired to a low expansion glass.

The coils:—

- ★ resist shock
- ★ resist temperature cycling
- ★ have a minimum temperature coefficient
- ★ have negligible frequency drift
- ★ have low self-capacitance

If a unique, perfectly designed, characteristically perfect inductance coil is what you require why not contact our Sales Department.

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Priory Park, ULVERSTON, N. Lancs.
Tel. ULVERSTON 2621 Telex. 6541

OXLEY

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Sub-miniature DESIGN

Presenting part of a wide range of components used throughout the world by the electronics engineer in search of quality and reliability.

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W.H.M.

WOW AND FLUTTER METER (R.M.S) MODEL 111

SYDNEY HOUSE, 35 VILLIERS ROAD, WATFORD WDI-4AL

WW—084 FOR FURTHER DETAILS

TRANSFORMERS
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SPECIALISTS IN
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VACUUM IMPREGNATION TO APPROVED STANDARDS

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CONTRACTORS TO G.P.O., A.W.R.E., L.E.B., B.B.C., ETC.
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01-653 2261 CR4.8LZ EST. 1933

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better baluns...

Hatfield Baluns provide a simple and effective solution to the problem of matching unbalanced to balanced impedances of different values. Illustrated are two examples from the Hatfield range of RF Power Transformers, which includes 100W, 500W, 1kW and 3kW types, all available on short delivery. These units are weatherproof, capable of being pressurised where required and completely resistant to corrosion. A wide range of impedance ratings is also available.

The range is comprehensive and is backed by many years experience in the design and manufacture of RF Power Transformers and incorporates the newest developments for high efficiency and low inertion loss.

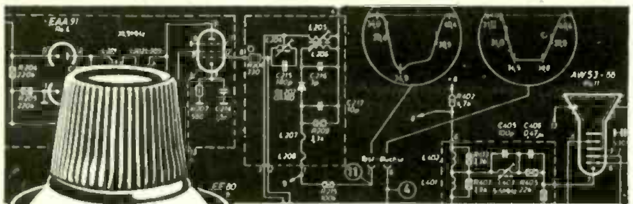
Ask for Folder B4/4 and for the latest edition of the Hatfield Short Form Catalogue.

HATFIELD BALUN

Dept. WW, **HATFIELD INSTRUMENTS LTD.**, Burrington Way, Plymouth, Devon
Telephone: Plymouth 72773/5. **Telex**: 45592 **Cables**: Sigjen Plymouth
SOUTH-EAST ASIA—for prompt service and deliveries contact
HATFIELD INSTRUMENTS (NZ) LTD., P.O. Box 561, Napier, New Zealand.

WW—086 FOR FURTHER DETAILS

FAULT LOCATION




KONTAKT "Cold Spray 75"

For rapid and effective fault location

Non-toxic, non-inflammable, Cold Spray 75 is a chemically inert coolant capable of producing temperatures of down to —42 centigrade. It can also be used to prevent heat damage during soldering processes, for the rapid freezing of small articles for biological and technical purposes and the prompt location of hairline cracks and other faults in temperature dependent components.

Other Kontakt products:
Kontakt 60 and Kontakt 61 for relay contact cleaning.
Plastic Spray 70, transparent protective lacquer.
Insulating Spray 72.
Kontakt WL. Spray Wash.
Antistatic Spray 100. Antistatic agent for plastics.
Politur 80. Polish and cleaner.
Fluid 101. Dehydrating Fluid.

Details from UK distributors.

SPECIAL PRODUCTS DISTRIBUTORS LTD.
81 Piccadilly, London, W.1 Tel: 01-629 9556

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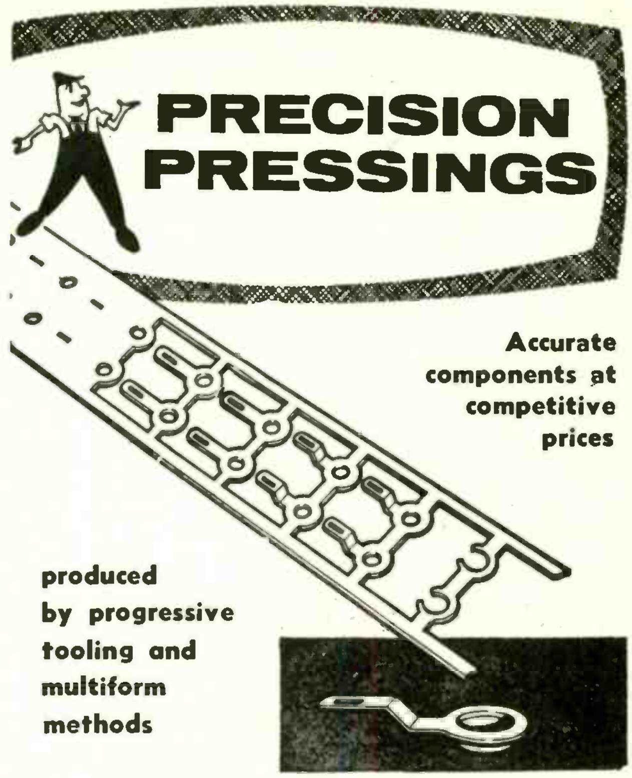

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Accurate components at competitive prices

produced by progressive tooling and multiform methods

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6mm tubular midget flange S6/8 cap over-all length 14.5 mm.

It is one of the many Vitality Instrument and Indicator Lamps that are made in an unusually large number of types, ratings and sizes. It may be just what you need for an existing or new project. If not, another from the hundreds of types and ratings detailed in the Vitality Catalogue may well be.

**Many a product owes its success to the intelligent addition of an indicator light.*

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VITALITY BULBS LTD MINIATURE AND SUB-MINIATURE LAMP SPECIALISTS
BEETONS WAY, BURY ST. EDMUNDS, SUFFOLK. TEL. BURY 2071. S.T.D. 0284 2071
A member of the General Instrument Group

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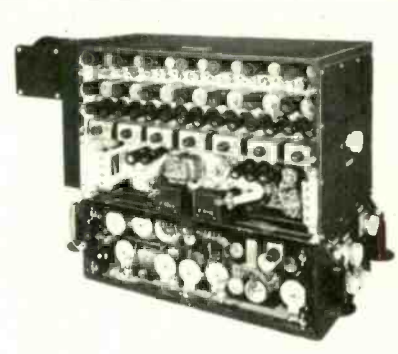
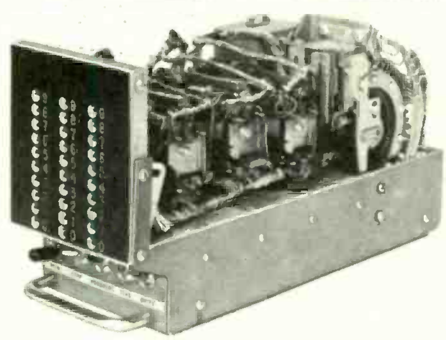


Ballistics Computers by Westinghouse. Nine servo amplifiers with associated motors. Brand new in sealed containers. £95, delivered.



Automatic Numbering Machine by Western Union. Four Uniselectors and 30 neons. Ideal amateur computer. Application leaflet. £12.10s. post free.

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COMPUTER TRAINING PRODUCTS

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CONVERTOR/BATTERY CHARGER. Input 240v 50 c/s, output 12v 5 amp DC. Input 12v DC, output 240v AC. 170 watt max. With fuse and indicator lamps. Size 9½ × 10 × 4½in. Weight 19lb. An extremely compact unit that will give many years' reliable service. Supplied with plug and lead. Only **£4/10/-**. P. & P. 15/- extra.
As above—fully serviceable—perfect interior but soiled exterior cases. £3. P. & P. 15/-.

G.M. TUBES. Brand new. G24/G38/G60 at **27/6** ea. G53/1, brass cased. **£6** ea.

PHOTOMULTIPLIERS. EMI 6097X at **£8/10/-** ea.

TRANSISTOR OSCILLATOR. Variable frequency 40 c/s to 5 kc/s. 5 volt square wave o/p. for 6 to 12v DC input. Size 1⅝ × 1⅛ × 1⅛in. Not encapsulated. Brand new. Boxed. **11/6** ea.

TIMER UNIT. Standard primary transformer giving 18V 4 amp., G.E.C. bridge rectifier in bench or wall mounting case 10 × 10 × 5in. Complete with internal one second timer sub-chassis. Checked and tested **£2/15/0.** P. & P. 15/-.

COUNTENAY TIMER sub-chassis with 2-12AU7. transistor, relay etc. Requiring 12V. A.C. or D.C. to operate 22/6.

50 Watt AUDIO AMPLIFIERS by GEC—4KT 66's 4/8/25 or high impedance inputs 15 ohm out. Standard mains in; metered output etc. No electrolytics. Absolute reliability **£20** only. Carr. 30/-.

AMPLIFIERS. Compact unit by Parmeko—rated 17 watts, capable of double. 2-KT66/2B254M; ECC81; 2-EF86; 5U4, matching to 15 ohms. High impedance or transformer input. Size 14½ × 8½ × 8½in. high. Standard mains input. Fully tested **£8/10/-**, including carriage.

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Omron/Schrack octal based plug-in relays. 2 pole c/o 5A, 6v only. Brand new. Boxed. **12/6** ea.
G.E.C. 4 pole c/o 6/12v operation 180 ohms. Platinum contacts. Brand new. Boxed **12/6** ea.
Min. VARLEY type VP4. 4 pole c/o 430 ohm or 15 K/ohm. Brand new **6/6** ea.

Min. **SIEMENS.** 4 pole c/o. 24V operation. Brand new **8/-** ea.
S.T.C. sealed 2 pole c/o 48V. 2,500 ohm 48v. **3/6** ea. 12v **7/-** ea.

CARPENTERS polarised Single pole c/o 20 and 65 ohm coil as new, complete with base **7/6** ea. Single pole c/o 680, 1,110 and 1,570 ohm coil. As new **6/6** ea.

POTENTIOMETERS

COLVERN Brand new. 5; 10; 50; 100; 250; 500 ohms; 1; 2.5; 5; 10; 25; 50k all at **2/6** ea. Special Brand new **MORGANITE** 250K 1 in. sealed. Normal price 9/-, our price **3/6** ea.

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TRIM POTS. Paignton-solder lugs 5, 10 & 25K at **7/6** ea.; Pins- 10; 20; 50; 100; 200; 250; 500 ohms: 2.5; 25 and 50K at **15/-** ea.

DARSTAN-preset-sealed ½" dia. ¼ high. 1; 2 and 5K **2/-**

HIGH RESOLUTION 25K 80 turns. Complete with knob **6/6**

COLVERN 50K Ten turn complete with dial **£1** P. & P. 2/6 ea.

GENERAL CONTROLS. 100K Ten turn. Brand new. Boxed **25/-** ea.

ALMA precision resistors 100K; 400K; and 998K—0.1% **5/6** ea; 3.25K—0.1% **4/-** ea.

DALE heat sink resistors, non-inductive 50 watt. Brand new. 15 ohms—**6/6** ea.; 8.2K—**5/-**. Excellent dummy load

CAPACITORS

ERIE feed through ceramicons 100 pf—**9d.** ea.
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SOLARTRON	711S.2 D.B. DC—9 mc/s **£60**
SOLARTRON	643 DC—15 mc/s **£80**
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COSSOR	1049; 1049 Mk. 3. DB. **£22/10** and **£30**
HARTLEY	13A DB. **£18/10/-**

All carefully checked and tested. Carriage 30/- extra.

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TF 885 Video Oscillator Sine/Square **£40** Carr. 30/-
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TF 517 VHF Generator 10 mc/s—300 mc/s **£6** Carr. £1
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HEINZ GUNTHER AM/FM Generator 9—200 mc/s. **£30** Carr. £1

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FREQUENCY Meter BC 221. **£17/10/0**; with built-in stab. P.U. **£22/10/0** Carr. 15/- With Charts.

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VIBRATING REED ELECTROMETER type N 572 by ECKO. Range 10 to the -14. Max sensitivity FSD for 1 of 0.03 Micro-microamps. **£25** ea. Carr. £1

RACAL FREQUENCY COUNTERS
SA 20 4 decades 100 kc/s **£20** ea.
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SA 28 as SA 21 with convertor extending range to 30 mc/s **£65** ea.

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GENERAL RADIO Precision Capacitor type 722. 50 pf to 290 pf. **£75** Model 222F at **£55**

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TRANSISTOR Stabilised Power Unit. 48v, 4 amp. Manufactured by E.M.I. Open chassis. Brand new. Highest quality. Size 10½ × 5½ × 6½in. high. **£6** ea.

RACAL stabilizer unit 24V. raw DC in 20 volts 1amp stab and 12V. 5 MA Zener stab out. Brand new condition. Size 5 × 3 × 6 in. Complete with circuit diagram. **35/-** ea.

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19in. Rack Mounting **CABINETS** 6ft. high 2ft. deep. Side and rear doors. Fully tapped, complete with base and wheels. **£12/10/0** Carriage at cost.

V.H.F. RECEIVER TYPE 715 by BCC. Complete, tested and working (Less crystal). 12v DC input. Ideal conversion 2 and 4 metres. In good condition. Supplied with conversion data. Only **£3/10/0** P. & P. 7/6 ea.

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SUNVIC DC chopper Amplifier type DCA 1. Superb condition. **£22/10/0** ea. Carr. 20/-

SEQUENCHAL TIMERS 8 individual timer circuits each with 0-100 sec calibrated dials. Ideal displays, processes, etc. Standard mains input **£25** Carr. 25/-

Ex- SOUTHERN ITV CAMERA with image orthicon tube and single lens. Mounted on tripod. Sold as seen. **£40**

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MODERN Transistorised 10 line automatic desk top exchange. Complete with 10 A.E.I. Telephones, standard G.P.O. type dialling to call any other line. Exchange size 16 × 5 × 6 housed in attractive mahogany case. Complete set. **£55**

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EHT ELECTROSTATIC Ernest Turner etc. 0-750V **£2** ea.; 0-3.5 KV **£2/15/0** ea.; 0-5 KV **£3/10/0** ea.; 0-7.5 KV **£4/5/0** ea.

TAYLOR 100-0-100 Micro amp scaled size 4 × 2" with internal lamp scaled 6-0-6 **1/10/0** ea.

GRIFFIN & GEORGE 3" round in sloped open ended case with terminals 3 types 0/20; 0/100 and 0/250. All 50 c/s. **£1** ea.

TRANSFORMERS. All standard inputs.
18v 6 amp and 12v ½ amp. Sep. windings, **18/6** ea.
18v 12 amps at **£3** ea.
3kV 4·5mA, 4v 0·5 amp × 2, 4v 1·1 amp. **£3/10/-** ea.
350-0-350 75mA, 5v 2 amps × 2, **21/-** ea.
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Gardners. Potter. Multi 6·3's combine to give 48v at 4 amps or 6·3 at 45A. With 350-0-350 at 50mA. **£2/10/-** ea.
Parmeko/Gardners. Potted. 475-60-0-60-475 at 160 mA; separate winding 215-0215 at 45mA; 6·3v 5A; 6·3v 0·75A; 5v 3A. As new. **£3** ea.
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Parmeko 65v 1 amp. Separate 0-18-24v at 0·5 amp. **30/-** ea.
Gard/Parm/Part. 450-400-0-400-450. 180 MA. 2 × 6.3v. **£3** ea.

E.H.T. Brand new 5kV 5MA with rectifier heater winding. Size 3 × 3 × 3½in. **27/6** ea.

ADVANCE Constant Voltage Trans. 6 volts 50 watt. As new **£3** P. & P. 10/-
Gardners 4v 30 amp. Brand new **£1/10/0** incl. postage. 3 for **£3/10/0** incl. postage.
Gardners 5v 30amp. Brand new **£2** ea. incl. postage.

CHOKES. 5H; 10H; 15H; up to 120mA. **8/6** ea. Up to 250mA **12/6** ea.
Large quantity LT. HT. EHT transformers. Your requirements, please.
Panel switches DPDT ex eq. **2/6** ea.; DPST Brand new **3/6** ea.; DPDT twice, brand new **6/-**; heavy duty DPST brand new **6/-** ea.

PRECISION continually rotarable stud switches. Single pole. 80 way, can be stacked if required. **£3** ea.

PRECISION rotary stud switches 2 pole 12W size 2" sq., ¼" shaft. **£2/10/0** ea.

Min. **SEALED** 4 pole 3 way and 3 pole 4 way rotary switches. ⅛" shaft ⅛" dia. × ⅛" **10/-** ea.

CASH WITH ORDER **OFFICIAL ORDERS WELCOMED**

FOR CALLERS. Always a large quantity of components, transformers, chokes, valves, capacitors, odd units, etc., at 'Chiltmead' prices. Callers welcome 9 a.m. to 10 p.m. any day.

CHILTMEAD LTD.

22 SUN STREET · READING · BERKS

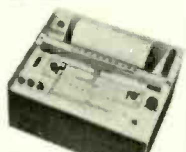
Off Cumberland Road (Cemetery Junction) **Tel. No. Reading 65916 (9 a.m. to 10 p.m.)**

ELECTRONIC BROKERS

MEASURING INSTRUMENTS AND RECORDERS

NEW
6 Pen Event Recorder, 6 in. Chart width. Available in wide range of chart speeds. Rack mounted £79/10/0. Case to suit extra.

NEW AMERICAN 5" CHART RECORDER



Good general purpose potentiometric recorder. Suitable for research and laboratory work. Range 0-10 m.v. Variable zero set, Zenor divide reference. Input impedance. Max 100 Kohms.
Price £69.10.0. P.&P. 30/-.

PORTABLE AC/DC PEN RECORDER

A most versatile pen recorder. Produces a trace on a curvilinear 3½ in. strip chart. Two speeds 1 in. and 6 in./hr. Limiting contacts to give alarm, and limits the current when it exceeds the high and/or low preset values. Range: 0 - 1MA D.C. Meter Resistance 400 ohms; 0 - 1MA A.C. Meter Resistance 1800 at 50 Hz; —10 to + 5 dB into 600 n Impedance Source. Chart speed: 1 in. and 6 in./hr. Chart width: 3½ in. curvi-linear. Power supply: 230V 50 Hz driving Synchronous Motor.
Price: £52.10.0. Postage and packing £1 5s. 0d.

STRIP-CHART INDICATING RECORDER

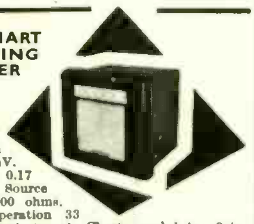
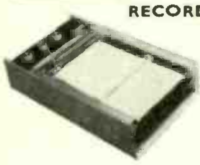


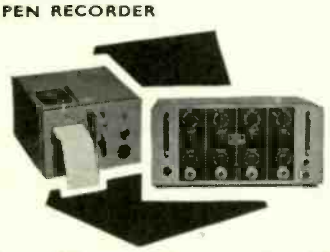
Chart width 9½ in. 10 mV. Sensitivity ± 0.17 of full scale. Source impedance 100 ohms. Speed of operation 33 sec. for full-scale travel. Chart speed ½ in., 3 in., 6 in. per hour. Single point. £49.10.0. P. & P. 30/-.

RECORDER SP 20 Series



General Purpose Single Pen potentiometric instrument for continuous recording for any input signal from 0-10mV D.C. Suitable for use with Spectrophotometer and other laboratory instruments. Chart speed 0.5 to 8.4 cm/min. Linearity ±0.25%. Fully transistorised. Chart width 200 mm. Input impedance 10K ohms max. Available S.P. 20 Plain Linear. S.P. 21 Flat Bed. S.P. 22 Linear/Log. From £135 each. P. & P. 40/-.

PEN RECORDER



Portable 1, 2 and 4 channel pen recorders by Kelvin Hughes. General purpose recorders providing clear instantaneous and permanent records of phenomena with comparatively high rates of change. The torsion-strip suspension of the moving-coil renders the instrument immune to the effects of vibration and accelleration.
Six possible chart speeds, chart width 55 mm. length 150 ft., linearity 8 v. at 3 m.A. response D.C. to 100 c/s. Single pen with amplifier £99; 2 pen recorder £85. 4 pen with amplifier £149. Also 5 pen recorder complete with amplifiers, specification as above but housed in cabinet £225. P. & P. extra.

ULTRA VIOLET RECORDER 12 Channel NEP 1050 with 6 galvanometers £280.

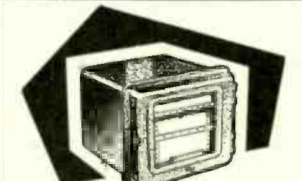
ULTRA VIOLET PHOTOGRAPHIC RECORDER 12 Channel mirror Galvanometer Honeywell 1000 with 6 galvos £280.
24 Channel Siesmic Recorder by Film & Equipments £325. Carriage extra.

E H T INSULATION TESTER

From 1 - 5 Kv A.C. and D.C. Complete with probes. New equipment. Price £52/10/0. Carr. £2/10/0.

NEW PORTABLE RECORDING AMMETER

Specification. Type: Moving Coil, D.C. Range: 0-5 amp. D.C. Chart Width: 100 mm. Scale Length: 127 mm. Chart Speeds: 20, 60, 180, 600, 1800 and 5400 mm/hr. Dimensions: 180h × 163 w × 245mm. Weight: 5.5kg. List price £65. Our price £35.



POTENTIOMETRIC 6 POINT STRIP CHART RECORDER BRAND NEW

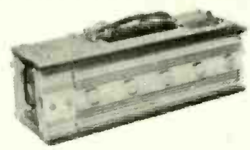
For use with thermocouplers, pyrometers and other e.m.f. sources. 6 point. Range (—100) —0—(+100) mV; 0—1,600 deg. C. 6½ in. chart width; pen speed 8 secs. Accuracy ±0.5%; 10 chart speeds 20-720mm/hr. Tropicalised. Including tools and spares. Listed at over £200. Our price £79.10.0. Also available 0-100mW F.S.D. £89.10.0.

POWER SUPPLIES

AIRMEC 698B KLYSTRON POWER SUPPLY

Rack mounted (19 in.). Mains operated. Cathode volts from 1.0 to 2.4 kv. negative. Grid Volts, 0 to 220V negative. Reflector Volts, 0 - 500V negative. Cathode Current, 0.18mA max. Heater 4V at 1.5A. Internal Modulation—Square wave 2 - 4 KHz 7V p-p. Saw Tooth 150 - 600 Hg 0 - 30V peak. Price £45. P. & P. 40/-.

★ HIGH PRECISION ★ FULLY STABILISED TRANSISTORISED LOW VOLTAGE POWER SUPPLIES



incorporating
- S.C.R. Panel for overload projection.
- OVERLOAD & CIRCUIT BREAKER WITH MANUAL RESET button.
- RIPPLE beiter, better than 3000 : 1.
- CHOKE OF CAPACITOR transistorised 120/130 volt A.C. INPUT.

Available in the following types:

6 Volt 9 Amp	£12.10.0
6 Volt 12 Amp	£17.10.0
6 Volt 16 Amp	£22.10.0
12 Volt 8 Amp	£22.10.0
12 Volt 16 Amp	£25. 0.0
12 Volt 22 Amp	£25. 0.0
20 Volt 16 Amp	£25. 0.0
24 Volt 4 Amp	£22.10.0
30 Volt 8 Amp	£18.10.0
56 Volt 7 Amp	£25. 0.0

Ex-equipment but fully tested in our laboratory. Carr. 30/-

ADVANCE TRANSISTORISED DC POWER UNITS

	Imput Volts	Output Volts	Amps	Price
DC 4	200-245±15%	12	4	£17/10/-

METERS

2 in. dia. mounting A.C. voltmeter 0-300 V. A.C. £1.15.0. Carriage 6/-.
3½ in. dia. Electrostatic Kilo Voltmeter in wooden case. £2.15.0. Carriage 10/-.
Precision A.C. & D.C. Wattmeter. Model S.67 certificated. Accuracy to ½% up to 133 c/s. Range 250/450 V. and 0.5 to 1 A. £29.10.0. Carriage 30/-.

INDICATING MEASURING AMPLIFIER PR 7410

Suitable for vibration and frequency analysis. Frequency response 10-1,000 Hz. £45. Carr. 40/-.

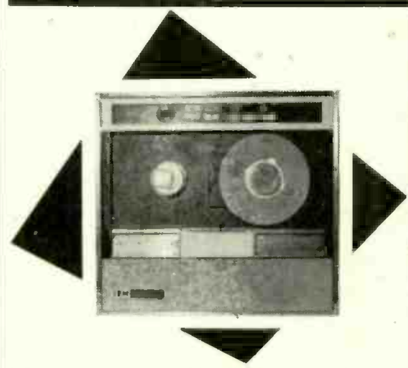
BRAND NEW S.E. LABORATORIES TRANSDUCER

complete with encapsulated Amplifier/demodulator S.E. 441/2
Frequency D.C.—60 c.p.s.
Available in the following ranges:
SE150, SE50 or SE165A.

0 - 50 p.s.i.	0 - 500 p.s.i.	0 - 3000 p.s.i.
0 - 200 p.s.i.	0 - 750 p.s.i.	0 - 4000 p.s.i.
0- 350 p.s.i.	0 - 2000 p.s.i	

Also available differential types ± 10 p.s.i.
Also available differential types, + 10 p.s.i.
List price £70+. Our price £15

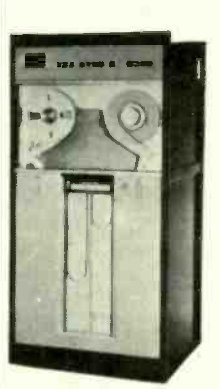
COMPUTER AND PERIPHERAL EQUIPMENT



7 TRACK DIGITAL MAGNETIC TAPE STORAGE DECK

These machines originally ex-computer, are multi-track recording units, ideal for data storage. Record and Replay heads encased in one common unit. Low resistance heads. Frequency response approximately 30 Kc/s. to 50 Kc/s. Bit density 557 b.p.i. ½ in., 10½ in. spools 230 V. to 380 V. A.C. Capstan Motor speed 1,500 r.p.m. 48 V. D.C. Rewind motors complete with vacuum Assembly. Finished in brush aluminium and matt-black. Size 27 in. × 26 in. × 8 in. Weight 90 lb. Price £72.10.0. Carriage extra.

MODEL 72 MAGNETIC TAPE DATA STORAGE UNIT



This unit consists of ½ in. 8 channel read-write heads. Can be used to record any 6 bit code. Data can be read in either a forward or backward direction plus giving search facilities. The unit consists circuits for receiving and storing instruction signals. Recording density 250 characters per inch. Tape speed 100 in. per second, price £190. Excellent condition.

½" 7 TRACK

Ex-computer record/replay head complete with guides. Little used. Price £12.10.0 Carriage 15/-.

BRAND NEW

Gresham Lion 1 in. 1 + 7 track record/replay heads. Of the highest professional quality. Cost £100 plus price £12.10.0. Carr. 15/-.

9 TRACK 1 in. Record/replay heads with sprocket drive, driven by synchronous motor. Mounted with integrated head assembly eliminating alignment problems. This can be fitted to any suitable type of transport system. Price £8.10.0. Carriage 15/-.

PROGRAMME BOARDS BY SEALECTRO

These boards are basically a multi pole multi throw switch device consisting of a X-Y Matrix with two contact decks in the Z Plane running at 90 degrees to each other. Contact is made by either, shorting or plugging in pins. Ideal for prototype work, etc. Boards available in 24 × 60 2 plane £12.10.0. Pins available 1/3 each.

MEMORY PLANES

Ferrite core memory planes with wired Ferrite cores. Used for building your own computer or as an interesting exhibit in the demonstration of a computer. Mounted on plastic material, frame 5 × 8 in. Consisting of matrices 40 × 25 × 4 cores each one individually addressable and divided into 2 halves with independent sense and inhibit wires. £8.10.0. P. & P. 3/-.

MULLARD MATRIX CORE STORE STACKS

A.W. 510 5 planes 8×16 cores/per plane £12/10
A.W. 511 5 planes 18×32 cores/per plane £25
A.W. 534 20 planes 64×64 cores/per plane £89/10
A.W. 597 8 planes 32×32 cores/per plane £55
Single plane 40×25×4 £8/10
Flexi-writer 7 hole punch and keyboard £199/10

MEMORY STORE

M. M. 1044 complete with logic circuits mounted in Imhof cabinet £400

COMPUTERS

Burroughs E 201 225 words store. £450

COMPUTER. 802B Hybrid computer with 1K store, in full working order. Complete with paper tape punches, and compatible for Holerith 80-Hole card-periphery. Numerous programmes available including test programmes. Full supporting literature. PRICE ON APPLICATION

SYNCHRONOUS MOTORS

Model 87 1 r.p.h. and 1/60 r.p.h. Self starting complete with gearing shaft ½" dia. ½" long. 200/250 V 50 Hz. New Condition Ex. Equipment. 30/-. P. & P. 3/-.

BRAND NEW COMPUTER TAPES AND EMPTY SPOOLS

Made by well known manufacturers

½ in. certified 2,400 ft. 800 b.p.i.	£8.10.0
½ in. 2,400 ft.	£6.10.0
½ in. Highest grade 2,400 ft.	£3. 0.0
½ in. 10½ in. dia. spool and cassette	£1.10.0
½ in. 8½ in. dia. spool and cassette	£1.10.0
1 in. metal 10½ in. dia. spool and cassette	£2.10.0
½ in. N.A.B. centres 10½ in. spool only	£1. 0.0

TAPE PUNCH MODEL 25 7 HOLE

A multiwire tape punch designed for general application involving the conversion of parallel wire electrical impulses into punched papertape at 33 characters per second. Unit completely self-contained requiring only motor power and signal supplies. Price £45.

7 HOLE NON PARITY TAPE PUNCH

New condition £45.

LOW SPEED 7 HOLE TAPE PUNCH

60 characters per second by well-known manufacturer. Price £45.

TELETYPE 8 HOLE PAPER PUNCH MU27 PRICE £75.

Also available 5 hole punch BRPE2 as above. This model has interchangeable heads. Complete with spooler. Price £35.

HIGH SPEED 5/7 HOLE OPTICAL READER

20 characters per second. £19.10.

CARD READERS

80 column 1500/80 model, punch
80 column 1400/80 model verifier. } £325
Excellent condition.

HOLLERITH 80 COLUMN CARD PUNCH TYPE HO29 & VERIFIER H129 £225.

DECODER 4 DIGIT READOUT

Can be used in constructing frequency counter or Digital Voltmeter. Consists of 4 transistorised cards each containing 10 NOR gates £19.10.0. Circuits supplied with Decoder. 5 Digit £25. P. & P. 15/-.

TRANSFER CASE

For sending data by personal carrier, GPO post, passenger train, etc. ideal. Suitable for despatching tape 20/-. P. & P. 5/-.

EICHNER 8 Hole Punch £49/10/0.

EICHNER 8 Hole Reader £29/10/0.

CANCELLED EXPORT ORDER

90 Column card sorter and punch type 425/0 price on application.

SPOOLERS 1" and ½"

Both hand and motor drives available at £3.0.0 and £5.0.0 respectively.

BRAND NEW TAPE SPOOLER

Suitable for 1 in., ½ in. and ½ in. tapes. Fully self-contained £99.10.0.

5" TAPE PUNCH

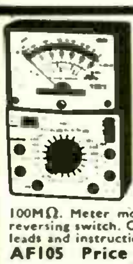
Suitable for machine control complete with 50 reels of tape £35.

HR QUALITY COMPONENTS AND EQUIPMENT

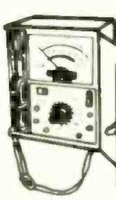
NEW RANGES FOR THE AMATEUR AND PROFESSIONAL USER

* QUALITY PANEL METERS

38 Series. Face size 42 x 42mm (1⅝in x 1⅝in). 50µA, 37/6; 100µA, 35/–; 200µA, 32/6; 500µA, 27/6; 1mA, 5mA, 10mA, 50mA, 100mA, 500mA, 25/– each; 10V, 20V, 50V, 100V, 300V and 500V, 25/– each; 1A and 5A, 25/– each. "S" meter, 1mA, 29/6. VU meter, 37/6.
65 Series. Face size 86 x 78mm (3⅜ x 3⅛in). 50µA, 62/6; 100µA, 52/6; 200µA, 47/6; 500µA, 45/–; 1mA, 5mA, 10mA, 500mA, 37/6 each. "S" meter, 1mA, 42/6.
Other ranges and sizes available. List on request with full details.

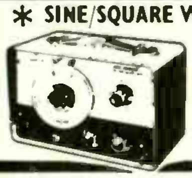


* 50,000 OHMS PER VOLT MULTIMETER



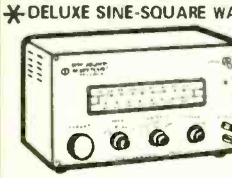
Recommended quality instrument with mirror scale and overload protection. 0/0·3/3/12/60/120/300/600/1200V d.c. (50Kµ/V); 0/6/30/120/300/600/1200V a.c. (10Kµ/V); 0/30µA/6/60/300mA, 0/12A; resistance 0/10kΩ/1/10/100MΩ. Meter movement 20µA, Polarity reversing switch. Complete with batteries, leads and instructions.
AF105 Price £8.10.0 p.p. 2/6
Leather case 28/6

* SINE/SQUARE WAVE AUDIO GENERATOR



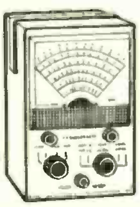
Provides audio output on 4 bands. Sine wave 20c/s to 200kc/s, output up to 7V; square wave 60c/s to 30kc/s, 7V p-p. Distortion under 2%. Output impedance 1kΩ. Variable output amplitude control. Supplied with leads and instructions. A.C. mains operated.
TE22 Price £16.10.0.

* DELUXE SINE-SQUARE WAVE RC AUDIO GENERATOR



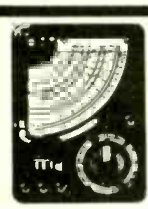
Weinbridge RC Audio oscillator featuring four overlapping scales covering 18c/s to 200 Kc/s. Output waveforms are sine, square and complex. Mirrored scale with smooth geared tuning control. Output 5 volts RMS or 10 volts P-P. Sinewave response ± ½dB. Distortion under 1% at 1Kc/s. Stability ± 1%. Accuracy ± 2%. O/P impedance under 3Kohms. Variable Attenuator. Mains operated. With Handbook.
ORC 27A Price £28 10 0 pp.10/-

* VACUUM TUBE VOLTMETER



Features low price for such an instrument. Large 6in full view scaled meter. 28 ranges. D.C. volts: 0/1½/5/15/50/150/500/1500. A.C. volts: 0/1½/5/15/50/150/500/1500 r.m.s.: 0/1·4/4/14/40/140/400/1400/4000 p-p. Resistance: R x 10–100–1k–10k–100k–1m–10m. Range 0·2 ohm to 1000MΩ. dB scales: —10 to +65dB. Complete with instructions and leads.
MODEL TE65
£17.10.0 p.p. 7/6
HV Probe 50/–
R.F. Probe 42/6

* 20,000 OHMS PER VOLT MULTIMETER

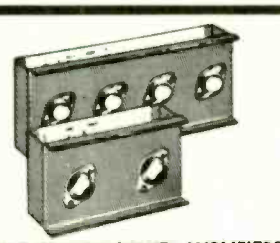


Popular model but with extra scale range. 20,000 ohms per volt. 0/5/25/50/250/500/2500V d.c., 0/10/50/100/500/1000V a.c., 0/50µA, 0/2½/250mA. Resistance 0–6kΩ and 6MΩ. Also dB scales or capacitance.

Model 200H 77/6 pp.2/-
(Leather case, Price 15/-

* PORTABLE OSCILLOSCOPE

Features 3in clear view tube, easy to use controls and good stability. Y amp. Sensitivity. ·1V p-p/CM. Bandwidth 1·5 cps—1·5 MHz. Input Imp. 2 meg Ω. 25 PF. X amp sensitivity. ·9V p-p/CM. Bandwidth 1·5 cps—800 KHz. Input imp. 2 meg Ω. 20 PF. Time base. 5 ranges 10 cps—300 KHz. Synchronization. Internal / external. Illuminated scale. 140 x 215 x 330 MM. Weight 15½lbs. 220/240V. A.C. Supplied brand new with handbook.
TO3 Price £35 p.p. 10/–

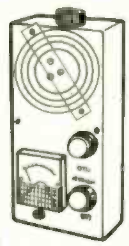


* TRANSISTOR POWER AMPLIFIERS

12 watt 3 ohm 100mV Input 24 volt supply. Model MPA 12/3 £4.10 p.p. 3/–
12 watt 12–16 ohm 100mV Input 40 volts supply. Model MPA 12/15 £5.5 p.p. 13/–
25 watt 8–16 ohm 180mV Input 50/60 volt supply. Model MPA 25 £7.10 p.p. 4/6
Power Supplies 24–40 volt 90/ p.p. 3/6
50–60 volt 97/6 p.p. 4/6
Model PA7. 7 watt Amplifier 3 ohms O/P. 7mV Input, operates 12–18 volts D.C. Price 72/6 p.p. 2/6

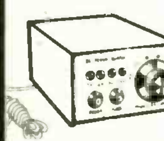
* 100 WATT AMPLIFIER—details on request.

* GRID DIP METER

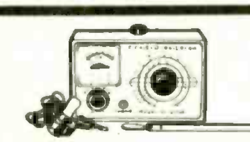


All transistor grid dip meter, absorption wavemeter and osc. detector. Frequency range 440kc/s to 280Mc/s in 6 coils. Uses 3 transistors plus diode with 500µA meter. Internal battery.
TE15
Price .. £11.10.0
pp.3/6

* DC STABILISED POWER SUPPLY



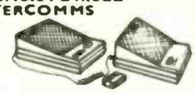
Switched DC Stabilised Outputs UP TO 1AMP. 3-6-9 & 12 VOLTS. Indicator lamp for each voltage. Fully fused mains operated. Negligible ripple. Regulation 1%.
SE101A Price £8 15 0



* FIELD STRENGTH METER

5 Ranges 1 – 250 mc/s. Fitted 200µA meter. Earphone output. Calibrated tuning scales.
FL30HA Price 72/6 pp.2/-
Also non-calibrated type peaking F/S meter.. FSI Price 45/- pp.2/6

★ TRANSISTORISED INTERCOMMS



2-station, £3.10.0; 3-station, £5.15.0; 4-station, £6.12.6 (2-station uses no wires) mains operated, £11.19.6. Telephone amplifier, 59/6.

* SIGNAL INJECTOR

New model for checking all audio and RF up to VHF. Simple to use. Battery operated. Output approx. 1kc/s. 1·4V pp. Harmonics up to VHF.
SE250B Price 35/– p.p. 1/6

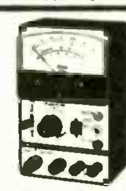
*MATCHING SIGNAL TRACER
SE 500 Price 27/6 p.p. 1/6

Suppliers of quality components and equipment for over 25 years

AUDIO – HIGH FIDELITY
Complete range in stock to suit all HI-FI and Public Address requirements.

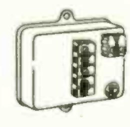
COMPONENTS
UK's largest supplier of components.
EVERYTHING YOU NEED

SEE CATALOGUE ON FACING PAGE



*TRANSISTOR CHECKER

Complete capacity for checking all transistors npn and pnp for alpha, beta and German. Also diodes complete with leads and instructions, ZQM-2, Price £5.19.6, p.p. 3/6.



EXPERIMENTER'S MODULE

Terrific offer of brand new STC time delay electronic units. Adjustable 3–15 secs. 9–12V operated. Supplied complete with suggested uses circuits. STC Module Price 35/–.

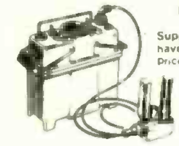
9 & 12V 100mA STABILISED SUPPLY

Size 3" x 2" x 1⅛". Fused ready to use. U.K. made Transistorised.
9V 45/- pp.2/6
12V 47/6 pp.2/6

Transistors

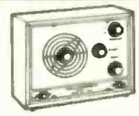
Huge quantities in stock for Industrial users—Write for Industrial Price List. Includes all Types of Semiconductor Device.

PORTABLE GEIGER COUNTERS



FOR MEASUREMENT OF RADIO-ACTIVITY.
Supplied complete with instructions haversack, cables and probe. List price £70 **OUR PRICE. NEW. TESTED COMPLETE WITH BATTERIES**
£7.10.0
POST 10/-
SPARE BATTERIES 15/- PAIR. POST 5/-

DOSIMETER POCKET-TYPE 0-50r 12/6



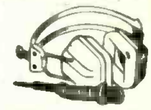
NOMBREX

TRANSISTORISED Test Equipment

MODEL		£	s.	d.	Leaflet No.
29s	RF. Gen.	21	0	0	35
29x	Xtal RF Gen.	29	10	0	35
30	Audio Generator	19	10	0	24
31	R.F. Generator	12	10	0	25
32	C.R. Bridge	10	10	0	26
33	Inductance Bridge	20	0	0	29

(PRICE: £ s. d.)

STEREO HEADPHONES



Featuring soft Padded Headsets, wide frequency response. Adjustable Headbands. Fitted Jack plugs.

DHO 2/5 Recommended 25C/S-15KC/S .. £2.19.6
SE28 Built in Tweeters and Volume Controls £9.19.6
KOSS. KO727 £16.10.0. PRO-4A .. £23. 0.0
SP-3KC £11.15.0

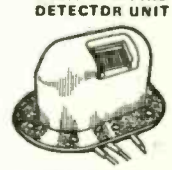
CALL FOR DEMONSTRATION

Mono Switched 8/16 ohms and 4K ohms Price £4.4.0

Stereo Headphone Amplifiers
Inputs for PU/Tuner, Battery Model Mains Operated
High Quality
Eagle HA10 .. .. £8.19.6
Shure SA2/E £18.18.0

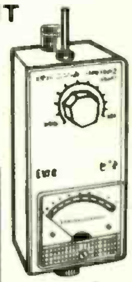
GRAVINER FIRE DETECTOR UNIT

The Detector Unit consists essentially of a highly sensitive 931A photo-electric cell combined with a firing circuit. Incorporates a single cold cathode electronic relay, capacitors and resistors designed to fail to safety if external wiring is open or short circuited. Encapsulated in a resin which fully insulates the unit electrically and provides a high degree of mechanical and thermal shockproofing. Original price £74. OUR PRICE. BRAND NEW £6 each, with data sheet



SIZE 4 x 3 x 2½ in.
Limited quantity available.

* SWR ALIGNMENT METER

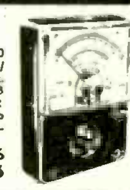


Ideal for all transmitter alignment. Built-in field strength meter 100µA. Complete. Ready to use. SWR 1:1 to 1:3.
SWR 3 .. Price 69/6
p.p. 2/6

WELLER SOLDERING IRONS

8200 Gun & Iron 59/6
8200D PK Gun Kit .. 79/6
ANTEX CN Iron 29/6
ANTEX Iron Kit 42/6

* MULTIMETER



Return of a popular model. 2000 ohms/V. 0/10/50/500/1000V a.c./d.c., 0/50µA. 0/10/250µA d.c. 0/10/100kΩ/1MΩ resistance. dB and capacitance scales. Size 5in. x 3½in x 1⅛in. Robust and easy to use. Complete with leads, batteries and instructions.
THL 33A 82/6 p.p. 2/6
Leather case Price 22/6

* ALL ITEMS OFFERED ARE BRAND NEW STOCK – ALWAYS IN STOCK *

HENRY'S RADIO LTD.
303 & 309 Edgware Rd, London W2

'303' Components/Equipment/Organ Parts also MAIL ORDER DEPT. 01-723-1008/9
'309' Test Gear/High Fidelity etc. 01-723 6963

ALL MAIL ORDERS TO '303'

SHOP HOURS 9 a.m.—6 p.m.. THURSDAY 1 p.m. OPEN ALL DAY SATURDAY.

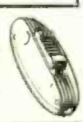
2¼kW FAN HEATER

Three position switching to suit changes in the weather. Switch up for full heater (2¼kW), switch down for half heat (1¼kW), switch central blows cold for summer cooling—adjustable thermostat acts as auto control and safety cut-out. Complete kit **£3.15.0**. Post and ins. 7/6. Made-up model **£4.5.0**. Post and ins. 7/6.

FLUORESCENT CONTROL KITS

Each kit comprises seven items—Choke, 2 tube ends, starter, starter holder and 2 tube clips, with wiring instructions. Suitable for normal fluorescent tubes or the new "Grolux" tubes for fish tanks and indoor plants. Chokes are super-silent, mostly resin filled. Kit A—15-20 w. **19/6**. Kit B—30-40 w. **19/6**. Kit C—80 w. **23/6**. Kit E—65 w. **19/6**. Kit MF1 is for 6in., 9in. and 12in. miniature tubes. **19/6**. Postage on Kits A and B 4/6 for one or two kits then 4/6 for each two kits ordered. Kits C, D and E 4/6 on first kit then 3/6 for each kit ordered. Kit MF1 3/6 on first kit then 3/6 on each two kits ordered.

BLANKET SWITCH



Double pole with neon let into side so luminous in dark, ideal for dark room light or for use with waterproof element—new plastic case. **5/6** each. 3 heat model **7/6**.

BLANKET SIMMERSTAT

Although looking like, and fitted as, an ordinary blanket switch, this is in fact a device for switching the blanket on for varying time periods, thus giving a complete control from off to full heat. Also suitable for controlling the temperature of any other appliances using up to 1 amp. Listed at **27/6** each, we offer these while our stocks last at only **12/6** each.

REED SWITCHES

Glass encased, switches operated by external magnet—gold welded contacts. We can now offer 3 types:
Miniature. 1in. long × approximately ⅛in. diameter. Will make and break up to ½A up to 300 volts. Price **2/6** each. **24/-** dozen.
Standard. 2in long × 3/16in. diameter. This will break currents of up to 1A, voltages up to 250 volts. Price **2/-** each. **18/-** per dozen.
Flat. Flat type, 2in. long, just over 1/16in. thick, approximately ¼in. wide. The Standard Type flattened out, so that it can be fitted into a smaller space or a larger quantity may be packed into a square solenoid. Rating 1 amp 200 volts. Price **6/-** each. **£3** per dozen.
Small ceramic magnets to operate these reed switches **1/3** each. **12/-** dozen.

HIGH CAPACITY ELECTROLYTICS

Brand new, not ex-equipment.
100 mfd. 25v., **1/3** each **12/-** doz.
200 mfd. 25v., **1/6** each **15/-** doz.
500 mfd. 12v., **2/-** each **£1.1.0** doz.
1000 mfd. 12v., **3/-** each **£1.10.0** doz.
5000 mfd. 12v., **4/9** each **£2.8.0** doz.
10,000 mfd. 6v., **5/9** each **£3.0.0** doz.
10,000 mfd. 15v., **8/6** each **£4.10.0** doz.
15,000 mfd. 10v., **10/6** each **£5.0.0** doz.
60,000 mfd. 8v., **22/-** each **£10.0.0** doz.
70,000 mfd. 13v., **40/-** each **£20.0.0** doz.

TELESCOPIC AERIAL

For portable, car radio or transmitter. Chrome-plated—six sections extends from 7¼ to 47in. Hole in bottom for 6BA screw. **7/6**.

TOGGLE SWITCH

3 amp 250v. with fixing ring. **1/6** each **15/-** doz.

80 OHM BALANCED ARMATURE EAR PIECE

Usable as microphone or loudspeaker. **4/6** each.

MINIATURE EAR PIECE

As used with imported pocket radios. **1/6** each **15/-** doz.

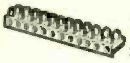
ISOLATION SWITCH

20 Amp D.P. 250 Volts. Ideal to control Water Heater or any other appliance. Neon indicator shows when current is on. **4/6** **48/-** per dozen.

FLEX BARGAINS

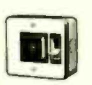
Screened 3 Core Flex. Each core 14/0076 Copper PVC insulated and coloured, the 3 cores laid together and metal braided overall. Price **£3.15.0** per 100 yds. coil
15A 3 Core Non-kink Flex. 70/0076 insulated coloured cores, protected by tough rubber sheath, then black cotton braided with white tracer. A normal domestic flex as fitted to 3kW fires. Regular price 3/6 per yd. 50 yd. coil **£4**, or cut to your length 2/- per yard.
10A 3 Core Non-kink Flex. As above but cores are 28/0076 Copper. Normal price 2/6 per yd. 100 yd. coil **£7.10.0**, or cut to your length **1/9** yd.
6A 2 Core Flex. As above, but 2 cores each 23/0076 as used for Vacuum Cleaners, Electric Blankets, etc. **39/6** 100 yd. coil.

15/20 AMP CONNECTORS



Polythene insulated 12-way strip. **2/6** each **24/-** doz.

13 AMP FUSED SWITCH

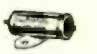


Made by G.E.C. For connecting water heater etc., into 13 amp ring main. Flush type **3/6** each **30/-** doz. Metal boxes for surface mounting **1/6** each **15/-** doz.

MICRO SWITCH

5 amp. changeover contacts. **1/9** each **18/-** doz.

SUPPRESSOR CONDENSER TCC



.1 mfd. 250v. A.C. working metal cased with fixing lug. **1/9** each **18/-** doz.

HEAT & LIGHT LAMP

275W. internally mirrored bulb, with b.c. end for plugging into lamp holder. **19/6** each plus 4/6 post and insurance.

TUBULAR TYPE BY PHILLIPS

500W. **29/6** plus 4/6 post and insurance.

750 MICRO AMP MOVING COIL METER

2¼in. flush mounting, ex-W.D. **15/-** each plus 3/6 post and insurance for any quantity.

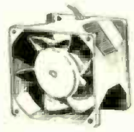
DIGITAL CLOCK

An imposing instrument ideal for modern reception centre or for Managing Director's office—definitely a showpiece to create interest and efficiency—mains frequency controlled so always keeps right time without adjustment—in black semi-matt perspex case—made up, tested and guaranteed—offered for only the cost of components **£29.10.0**, post and insurance 10/-.

SOLDER GUN

A must for every busy man, gives almost instant heat: also illuminates job. 100 watt 220/240v. **39/6** (saves you over 30/-), post and ins. 4/6. BIG JOB 250 watt model **99/6** (saves you over £3.10), post and ins. 6/6.

MINIATURE EXTRACTOR FAN



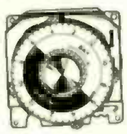
Beautifully made by famous German Company, PAPST System, 230/240 A.C. Mains operated, size 3½in. × 3½in. × 2in. Made for instrument cooling but ideal to incorporate in a cooker hood, etc. **65/-** P. & p. 2/9.

HORSTMANN 'TIME & SET' SWITCH

(A 30 Amp Switch). Just the thing if you want to come home to a warm house without it costing you a fortune. You can delay the switch on time of your electric fires, etc., up to 14 hours from setting time or you can use the switch to give a boost on period of up to 3 hours. Equally suitable to control processing. Regular price probably around £5. Special snip price **29/6**. Post and ins. **4/6**.

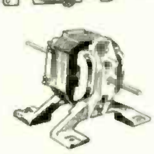
DISTRIBUTION PANELS

Just what you need for work bench or lab. 4 × 13 amp sockets in metal box to take standard 13 amp fused plugs. Supplied complete with 6 feet of heavy cable and 13 amp plug. Similar panels advertised at £5. Our price: Kit of parts **39/6**, plus 3/6 post and insurance. Made up **45/-** plus 4/6 P. & I.



24 HOUR TIME SWITCH

Mains operated. Adjustable Contacts give on/off per 24 hours. Contacts rated 20 amps, repeating mechanism so ideal for shop window control, or to switch hall lights (anti-burglar precaution) while you are on holiday. Made by the famous Smiths Company. This month only **39/6** complete with perspex cover, new and unused, plus 3/6 postage and insurance, a real snip which should not be missed.

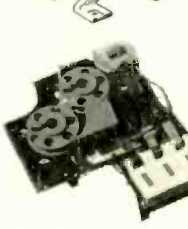


DOUBLE ENDED MAINS MOTOR

On feet with holes for screw-down fixing. To drive models, oven, blower heater, etc. 10/- each, plus 3/6 post and insurance. 6 or more post free.

DIAMOND H OVEN THERMOSTAT

Type 20 TH with capilliary tube and sensor, 20 amp A.C. type as fitted to many cookers adjustable by control knob (not supplied). **12/6** each.



BATTERY OPERATED TAPE DECK

With Capstan control. This unit is extremely well made and measures approx. 6 × 5 × 2in. deep. Has three piano key type controls for Record, Playback and Rewind. Motor is a special heavy duty type intended for operation off 4/5 volts. Supplied complete with 2 spools ready to install. Record Replayhead is the sensitive M4 type intended for use with transistor, amplifier. Price **79/6**. Post and insurance 4/6.

PROTECT VALUABLE DEVICES

From thermal runway or overheating. Thryistors, rectifiers, transistors, etc., which use heat-sinks can easily be protected; simply make the contact thermostat part of the heat sink. Motors and equipment generally can also be adequately protected by having thermostats in strategic spots on the casing. Our contact thermostat has a calibrated dial for setting between 90°-190°F, or with a dial removed range setting is between 80° to 800°F. Price **10/-**.

ATLAS SLIMLINE FLUORESCENTS

THE TWENTYLITE AND TWIN FORTY

A Fluorescent lighting unit made by the famous Atlas company, with super silent polyester filled choke and radio suppressed starter. The tube springs in and out and the whole unit is beautifully made and finished white enamel. Amazingly economical. If left on all the time costs only one penny per day (uses ½ unit). Measures 2ft. long. Is ideal Kitchen, Bedroom, Hallway, Porch, Loft, etc. Don't miss this amazing offer, **39/6** with tube. Assembled ready to install. 4 ft. twin model **59/6**. Post and ins. 6/6 extra.

1 WATT AMPLIFIER & PRE-AMP

5 transistors—highly efficient made for use with tapehead G4 but equally suitable for microphone or pick up. Limited quantity **29/6**. Full circuit diag. also shows tape controls **5/-**.

VARYLITE

Will dim incandescent lighting up to 600 watt from full brilliance to out. Fitted on M.K. flush plate, same size and fixing as standard wall switch so may be fitted in place of this, or mount on surface. Price complete in heavy plastic box with control knob **£3.19.6**.

HI FI BARGAIN

FULL F1 12 INCH LOUDSPEAKER. This is undoubtedly one of the finest loudspeakers that we have ever offered, produced by one of the 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.—specify 3 or 15 ohms—Main resonance 60 c.p.s.—Chassis Diam. 12in.—12⅜ over mounting lugs—Baffle hole 11in. Diam.—Mounting holes 4, holes—¼in. diam. on pitch circle, 11⅝in. diam.—Overall height 5¼in. A £6 speaker offered for only **£3.9.6** plus 7/6 p. & p. Don't miss this offer. 15in. 30 watt **£7.19.6**. 18in. 100 watt **£24.10.0**.

TAGENTIAL HEATER UNIT

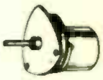
Winter is coming but act today and you won't dismay. This heater unit is the very latest type, most efficient, and quiet running. Is as fitted in Hoover and blower heaters costing £15 and more. We have a few only. Comprises motor, impeller, 2kW. element and 1kW. element allowing switching 1, 2 and 3kW. and with thermal safety cut-out. Can be fitted into any metal line case or cabinet. Only need on/off switch. **79/6**. Postage and insurance 6/6. Don't miss this.

MINIATURE WAFER SWITCHES

2 pole, 2 way—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.

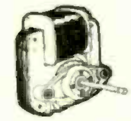
INSTRUMENT MOTOR WITH GEARBOX



Made by famous Smiths Company. Very powerful, although only quite small. Overall dimensions approx. 1¼in. deep by 2in. dia. Available with the following speeds.
Revs. per day 2—8—12
Revs. per hour 1, 2, 4, 6, 12, 20, 30.
Revs. per minute 1, 2, 3, 4, 6, 8, 15, 30, 60. **17/6** each.

DRILL CONTROLLER

Electronically changes speed from approximately 10 revs. to maximum. Full pow... speeds by finger-tip ... Kit includes all parts everything and full ... tions **19/6**, plus 2/... insurance. Made up ... available **37/6** plus 2/...



MAINS MOTOR

Precision made—as used in reco... decks and tape recorders—ideal a... for extractor fans, blower, heater ... New and perfect. Snip at **9/6**. Post... 3/- for first one then 1/- for eac... ordered. 12 and over post free.

ELECTRIC CLOCK WITH 25 AMP SWITCH

Made by Smith's, these units are as fitted to many top quality cookers to control the oven. The clock is mains driven and frequency controlled so it is extremely accurate. The two small dials enable switch on and off times to be accurately set. Ideal for switching on tape recorders. Offered at only a fraction of the regular price—new and unused only **39/6**, less than the value of the clock alone—post and insurance 2/9.

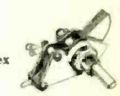
THERMAL CUTOUT

A miniature device ⅝in. dia. on one screw fixing mount—can be used for motor overload protection—fire alarm—soldering iron switch off, etc., etc.—15 amp contacts open with flame radiant or conducted heat. **1/6** each, **15/-** doz. **£5** 100.

COPPER CLAD ELEMENT

1250 watts—4ft. long but bent to U shape, ideal for overhead heater—just mount reflector above. **12/6** each, plus 4/6 post. **£6** doz. post paid.

0·0005mFd TUNING CONDENSER

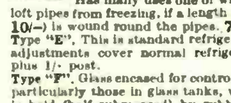


Proved design, ideal for straight or reflex circuits **2/6** each. **24/-** doz.

Battery Record Player. Made by Collaro. This is made up on a unit plate with speed selector and pick-up. The turntable is a heavy one and measures approximately 9½in. Pick-up is fitted with the famous "Studio" cartridge. Price **69/6**, post and insurance 6/6.
E.H.T. Condenser. 28Kv. 0.0011 mfd. Suitable for transmitting test conditions 6A at 300k/c. Bakelite case. **18/6** each.
85 Watt Tubular Element. Very well made unit. The element is wound on a porcelain former then encased in a brass tube terminated with beaded leads 12in. long. Normal mains voltage. Price **5/-** each or **54/-** per doz.
Press to Make Switch. Double pole, 5 amp contacts or can be used as single pole, 10 amp, contacts 250 volt working. Single hole fixing. **2/6** each, **24/-** doz.
Door Switch. Contacts open when plunger is depressed. Prevents lights being left on. 15 amp contacts, 230 volt working. Made by Arrow. **3/6** each, **36/-** per doz.
Rotary Appliance Switch. 16 amp, 230 volt on moulded ceramic base. Operated by pointer knob (not supplied). **2/-** each, **18/-** per doz.
1/40th h.p. Motor. Made by the French (Cassor) Company. This is an excellent totally enclosed motor, powerful enough to operate small lathe, drilling machine, washing machine, etc. Its speed is 1,450 r.p.m. Made for normal 50 cycle, 230/250 volts mains, totally enclosed, size 2¾ × 3½in. dia. with 1in. of ¼in. spindle. Price **19/6** plus 4/6 postage and insurance.
Burglar Alarm Kit. Protect your home and family by frightening away the intruder. With our circuit a mains operated bell rings loudly directly the door or window is opened. Kit comprises 12 reed switches, 12 magnets, relay, mains transformer and bell with circuit. Price **49/6**.

THERMOSTATS

Type "A" 15 amp. for controlling room heaters, greenhouses, airing cupboard. Has spindle for pointer knobs. Quickly adjustable from 30-80°F. **9/6** plus 1/- post. Suitable box for wall mounting. **5/-**. Post and packing 1/-.
Type "B" 15 amp. This is a 17in. long rod type made by the famous Sunvic Co. Spindle adjusts this from 50-550°F. Internal screw alters the setting, so this could be adjustable over 30° to 1000°F. Suitable for controlling furnace, oven, kiln, immersion heater or to make flame-stat or fire alarm. **8/6** plus 2/6 post and insurance.



Type "D". We call this the Ice-stat as it cuts in and out at around freezing point. 2/3 amps. Has many uses one of which would be to keep the loft pipes from freezing, if a length of our blanket wire (16yd. **10/-**) is wound round the pipes. **7/6**. Post and packing 1/-.
Type "E". This is standard refrigerator thermostat. Spindle adjustments cover normal refrigerator temperature. **7/6**, plus 1/- post.
Type "F". Glass encased for controlling the temp. of liquid—particularly those in glass tanks, vats or sinks—thermostat is held (half submerged) by rubber sucker or wire clip—ideal for fish tanks—developers and chemical baths of all types. Adjustable over range 50° to 150°F. Price **18/-**, plus 2/- post and insurance.

Where postage is not stated then orders over £3 are post free. Below £3 add 2/9. Semi-conductors add 1/- post. Over £1 post free. S.A.E. with enquiries please.

ELECTRONICS (CROYDON) LTD

Dept. WW, 266 London Road, Croydon CRO-2TH
Also 102/3 Tamworth Road, Croydon

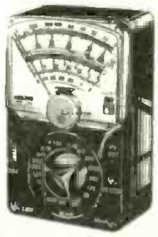
Lasky's

TMK METER KITS

ANOTHER LASKY'S EXCLUSIVE

These two new meter kits by TMK offer the professional, electronics hobbyist and student the unique opportunity of building a really first class precision multimeter at a worthwhile saving in cost. The impact resistant bakelite cabinets are supplied with the meter scale and movement mounted in position; the model 200 also has the rotary range selector in position. The highest quality in components and 1% tolerance resistors are used throughout. Both offer professional standards of accuracy. Supplied complete in every detail with full constructional, circuit and operating instructions.

MODEL 200



20,000 O.P.V. Multimeter. Features 24 measurement ranges with mirror scale. Large 3 x 2in. meter, full scale accuracy: DCV and current: ± 2%. ACV: ± 3%, resistance ± 3%. Special 0.6V DC range for transistor circuit measurements.

SPECIFICATION:

- DCV: 0-0.6-6-30-120-600-1,200V at 20K/OPV.
- ACV: 0-6-30-120-600-1,200V at 10K/OPV.
- DC Current: 0-0.06-6-60-600mA.
- Resistance: 0-10K 100K 1M 10M/ohms (58-580-5.8K-58K at mid-scale).
- Capacitance. 0.002 0.2 μF (AC 6V range).
- Decibels −20 to +63dB.
- Output: 0.05 μF blocking capacitor. Uses two 1.5V (U.7 type) batteries. Black bakelite cabinet, size 5¼ x 3⅞ x 1⅞in. Complete with test leads.

LASKY'S KIT PRICE 85/- Post 3/6

MODEL 5025

50,000 O.P.V. FEATURING 57 MEASUREMENT RANGES

A highly reliable instrument using an entirely new range selection mechanism which permits the use of a really large meter in a more compact cabinet. The range selected is clearly indicated on the actual meter face facilitating instant identification without taking your eyes from the meter. High speed rotary range selection knob; also features polarity reversal switch, shielded meter movement with overload protection circuit. Special A and mA measurement ranges.

SPECIFICATION:

- DCV: 0-0.25-2.5-10-50-250-1,000V at 25K/OPV 0-0.125-1.25-5.0-25-125-500V at 50K/OPV.
- ACV: 0-3-10-50-250-1,000V at 2.5K/OPV 0-1.5-5-25-125-500V at 5K/OPV.
- DC μA: 0-25 μA at 125mA; 0-50 μA at 250mA.
- DCmA: 0-2.5-25-250mA at 125mV, 0-5-50-500mA at 250mV.
- DC Amps: 0-5A at 125mV; 0-10A at 250 mV.
- Resistance 0-10M/ohms (13, 65, 650.6.5K and 65K/ohms at centre scale).
- Output Capacitor (0.1 μF, 400Vw) in series with ACV ranges.
- Decibels: −20 to +81.5dB in 10 ranges.

Operates on two 1.5V (U.7 type batteries). Black bakelite cabinet, size 5¼ x 6¾ x 2¾in. Strong resilient plastic handle. Complete with test leads.

LASKY'S KIT PRICE £10.10.0 Post 5/-

ALSO AVAILABLE READY-BUILT AND TESTED £12.10.0. Post 5/-

TMK 100K "LAB" MULTIMETER

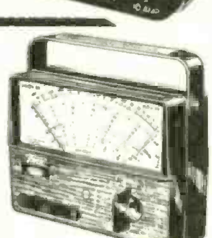
FULLY BUILT AND TESTED

A highly accurate Multimeter using a 10 μA. Meter hand calibrated to a DC accuracy of ± 3% of full scale. Special features: ultra large meter scale, 6½x3½in., incorporating an entirely new type of range selection panel which gives instant identification without taking your eyes from the meter. An audible buzzer is provided for easy short testing. SPEC. DCV ranges: 0.5, 2.5, 10, 50, 250, 500, 1,000V at 100K/OPV. ACV ranges: 3, 10, 50, 250, 500, 1,000V at 5K/OPV. DC current: 0-10, 100 A, 0-10, 100mA 0-2.5, 10Amps. Resistance: 0-1K, 10K, 100K, 10M, 100M/ohms. Decibels: −10 to +49.4dB. Continuity test: Audible buzzer. Operates on 1x1.5V U2 and 1x15V 8.154 type batts. Cabinet size 7⅞x6⅞x3⅛in. Weight 4lb.

LASKY'S PRICE £19.10.0 Post 5/-

TMK Model PL-436

FULLY BUILT AND TESTED



20,000 O.P.V. Multi-tester for the amateur or professional. Features mirror scale and wood grain finish front panel. SPEC.: DC/V ranges: 0.6, 3, 12, 30, 120, 600V at 20K/O.P.V. AC/V ranges: 3, 30, 120, 600V at 8K/O.P.V. DC current: 50μA, 0.6, 60, 600mA. Resistance: 10K, 100K, 1M and 10M ohms end scale (65, 650, 6.5K and 65K ohms centre scale). Decibels: −20 to +57dB in four ranges. Operates on 2 x 1.5V U7 type batts. Size: 5⅞ x 4⅞ x 2⅛in. Complete with batteries and operating instructions.

LASKY'S PRICE £6.19.6 Post 5/-

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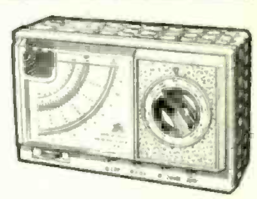
TTC Model C-1051

POCKET MULTIMETER

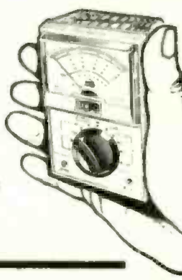


A completely new design 20,000 O.P.V. pocket multimeter with mirror scale and built-in thermal protection. Exceptionally large easy to read meter with D'Arsonval movement. Colour coded scales. Single positive click-in, recessed selection switch for all ranges. Ohms zero adjustment. Range spec. a.c. volts: 0-6-30-300-1,200V at 10K/ohms/V. DC volts: 0-3-15-150-300 1.2KV at 20K/ohms/V. Resistance: 0-60K-6megs. DC current 0-60 μA—300mA. Decibels: −20dB to +17dB. Hand calibration gives extremely high standard of accuracy on all ranges. Uses one 1½V penlight battery. Strong impact resistant plastic cabinet—size only 4⅞x3⅛x1⅛in. Two colour buff/green finish. Complete with test leads and battery.

LASKY'S PRICE 75/- Post 2/6

ALSO AVAILABLE C-1052 3 KOPV METER **£5.19.6**

TTC MODEL C-1000

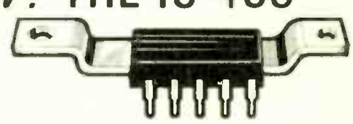


A really tiny 1,000 O.P.V. pocket multi-tester with "big" meter performance. Precision 2 jewel meter movement. Hand calibrated to ± 3% accuracy on full scale of DC ranges. 4% on AC ranges. 2⅛in. square meter. SPECIFICATIONS: AC/V ranges: 0-10, 50, 250, 1,000V at 1K/O.P.V. AC/V ranges: 0-10, 50, 250 100V at 1K/O.P.V. DC current: 0-1-100mA. Resistance: 0-150K/ohms (3,000 ohms centre scale). Decibels: −10 to +22dB. Operates on one penlight cell. Two colour buff/green case size only 3½x2⅛x1in. Click stop range selection switch. Ohms zero adjustment. Complete with test leads, battery and ins...

LASKY'S PRICE 39/6 Post 2/6

AVAILABLE NOW! THE IC-403

INTEGRATED CIRCUIT AMPLIFIER MODULE



Originally developed for computer and space projects—these tiny modules—size only 25x10x5 millimetres—represent the most amazing breakthrough in circuit design since the introduction of the transistor. The IC-403 is an integrated power and pre-amplifier requiring only the addition of tone and volume controls, power source and speaker to form a complete audio amplifier of 3W output.

SPECIFICATION (ratings at 25°C): Output power typically 3W from 250mV input. Frequency response 20Hz to 80KHz +3dB. Max. operating voltage 21V. Min. operating load 7.5 ohms. Pre-amp. input imp. 2M/Ohms. Pre-amp. O.C. input current 50nA.

THE IC-403 IS AVAILABLE FROM STOCK EXCLUSIVELY FROM LASKY'S—COMPLETE WITH INSTRUCTION DATA AND SUGGESTED CIRCUIT APPLICATIONS. FREE INSTRUCTION DATA LEAFLET ON REQUEST. JUST SEND S.A.E.

LASKY'S PRICE 49/6 Post 1/6. **2 for 95/-** post free.

Also available from stock Sinclair IC-10. 59/6 post free.

DENSHI BOARD KITS

EDUCATIONAL CIRCUIT SYSTEM

The **DENSHI BOARD** system enables the young experimenter and electronics hobbyist to produce a wide range of transistor circuits of increasing sophistication—without soldering or the use of any tools at all! Basically the system comprises a slotted circuit board into which plug-in components and bridge pieces are set to produce up to 30 different circuits. The components are incapsulated in transparent plastic blocks bearing the appropriate circuit symbol and value thus enabling even the complete novice to visually grasp the fundamentals of circuitry after only a few moments study. **Each DENSHI BOARD KIT comes complete with 80-page manual of circuits and data.**

THESE ARE JUST A FEW OF THE CIRCUITS YOU CAN BUILD IN MINUTES; VARIOUS RADIO RECEIVERS, AMPLIFIERS, MORSE CODE PRACTICE DEVICE, SIGNAL INJECTOR, SIGNAL TRACER, WIRELESS MICROPHONE, ETC.

DENSHI BOARD KIT SR-1A *comprises:* Base board; tuner block; 4 resistors; choke coil transformer; 2SA transistor for RF; 2 diodes; 3 capacitors; battery block; morse key; antenna lead; crystal earphone; various bridge and connecting pieces and 80 page manual. **This kit permits the building of 16 basic circuits.**

LASKY'S PRICE £4.19.6 POST 3/6

DENSHI BOARD KIT SR-2A *as SR-1A plus:* 2SB transistor for AF; 2 resistors; 1 capacitor; crystal microphone; test probes; electrode; additional connecting pieces; 9V battery. **This kit permits the building of 30 circuits.**

LASKY'S PRICE £7.2.6 POST 3/6

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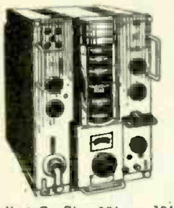
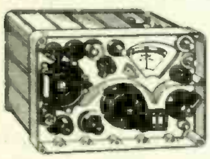
ADMIRALTY B.40 RECEIVERS



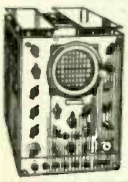
High quality 10 valve receiver manufactured by Murphy. Coverage in 5 bands 650 Kc/s-30 Mc/s. I.F. 500/Kc/s. Incorporates 2 R.F. and 3 I.F. stages, bandpass filter, noise limiter, crystal controlled B.F.O. calibrator I.F. output, etc. Built-in speaker, output for phones. Operation 150/230 volt A.C. Size 19½ × 13½ × 16in. Weight 114lb. Offered in good working condition. **£22/10/0.** carr. 30/-. With circuit diagrams. Also available B41 L.F. version of above. 15 Kc/s-700 Kc/s. **£17/10/-.** Carr. 30/-.

R209 Mk. II COMMUNICATION RECEIVER



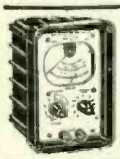
11 valve high grade communication receiver suitable for tropical use. 1-20 Mc/s. on 4 bands. AM/CW/FM operation. Incorporates precision vernier drive, B.F.O. Aerial trimmer, internal speaker and 12v. D.C. internal power supply. Supplied in excellent condition, fully tested and checked. **£15.0.0** Carr. 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, lid, etc. **£25.** Carriage 30/-.

MARCONI CT44 TF956 AF ABSORPTION WATTMETER

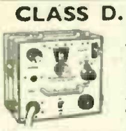


1 μ/watt to 6 watts. **£20.** Carr. 20/-.

PLESSEY SL 403A

3-watt. integrated amplifier circuit. **49/6** post paid.

CLASS D. WAVEMETERS



A crystal controlled heterodyne frequency meter covering 1.7-8 Mc/s. Operation on 6 v. D.C. Ideal for amateur use. Available in good used condition **£5.19.6** Carr. 7/6. Or brand new with accessories **£7.19.6** Carr. 7/6.

CLASS D WAVEMETERS No. 2

Crystal controlled. 1.2-19 Mc/s. Mains or 12v. D.C. operation. Complete with calibration charts. Excellent condition **£12/10/0.** Carr. 30/-.

EDDYSTONE V.H.F. RECEIVERS

770R. 19-165 Mc/s. **£150.**
Both types in excellent condition.

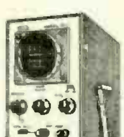
LELAND MODEL 27 BEAT FREQUENCY OSCILLATORS

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

RACAL MA.168 TRANSISTORISED DIVERSITY SWITCH

Brand new condition **£15.** Carriage 10/-.

T.O-2 PORTABLE OSCILLOSCOPE



A general purpose low cost economy oscilloscope for every-day use. Y amp. Bandwidth 2 CPS—1 MHZ. Input imp. 2 meg Ω. 25 PF. Illuminated scale. 2" tube. 115 × 180 × 230 mm. Weight 8lbs. 220/240v. A.C. Supplied brand new with handbook. **£22/10/-.** Carr. 10/-.

TO-3 PORTABLE OSCILLOSCOPE. 3" TUBE

Y amp. Sensitivity. .1v p-p/CM. Bandwidth 1.5 cps—1.5 MHZ. Input imp. 2 meg Ω. 25 PF. X amp sensitivity. ·9v p-p/CM. bandwidth 1.5 cps—800 KHZ. Input imp. 2 meg Ω 20 PF. Time base. 5 ranges 10 cps—300 KHZ. Synchronization. Internal/external. Illuminated scale. 140 × 215 × 330 mm. Weight 15½lbs. 220/240 V. A.C. Supplied brand new with handbook. **£35/-/-.** Carr. 10/-.

SOLARTRON MONITOR OSCILLOSCOPE TYPE 101

An extremely high quality oscilloscope with time base of 10 μ/sec. to 20 m/sec. Internal Y amplifier. Separate mains power supply, 200/250 V. Supplied in excellent condition with cables, probe, etc., as received from Ministry. **£8/19/6.** Carr. 30/-.

FIELD TELEPHONES TYPE L. Generator ringing, metal cases. Operate on 2 1.5 v. batteries (not supplied.) Excellent condition. **£4.10.0** per pair. Carr. 10/-.

UNR-30 4 BAND COMMUNICATION RECEIVER

Covering 550 Kc/s-30 Mc/s. Incorporates BFO. Built-in speaker and phone jack. Metal cabinet. Operation 220/240 v. A.C. Supplied brand new, guaranteed with instructions. **13gns.** Carr. 7/6.

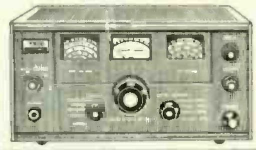
HAMMARLUND SP600 JX COMMUNICATION RECEIVER

Frequency range 540 Kc/s to 54 Mc/s in 6 Bands. Few available in excellent condition, tested and checked. **£100** each.

LAFAYETTE SOLID STATE HA600 RECEIVER

5 BAND AM/CW/SSB AMATEUR AND SHORT WAVE. 150 kc/s-400 Kc/s AND 550 Kc/s-30 Mc/s. F.E.T. front end ● 2 mechanical filters ● Huge dial ● Product detector ● Variable BFO ● Noiselimiter ● S Meter ● 24½in. Bandspread ● 230 v. A.C./12 v. D.C. neg earth operation ● RF gain control. Size 15in. × 9½in. × 8½in. Wt. 18 lbs. EXCEPTIONAL VALUE **£45.** CARR. 10/-. S.A.E. FOR FULL DETAILS.

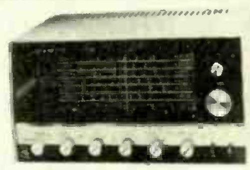
TRIO COMMUNICATION RECEIVER MODEL 9R-59DE



4 band receiver covering 500 Kc/s to 30 Mc/s, continuous and electrical bandspread 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. Bandspread 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. **£42.** Carriage paid Trio Communication Type Headphones. Normally £5.19.6. Our price **£3.15.0** if purchased with above receiver.

TRIO TS 510 Amateur Transceiver with speaker and mains P.S.U.	£212 0
TRIO JR 500SE 10-80 Metre Amateur Receiver	£69 10

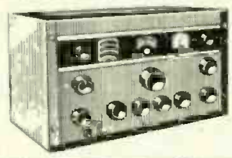
LAFAYETTE HA.800 SOLID STATE AMATEUR COMMUNICATION RECEIVER SIX BANDS 3.5-4, 7-7.3, 14-14.35, 21-45, 28-29.7, 50-54 Mc/s.



Dual conversion on all bands. 2 × 455 Kc/s mechanical filters. Product detector. Variable B.F.O 100 Kc/s crystal calibrator. 'S' meter. Huge slide rule dial. Operation 230v AC or 12v DC. Size 15" × 9½" × 8½". Complete with instruction manual. **£57.10.0.** Carr. Paid. (100 Kc/s Crystal **39/6** extra.)

TRIO JR-310 NEW AMATEUR BAND 10-80 METER RECEIVER IN STOCK £77.10.0

RCA COMMUNICATIONS RECEIVERS AR88D



Latest release by ministry BRAND NEW in original cases. 110-250v. A.C. operation. Frequency in 6 Bands. 535 Kc/s—32 Mc/s continuous. Output impedance 2.5-600 ohms. Incorporating crystal filter, noise limiter, variable BFO, variable selectivity, etc. Price **£87.10.0.** Carr. £2.

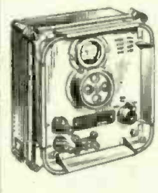
LAFAYETTE PF-60 SOLID STATE VHF FM RECEIVER

A completely new transistorised receiver covering 152-174 Mc/s. Fully tuneable or crystal controlled (not supplied) for fixed frequency operation. Incorporates 4 INTEGRATED CIRCUITS. Built-in speaker and illuminated dial. Squelch and volume controls. Tape recorder output. 75 Ω aerial input. Headphone jack. Operation 230 v. A.C./12 v. D.C. Neg. earth. **£37/10/-.** Carr. 10/-.

SOLARTRON CD711S.2. DOUBLE BEAM OSCILLOSCOPE

An extremely high quality oscilloscope originally costing £400. Switched beam. Identical Y1, Y2 Amplifiers D.C. to 9 Mc/s. Sensitivity 3mV/CM to 100 V/CM. Time base 10μ/sec. to 10 M/secd. Calibrator. X amplifier D.C. to 2.5 Mc/s. Z Modulation. 110/250 v. A.C. Supplied in good working order. **£65.** Carriage 50/-.

CRYSTAL CALIBRATORS NO. 10



Small portable crystal controlled wavemeter. Size 7in. × 7½in. × 4in. Frequency range 500 Kc/s—10 Mc/s (up to 30 Mc/s on harmonics). Calibrated dial. Power requirements 300 V.D.C. 15mA and 12 V.D.C. 0.3A. Excellent condition. **89/6.** Carr. 7/6.

SEW PANEL METERS

Type MR.38P. 1 21/32in. square fronts.

50μA	40/-	50mA	27/6	100V. D.C.	27/6
50-0-50μA	37/6	100mA	27/6	150V. D.C.	27/6
100μA	37/6	150mA	27/6	300V. D.C.	27/6
100-0-100μA	35/-	200mA	27/6	500V. D.C.	27/6
200μA	35/-	300mA	27/6	750V. D.C.	27/6
500μA	30/-	500mA	27/6	15V. A.C.	27/6
500-0-500μA	27/6	750mA	27/6	50V. A.C.	27/6
1mA	27/6	1 amp	27/6	150V. A.C.	27/6
1-0-1mA	27/6	2 amp	27/6	300V. A.C.	27/6
2mA	27/6	5 amp	27/6	500V. A.C.	27/6
5mA	27/6	3V. D.C.	27/6	S meter 1mA	32/-
10mA	27/6	10V. D.C.	27/6	VU meter	42/-
20mA	27/6	20V. D.C.	27/6		

FULL RANGE OF OTHER SIZES IN STOCK—SEND SAE FOR LEAFLET

LAFAYETTE STEREO AMPLIFIER MODEL STEREO 10

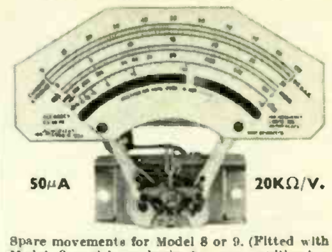
Completely transistorised 5 watts per channel I.H.F. music power. Inputs for gram and tuner. Separate volume controls and variable tone control for Bass and Treble. A compact size, big performance stereo amplifier ideal for limited space systems. Beautifully finished in grey and aluminium. Size 7½in. × 2 15/16 in. × 5½in. AC. 220/240v.

Price **£11.19.6** Carr. 7/6.

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.

AVOMETER MOVEMENTS



50μA 20KΩ/V.

Spare movements for Model 8 or 9. (Fitted with Model 9 scale) or basis for any multimeter. Brand New and Boxed **69/6** P. & P. 3/6

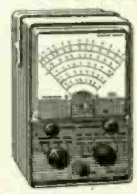
AVO 48A

Perfect order with set of shunts and resistances **£12.10.0.** P. & P. 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/-.

TE-65 VALVE VOLTMETER

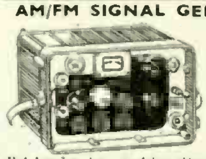


High quality instrument with 28 ranges. D.C. volts 1.5-1,500 v. A.C. volts 1.5-1,500 v. Resistance up to 1,000 megohms. 220/240v. A.C. operation. Complete with probe and instructions **£17/10/0.** P. & P. 6/-. Additional Probes available; R.F. 35/- H.V. 42/6.

COSSOR 1049 DOUBLE BEAM OSCILLOSCOPES

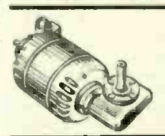
D.C. coupled. Band width 1 Kc/s. Perfect order. **£25.** Carr. 30/-.

AM/FM SIGNAL GENERATORS



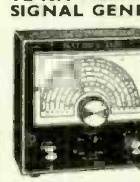
Oscillator Test No. 2. A high quality precision instrument made for the Ministry by Airmec. Frequency coverage 20-80 Mc/s. AM/CW/FM. Incorporates precision dial, level meter, precision attenuator 1μV-100Mv. Operation from 12 volt D.C. or 0/110/200/250 v. A.C. Size 12 x 8½ x 9in. Supplied in brand new condition complete with all connectors, fully tested. **£45.** Carr. 20/-.

GEARED MAINS MOTOR



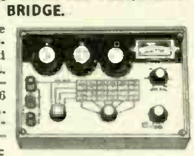
Parslux type SD19 230/250 v. A.C. Reversible. 30 r.p.m. 40 lb. ins. Complete with capacitor. Excellent condition. **99/6.** Carr. 10/-.

TE-16A TRANSISTORISED SIGNAL GENERATOR



5 Ranges 400 KHZ-30 MHZ. An inexpensive instrument for the handy-man. Operates on 9v. battery. Wide easy to read scale. 800 KHZ modulation. 5¼" × 5¼" × 3½". Complete with instructions and leads. **£7/19/6.** P/P 4/-.

TRANSISTORISED L.C.R. A.C MEASURING BRIDGE.



A new portable bridge offering excellent range and accuracy at low cost. Ranges: R. 1Ω—11.1 MEG Ω 6 Ranges ± 1%. L. 1μH—111 HENRIES. 6 Ranges — 2%. C. 10PF ± 1110MFD. 6 Ranges ± 2%. TURNS RATIO 1:1/1000—1:11100. 6 Ranges ± 1%. Bridge voltage at 1,000 CPS. Operated from 9 volts. 100μA. Meter indication. Attractive 2 tone metal case. Size 7½" × 5" × 2". **£20.** P. & P. 5/-.

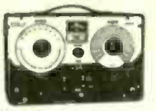
AUTO TRANSFORMERS

0/115/230v. Step up or step down. Fully shrouded
150 W. **42/6.** P. & P. 3/6
300 W. **59/6.** P. & P. 4/6
500 W. **£4/10/0.** P. & P. 6/6
1,000 W. **£6/10/0.** P. & P. 7/6
1,500 W. **£7/19/6.** P. & P. 8/6
7,500 W. **£15/10/0.** P. & P. 20/-.

G. W. SMITH & Co. (Radio) Ltd.

ALSO SEE OPPOSITE PAGE

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 600 Ω 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. £30. Carr. 7/6.

VOLTAGE STABILISER TRANSFORMERS.

180-260v. input. Output 230v. Available 150w or 225w. £12.10.0. Carr. 5/-.

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, £15.

P. & P. 7/6. S.A.E. for details.

PEAK SOUND PRODUCTS

Full range of Amplifiers, kits, Speakers in stock.

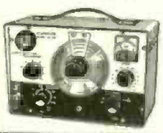
TE22 SINE SQUARE WAVE AUDIO GENERATORS

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. £16.10.0. Carr. 7/6.

MARCONI TF885 VIDEO OSCILLATORS

0-5 mc/s Sine Square Wave £45. Carr. 20/-.

LAFAYETTE TE-46 RESISTANCE CAPACITY ANALYSER



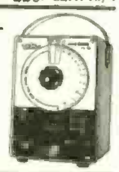
2 pf-2,000 mfd. 2 ohms-200 megohms. Also checks impedance turns ratio insulation. 200/250 v. A.C. Brand New, £17.10 Carr. 7/6.

MARCONI TF.142E DISTORTION FACTOR METERS

Excellent condition. Fully tested £20. Carr. 15/-.

TY75 AUDIO SIGNAL GENERATOR

Sine Wave 20 CPS—200 Kc/s. Square Wave 20 CPS—30 Kc/s. High and low impedance output. Output variable up to 6 volts. 220/240 volts A.C. Brand new with instructions. £16. Carr. 7/6. Size 210 × 150 × 120 mm.



MARCONI TF195M BEAT FREQUENCY OSCILLATORS

0-40 kc/s. £20. Carr. 30/-.

TE-20D RF SIGNAL GENERATOR

Accurate wide range signal generator covering 120 Kc/s—500 Mc/s on 6 bands. Directly calibrated. Variable RF. attenuator, audio output. Xtal socket for calibration. 220/240V. A.C. Brand new with instructions. £15. Carr. 7/6. Size 140 x 215 x 170 mm.

ADVANCE TEST EQUIPMENT

Brand new and boxed in original sealed cartons.

VM.76. VALVE VOLTMETER. R.F. measurements in excess of 100 Mc/s and D.C. measurements up to 1000 v. with accuracy of ±2%. D.C. range 300 MV to 1 KV. A.C. range 300 MV to 300 V RMS. Resistance 0.02—500 M. Price £72.

VM.79. UHF MILLIVOLT METER. Transistorised. A.C. range 10 Mv—3V. D.C. current range 0.01/A—0.3 Ma. Resistance 1 ohm—10 megohms. £125.

H1B. AUDIO SIGNAL GENERATOR. 15 c/s—50 Kc/s, sine or square wave. Price £30.

J1B. AUDIO SIGNAL GENERATOR. 15 c/s—50 Kc/s. Price £30.

TT1S. TRANSISTOR TESTER. £37/10/-.

Carriage 10/- per item.

MODEL ZQM TRANSISTOR CHECKER

It has the fullest capacity for checking on A. B and Ico. Equally adaptable for checking diodes, etc. Spec.: A: 0.7-0.9967. B: 5-200. Ico: 0/50 micro-amps. 0.5 mA. Resistance for diode 200Ω + 1 MEG. Supplied complete with instructions, battery and leads. £5/19/6. P. & P. 2/6.

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•1025 Stereo	£6.19.6	A70 MKII	£11.19.6
•2025 Stereo	£7.19.6	•SL65	£14.14.6
•2025T/C Mono/ Stereo	£8.17.6	AP75	£17.17.0
•3000 Stereo	£9.19.6	401	£28. 7.6
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WB4 Bases £3/19/6. Perspex cover £3/10/0

•Special offer base and cover available for these models at £4.15.0. Carr. 5/-.

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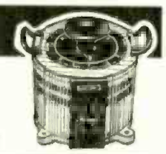
LAFAYETTE LA-224T TRANSISTOR STEREO AMPLIFIER

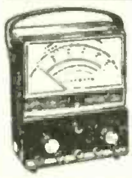
19 transistors, 8 diodes. IHF music power 30 watts at 8 ohms. Res. 30-20,000 ±2 dB at 1 w. Distortion 1% or less. Inputs 3 mV and 250 mV. Output 3-16 ohms. Separate L and R volume controls. Treble and bass controls. Stereo phone jack. Brushed aluminium, gold anodised extruded front panel with metal case. Size 10½in. × 3 1/16 in. × 7 11/16 in. Operation 115/230 volt A.C. £28. Carr. 7/6.

Variable Voltage TRANSFORMERS



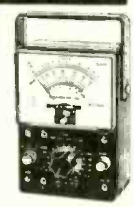
Brand new, guaranteed and carriage paid.
High quality construction. Input 230 v. 50-60 cycles.
Output full variable from 0-260 volts. Bulk quantities available.
1 amp.—£5/10/-; 2.5 amp.—£6/15/-; 5 amp.—£9/15/-;
8 amp.—£14/10/-; 10 amp.—£18/10/-; 12 amp.—£21; 20 amp.—£37

MULTIMETERS for EVERY purpose!



TE-900 20,000Ω/VOLT GIANT MULTIMETER Mirror scale and overload protection. 6in. full view meter. 2 colour scale. 0/2.5/10/250/1,000/5,000 v. A.C. 0/25/12.5/10/50/250/1,000/5,000 v. D.C. 0/50μA/110/100/500mA/10 amp. D.C. 02K/200K/20 MEG. OHM. £15/-/-. P. & P. 5/-.

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/200M Ω. —20 to +17dB. £12/10/-. P. & P. 3/6.



MODEL TE-90 50,000 O.P.V. Mirror scale overload protection. 0/3/12/60/300/600/1,200 v. D.C. 0/6/30/120/300/1,200. v D.C. .03/6/60/600 MA. D.C. 16K/160K/1.6/16 MEG Ω. —20 — + 63db. £7/10/0. 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 MegΩ. £5/10/-. P. & P. 3/-.

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-12. 20,000 O.P.V. 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.

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/12/300m A.D.C. 0/60K/6 meg. ohm. 92/6. P. & P. 2/6.

MODEL PT-34. 1,000 O.P.V. 0/10/50/250/500/1,000V. a.c. and d.c. 0/1/100/500 mA. d.c. 0/100 K Ω 39/6. P. & P. 1/6.

MODEL TE-10A. 20kΩ/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.

LAFAYETTE 57 Range Super 50KΩ/V. Multimeter. D.C. volts 125mv—1000v. A.C. volts 1.5v—1000v. D.C. Current 25μA—10 Amp. Ohms 0—10 MegΩ. D.B.—20 to +81 db. Overload protection. £12/10/-. P. & P. 3/6.

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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. 99/6.

SINCLAIR EQUIPMENT

Z12. 12 watt amplifier 89/6.
PZ4. Power supply Unit 89/6.
STEREO 25, Pre-amplifier £9/19/6.
Q.14 Speakers £7/19/6.
Micromatic Radio Kit 49/6. Built 59/6.

NOW AVAILABLE IC10 59/6

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SPECIAL OFFER

2 Z12 amps. PZ4 Power Supply, Stereo 25, Preamplifier £22
or with two Q.14 Speakers £37

NEW SINCLAIR 2000 SYSTEM

35 watt Integrated Amplifier, £29. Carr. 5/-. Self-powered FM Tuner, £25. Carr. 5/-.

ECHO HS-606 STEREO HEADPHONES

Wonderfully comfortable. Lightweight adjustable vinyl headband, 6ft. cable and stereo jack plug. 25-17,000 cps., 8Ω imp. 67/6. P. & P. 2/6.

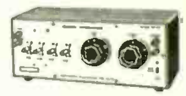
HOSIDEN DH04S 2-WAY STEREO HEADPHONES

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. 1000's of applications. Beautifully finished in ebony. Supplied complete with batteries and wall brackets. £6/19/6 pair. P. & P. 3/6.

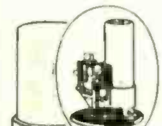
TE111 DECADE RESISTANCE ATTENUATOR



Variable range 0-111 db. Connections. Unbalanced T and Bridge T. Impedance 600 ohms. Range (0.1 db × 10) + (1 db × 10) + 10 + 20 + 30 + 40 db. Frequency: DC to 200 KHZ (—3db). Accuracy: 0.05 db. + indication db × 0.01. Maximum input less than 4 watts (50 volts). Built in 600 Ω load resistance with internal/external switch. Brand new £27/10/-. P. & P. 5/-.

CAR LIGHT FLASHERS

Heavy duty light flasher employs a condenser discharge principle operating on electro mechanical relay. (As inset.) Housed in strong plastic case. Flashing rate between 60-120 per minute. 12 volt D.C. operation. Maximum load 6 amps. Size 2 11/16 in. dia. by 4in. Supplied brand new at a fraction of original cost. 6/6 each, P. & P. 2/6. (3 for 17/6, P. & P. 4/6.)



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Cosmocord ½ track heads: Post extra.

Record/replay. High imp.	65/-
Erase. Low imp.	20/-

Marriott ½ track heads. Post extra.

Record/Playback, high imp.	65/-
Erase, low imp.	20/-

AMERICAN RECORDING TAPES

First grade quality American tapes. Brand new and guaranteed. Discounts for quantities. Postage 2/-. Over £3 post paid.

3in. 225ft. L.P. Acetate	3/6
3¼in. 600ft. T.P. Mylar	10/-
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6in. 900ft. L.P. acetate	10/-
5in. 1,200ft. D.P. Mylar	15/-
5¾in. 1,200ft. L.P. acetate	12/6
5¾in. 1,200ft. L.P. Mylar	16/-
5¾in. 1,800ft. D.P. Mylar	22/6
5¾in. 2,400ft. T.P. Mylar	39/6
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. 3,600 ft. T.P. Mylar	45/-

MAXELL TAPE CASSETTES

C60—10/3; C90—14/3; C120—19/6. Post extra.

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2N706	2/9	2N3709	3/-	BC108	2/6
2N1132	9/9	2N3710	3/3	BC109	2/9
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2N1304	4/6	2N3906	7/6	BC149	4/3
2N1305	4/6	2N3731	23/-	BC153	10/-
2N1306	6/9	2N3820	25/6	BC154	11/-
2N1307	6/9	2N3325	10/6	BC157	3/9
2N1308	8/9	2N3794	3/3	BC158	3/6
2N1309	8/9	2N4286	3/3	BC159	3/9
2N1613	6/-	2N4289	3/3	BC167	2/6
2N1711	7/-	2N4291	3/3	BC168	2/3
2N2218	9/3	2N4292	3/3	BC169	2/6
2N2147	18/9	2N4410	4/9	BC177	6/3
2N2369A	6/9	2N5192	25/-	BC178	5/8
2N2646	10/9	2N5195	29/3	BC179	6/-
2N2924	4/3	40406	16/3	BD121	18/-
2N2925	5/3	40408	14/6	BD123	24/3
2N2926R	2/3	AC126	6/6	BF178	10/6
2N2926O	2/3	AC127	6/-	BFX29	10/9
2N2926Y	2/3	AC128	6/-	BFX85	8/3
2N2926G	2/6	AC176	11/-	BFX88	7/9
2N3053	5/6	ACY22	3/9	BFY50	4/6
2N3054	14/3	ACY40	4/-	BFY51	4/3
2N3055	16/6	AD140	19/-	BSX20	3/9
2N3391A	5/6	AD149	17/6	MJ480	21/-
2N3702	3/6	AD161 }	16/- pr.	MJ481	27/-
2N3703	3/3	AD162 }		MJ491	30/-
2N3704	3/9	AF118	16/6	P346A	5/9
2N3705	3/5	AF124	7/6	V405A	7/9
2N3706	3/3	AF127	7/-		

RESISTORS

Code	*Power*	*Tolerance*	*Range*	*Values available*	*1 to 9*	*10 to 99*	*100 up*
C	1/20W	5%	100Ω–220K Ω	E12	18	16	15
C	1/8W	5%	4·7Ω–1M Ω	E24	2·5	2	1·75
C	1/4W	10%	4·7Ω10M Ω	E12	2·5	1·75	1·5
C	1/2W	5%	4·7 Ω–10M Ω	E24	3	2·25	2
MO	1/2W	2%	10 Ω–1M Ω	E24	9	8	7
C	1W	10%	4·7 Ω–10M Ω	E12	4	3·25	3
WW	1W	10% ± 1/20 Ω	0·22 Ω–3·3 Ω	E12		15d. all quantities	
WW	3W	5%	12 Ω–10K Ω	E12		15d. all quantities	
WW	7W	5%	12 Ω–10K Ω	E12		15d. all quantities	

Codes: C = carbon film, high stability, low noise.
MO = metal oxide, Electrosil TR5, ultra low noise.
WW = wire wound, Plessey.

Prices are in pence each for each ohmic value and power rating. (Ignore fractions of one penny on total resistor order.)

Values:
E12 denotes series: 1, 1·2, 1·5, 1·8, 2·2, 2·7, 3·3, 3·9, 4·7, 5·6, 6·8, 8·2 and their decades.
E24 denotes series: as E12 plus 1·1, 1·3, 1·6, 2, 2 4, 3, 3·6, 4·3, 5·1, 6·2, 7·5, 9·1 and their decades.

NEW PLESSEY INTEGRATED CIRCUIT POWER AMPLIFIER TYPE SL403A. Only **57/- each.** Operates with 18V power supply. Sensitivity 20mV into 20M Ω, 3 watts into 7·5 Ω. Supplied complete with application Data on orders for 2 or more.

PE NOV. 69 STEREO AMPLIFIER KIT less metalwork .. **£11/18/- NET complete**

CARBON SKELETON PRE-SETS
Small high quality, type PR: Linear only: 100 Ω, 220 Ω, 470 Ω, 1K Ω, 2K2, 4K7, 10K, 22K, 47K, 100K, 220K, 470K, 1M Ω, 2M2, 5M, 10M Ω vertical or horizontal mounting .. **1/- each**

S-DeCs PUT AN END TO "BIRDS-NESTING". Components just plug in.
Saves valuable time. Use components again and again.
S-DeC .. .. .. Only 30/6 post free
Compact T-DeC, increased capacity, may be temperature-cycled.
T-DeC .. .. .. only 51/- post free

WAVECHANGE SWITCHES
1P 12W; 2P 6W; 3P 4W; 4P 3W—long spindles .. .. **4/9 each**
SLIDER SWITCHES
Double pole, double throw .. .. **3/- each**

MULLARD SUB-MIN ELECTROLYTICS
C426 RANGE .. .. .. **Price 1/3 each**
Axial leads. Values (μF/V): 0·64/64; 1/40; 1·6/25; 2·5/16; 2·5/64; 4/10; 4/40; 5/64; 6·4/6·4; 6·4/25; 8/4; 8/40; 10/2·5; 10/16; 10/64; 12·5/25; 16/40; 20/16; 20/64; 25/6·4; 25/25; 32/4; 32/10; 32/40; 32/64; 40/16; 40/2·5; 50/6·4; 50/25; 50/40; 64/4; 64/10; 80/2·5; 80/16; 80/25; 100/6·4; 125/4; 125/10; 125/16; 160/2·5; 200/6·4; 200/10; 250/4; 320/2·5; 320/6·4; 400/4; 500/2·5.

LARGE CAPACITORS. ALL NEW STOCK
High ripple current types: 2000μF 25V **7/4**; 2000μF 50V **11/4**; 5000μF 25V **12/6**; 5000μF 50V **21/11**; 1000μF 100V **16/3**; 2000μF 100V **28/9**; 5000μF 70V **36/-**; 5000μF 100V **58/3**; 1000μF 50V **8/2**; 2500μF 64V **15/5**; 2500μF 70V **19/6**.

MEDIUM RANGE ELECTROLYTICS
Axial leads. Values (μF/V): 50/50 **2/-**; 100/25 **2/-**; 100/50 **2/6**; 250/25 **2/6**; 250/50 **3/9**; 500/25 **3/9**; 1000/10 **3/-**; 500/50 **6/-**; 1000/25 **4/-**; 1000/50 **7/-**; 2000/25 **6/-**.

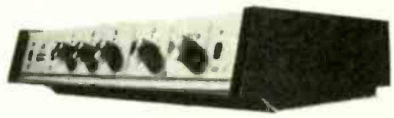
SMALL ELECTROLYTICS
Axial leads: 5/10, 10/10, 25/10, 50/10 **1/- each**
25/25, 47/25, 100/10, 220/10 .. .. **1/3 each**

COMPONENT DISCOUNTS
10% on orders for components for £5 or more.
15% on orders for components for £15 or more.
(No discount on net items)

POSTAGE AND PACKING
Free on orders over £2.
Please add 1/6 if order is under £2.
Overseas orders welcome: carriage charged at cost.

PEAK SOUND AMPLIFIER KITS

The new Englefield Kits



Build it 12+12 or 25+25

Brilliant new styling and available in two forms:

STEREO 15 WATTS PER CHANNEL
Supplied in kit form with complete amplifier and pre-amplifier modules and power supply components. Output per channel into 15Ω —13 watts R.M.S. Price **£38.4.0 Net**

STEREO 25 WATTS PER CHANNEL
Supplied in kit form with complete amplifier, pre-amplifier and regulated power supply modules. Output per channel into 15Ω —28 watts R.M.S. Price **£58.15.0 Net**

Specifications on these amplifiers in accordance with the Specifications in Guarantee published in Peak Sound advertisements.

Inputs:
Magnetic, RIAA 3·5mV
Ceramic 35mV
Tape 100mV
Radio 100mV
Signal to noise ratios: Better than 60dB all inputs.

ENGLEFIELD CABINET to house either above assemblies (as Illustrated) **£6.0.0.**
Other Peak Sound Products as advertised.
Mainline Kits as advertised.

COLVERN 3 WATT WIRE-WOUND POTENTIOMETERS: 10 Ω, 15 Ω, 25 Ω, 50 Ω, 100 Ω, 150 Ω, 250 Ω, 500 Ω, 1K Ω, 1·5K Ω, 2·5K Ω, 5K Ω, 10K Ω, 15K Ω, 25K Ω, 50K Ω.
Price .. .. **only 5/6 each**

CARBON TRACK POTENTIOMETERS
Double wiper ensures minimum noise level. Long plastic spindles.

Single gang linear ..	220 Ω, 470 Ω, 1K, etc. to 2·2M Ω	2/6
Single gang log. ..	4K7, 10K, 22K, etc. to 2·2M Ω ..	2/6
Dual gang linear ..	4K7, 10K, 22K, etc. to 1M Ω ..	8/6
Dual gang log. ..	4K7, 10K, 22K, etc. to 2M2 Ω ..	8/6
Log/Anti-log. ..	10K, 47K, 1M Ω only	8/6
Dual anti-log ..	10K only	8/6

Any type with ½ amp double pole mains switch .. extra 2/3

FETS n-channel
Low cost general purpose 2N5163, 25 volt .. only 5/- each
Audio/r.f. Texas 2N3819 .. .. 9/- each
Motorola 2N5459 (MPF105) .. .. 9/6 each

30 WATT BAILEY AMPLIFIER COMPONENTS:
Transistors for one channel £7/5/6 list, with 10% discount .. .. only £6/11/-
Transistors for two channels £14/11/- list, with 15% discount .. .. only **£12/7/5**
Capacitors and resistors for one channel, list £2.
Printed circuit board free with each transistor set.
Complete unregulated power supply kit £4/17/6 mono or stereo, subject to discount.
Complete regulated power supply kit £9/5/- subject to discount.
Further details on application.

MAIN LINE AMPLIFIER KITS AS ADVERTISED. PRICES NET AUTHORISED DEALER

SINCLAIR IC.10 INTEGRATED CIRCUIT AMPLIFIER AND PRE-AMPLIFIER
This remarkable monolithic integrated circuit amplifier and pre-amplifier is now available for despatch from stock. It is the equivalent of 13 transistor/18 resistor circuit plus 3 diodes and the first of its kind ever. It is d.c. coupled and applicable to an unusually wide range of uses all of which are detailed in the manual provided with it.
Sinclair IC.10 as advertised, post free .. 59/6 NET

ELECTROVALUE

DEPT. WW.701, 28 ST. JUDES ROAD, ENGLEFIELD GREEN, EGHAM, SURREY,
Hours: 9-5.30 daily; 1.0 p.m. Saturdays. ***Telephone: Egham 5533 (STD 0784-3)***

R.S.C. SENSATIONAL HIGH FIDELITY STEREO 'PACKAGE' OFFERS

Matching as recommended for optimum performance. Compare prices with equipment and cabinets purchased individually.

30 Watt Output

★ Goldring Transcription Turntable on Plinth.
★ Shure or Goldring Magnetic Pick-up Cartridge.
★ Super 30 Amplifier in veneered housing.
★ Pair of Stanway II Loudspeaker Units.

Special total price. Four fully wired units ready to "plug-in". Really superb performance. Send S.A.E. for leaflet. **86 Gns.** Carr. 30/-

'Package' prices apply providing all individual units are purchased from any branch within 3 months (see leaflet).

30 Watt Output

★ Garrard SP25 Mk. II Turntable on Plinth.
★ Goldring CS90 Ceramic diamond tipped Cartridge.
★ Super 30 Amplifier in veneered housing.
★ Pair of Stanway II Loudspeaker Units.

Extremely Attractive Plinths finished in Teak or Afrormosia veneer. Tinted Transparent Plastic "roll over" cover with handle.

Special total price. Four fully wired units ready to "plug-in." **76 Gns.** Carr. 30/-

13 Watt Output

★ Garrard SP25 Mk. II 4-speed Player Unit, on Plinth. ★ Goldring CS90 Ceramic P.U. Cartridge with diamond stylus. ★ TA12 Amplifier in veneered housing. ★ Pair of Dorchester Loudspeaker Units.

Special total price. **53 Gns.** Transparent Plastic cover 3 gns extra. Terms Dep. £10.0.3 and 9 monthly payments £5.15.5 (Total 59 Gns.) Carr. 25/-

13 WATT 'PACKAGE' as above but with Garrard 3000 and Sonotone 9TA cartridge in lieu of SP25 and CS90. Special total price **47½ Gns.** Transparent cover 3 gns. extra. Carr. 25/-

AUDIOTRINE HIGH FIDELITY LOUDSPEAKERS

Heavy construction. Latest high efficiency ceramic magnets. Treated Cone surround for low fundamental resonance. "D" indicates Tweeter Cone providing extended frequency range up to 15,000 c.p.s. Exceptional performance at low cost. Impedance 3 or 15 ohms.

Prices include carriage. PLEASE STATE IMPEDANCE

HF 510L 5" 10W	57/9	HF 120	12"	15W	79/9
HF 801D 8" 8W	59/9	HF 120D	12"	15W	89/9
HF 811D 8" 10W	£4/4	HF 126	12"	15W	£5/5/-
HF 102D 10" 10W	65/-	HF 126D	12"	15W	£5/15/-
HF 100D 10" 15W	£5/15				

AUDIOTRINE HI-FI SPEAKER SYSTEMS

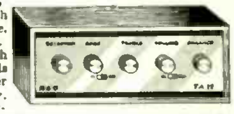
Consisting of matched 12in. 11,000 line 15 watt 15 ohm high quality speaker, cross-over unit and tweeter. Smooth response and extended frequency range ensure surprisingly realistic reproduction. **£5.15.0**
Or SENIOR 15 watt inc. HF 126 15,000 line Speaker £6/15. Carr. 6/6. Carr. 5/9

HI-FI 'SPEAKER ENCLOSURES

Teak or Afrormosia veneer finish. Modern design. Acoustically lined. Prices inc. carr.
JE8 Size 16 × 11 × 9in. Pressurised. Gives pleasing results with any 8in. Hi-Fi speaker. **£4.14.6**
SE8 For optimum performance with any 8in. Hi-Fi 'speaker. 22 × 15 × 9in. Ported **£5.15.0**
SE10 For outstanding results with Hi-Fi 10in. speaker. 24 × 15 × 10in. Ported **£5.19.9**
SE12 For high performance with 12in. Hi-Fi speaker and Tweeter. Size 25 × 16 × 10½in. Pressurised. **£6.19.9**

RSC TA12 Mk II 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. —2dB ★ Harmonic Distortion 0.3% at 1000 c.p.s. Hum and Noise —70dB ★ Sensitivities (1) 300 mV (2) 50 mV (3) 100 mV (4) 2 mV ★ Handsome brushed silver finish Facia and Knobs. Output rating I.H.F.M. Complete kit of parts with full wiring diagrams and instructions. **13½ GNS.** Carr. 7/9. Factory built with 12 mth. gntee. **17 GNS.** Or Dep. £5/2/6 and 9 mthly pymts. 34/- (Total £20/8/6). Or in Teak or Afrormosia veneer housing 20½ GNS. or Dep. £5/10/6 and 9 mthly. pymts. £2/1/7 (Total £24/4/9).

HIGH FIDELITY LOUDSPEAKER UNITS

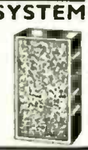
Cabinets of latest styling Satin Teak or Afrormosia veneer. Acoustically lined or filled with woollen damping material. Ported where appropriate. Credit terms available.

DORCHESTER Size 16 × 11 × 9in. Appr. Range 45-15,000 c.p.s. Rating 8-10 watts. Fitted High flux 13 × 8in. Dual cone speaker. Impedance 3 or 15 ohms. **£8.19.9** Carr. 7/6

STANWAY II Size 20 × 10½ × 9½in. Rating 10 watts. Incorporating Fane 13 × 8in. speaker with rubber cone surround and 11,000 line magnet. High flux tweeter. Handsome Scandinavian design cabinet. Range 35-20,000 c.p.s. Impedance 15 Ω. Gives smooth realistic sound output. Inc.carr. **16Gns.**

GLOUCESTER Size 25 × 16 × 10in. 12in. High flux 12,000 line speaker. Cross-over unit and Tweeter. Rating 10 watts. Frequency range 40-20,000 c.p.s. Impedance 15 ohms. **12½ Gns.**

THE 'YORK' HIGH FIDELITY 3 'SPEAKER SYSTEM



•Moderate size approx. 25 × 14 × 10 in. •Range 30-20,000 Complete kit. c.p.s. Impedance 15 ohms. • Performance comparable with units costing considerably more. Consists of (1) 12 in. 15 watt Bass unit with cast chassis. Roll rubber cone surround for ultra low resonance, and ceramic magnet. (2) 3-way quarter section series cross-over system. (3) 8 × 5in. high flux middle range speaker (4) High efficiency tweeter. (5) Woollen acoustic damping material. (6) Teak veneered cabinet. (7) Circuit and full instructions. **20 Gns.**
REMARKABLE VALUE HEAR IT AT ANY BRANCH

R.S.C. BATTERY/MAINS CONVERSION UNITS

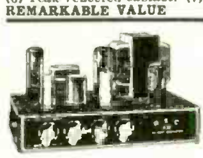
Type BM1. An all-dry battery eliminator. Size 5½ × 4½ × 2in. approx. Completely replaces batteries supplying 1.5 v. and 90 v. where A.C.mains 200/250 v.50 c/s. is available. Complete kit with diagram 52/6 or, Ready for use, 3 GNS.

SELENIUM RECTIFIERS
F.W. Bridged 6/12v. D.C. Output Input Max. 18v. A.C. 1a., 4/3; 1½a., 5/6; 2a., 6/11; 3a., 9/9; 4a., 12/9; 6a., 15/9.

R.S.C. TA6 6 Watt HIGH FIDELITY SOLID STATE AMPLIFIER

200-250v. A.C. mains operated Frequency Response 30-20,000 c.p.s. —2dB. Harmonic Distortion 0.3% at 1,000 c.p.s. Separate Bass and Treble 'lift' and 'cut' controls. 3 input sockets for Mike, Gram, Radio or Tape. Input selector switch. Output for 3-15 ohm speakers. Max. sensitivity 5mV. Output rating I.H.F.M. In fully enclosed enamelled case, 9½ × 2½ × 5½in. Attractive brushed silver finish facia plate 10½ × 3½in. and matching knobs. Complete kit of parts with full wiring diagrams and instructions. Or factory built with 12 months' guarantee. £8.19.9. **7 Gns.** Carr. 7/6.

R.S.C. A10 30 WATT ULTRA LINEAR HI-FI AMPLIFIER



Highly sensitive. Push-Pull high output, with Pre-amp./Tone Control Stages. Performance figures: Hum level —70dB. Frequency response ±3dB 30-20,000 c/s. Sectionally wound output transformer. All high grade components. Valves EF86, EF86, ECC83, 807, 807, GZ34. Separate Bass and Treble Controls. Sensitivity 36 millivolts. Suitable for High Impedance mic. or pick-ups. Designed for Clubs, Schools, Theatres, Dance Halls or Outdoor Functions, etc. For use with Electronic Organ, Guitar, String Bass, etc. Gram, Radio or Tape. Reserve L.T. and H.T. for Radio Tuner. Two inputs with associated volume controls so that two separate inputs such as Gram and "Mike" can be mixed. 200-250 v., 50 c/s. A.C. mains. For 3 and 15 ohm speakers. Complete Kit parts wiring diags., instructions. Twin-handled perforated cover 27/6. Or factory built with EL34 output valves and 12 months' guarantee for 18 gns. Tech. figs. apply to factory built units. Carr. 12/6. **15 Gns.**
TERMS: Deposit £6.3.0 and 9 monthly payments of 34/- (Total £21/9/0.) Send S.A.E. for leaflet.

INTEREST CHARGES REFUNDED On Credit Sales settled in 3 months.

R.S.C. A11 HIGH FIDELITY 12-14 WATT AMPLIFIER

Push-pull ultra linear output "built-in" tone control pre-amp. Two input sockets with associated controls allowing mixing of "mike" and gram, etc. etc. High sensitivity. 5 valves—ECC83 (2), EL84 (2), EZ81. High quality sectionally wound output transformer. IND. BASS AND TREBLE CONTROLS. Frequency response ±3dB 30-20,000 c/s. Hum level—60dB. SENSITIVITY 40 millivolts. For Crystal or Ceramic PUs. High Impedance "mikes". For Musical Instruments such as String Bass, Electronic Guitars, etc. Size approx. 12 × 9 × 7in. For AC mains 200-250v. 50 cps. Output for 3 and 15 ohm spkrs. S.A.E. for leaflet. Complete kit **9½ Gns.**
Full instructions and point-to-point wiring diagrams. Carr. 11/6 (or factory built 12½ Gns.) Twin handled metal cover 27/6. Terms on assembled units. Deposit 99/6 and 9 monthly payments of 23/-. (Total £15/6/6. RSC A11T transistorised version of above complete kit 9 Gns. (Assembled 13 gns.)

R.S.C. COLUMN SPEAKERS

Covered in two-tone Rexine/Vynair. Ideal for vocalists and Public Address. 15 ohm matching. TYPE C57 15 watts inc. five 7 × 4in. spkrs. £7/19/11. TYPE C48S, 30 watts. Fitted four 8in. high flux 8 watt speakers. Overall size approx. 42 × 10 × 5in. 16 Gns. Or deposit 67/- and 9 mthly pmts. 34/9 (Total £18/19/9). Carr. 10/-.
TYPE C412S, 50 watts. Fitted four 12in. 11,000 lines 15 watt speakers. Overall size 56 × 14 × 9in. approx. 26 Gns. Or deposit £5/17/6 and 9 monthly payments Carr. 15/- of 54/6 (Total £30/7/-).

R.S.C. MAINS TRANSFORMERS

FULLY GUARANTEED. Interleaved and Impregnated. Primaries 200-250 v. 50 c/s. Screened

MIDGET CLAMPED TYPE 2½ × 2½ × 2½in.

250 v., 60 mA. 6.3 v. 2 a.	17/11
250-0-250v., 60mA. 6.3v. 2a.	18/11

FULLY SHROUDED UPRIGHT MOUNTING

250-0-250v. 60mA., 6.3v. 2a., 0-5-6.3v. 2a.	24/9
250-0-250v. 100mA. 6.3v. 4a., 0-5-6.3v. 3a.	39/9
300-0-300v. 100mA. 6.3v. 4a., 0-5-6.3v. 3a.	39/9
300-0-300v. 130mA. 6.3v. 4a., c.t., 6.3v. 1a. For Mullard 510 Amplifier	47/11
350-0-350v. 100mA., 6.3v. 4a., 0-5-6.3v. 3a.	39/9
350-0-350v. 150mA. 6.3v. 4a., 0-5-6.3v. 3a.	47/9
425-0-425v. 200mA. 6.3v. 4a. c.t., 5v. 3a	89/9
425-0-425v. 200mA. 6.3v. 4a., 6.3v. 3a. 5v. 3a	93/9
450-0-450v. 250mA. 6.3v. 4a., ct., 5v. 3a.	99/9

TOP SHROUDED DROP-THROUGH TYPE

250-0-250v. 70mA. 6.3v. 2a., 0-5-6.3v. 2a.	23/9
250-0-250v. 100mA, 6.3v. 3.5a.	27/9
250-0-250v. 100mA. 6.3v. 2a., 6.3v. 1a.	28/9
350-0-350v. 80mA. 6.3v. 2a., 0-5-6.3v. 2a	29/11
250-0-250v. 100mA. 6.3v. 4a., 0-5-6.3v. 3a.	39/9
300-0-300v. 100mA. 6.3v. 4a., 0-5-6.3v. 3a.	39/9
300-0-300v. 130mA. 6.3v. 4a., 0-5-6.3v. 1a. Suitable for Mullard 510 Amplifier	46/9
350-0-350v. 100mA., 6.3v. 4a., 0-5-6.3v. 3a.	39/9
350-0-350v. 150mA., 6.3v. 4a., 0-5-6.3v. 3a.	46/11

FILAMENT or TRANSISTOR POWER PACK Types 6.3 v. 1.5a. 8/9; 6.3v. 2a. 9/9; 6.3v. 3a. 13/9; 6.3v 6a. 22/9; 12v. 1a. 9/11; 12v. 3a. or 24v. 1.5a. 23/9; 0-9-18v. 1½a. 19/11; 0-12-25-42v. 2a. 31/9.

CHARGER TRANSFORMERS 0-9-15v. 1½a. 18/9; 2½a 19/11; 3a. 21/11; 5a. 25/11; 6a. 29/9; 8a. 36/9.

AUTO (Step UP/Step DOWN) TRANSFORMERS

0-110/120v.-200-230-250v. 50-80 watts	19/9
150 watts, 33/6; 250 watts 49/9; 500 watts	105/-

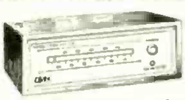
OUTPUT TRANSFORMERS

Standard Pentode 5,000Ω or 7,000Ω to 3Ω	8/9
Push-Pull 8 watts EL84 to 3Ω or 15Ω	14/9
Push-Pull 10 watts 6V6 ECL86 to 3, 5, 8 or 15Ω	24/9
Push-Pull EL84 to 3 or 15Ω 10-12 watts	23/9
Push-Pull Ultra Linear for Mullard 510, etc.	39/9
Push-Pull 15-18 watts, sectionally wound 6L6 KT66, etc., for 3 or 15Ω	35/9
Push-Pull 20 watt high quality sectionally wound EL34, 6L6, KT66, etc. to 3 or 15Ω	59/9

SMOOTHING CHOKES
150mA. 7-10H. 250Ω 12/9; 100mA. 10H. 200Ω 10/9; 80mA. 10H. 350Ω. 8/9; 60mA. 10H. 400Ω 4/11.

R.S.C. TFM1 SOLID STATE VHF/FM RADIO TUNER

Total cost of parts with detailed wiring diagrams and instructions. **14 Gns.** Inc. Carr. Or factory built 16½ gns. Or in Teak finished cabinet as illustrated 19½ gns. Terms: Deposit £5 and 9 monthly payments £2. Total £23.



★ High-sensitivity ★ 200-250v. A.C. Mains operation. ★ Sharp A.M. Rejection. ★ Drift-free reception. ★ Output ample for any amplifier (approx. 500 m.v.). ★ 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 and reliability. The pre-wired tuning head facilitates speed and simplicity of construction. Printed circuitry. Only high grade transistors and components used. A quality product at considerably less than the cost of comparable units. Stereo version. All parts 20 gns. Inc. Carr. Assembled 22½ gns. Inc. Carr.

High Quality LOUDSPEAKERS

In teak or afrormosia veneered cabinets. L13 13" × 8" 10 Watt Model. Gauss 10,000 lines. 3 or 15 ohms. **£4/19/9** Carr. 7/6
L12 12" 20 Watt Model. 15 ohm. Size 18 × 18 × 10in. Gauss 10,000 lines. Rexine. covered 10/- extra. Carr. 8/9 **£8/19/9**

TWO-WAY 'PHONE AMPLIFIER

Listen and speak with both hands free. Handsome black case. Battery operated. **59/9**

R.S.C. SUPER 30 MkII HIGH FIDELITY STEREO AMPLIFIER

HIGH GRADE COMPONENTS. SPECIFICATIONS COMPARABLE WITH UNITS COSTING CONSIDERABLY MORE

Employing Twin Printed Circuits 200/250v. A.C. mains operation.
TRANSISTORS: 9 high-quality types per channel.
OUTPUT: 10 Watts R.M.S. continuous into 15 Ω (Per channel) 15 Watts R.M.S. continuous into 3 Ω
INPUT SENSITIVITIES: Mag. P.U. 4 m.v. Ceramic P.U. 35 m.v. Tape Amp. 400 m.v. Aux. 100 m.v. Mic. 5 m.v. Tape Head 2.5 m.v.
FREQUENCY RESPONSE: ±2dB. 10-20,000 c.p.s.
TREBLE CONTROL: +17 dB to —14 dB at 10 Kc/s.
BASS CONTROL: +17 dB to —15 dB at 50 c/s.
HUM LEVEL: —80 dB.
HARMONIC DISTORTION: 0.1% at 10 Watts 1,000 c.p.s.
CROSS TALK: 52 dB at 1,000 c.p.s.

CONTROLS: 5-position Input Selector, Bass, Treble, Vol., Bal., Stereo/Mono Sw., Tape Monitor Sw., Mains Sw.
INPUT SOCKETS: (1) P.U. (2) Tape Amp. (3) Radio (4) Mic. or Tape Head. (Operation of Input Selector assures appropriate equalisation.)
CHASSIS: Strong Steel construction. Approx. 12 × 3 × 8 in.
FACIA PLATE: Attractive design in rigid Perspex. Spun silver matching control knobs as available.

COMPLETE KIT OF PARTS, point to point wiring diagrams and detailed instructions. **22Gns.** Carr. 15/-.

EMINENTLY SUITABLE FOR USE WITH ANY MAKE OF PICK-UP OR MIC. (Ceramic or Magnetic Moving Coil, Ribbon or Crystal.) CURRENTLY AVAILABLE. SUPERB SOUND OUTPUT QUALITY CAN BE OBTAINED BY USE WITH FIRST-RATE ANCILLARY EQUIPMENT. Unit factory built 28 Gns. or Deposit £7/5/- and 9 mthly. payments 56/3 (Total £32/11/3) or in Teak or Afrormosia veneer housing 31 Gns. Carr. 15/-. Terms: Deposit £7/3/6 and 9 mthly. payments 64/- (Total £35/19/6.) Send S.A.E. for leaflet.

R.S.C. SUPER 15 HIGH FIDELITY AMPLIFIER

Solid state. Approx. as Super 30 but single channel. Complete kit with full constructional details and point to point wiring diagrams. **12½ Gns.** Carr. 12/6. Or factory built: 15½ Gns., Carr. 12/6. Terms: Deposit 4 Gns. and 9 monthly payments 31/1 (Total £18/3/9); or in Teak or Afrormosia veneered housing 19 Gns.

Record Playing Units

MONEY SAVING UNITS Ready to plug into Amplifier.

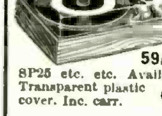
RP2C Consisting of Garrard SP25 Mk. II (with heavy turntable fitted Goldring CS90 high compliance ceramic Stereo/Mono cartridge with diamond stylus. Mounted on plinth. Transparent plastic cover included. **23Gns.** Inc. carr.

RP3C As above but with Goldring Lenco GL68 Transcription unit and CS90 Cartridge. Cover included. Inc. carr. **28Gns.**

Various other types with Magnetic P.U. Cartridges and 'Lift off' or 'Roll over' transparent covers at lowest prices.

R.S.C. PLINTHS

for Record Playing units. Cut for Garrard 1025, 2025, 3000, AT60, SP25 etc. etc. **59/9** Available with Transparent plastic cover. Inc. carr. **6 Gns.**



1 WATT TRANSISTOR AMPLIFIERS
Miniature size battery operated For 3-5 Ω L/speakers. Brand new boxed. 37/9

BRADFORD 10 North Parade (Half-day Wed.). Tel. 25349
BLACKPOOL (Agent) O & C Electronics 227 Church St.
BIRMINGHAM 30/31 Gt. Western Arcade. Tel.: 021-236 1279. Half-day Wed.
DERBY 26 Osmaston Rd. The Spot (Half-day Wed.). Tel. 41361
DARLINGTON 18 Priestgate (Half-day Wed.). Tel. 68043
EDINBURGH 133 Leith St. (Half-day Wed.). Tel. Waverley 5766
GLASGOW 326 Argyle St. (Half-day Tues.). Tel. CITy 4158
HULL 91 Paragon Street (Half-day Thurs.). Tel. 20505

R·S·C HI-FI CENTRES LTD.

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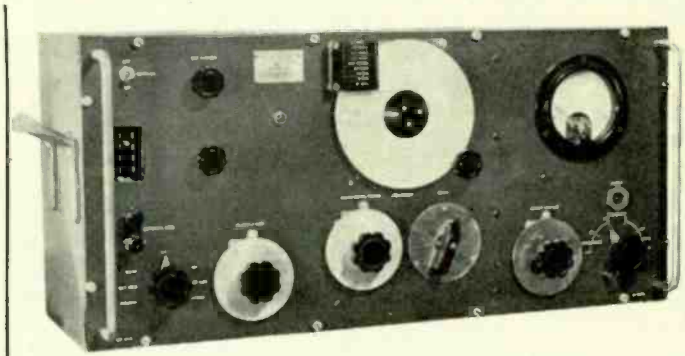

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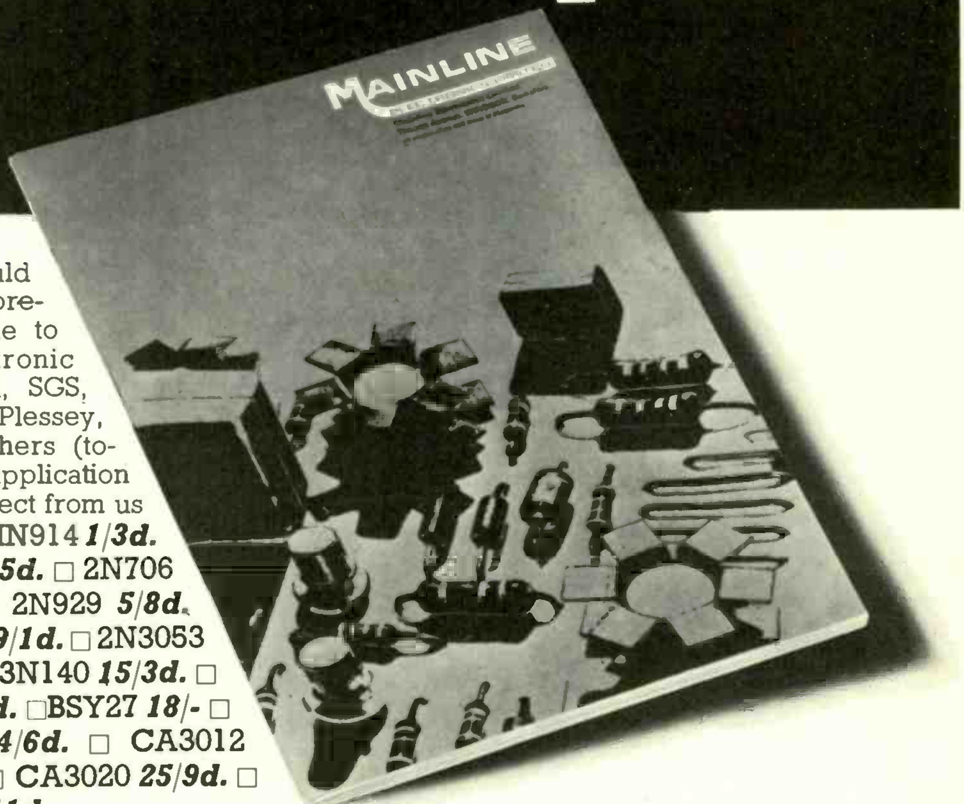

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872A 57/6
931A 72/6
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2050 15/-
5644 40/-
5651 7/3
5654 8/-
5672 7/-
5687 10/-
5691 25/-
5694 30/-
5702 15/-
5749 10/-
5763 12/-
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6060 6/-
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6062 14/-
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6146 27/6
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18115 4/6
18131 4/3
2152 4/3
2G210 12/6
2G381 5/-
2G382 6/-
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ACY20 5/-
ACY21 6/-
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AF117 7/-
BY100 5/6
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NKT404 12/6
NKT675 6/-
NKT677 5/-
NKT713 7/6
OC16 20/-
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OC20 15/-
OC24 15/-
OC25 11/-
OC26 7/6
OC28 16/-
OC29 15/-
OC35 11/6
OC44 4/6
OC45 4/-
OC71 4/6
OC72 6/-
OC74 6/-
OC75 6/-
OC76 6/-
OC77 8/-
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OC81D 4/-
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OC82D 6/-
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3DP1 40/-
3EG1 65/-
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3GP1 40/-
5BP1 80/-
5CP1 55/-
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CV1526 40/-
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E4504/B/16 76/-
ECR30 35/-
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VCR97 35/-
VCR138 50/-
VCR138A 50/-
VCR139A 35/-
VCR516 80/-
VCR517A 46/-
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Valves tested and released to A.R.B. specification if required.

Express postage 9d. per valve.
Ordinary postage 6d. per valve.
Over £5 postage free.
Tel. 01-769 0199/1649

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9 a.m.—5.30 p.m.
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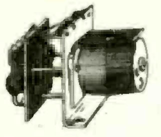
Complete range of TV Tubes available from £4.5.0.

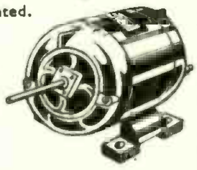
SEND S.A.E. FOR LIST of 6,000 TYPES

Electro-Tech Sales

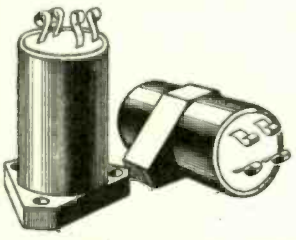
Motor Driven Variable Voltage Transformers by Ohmite (U.S.A.). Input 120/240v., 50/60. c.p.s. Output 0-240v. at 480 v.a A reversible 115v. a.c. geared motor drives the contact sweep arm in the direction required. There is a micro switch mounted at each end of the track which is cam-operated and intended to be connected as a safety-stop. First class condition. £8.15.0. Carriage 15/-.



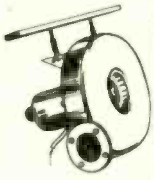
New "Croydon" 1/50th HP, cont. rating 240v. A.C. motor, 1500 RPM, foot mounted. Size: 3⅜" high × 5" long + spindle length 1⅛"×½" dia. A really beautiful motor at less than half maker's original price. £6.10.0 each. P. & P. 5/-.



MINIATURE "LATCHMASTER" RELAY
6, 12, or 24v. D.C. operation. One make one break, contacts rated 5 amps at 30 volts. Once current is applied, relay remains latched until input polarity is reversed. Manufactured for high acceleration requirements by Sperry Gyroscope Co. Size: Length ⅞", dia. 9/16" (including mount). Actual size as illustrated. Please state vertical or horizontal mount and voltage. £3.10.0 each. P. & P. free.



Brand new "Discus" Centrifugal Blower by Watkins & Watson, 240v. A.E.I. motor, cont. 2,850 r.p.m., overall diam. 10", outlet flange 2" I.D. additional coupling mounting flange supplied. Limited supply. £9.10.0. Carriage £1.0.0.



Victoreen "Hi-Meg" Resistors. One value only 50,000 meg ± 2%, glass encapsulated 15/- post free.

Welwyn high value Resistors Type GA 36501. Values between 9.4 and 10.9 kilo-meg ± 1%, glass encapsulated 15/- post free.

We have in stock a large, range of new laboratory equipment, Glassware and Filter Paper all below makers prices! It should pay you to pay us a visit when in our vicinity. We list here just a few selected items:

Griffin-Grundy, Incubator-Steriliser Type 1/200. Heating chamber 12" × 12" × 14" high, 2 × 300 watt elements, aluminium case, variable up to 200° C. Thermostat setting ± 0.5%, 240v., £27.10.0.

Griffin-Grundy Drying Oven. Model C2/10S. Designed to meet B.S.1377 spec. for soils drying, very useful as a general purpose drying oven. Outer casing zinc/steel in grey enamel. External size 40" × 21" × 35" high. The heated chamber constructed of compressed asbestos sheet. Internal size 36" wide 19" deep 20" high, four shelf runners, three perforated shelves supplied, heating by 6 × 300 Watt elements, thermostat setting 105°–110° C. Two doors hinged at outer edges. £97.10.0, one only.

Copper, gas heated hot air drying Ovens.

Internal size	20 × 20 × 20 cm.	£10. 0.0
	25 × 25 × 25 cm.	£11.10.0
	30 × 30 × 30 cm.	£12.10.0
Similar to above but hot water, double walled.		
	20 × 20 × 20 cm.	£15.10.0
	25 × 25 × 25 cm.	£16.15.0
	30 × 30 × 30 cm.	£18.18.0
SPEEDIVAC Vacuum Pump Type ES35		£30. 0.0
SPEEDIVAC Diffusion Pump Type E01		£25. 0.0

Roberval Balance, double pan, counter scale balances, capacity 4 lb., brass pans, 20 cm. diam. £25.0.0.

Griffin Flask Shaker. For up to eight bolthead or standard flasks 240v. AC/DC. £25.0.0.
Also in stock various centrifuges, balances, flask heaters, de-ionisers, etc.

BRAND NEW ALTERNATORS MANUFACTURED BY ENGLISH ELECTRIC CO.

Type	Motor V.	Ph.	Input C.P.S.	R.P.M.
1	220	3	50	3000
2	380/440	3	60	3600
3	115	3	60	3600
4	220	3	60	3600
5	220 D.C.			
6	110 D.C.			

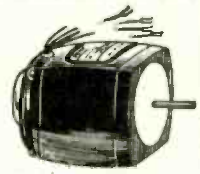
All types give the same Dual outputs as below.

V.	Ph.	C.P.S.	V.A.
115	3	400/20	50
85	1	400/20	300

£47.10.0 Each

Also in stock several types of heavier duty units. Full Details upon request.

NEW HYSTERESIS MOTORS BY WALTER JONES. Type 14050/12, 240v. 50 c/s 1500 RPM cont. rating, output 2.0 oz./in. Size: Length (less spindle) 3½". Width 2¾"×2½". Spindle 1"×3/16". Weight 3 lb. Maker's price in region of £22.10.0. Our price £7.15.0 each. P. & P. 5/-.



English Electric ¼ h.p. Motors. 240v. single-phase, standard foot mounted, 1,425 r.p.m., continuous rating. £4.15.0. Carriage 20/-.

Isolation Transformers. 1 to 1. 250v. input, 250v. centre tapped out, at 2 K.V.A., mounted in metal case measuring 8¾"×8¼"×11" high. Weight 65lb. £18.10.0. P. & C. 25/-.

K.L.G. Sealed Terminals. Type TLS1 AA, overall length 11/16", box of 100, 25s.
Type TLS1 BB, overall length 1", box of 100, 35s. P. & P. Free.

Mullard Geiger Muller Tubes Type MX115 (new). Max. threshold voltage 370. Min. plateau length (volts) 100. Active length 45mm. Wall thickness 375 M.G./sq. cm. Two-pin base. £3.10.0. Post free.

Dubilier Nitrogol Capacitors. 24 mfd. at 350 V.D.C. Size (approx.) 4½" high × 3"⅞ × 2¾". 10/- each. P. & P. 2/6.

Muirhead S.M. Drive Type B902C. 3" dia. (not calibrated). 180 deg. sweep. 10/- each. P. & P. 1/6.

Berco Rotary "Regavolt," variable voltage transformers input 240v. 50/60 cps., output 120-0-120v. at 6 amps. Not new, but in 1st class condition. Few only, £9.10.0. P. & C. 10/-.

Gardner Transformer Type I.T.N. 876 (new). Enclosed in ventilated metal case. Prim 200/250, sec. 2× 12v. windings rated 4 amps each (96 v.a. in series/parallel). £3.2.6. P. & P. 7/6.

American "Powerstat" Variable Voltage Transformer by Superior Electric Co. Input 120v. 50/60 c.p.s. Output 0–120v. at 2·25 amps. ¼" spindle with alternative pre-set locking device, Size (approx.) 3" dia. × 2" long. First class condition. £2.15.0. P. & P. 5/-.

Mallory Tubular Capacitor, with mounting clip. 1,000 mfd. 45 V.D.C. Size 2½" long by 1⅛" dia. 7/6 each. P. & P. 1/6.

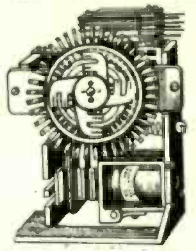
S.T.C. Midget Relay Type 4190 GC. (new). 2 change-overs, 12v. 40 m.a. coil (170 ohms). 10/6 each. P. & P. 1/6.

Jackson Air-Spaced Trimmers Type C803. Pre-set locking type, ceramic end-plate, 2-hole fixing. 3–10 p.f., 2/6. 4–20 p.f., 2/6. 4–60 p.f., 4/-. 5–100 p.f., 4/-. (Minimum order any 4 pieces.) P. & P. 1/6.

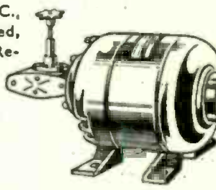
Advance Constant Voltage Transformer (new). Input 190–260v. Output volts 12 R.M.S. at 50 v.a. £4.19.6. Carriage 10/-.

Robust M.E.S. Dual-circuit Panel Lamp by Thorne, adjustable length with press-to-test dome. 1" fixing hole. Available red, green, amber. 10/6 each. P. & P. free.

SCHRACK ROTARY STEPPING RELAY RT304
48v. coil (28 ohm). The relay has 48 basic segments shorted in step by the 4 sweep contacts to 4 pole-plates (banks of 12). There are 2 secondary switches: (1) one c/o H/Duty contact set which changes over and back with each step; (2) two H/Duty changeovers which changeover on each 12th step and return on the following pulse. Size: Base 3½"×1⅞"×4½" high. New in maker's packing, limited supply, also few only, as above, but 110v. (1,290 ohm coil), £6.10.0 each. P. & P. free.

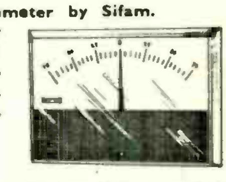


"Parvalux" Reversible 100 RPM Geared Motor Type S.D.14, 230/250v. A.C., 22 lb./in. Standard foot mounted, variable angle final drive. Removable 9-tooth chain spiggot on 3/16" spindle. 1st class condition. £7.10.0 each. P. & P. 10/-.



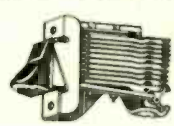
Precision Motor-driven Potentiometer By "Precision Line" (U.S.A.). Continuous track with 2 platinum contact wipers set at 90° C.W. resistance 300 ohm only, ± 5% LIN ±0·5%, ball bearing spindle column. Size: dia. 1 13/32", height 1 1/32", spindle length 11/32" by ⅛" dia. These potentiometers were purchased by the importer at a cost of approx. £25 each. Our price £6.15.0 each. P. & P. free

New 75-0-75 Micro-ammeter by Sifam.
750 ohm movement, clear reading, 5μa divisions × ⅛"; plastic front, projection ⅛" (tapering forward). Size: 4⅜"×3⅞". 57/6 each. P. & P. 2/6.

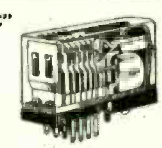


MINIATURE B.P.L. 500-0/500 Micro-Ammeter. 13/16" Diam. scale. Through-Panel mounting. 45/-. P. & P. free.

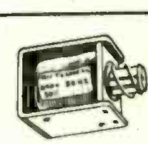
New beautifully-made 3 change-over **Key-Switch.** Neat action, either locking or spring-return, as required determined by reversing fixing-plate. Attractive plastic prestle. Available red, green, grey, cream. Limited number only. 17/6 each. P. & P. 1/6.



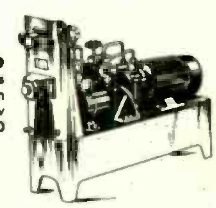
"AUTOMATIC ELECTRIC" ENCLOSED RELAYS
6v. 50Ω 2 c/o, 14/6
24v. 470Ω 4 c/o, 15/6
48v. 2,780Ω 4 c/o, 15/6
48v. 1,260Ω 6 c/o, 18/6
P. & P. free.



New "Magnetic Devices" solenoid 240v. A.C. Type 42117, 1 to 3 lb. pull, frame size 1⅛"× 1¼"×1". 20/- each. P. & P. free.



VICKERS-SPERRY-RAND Hydraulic Power Units as illustrated. Full details upon request. Approx. 60% below makers price at £150.0.0 each.



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AMPLIFIERS

	Rec. Retail Price	Discount Price
ARENA F210 2×10 watts Stereo Amplifier teak case	£34 13 0	£29 10 0
PHILIPS RH580 stereo amplifier magnetic input	£26 0 0	£21 5 0
DULCI 207M as above but accepts magnetic cartridge	£30 0 0	£21 15 0
GOODMANS Maxamp teak or walnut	£54 0 0	£42 15 0
LEAK Stereo 30 plus chassis model	£53 0 0	£43 10 0
LEAK Stereo 30 plus teak cased	£59 10 0	£48 12 6
LEAK Stereo 70 chassis model	£63 0 0	£50 15 0
LEAK Stereo 70 plus teak cased	£69 10 0	£55 15 0
NIKKO TRM 40B	£46 10 0	£39 10 0
NIKKO TRM 120	£95 0 0	£84 10 0
ROGERS RAVENSBOURNE teak cased	£64 0 0	£54 10 0
ROGERS RAVENSBROOK chassis model	Limited Quantity	£34 10 0
ROGERS RAVENSBROOK in teak case	£46 10 0	£39 10 0
SANSUI AU 222	£62 17 7	£56 10 0
SANSUI AU 555	£80 9 7	£69 10 0
TRUVOX TSA200 teak cased	£54 12 0	£45 0 0
ROGERS Cadet Mark III teak cased	£37 10 0	£34 10 0
QUAD 33 Control Unit and 303 Power Amplifier	£98 0 0	£92 10 0
TELETON 203E	£28 7 6	£22 10 0

FM TUNERS

	Rec. Retail Price	Discount Price
ARENA F211 with Decoder	£39 18 0	£34 15 0
DULCI FMT7 Mono tuner	£22 1 0	£18 10 0
DULCI FMT7S Stereo tuner	£29 8 0	£23 10 0
GOODMANS Stereomax teak stereo tuner	£82 10 5	£70 10 0
LEAK Stereo Troughline tuner chassis mounting	£51 10 6	£39 10 0
LEAK Stereo Troughline teak cased	£59 13 10	£48 10 0
QUAD Stereo Tuner	£51 0 0	£45 15 0
TRUVOX FM200 less Decoder	£37 12 11	£32 10 0

TUNER AMPLIFIERS

	Rec. Retail Price	Discount Price
ARENA T1500 teak only	£64 1 0	£57 10 0 (add 7 gns. for decoder)
ARMSTRONG 425	£79 14 9	£71 10 0
ARMSTRONG 426	£88 19 0	£79 10 0
B & O Beomaster 1000	£101 15 0	£94 10 0
GOODMANS 3000	£77 14 7	£67 10 0 (with decoder)
NIKKO FAM 12F	£68 8 3	£59 10 0
NIKKO ST 701	£136 3 11	£120 0 0
SANSUI 350	£129 1 10	£114 10 0
SANSUI 2000	£162 3 0	£147 10 0
SANYO DC60 2×30 watts rms	£99 0 0	£89 10 0 (with decoder)
TELETON F2000 2×5 watts rms	£51 19 0	£43 10 0 (with decoder)
TELETON R8000 Tuner/Amplifier with 2 speaker enclosures	£70 19 0	£49 10 0 (with decoder)

SPEAKERS

(Prices quoted for single speaker unless otherwise specified)

	Rec. Retail Price	Discount Price
ARENA HT14 bookshelf type in teak	£14 3 0	£12 10 0
ARENA HT10 teak or rosewood	£19 19 0	£17 10 0
CELESTION Ditton 10	£21 13 1	£17 15 0
CELESTION Ditton 15	£31 3 7	£26 5 0
GOODMANS Maxim	£20 15 6	£16 15 0
GOODMANS Marimba	£24 0 5	£19 15 0
GOODMANS Mezzo II	£30 18 0	£25 10 0
GOODMANS Magnum K	£40 2 0	£29 15 0
LEAK Sandwich	£43 10 0	£37 10 0
LEAK Mini Sandwich	£29 15 0	£25 5 0
LOWTHER Accousta PM6	£45 10 0	£40 10 0
LOWTHER Accousta PM7	£55 10 0	£50 10 0
KEF Cresta	£22 3 7	£18 10 0
KEF Celeste	£29 0 0	£25 0 0
KEF Concord	£43 10 0	£37 10 0
KEF Concerto	£53 10 0	£45 0 0
QUAD Electrostatic	£66 0 0	£59 10 0
WHARFEDALE Denton per pair	£33 12 0	£29 10 0
WHARFEDALE Super Linton per pair	£42 0 0	£37 10 0
WHARFEDALE Dovedale III	£39 10 0	£32 19 6
WHARFEDALE UNIT 3 Speaker Kit	£10 17 6	£9 5 0

PLAYING DECKS

	Rec. Retail Price	Discount Price
GARRARD 401	£31 14 2	£27 0 0
GARRARD AP75	£23 16 7	£17 15 0
GARRARD SP25 Mark II	£15 11 11	£11 5 0
GARRARD SRP22	£6 12 10	£5 10 0
GARRARD SL95	£45 9 1	£34 10 0
GARRARD SL75	£35 12 5	£30 10 0
GARRARD SL65	£18 8 4	£14 17 6
GARRARD SL55	£13 17 9	£11 12 6
GARRARD 60 Mark II	£17 5 10	£14 19 6
GARRARD 3500	£12 4 10	£10 19 6
GARRARD 2025 T/C	£11 3 11	£10 10 0
GARRARD 1025	£10 6 2	£9 10 0
GOLDRING GL68	£22 7 2	£17 15 0
GOLDRING GL75	£35 15 5	£28 15 0
GOLDRING GL75P	£46 18 8	£37 10 8
THORENS TD150	£29 8 1	£26 10 0
THORENS TD150A	£35 14 6	£31 10 0
THORENS TD150AB	£39 16 9	£35 10 0
THORENS TD125	£63 4 9	£54 5 0

Plinths, tops and accessories of above available at 10% discount on retail price.

STEREO CARTRIDGES

	Rec. Retail Price	Discount Price
AUDIO TECHNICA AT66	£6 6 0	£5 10 0
SHUR M3DM	£7 8 3	£6 2 6
SHURE 31E	£12 19 5	£11 10 0
SHURE 32E	£12 0 11	£10 15 0
SHURE 55E	£16 13 6	£13 19 0
SHURE 44E	£14 16 6	£12 19 6
SHURE M75E	£25 18 10	£23 5 0
SHURE V13 Mk II	£40 15 3	£35 0 0
GOLDRING CS90	£5 4 0	£4 2 6
GOLDRING 800	£13 0 0	£11 12 6

STEREO TAPE DECKS AND RECORDERS

	Rec. Retail Price	Discount Price
AKAI Model 4000D 3-head stereo tape deck	£99 19 6	£84 10 0
AIWA TP 1011 professional stereo 3 head tape deck	£164 6 0	£139 10 0
SANYO MR910 4 track stereo tape recorder	£83 10 0	£74 10 0
SANYO MR929 4 track stereo tape recorder, 2 detachable speakers	£100 16 0	£89 10 0
SANYO MR801 stereo tape deck	£79 0 0	£67 10 0
REVOX model 1104 4-track tape deck	£187 19 0	£169 10 0
GRUNDIG TK247 de-luxe stereo tape recorder	£139 18 9	£102 10 0

MONAURAL MAINS TAPE RECORDERS

	Rec. Retail Price	Discount Price
GRUNDIG TK120 continental twin-track tape recorder	£39 5 0	£29 10 0
GRUNDIG TK144 4-track tape recorder	£47 13 1	£41 10 0
GRUNDIG TK149 Automatic 4-track tape recorder	£55 18 10	£49 10 0
PHILIPS 4307 4-track tape recorder	£48 11 0	£41 10 0
PHILIPS 4308 2-speed 4-track tape recorder	£60 0 10	£51 10 0

COMPLETE HI-FI SYSTEMS

	Rec. Retail Price	Discount Price
PHILIPS GF818 Philips autochange player, integrated 2×4 watts amplifier, 2 separate speakers, all in teak finish	£51 9 0	£45 0 0
RADON 404 SYSTEM Garrard SP25, separate 2×8 watt amplifier, 2 bookshelf type speakers teak or blond oak	£57 4 0	£49 10 0
WINDSOR 1500 Garrard 2025 T/C, integrated 2×4 watt amplifier, 2 separate speakers, all finished in teak	£57 15 0	£49 19 6
TOSHIBA SOPHIA Transcription turntable, magnetic cartridge, integrated tuner amplifier, with stereo decoder, fitted hinged perspex top, 2 separate speakers, walnut finish	£82 19 0	£75 0 0
SANYO DC534E Transcription turntable, magnetic cartridge, integrated tuner/amplifier, 2×12 watts rms, decoder, fitted hinged perspex top	£132 10 0	£119 10 0
Matching SANYO SX/X speakers per pair	£37 16 0	£32 10 0

All goods are in manufacturer's sealed cartons and are insured against loss or damage in transit. **Guaranteed "by return" service.** *Add 7/6 to all orders for p. & p. Send cash/cheque with order. Personal Callers Welcome—Business Hours.*

SMITH'S RADIO SERVICE (Wolverhampton) LTD.

Mail Order Department, 26 Victoria Street, Wolverhampton, Staffs. Tel: Wolv. 29246

THERE ARE GEMS IN IRELAND

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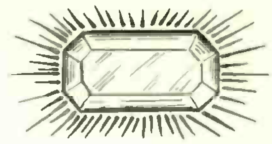
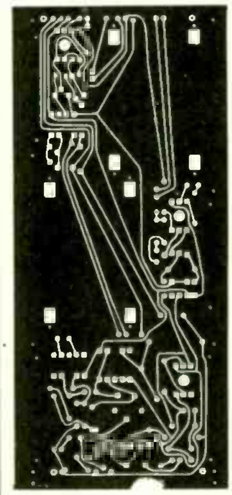


THIS is another



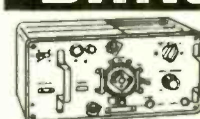
IF YOU WANT A REAL GEM CONTACT

TECLARE LTD

ENNIS, CO. CLARE. Phone: 21559

AFTER ALL, WE'RE IN THE EMERALD ISLE

SURPLUS (EX GOVT.) BARGAINS

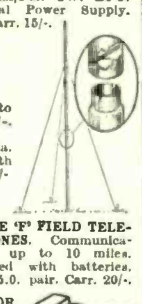


AMPLIFIER RF No. 2 MK III. Increases output of 19 set to 25 watts. Brand New. 12v operation. 75/-. Carr. 15/-. No. 19 Sets and Ancilliary Equipment Available. 12v D.C. Power Units 50/-. Carr. 10/-. 12/24v D.C. Power units with Vibrator Mk. II No. 2 70/- Carr. 10/-. **H/MIC SETS.** Used 15/-. New 22/6. P & P 5/-. Mains P.S.U.'s for 19 TM/RC £6.15.0. Carr. 10/-. R.F. Antenna Tuner (ATU) 25/-. P. & P. 5/-.

COLLINS TCS RECEIVER. 7 valve Int. Octal Covers 1.5-12 Mc/s Tuneable RF.AF.BFO. Power required 240v D.C. 80 MA 12v 1.25A. £8.10.0. Carr. 15/-. **CR 100 RECEIVERS.** Amateur Shipping Broadcast. 60Kc/s-30Mc/s A.C. or D.C. Mains operation. Fully tested. £23.10.0. Carr. 50/-.

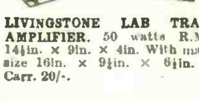
B.41 RECEIVER LF Version of B.40. Coverage 15Kc/s-700Kc/s. Mains Operation. As new £8.10.0. Carr. 30/-.

R.209 MK II COMMUNICATION RECEIVERS. 11 valve. Covers 1-20 Mc/s. 4 bands. AM/FM. CW. BFO. 12v D.C. Internal Power Supply. Tested. £13.10.0. Carr. 15/-.



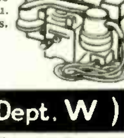
TELESCOPIC MASTS. 20ft. Closes to 5ft. 9in. 70/-. Carr. 15/-. 34ft. Ditto 80/-. Carr. 15/-.

35ft. **AERIAL MASTS.** Seven 2in. dia. sections. Interlock 8in. Complete with Base, Nylon Guys. £12.10.0. Carr. 50/-



TELE 'F' FIELD TELEPHONES. Communication up to 10 miles. Tested with batteries. £5.15.0. pair. Carr. 20/-.

LIVINGSTONE LAB TRANSISTOR AMPLIFIER. 50 watts R.M.S. Size 14½in. × 9in. × 4in. With mains p.s.u. size 16in. × 9½in. × 6½in. 22 Gns. Carr. 20/-.



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"Eiling Lodge," Codicote, Hitchin, Herts. Phone: Codicote 242
C.W.O. Carriage charges apply to mainland only.

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TRANSISTORS Brand new and fully guaranteed. PLEASE NOTE:—A large number of our transistors have now been reduced in price. Many more semi-conductors in stock. Please enquire for types not listed.

2G301	4/-
2G302	4/-
2G303	4/-
2G306	8/6
2G308	6/-
2G309	6/-
2G371	3/-
2G374	5/6
2G381	4/6
2N388A	10/6
2N404	4/6
2N696	4/6
2N697	5/-
2N698	6/-
2N699	7/-
2N706	2/6
2N706A	2/6
2N708	4/-
2N709	12/6
2N718	6/-
2N718A	6/-
2N726	5/-
2N727	5/-
2N743	4/6
2N744	4/6
2N753	5/6
2N914	3/6
2N916	3/6
2N918	6/-
2N929	5/6
2N930	7/-
2N987	10/6
2N1090	6/6
2N1091	6/6
2N1131	6/6
2N1132	6/6
2N1302	3/6
2N1303	3/6
2N1304	4/6
2N1305	4/6
2N1306	5/-
2N1307	5/-
2N1308	6/-
2N1309	6/-
2N1420	5/6
2N1507	5/6
2N1525	7/6
2N1526	7/6
2N1527	7/6
2N1605	9/6
2N1613	5/6
2N1631	8/6
2N1632	8/6
2N1637	8/6
2N1638	7/6
2N1639	7/6
2N1711	6/6
2N1889	6/6
2N1893	8/6
2N2147	14/6
2N2148	12/6
2N2160	12/6
2N2193	5/6
2N2193A	5/6
2N2194A	4/6
2N2217	6/6
2N2218	6/6
2N2219	6/6
2N2220	5/-
2N2221	5/-
2N2222	6/6
2N2287	21/6
2N2297	6/-
2N2303	5/-
2N2368	5/-
2N2369	5/-
2N2369A	5/6
2N2410	8/6
2N2411	11/-
2N2412	12/-
2N2483	5/6
2N2484	8/-
2N2539	4/6
2N2540	4/6
2N2613	7/9
2N2614	7/6
2N2645	6/-
2N2646	11/6
2N2696	6/6
2N2711	6/-
2N2712	6/-
2N2713	5/6
2N2714	6/-
2N2865	12/6
2N2904	8/-
2N2904A	8/-
2N2905	8/-
2N2905A	8/-
2N2906	6/-
2N2906A	6/-
2N2907	8/-
2N2923	4/-
2N2924	4/-
2N2925	3/6
2N2926	
Green	3/-
Yellow	2/9
Orange	2/9
2N3011	12/6
2N3014	6/6

2N3053	6/6
2N3054	12/6
2N3055	15/-
2N3133	6/-
2N3134	6/-
2N3135	5/-
2N3136	5/-
2N3390	7/6
2N3391	5/-
2N3391A	6/-
2N3392	5/-
2N3393	5/-
2N3394	5/-
2N3402	5/6
2N3403	5/6
2N3404	7/6
2N3405	9/-
2N3414	5/6
2N3415	6/6
2N3416	7/6
2N3417	9/6
2N3439	39/6
2N3440	25/-
2N3605	5/6
2N3606	5/6
2N3607	4/6
2N3662	7/6
2N3663	8/-
2N3702	3/6
2N3703	4/6
2N3704	4/6
2N3705	4/-
2N3706	4/6
2N3707	4/-
2N3708	3/6
2N3709	3/6
2N3710	4/-
2N3711	4/-
2N3819	9/-
2N3820	21/6
2N3823	17/6
2N3854	5/6
2N3854A	5/6
2N3855	5/6
2N3855A	6/-
2N3856	6/-
2N3856A	6/-
2N3858	5/-
2N3858A	5/-
2N3859	5/6
2N3859A	6/6
2N3860	6/-
2N3877	9/-
2N3877A	9/6
2N3900	10/6
2N3900A	11/6
2N3901	19/6
2N3903	7/-
2N3904	7/-
2N3905	7/6
2N3906	7/6
2N4058	5/6
2N4059	5/-
2N4060	5/-
2N4061	4/6
2N4062	4/6
2N4244	9/6
2N4245	8/6
2N4254	8/6
2N4255	7/6
2N4284	3/6
2N4285	3/6
2N4286	3/6
2N4287	3/6
2N4288	3/6
2N4289	4/6
2N4290	4/-
2N4291	3/6
2N4292	3/6
2N4433	5/6
2N4434	5/6
2N4435	5/6
2N5027	10/6
2N5028	11/6
2N5029	9/6
2N5030	8/6
2N5172	3/-
2N5174	10/6
2N5175	10/6
2N5176	9/-
2N5232	5/6
2N5232A	6/-
2N5245	12/6
2N5246	12/6
2N5249	13/6
2N5249A	13/6
2N5305	7/6
2N5306	8/-
2N5307	7/6
2N5308	7/6
2N5309	12/6
2N5310	8/6
2N5354	5/6
2N5355	5/6
2N5356	10/6
2N5365	9/6
2N5366	10/-
2N5367	11/6
2N5457	7/6
2S005	15/-
2S020	37/6
2S102	6/6

2S103	6/6
2S104	6/6
2S501	5/6
2S502	5/6
2S503	5/6
3N83	37/6
3N128	18/6
3N140	19/6
3N141	21/6
3N142	16/6
3N143	19/6
3N152	24/-
R.C.A.:	
40250	12/6
40309	9/6
40310	13/-
40311	10/6
40312	13/6
40314	10/6
40315	10/6
40316	13/-
40317	11/-
40319	15/-
40320	10/6
40323	10/6
40324	12/6
40326	10/6
40329	7/6
40344	8/6
40347	9/6
40348	14/6
40360	11/6
40361	12/6
40362	14/6
40370	8/6
40406	16/-
40408	16/-
40467	16/6
40468A	16/6
AC107	6/-
AC126	4/-
AC127	5/-
AC128	4/-
AC154	4/6
AC176	5/-
AC187	12/-
AC188	12/-
ACY17	5/-
ACY18	5/-
ACY19	5/-
ACY20	5/-
ACY21	5/-
ACY22	4/-
ACY28	4/-
ACY40	4/-
ACY41	5/-
ACY44	8/-
AD140	8/-
AD149	11/6
AD150	16/6
AD161	7/6
AD162	7/6
AF106	9/-
AF114	5/-
AF115	6/-
AF116	5/-
AF117	5/-
AF118	12/6
AF119	4/-
AF124	4/6
AF125	4/6
AF126	4/-
AF127	3/6
AF139	7/6
AF178	12/6
AF179	11/6
AF180	12/6
AF181	8/6
AF239	7/6
AF279	16/6
AF280	16/6
AFZ11	5/6
AFZ12	8/6
ASY26	5/6
ASY27	8/6
ASY28	5/6
ASY29	5/6
ASY36	5/-
ASY50	5/-
ASY51	6/6
ASY53	5/-
ASY54	5/-
ASY62	5/-
ASY63	3/6
ASY72	5/-
ASY83	5/-
ASY86	6/6
ASZ20	7/6
ASZ21	7/6
AUY10	30/-
BC107	3/6
BC108	3/6
BC109	3/6
BC113	6/6
BC115	6/6
BC116	12/6
BC118	6/6
BC121	4/-
BC122	4/-
BC125	11/-

BC126	11/-
BC140	11/-
BC147	3/6
BC148	3/6
BC149	3/6
BC157	4/-
BC158	3/6
BC159	4/-
BC160	12/6
BC167	3/6
BC168B	3/9
BC168C	3/9
BC169B	3/9
BC169C	3/9
BC170	3/6
BC171	3/6
BC172	3/6
BC182L	4/6
BC183L	4/6
BC184L	4/6
BC212L	5/-
BCY10	5/6
BCY12	5/6
BCY30	5/6
BCY31	5/6
BCY32	7/6
BCY33	4/-
BCY34	4/6
BCY38	4/6
BCY39	7/6
BCY40	6/6
BCY42	3/-
BCY43	3/-
BCY54	7/6
BCY58	4/6
BCY59	4/6
BCY60	19/6
BCY70	4/6
BCY71	8/6
BCY72	4/-
BCZ10	4/6
BCZ11	4/6
BD121	17/6
BD123	21/6
BD124	12/-
BF115	5/-
BF117	9/6
BF167	5/6
BF173	7/6
BF177	11/6
BF178	10/6
BF179	11/6
BF180	7/-
BF181	6/6
BF184	7/6
BF185	5/6
BF194	5/-
BF195	5/6
BF196	5/6
BF197	5/6
BF198	5/6
BF200	10/6
BF224	6/-
BF225	6/-
BF237	6/6
BF238	6/6
BFX12	4/6
BFX13	4/6
BFX29	12/6
BFX30	9/-
BFX43	8/6
BFX44	8/6
BFX68	13/6
BFX68A	13/6
BFX84	7/6
BFX85	9/-
BFX86	6/6
BFX87	6/6
BFX88	5/-
BFX89	12/6
BFX92A	12/6
BFY10	4/6
BFY11	4/6
BFY17	4/6
BFY18	4/6
BFY19	4/6
BFY20	12/6
BFY21	8/6
BFY24	9/-
BFY25	5/-
BFY26	4/-
BFY29	10/-
BFY30	10/-
BFY36	4/-
BFY37	5/-
BFY41	10/-
BFY43	12/6
BFY50	4/6
BFY51	4/6
BFY52	4/6
BFY53	4/6
BFY56A	11/-
BFY75	6/-
BFY76	8/6
BFY77	11/6
BFY90	12/6
BFW58	5/6
BFW59	5/-
BFW60	5/-
BSX19	3/6
BSX20	3/6

BSX21	7/6
BSX26	10/6
BSX27	10/6
BSX28	6/-
BSX60	19/6
BSX61	12/6
BSX76	4/6
BSX77	6/6
BSX78	6/6
BSY10	5/6
BSY11	5/6
BSY24	4/-
BSY25	4/-
BSY26	4/-
BSY27	4/-
BSY28	4/-
BSY29	4/-
BSY32	5/-
BSY36	5/-
BSY37	5/-
BSY38	4/6
BSY39	4/6
BSY40	6/6
BSY51	8/6
BSY52	9/-
BSY53	8/6
BSY54	10/6
BSY56	6/-
BSY78	9/6
BSY79	9/6
BSY82	10/6
BSY83	10/6
BSY84	11/6
BSY85	13/6
BSY87	10/6
BSY90	11/6
BSY95A	2/6
BSW41	8/6
BSW70	5/6
D16P1	7/6
D16P2	8/-
D16P3	7/6
D16P4	8/-
GET102	6/-
GET113	4/-
GET114	4/-
GET116	10/6
GET118	4/-
GET119	4/-
GET120	6/6
GET873	3/-
GET880	6/-
GET887	4/-
GET889	4/6
GET890	4/6
GET896	4/6
GET897	4/6
GET898	4/6
MAT100	6/-
MAT101	6/-
MAT120	6/-
MAT121	6/-
MJ400	21/6
MJ420	22/6
MJ421	22/6
MJ430	20/6
MJ440	19/6
MJ480	20/6
MJ481	27/6
MJ490	22/6
MJ491	29/6
MPF102	8/6
MPF103	7/6
MPF104	7/6
MPF105	8/-
MPS3638	6/6
NKT0013	9/6
NKT124	8/6
NKT125	5/6
NKT126	5/6
NKT128	5/6
NKT135	5/6
NKT137	6/6
NKT210	6/-
NKT211	6/-
NKT212	6/-
NKT213	6/-
NKT214	4/6
NKT215	4/6
NKT216	7/6
NKT217	8/6
NKT219	6/-
NKT223	5/6
NKT224	5/-
NKT225	4/6
NKT229	6/-
NKT237	7/-
NKT238	5/6
NKT240	5/6
NKT241	5/6
NKT242	4/-
NKT243	12/6
NKT244	3/6
NKT245	4/-
NKT261	4/-
NKT262	4/-
NKT264	4/-
NKT271	4/-
NKT272	4/-
NKT274	4/-

NKT275	4/-
NKT281	5/6
NKT401	17/6
NKT402	18/-
NKT403	15/-
NKT404	12/6
NKT405	15/-
NKT406	12/6
NKT451	12/6
NKT452	12/6
NKT453	9/6
NKT603F	6/6
NKT613F	6/6
NKT674F	5/-
NKT677F	5/-
NKT713	5/-
NKT717	8/6
NKT734	5/6
NKT736	7/-
NKT773	5/-
NKT781	6/-
NKT10339	6/6
NKT10419	6/-
NKT10439	7/6
NKT10519	6/6
NKT20329	9/6
NKT20339	7/6
NKT80111	15/6
NKT80112	19/6
NKT80113	22/6
NKT80211	18/6
NKT80212	18/6
NKT80213	18/6
NKT80214	18/6
NKT80215	18/6
NKT80216	18/6
OC20	21/6
OC22	8/-
OC23	8/-
OC24	8/-
OC25	8/-
OC26	6/6
OC28	8/6
OC35	6/6
OC36	6/6
OC38	10/6
OC41	4/6
OC42	5/-
OC44	4/-
OC45	2/6
OC46	3/-
OC70	3/-
OC71	2/6
OC72	2/6
OC74	4/6
OC75	4/6
OC76	3/-
OC77	5/6
OC78	3/-
OC78D	3/-
OC81	4/-
OC81D	4/6
OC82	4/-
OC82D	3/-
OC83	4/6
OC84	5/-
OC123	4/6
OC139	6/6
OC140	6/6
OC170	6/-
OC171	6/-
OC200	6/6
OC201	7/6
OC202	10/6
OC203	6/6
OC204	6/6
OC205	8/6
OC207	7/6
OCP71	10/6
ORP12	8/6
ORP60	10/-
ORP61	10/-
P346A	4/6
TIS34	17/6
TIS43	9/-
TIS44	2/6
TIS45	3/6
TIS46	3/6
TIS47	3/6
TIS48	3/6
TIS49	3/6
TIS50	5/6
TIS51	4/-
TIS52	4/-
TIS53	6/-
TIS60	6/6
TIS61	6/6
TIP31A	19/6
TIP32A	22/6
ZTX107	3/6
ZTX108	3/6
ZTX109	3/6
ZTX300	4/-
ZTX301	4/-
ZTX302	5/-
ZTX303	5/-
ZTX304	7/6
ZTX500	5/-
ZTX501	5/-
ZTX502	6/-
ZTX503	5/-
ZTX504	12/6

SILICON RECTIFIERS

PIV	50	100	200	400	600	800	1000	12000
1A	2/9	3/-	3/3	3/6	3/9	4/-	4/6	—
3A	3/-	—	—	4/6	—	6/-	—	—
6A	—	—	5/-	6/6	7/6	9/-	10/-*	—
10A	8/-	12/6	13/6	16/6	16/6	19/6	23/-	30/-
17A	—	15/6	16/9	21/-	21/-	26/-	32/6	43/6

*5 AMP only. 1 AMP Types are plastic.

DIODES & RECTIFIERS

1N461	1/6	AA119	2/-	BY103	4/6	OA70	1/6
1N914	1/6	AAZ13	2/-	BY122	7/6	OA73	2/-
1N916	1/6	AAZ15	2/6	BY124	3/-	OA79	1/9
1N4007	4/6	AAZ17	2/6	BYX10	5/6	OA81	1/6
1S010	3/-	BA100	2/-	BYX10	9/-	OA85	1/6
1S021	4/-	BA102	4/-	BYZ11	7/6	OA90	1/6
1S025	5/-	BA115	1/6	BYZ12	6/6	OA91	1/6
1S113	3/-	BAX13	2/6	BYZ13	5/-	OA95	1/6
1S120	2/6	BAX16	2/6	FST3/4	4/6	OA182	2/-
1S121	2/6	BAY18	3/6	FST3/8	6/-	OA200	2/-
1S130	2/6	BAY31	1/6	OA5	2/6	OA202	2/-
1S131	3/-	BAY38	2/6	OA9	2/-		
1S132	2/6	BY100	4/6	OA47	1/6		

RCA INTEGRATED CIRCUITS

CA3005	30/-	CA3021	42/6	CA3039	25/-
CA3011	20/-	CA3022	35/-	CA3041	32/6
CA3012	25/-	CA3023	32/6	CA3042	32/6
CA3013	30/-	CA3026	27/6	CA3043	35/-
CA3014	30/-	CA3028A	25/-	CA3044	32/6
CA3018	25/-	CA3028B	35/-	CA3045	32/6
CA3019	25/-	CA3035	35/-	CA3046	25/-
CA3020	30/-	CA3036	20/-	CA3051	25/-

Data and application sheets 2/- per type.

PLESSEY

SL402A	49/6
SL403A	54/-
Data & Application Sheet	2/-

FAIRCHILD

FAIRCHILD	1-6	6-11	12+
L900 Buffer	11/-	9/6	8/4
L914 Dual Gate	11/-	9/6	8/4
L702C	40/-		
L923 JK Flip Flop	14/-	12/6	11/9
L709 Op Amp	27/6	23/-	21/-

Quantity Prices on Application.

MOTOROLA

MC724P Quad 2 Input Gates	19/6
MC789P Hex Inverter	19/6
MC790P Dual JK Flip Flop	32/6
MC792P	20/-
MC799P Dual Buffer	29/6

MULLARD I.C's

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FCH 221	Triple 3 Input DTL Line	28/6
FCJ 101	3 Input JK Flip Flop	35/-
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TAA 243	Operational Amplifier	45/-
TAA 263	Linear A.F. Amplifier	18/6
TAA 320	Most L.F. Pre Amplifier	15/6

GENERAL ELECTRIC

PA230	Low Level Amplifier	27/6
PA234	1 Watt audio Amplifier	26/6
PA237	2 Watt Audio Amplifier	45/-
PA246	5 Watt Audio Amplifier	57/6

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PIV	50	100	200	300	400
1A	5/-	5/6	7/6	8/-	9/6
3A	6/-	7/6	8/-	9/-	10/6
5A	—	8/-	9/-	—	12/6
7A	—	11/-	13/-	14/-	19/6
25A	27/6	30/-	33/-	—	37/6

Also 12 Amp 100 PIV 15/-, 600 PIV 35/6.

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	.15 Matrix	.1 Matrix
2½" × 3¾"	3/6	4/-
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3¾" × 5"	5/6	5/6
3¾" × 17"	16/-	21/6
3¾" × 17" (Plain)	—	11/6
5" × 17" (Plain)	17/-	—
Vero Pins (Bag of 36)	3/-	3/-

Vero Cutter 9/-.

RESISTORS

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¼ watt 10% .. .. 4d. 1 watt 10% .. 6d.
½ watt 5% .. .. 5d.
2 watt 10% 1/-

Wire Wound

2.5 watt 5% (Up to 270 ohms only)	1/6
5 watt 5% (Up to 8.2k ohms only)	2/-
10 watt 5% (Up to 25k ohms only)	2/9

CAPACITORS.

Polyester, ceramics, Polystyrene, silver mica, tantalum, trimmers etc.

Electrolytics

MFD.	V.		MFD.	V.		MFD.	V.	
1	40	1/9	25	50	1/6	320	10	1/6
1.6	25	1/6	32	40	1/6	400	16	2/9
2	350	2/-	32	450	3/9	500	6	2/6
2.5	16	1/9	40	6.4	1/6	500	25	3/9
4	10	1/6	40	16	1/6	500	50	4/9
4	40	4/9	50	12	1/6	640	16	3/6
4	350	2/3	50	25	1/6	640	25	5/-
5	18	1/6	50	50	2/-	1000	16	5/-
5	50	1/6	64	25	1/6	1000	25	5/-
6.4	6.4	1/9	80	16	1/6	1000	50	7/6
8	40	1/6	80	25	1/6	2000	25	8/6
8	450	3/-	100	6.4	1/6	2000	50	12/6
10	12	1/6	100	12	1/6	2500	25	9/6
10	25	1/6	100	25	1/9	2500	50	13/6
12.5	25	1/9	100	50	2/6	3000	25	10/6
16	10	1/6	125	10	1/6	5000	25	12/6
16	15	1/6	200	10	1/6	5000	50	19/6
16	450	3/3	250	25	2/9	16 + 16	450	7/6
25	6.4	1/6	250	50	3/9	32 + 32	450	7/6
25	10	1/6						
25	25	1/6						

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VA1015	3/9	VA1038	2/6	VA1074	2/6	VA1097	4/-
VA1026	2/6	VA1039	3/-	VA1075	4/6	VA1098	4/-
VA1033	2/6	VA1040	2/6	VA1077	4/-		

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50-0-50	,,	35/-
100-0-100	,,	32/6
500-0-500	,,	25/-
1	Milliamp	25/-
5	Milliamp	25/-
10	,,	25/-
50	,,	25/-
100	,,	25/-
500	,,	25/-
1	Amp	25/-
5	,,	25/-
10	Volts	25/-
20	,,	25/-
50	,,	25/-
300	,,	25/-
500	,,	25/-

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9" × 4"	23/6	5"	14/6
8" × 5"	19/6	8"	27/6
7" × 4"	15/6	12"	39/6
5" × 3"	12/6		

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A 4 Germ. R.F. PNP T0-1	=OC44-45, NKT72/125, ASY54	£1.10	£4.10	£7.10	£60
A 5 Germ. R.F. PNP T0-5	=2N1303, NKT164-7, 2G301-3	£1.10	£4.10	£7.10	£60
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BFY51	2N708	2N2904	2S102	2N2906
BFX84	2N929	2N2905	2S103	2N2907
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AC130	ACY30	NKT213	OC45	2G303
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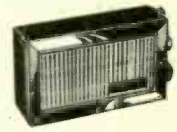

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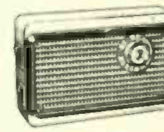

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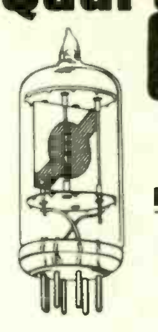

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HFE. 15-100
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PNP SILICON
PLASTIC ENCAPSULATION
Spec:—
ICER AT VCE = 10v
1mA MAX.
HFE. 10-200
These are of the 2N3702/3 and 2N4059/62 range.

TYPE C
NPN SILICON
TO-18 CAN
Spec:—
ICER AT VCE = 20v
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B87	100	GERM. PNP TRANS. EQUIV. TO OC44, OC45, OC81, ETC.	10/-
B88	50	SIL. TRANS. NPN, PNP, EQUIV. TO OC200/1, 2N706A, BSY95A, ETC.	10/-
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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 THURSDAY, 12 p.m., 8th JAN. for the FEB. issue, subject to space being available.

ELECTRONIC SYSTEMS SERVICE ENGINEERS

THE JOB

Systems Service Engineering on Advanced Training Aids for Aircraft, Radar Networks, Nuclear Reactors and Submarines.

THE MAN

Electronic Engineer preferably with O.N.C. or H.N.C. having had practical experience of electronic devices with a keen desire to learn new techniques and applications.

THE AWARDS

Salary offered will be up to £1700. High job interest. Opportunity to work on complex systems incorporating digital and analogue computers, associated peripherals, colour television systems and servo systems, as a member of a team. Opportunity to fly and operate simulated aircraft and other equipments. High quality training will also be given.

OTHER BENEFITS

Our terms and conditions of employment are good and include contributory pension scheme, free life assurance, etc. We are not merely offering posts which will afford candidates opportunities of attaining a good job. Selected candidates will be offered long-term careers. Opportunities for travel at home and overseas.

There are vacancies at both Aylesbury and Crawley locations. Applications should be made in the first place to

H. C. Hall, Personnel Manager
REDIFON LIMITED
Flight Simulator Division
Gatwick Road, Crawley, Sussex
Tel: Crawley 28811

REDIFON

A Member Company of the Rediffusion Organisation

2694

RACAL INSTRUMENTS LIMITED
AIRMEC DIVISION
SEATON, DEVON

REQUIRE TEST ENGINEERS

To work on a wide range of analogue and digital measuring instruments employing the latest techniques.

Entrants may be graded as Test Engineers Grade I, Grade II or Project Leaders according to qualifications and experience.

Salaries up to £1,600 per annum.

These positions offer permanent and progressive employment in a seaside area of great natural beauty. Both private and local authority housing will be available.

Apply:

Personnel Department,
Racal Instruments Limited,
Airmec Division, Seaton, Devon.
Or telephone Mr. G. Hatt, Chief of Test.
Seaton 1100/1.

2727

SENIOR ELECTRONICS INSPECTOR

Due to expansion a vacancy for inspector has been created. Applicant will preferably have several years of inspection experience and be familiar with defence specifications and B.S. 9,000 procedure. A knowledge of high precision electrical and coactual connectors would be advantageous, but a sound basic knowledge of electronic equipment may in itself be sufficient.

Attractive conditions of employment and commencing salary would be offered with good prospects of promotion for the right man.

Please apply in writing to:

Technical Manager,
PRECISION CONNECTORS LIMITED,
56-58 GREEN STREET,
FOREST GATE,
LONDON, E.7. Tel.: 01-552 3405

A member of the Delta Metal Group of Companies.

2736

Government of UGANDA
REQUIRES
BROADCASTING ENGINEERS

To serve on contract for one tour of 21-27 months in the first instance. Salary according to experience in scale Uganda Shg. 21,120-27,780 (£Stg. 1,232-1,620) a year, plus an Inducement Allowance, normally tax free, of £Stg. 778-886 a year, paid direct into a Uganda bank account nominated by the officer. Gratuity 25% of total emoluments drawn. Liberal paid leave. Accommodation provided at reasonable rental. Outfit and education allowances. Free passages. Contributory pension scheme available in certain circumstances.

Candidates must possess the City and Guilds Final Certificate in Telecommunications (with Radio) or an equivalent qualification and have wide practical experience of technical broadcasting equipment including transmitting and studio control equipment.

The officer will be required to undertake senior operational duties including the maintenance of broadcasting equipment in transmitting stations and studios; outside broadcasts and recordings in remote districts; and to give assistance with the training of junior engineering staff.

Apply to CROWN AGENTS, 'M' Division, 4 Millbank, London, S.W.1., for application form and further particulars stating name, age, brief details of qualifications and experience and quoting reference M2K/690995/WF.

2691

TECHNICIAN
required for
ELECTRONICS WORKSHOP

Applicants should have a minimum of two years' experience of construction and/or servicing of electronic equipment using transistors and integrated circuits, and some knowledge of digital and pulse techniques. Qualifications to ONC or Intermediate City and Guilds technicians level. Opportunities for day release. Salary according to age, qualifications and experience.

Apply to the Administrative Secretary, Medical Research Council's Laboratory of Molecular Biology, Hills Road, Cambridge.

2731

NORTH-EAST ESSEX TECHNICAL COLLEGE
Sheepen Road, Colchester
DEPARTMENT OF ELECTRICAL ENGINEERING

LECTURER GRADE II

is required to teach TELECOMMUNICATION SUBJECTS up to first degree standard. Applicants must have a University degree in Electrical Engineering or Physics with suitable teaching and/or industrial experience. Salary: Lecturer Grade II—£1,827-£2,417 p.a. Assistance with removal expenses may be considered.

Application forms are available from the Principal at the College, to whom they should be returned within fourteen days of the appearance of this advertisement. Please state ref. WW.

2730

Rank Strand Electric Limited, who are leaders in their field of theatre and television studio equipment, require two

electronics commissioning engineers

around £1,500 p.a.

To test and commission sophisticated lighting control systems into theatres and television studios at home and abroad.

Based with the Research and Development Unit at Brentford, Middlesex, they will initially complete a three-month training course before commencing operations in the field.

Applicants must have sound knowledge and experience of electronics. Ability to communicate effectively with customers important. Knowledge of theatre and television an advantage.

Must be willing to travel extensively and work irregular hours.

AUDIO VISUAL DIVISION

Please apply for application form: The Personnel Officer, Rank Strand Electric Limited, 29 King Street, Covent Garden, London, W.C.2. 836 4444 ext. 147/148

The Rank Organisation
The man with the gong – a man of many skills

2681

Become a

RADIO TECHNICIAN

and work at the nerve centres of civil aviation

The National Air Traffic Control Service of the Board of Trade needs Radio Technicians to install and maintain the very latest electronic aids at Civil Airports, Air Traffic Control Centres, Radar Stations and specialist establishments. Vacancies exist in various parts of the United Kingdom.

This is responsible demanding work (for which you will get familiarisation training) involving communications, computers, radar and data extraction, automatic landing systems, and closed-circuit television. It offers excellent prospects with ample opportunities to study for higher qualifications in this fast-expanding field.

If you are 19 or over, with at least one year's practical experience in telecommunications, fill in the coupon now. Preference will be given to those having ONC or qualifications in Telecommunications.

Salary: £985 (at 19) to £1,295 (at 25 or over); scale maximum £1,500 (higher rates at Heathrow). Some posts attract shift-duty payments. The annual leave allowance is good and there is a non-contributory pension scheme for established staff.

Complete this coupon for full details and application form:
To: A. J. Edwards, C. Eng., M.I.E.E., M.I.E.R.E., Room 705, The Adelphi, John Adam Street, London WC2, marking your envelope 'Recruitment'.

Name ....

Address ....

.... WW/B3

Not applicable to residents outside the United Kingdom.

NATCS National Air Traffic Control Service

2689

INTERTEL

COLOUR TELEVISION

requires

ENGINEERS

in their Vision and Video Tape Departments to be based at their Dean Street, London, Studio. Applicants should have a good working knowledge of Colour Television Practice.

Applications to:

CHIEF ENGINEER
INTERTEL COLOUR TELEVISION
WYCOMBE ROAD, WEMBLEY
MIDDLESEX

2726

computer engineering

NCR requires additional ELECTRONIC, ELECTRO MECHANICAL ENGINEERS and TECHNICIANS to maintain medium to large scale digital computing systems in London and provincial towns.

Training courses will be arranged for successful applicants, 21 years of age and over, who have a good technical background to ONC/HNC level, City and Guilds or radio/radar experience in the Forces.

Starting salary will be in the range of £900/£1,250 per annum, plus bonus. Shift allowances are payable, after training, where applicable. Opportunities also exist for Trainees, not less than 19 years of age, with a good standard of education, an aptitude towards and an interest in, mechanics, electronics and computers.

Excellent holiday, pension and sick pay arrangements. Please write for Application Form to
Assistant Personnel Officer
NCR, 1,000 North Circular Road,
London, NW2
quoting publication and month of issue.

Plan your future with **NCR**

Government of Zambia

REQUIRES

MAINTENANCE ENGINEER

for the Zambia Broadcasting Services, Ministry of Information, Broadcasting and Tourism, on contract for one tour of 36 months in the first instance. Commencing salary Kwacha 3,408 (£Stg. 1988) rising to Kwacha 3,516 (£Stg. 2051) a year, plus an Inducement allowance of Kwacha 1002–1034 (£Stg. 585–£Stg. 603). A Direct Payment of £291 is also payable direct to the officer's bank in the U.K. Salaries are subject to upward revision with effect from 1st January 1970. Gratuity 25% of total salary drawn. Both Gratuity and Direct Payment are normally TAX FREE. Free passages. Accommodation at moderate rental. Education allowances. Liberal leave on full salary or terminal payment in lieu. Contributory pension scheme available in certain circumstances.

Candidates, between 25–55, must have passed City and Guilds final certificate in Telecommunications or equivalent and should have had at least eight years experience with a broadcasting organisation, with particular experience in the installation of recording equipment and studio control equipment.

The officer will be required to maintain and service audio-visual aid equipment and install and operate public address/recording film projection equipment when and where required. He will be required to supervise workshops and staff in the absence of the Senior Maintenance Engineer.

Apply to CROWN AGENTS, 'M, Division, 4 Millbank, London, S.W.1., for application form and further particulars stating name, age, brief details of qualifications and experience and quoting reference number M2Z/691029/WF.

2692

EXETER AND MID-DEVON HOSPITALS
MANAGEMENT COMMITTEE
GROUP WORKS DEPARTMENT

Technician—Medical Physics Grade II,

for maintenance of dialysis machines and electronic equipment.
Salary £1,313 x (8) to £1,671.
Qualifications required—H.N.C. or H.N.D. in Electrical Engineering or equivalent.

Applications together with names of three referees to reach the Group Engineer, 26 Queen Street, Exeter, Devon, within 10 days.

2769

COMPUTER STAFF

Vacancies exist in our Computer Services Dept. for EQUIPMENT CONTROLLERS to be responsible for the installation and performance monitoring of three IBM360/50 Computers used for real-time data processing. Applicants should have some knowledge of digital computers and may at present be employed as commissioning engineers or in a similar post. Knowledge of teleprocessing, Datel services and computer terminal equipment would be an advantage though it is not essential as full training will be given.
Salary up to £2000 according to experience and ability. Assistance with house purchase is available.

Please apply in writing giving full particulars to: P. Jordan, Computer Services Manager, CENTRE-FILE LTD., Park House, 16 Finsbury Circus, London, E.C.2.

2763

GEC-Marconi Electronics

Technicians and Engineers for St. Albans and Luton

qualified or not!

Vacancies in all grades

- **VACANCIES** exist for work on testing and calibrating valve and solid-state electronic measuring equipments embracing all frequencies up to u.h.f. in Production, Service and Calibration departments.
- **APPLICATIONS** are invited from people of all ages with experience or formal training in electronics and from ex-Armed Services technicians.
- **SALARIES** up to £1,600 negotiable and backed by valuable fringe benefits.
- **RE-LOCATION** EXPENSES available in many instances.
- **CONDITIONS** excellent; free life assurance, pension schemes, canteen, social club.
- **37½-hour,** 5-day, office-hours week.
- **WRITE** or 'phone Personnel Department stating age, details of previous employment, training, qualifications, approximate salary required.

mi Marconi Instruments Limited

Longacres, St. Albans, Herts. Tel: St. Albans 59292
Luton Airport, Luton, Beds. Tel: Luton 31441

A GEC-Marconi Electronics Company

2671

Product Test Technicians

Career Opportunities with IBM Manufacturing

We need high calibre men to fill vacancies created by promotion and programme expansion.

The job

Is to commission the latest IBM products and systems in production at the Scottish plant, near Greenock, and requires an intimate knowledge of the equipment under test, which can include computers, punched card and tape peripherals, magnetic disk and tape storage, high and low speed printers, visual display units, multiplexors, Teleprocessing and optical character recognition equipment. The products have to be tested thoroughly, and all faults traced and rectified. The work is interesting and absorbing, and the prospects for the right man are good.

Training

Will be a mixture of formal and "on the job" instruction. We will teach you all you need to know about IBM equipment – providing your basic knowledge is to the required level.

Pay and conditions

Starting salaries will be excellent.

Benefits include a non-contributory pension, immediate free life assurance and full sickness pay for up to 26 weeks in any 12 months. The 254,000 square feet plant is modern and situated in a pleasant rural valley. There is a subsidised restaurant.

Working conditions are excellent and there are good recreational facilities in the area. IBM will assist with removal expenses where applicable.

The man

Will be at least 18 and probably less than 30 and have a strong electronic background, with experience in, for example, the testing of electronic products, maintenance of radio, radar or TV or similar work in the armed forces.

He will probably have, or be near to attaining, a qualification such as HNC, ONC, first class PMG, final RTEB, or final City and Guilds (Course Nos. 47, 48, 49, 57, 300). A knowledge of transistor circuitry and the use of oscilloscopes will be a distinct advantage.

If you have what we need, and are keen to join a vigorous, expanding and up-to-the-minute industry, please write, giving details of your age, experience and qualifications, and quoting ref. No. PT2/WW/169
to: Manager, Personnel Selection,
IBM United Kingdom Limited,
P.O. Box 30, Spango
Valley, Greenock.

IBM

2690

ASSISTANT ENGINEERS (INSTRUMENTS)

for

TRAWSFYNYDD NUCLEAR POWER STATION
Trawsfynydd, Merionethshire, North Wales.

The work involves the diagnosing of system faults, carrying out special investigations, originating, modifications and designing special test equipment. The successful applicant will also be expected to assist in the training of Maintenance Craftsmen. Some experience within this field would be an advantage.

Applicants must possess academic qualifications leading to Graduate Membership of the I.E.E. or I.E.R.E.

Salary is within the range £1,500 – £1,880 per annum. Superannuable.

Conditions of service are in accordance with the National Joint Board Agreement for the Electricity Supply Industry.

Applications in writing stating age, experience etc., to **Regional Personnel Manager, 825 Wilmslow Road, East Didsbury, Manchester M20 8RU** to arrive not later than 30th December 1969. Please quote Vacancy No. E.566/567/W.

2696

University of London Audio-Visual Centre

requires

TELEVISION ENGINEERS and JUNIOR TELEVISION ENGINEERS

to work on maintenance and operational duties with its studio and mobile equipment, under the supervision of the **Chief Engineer, R. H. Bradley, MBE.**

Applicants for the post of Television Engineer should have technical experience in broadcast or educational television. A broad knowledge of other audio-visual equipment would be an advantage.

Applicants for the Junior posts should be 18-20 years old, with a basic knowledge of electronic equipment and some experience in its use. Formal technical or educational qualifications would be an advantage.

Salaries:
TV Engineer. Starting at £1600-£2000 according to qualifications and experience. University Pension Scheme.
Junior TV Engineer. Starting salary £800-£1000 according to qualifications.

Applications to the Director:
University of London Audio-Visual Centre
11 Bedford Square, London, WC1

2759

EAST AFRICAN COMMUNITY

Meteorological Department

requires

Sectional Engineer Grade II (Telecomms.)

To serve on contract for one tour of 21-27 months in the first instance. Salary in scale EA.Shg. 24300–27780 (approx. £S.1417–1620 p.a.) plus an Inducement Allowance normally tax free, of £S.822–886 p.a. paid direct into officer's bank in U.K. Gratuity 25% of total emoluments. Generous paid leave. Education Allowances. Furnished accommodation at reasonable rental. Free passages. Contributory pension scheme available in certain circumstances.

Candidates, up to age 45, must possess O.N.C. or City and Guilds Final Certificate (Telecomms) plus 7 years relevant experience in telecomms. engineering. Equivalent experience in one of the armed services is acceptable. Candidates must have a good theoretical and practical knowledge of FSK, ISB and SSB receivers and transmitters and of Mufax and facsimile transmitters and recorders. A good working knowledge of radar systems is essential.

The officer will be responsible to the Chief Sectional Engineer for the operation and maintenance of the Department's radio telecommunications, radio-sounding and radar equipment. He will be liable for service anywhere in East Africa but will probably be stationed at Entebbe, Dar es Salaam or Nairobi.

Apply to CROWN AGENTS, 'M' Division, 4 Millbank, London, S.W.1., for application form and further particulars stating name, age, brief details of qualifications and experience and quoting reference number M2K/690413/WF

TECHNICIAN

required for calibration and servicing of flow meter instruments. Electronic experience required in television servicing or pulse techniques. Transistor experience essential. Digital experience an advantage. Good commencing salary and prospects. Permanent pensionable position.

Apply: **B. RHODES & SON LTD., Danes Road, Off Crow Lane, Romford, Esssex. Telephone Romford 62333/4/5.**

2774

ELECTRONICS TECHNICIANS

SENIOR TECHNICIAN prototype wireman required for research contract. TECHNICIAN for interesting project and development work in research and teaching laboratories. Day release available.

Incremental salary ranges £868-£1252, £1151-£1486 depending on age, experience and qualifications. 37½ hour week, good working conditions and holidays.

Apply in writing to Mr. E. Thompson, Royal School of Mines, Mining & Mineral Technology Department, Prince Consort Road, London SW7

2764

Electronics Engineer

Professional Audio, Video and Instrumentation Equipment.

3M Company, one of the world's foremost names in magnetic recording, is expanding distribution of its "Mincom" range of equipment in the audio, video and instrumentation fields in the United Kingdom.

An interesting opportunity is available for a young man aged 23-26 to join us as an Electronics Engineer. He must possess a good electronics background, possibly obtained in the radio communications field. Ideally he should be qualified to C & G or ONC/HNC standard but lesser qualifications may be acceptable in the case of an applicant with exceptional practical experience.

The position will be London based but ultimately the successful applicant will be required to undertake some travelling working on his own initiative on field assignments.

This is a progressive position in a fast growing field. The starting salary will be attractive and there are first class employee benefits. Please write in confidence with concise details, age, qualifications and experience to:

**Mr. D. J. Stuckey (Ref. MT)
3M Company Ltd.,
3M House,
Wigmore Street,
London W1A 1ET.**

3M COMPANY

2684

TECHNICAL AUTHORS

We are one of the World's leading manufacturers of Flight Simulators which incorporate both analogue and digital computers. We require Technical Authors with a sound knowledge of electronics who preferably have some knowledge of basic digital computer operation. Authors will produce operating and maintenance manuals, and must be able to write literature in a clear and concise style. Formal qualifications are desirable, but not essential. There will be ample opportunity to employ a measure of creative expression. Simulation is based on novel applications of known techniques. This work is certainly not of a monotonous nature.

INSTRUCTORS

are required to lecture to customers and engineers on digital and analogue computing techniques at basic, intermediate and advanced levels. Students are required to maintain and programme highly sophisticated flight simulators. Applicants should preferably be qualified to at least H.N.C. level or equivalent. Preference will be given to those with practical analogue or digital computing experience, but applications from men with several years' industrial experience and/or who have a flair for and a genuine interest in lecturing will certainly be welcome. Training in the Company's advanced computing techniques will be given.

This Company offers good working conditions, welfare benefits. There is a contributory pension scheme coupled with free life assurance.

Apply to: H. C. Hall, Personnel Manager,
REDIFON LIMITED
Flight Simulator Division,
Gatwick Road, Crawley, Sussex
Telephone: Crawley 28811

REDIFON

A Member Company of the Rediffusion Organisation

2695

ST. JOHN'S COLLEGE OF EDUCATION • YORK

Dept. of Closed Circuit Television

Applications are invited for the post of SENIOR TECHNICIAN, to join a team making television programmes for this and five associated colleges.

Duties will include the maintenance of cameras and videotape recording equipment. Opportunities for operational and production work will occur. A mobile recording van is in regular use and ability to drive would be an advantage.

Salary: Local Government Scales: Technical Grade 6 (at present £1,540-£1,775): the post is superannuated and good holidays are given.

Applications (no special form), should be made in writing to the Principal, stating qualifications, experience and the names of two referees. Closing date 31st December, 1969. 2762

SOUTH AFRICA

FULLY QUALIFIED RADIO & TELEVISION TECHNICIAN

Applicants should be capable of supervising a workshop from which the installation and repairs to all types of radios and television are undertaken.

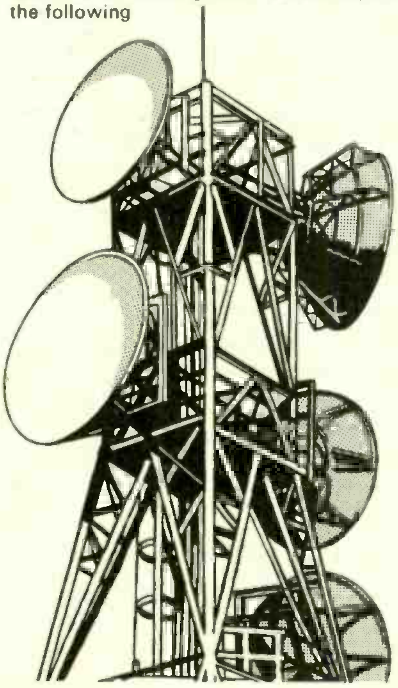
Applications with full details of experience etc., should be sent in the first instance to Mr. E. B. UNWIN.

NEL & UNWIN (PTY) LTD.
P.O. BOX 199, KROONSTAD
SOUTH AFRICA

2725

CONTINUOUS EXPANSION

Standard Telephones & Cables, Microwave and Line Division based at Basildon are growing fast. In order to keep pace with this consistent growth rate we require the following



Installation Engineers Technicians & Testers

Ref. 25720

To test and commission Multiplex, Co-axial Line and Microwave Radio Systems.

Ideal candidates will be less than 45 years of age with practical experience on some of the above equipment. These challenging posts call for drive, initiative and common sense. It is necessary for applicants to be prepared to work anywhere in the U.K.

Test Technicians

Ref. 27221

The diversity of products manufactured at the Basildon Plant demands experienced testing staff for work on complex transmission systems.

Candidates should hold an ONC in electrical engineering and be able to offer considerable practical experience in the field of testing and fault clearing all types of land-unit, pcm and microwave equipment.

Applications should be addressed to
The Personnel Officer,
STC Chester Hall Lane,
Basildon, Essex.

STC

91

TECHNICIAN

required in APPLIED ACOUSTICS RESEARCH LABORATORIES situated near Fulham Broadway, S.W.6. Varied work, but a knowledge of electronic construction and design an advantage. Day release facilities for further study.

Salary: £868—£1,252 p.a., depending upon age, experience and qualifications.

Application forms and further information from the Superintendent of Laboratories (T.A.), Department of Physics and Electronics, Chelsea College, Manresa Road, London, S.W.3.

2735

EAST SUFFOLK COUNTY COUNCIL

Lowestoft College of Further Education
Principal A. E. Boddy, B.Sc. (Econ.), F.R.G.S.

LECTURER GRADE 1

required for City and Guilds Radio and Television Servicing Mechanics' and Technicians' Courses, including colour television.

Applicants should have appropriate technical qualifications, together with suitable Industrial and Teaching experience. Ability to offer teaching in similar courses would be an advantage.

The appointment is vacant as from the 1st April, 1970, but an earlier commencing date may be negotiated.

Salary in accordance with the Burnham Scale for Lecturers Grade I, £1,110 to £1,955, plus increments for approved qualifications and training. Starting point within the scale determined by previous Industrial and Teaching experience.

Applications should be sent as soon as possible to The Principal of the College, on application forms available from the Secretary, Lowestoft College of Further Education, St. Peter's Street, Lowestoft, Suffolk.

2768

1967 THE QUEEN'S AWARD TO INDUSTRY

SENIOR LABORATORY TECHNICIAN

A SENIOR ASSISTANT with a good understanding of electronics is needed to join a small team providing physics support to the Isotope Production Unit at Harwell. The team is mainly concerned with making accurate measurements of a wide variety of radiation sources and with the development and maintenance of the necessary measurement system. The post is tenable at Harwell.

QUALIFICATIONS & EXPERIENCE:—
The minimum age for appointment is 27 and the minimum qualifications necessary are four 'O' levels including English Language and Mathematics or a Science subject. Electronics experience is essential and experience in the measurement of radiation sources would be advantageous.

SALARY: £1,350 rising to £1,755

APPLY TO: The Personnel Officer

THE RADIOCHEMICAL CENTRE

Amersham Bucks

SKILLED IN ELECTRONIC ENGINEERING?

Help keep aircraft on the straight and narrow

Air traffic has become so congested that complex electronic techniques are used as an aid in controlling aircraft both on airways and on airport approaches. As a Telecommunications Technical Officer III in the National Air Traffic Control Service of the Board of Trade, your job would be to install and maintain various air navigational and landing aids at civil airports, and communications and computer systems at radar stations and signals centres.

Because you handle such advanced equipment, you will receive thorough training. Study for higher qualifications is encouraged, and this could range from short courses with financial assistance to full-time study at a university or technical college.

Pay: (London rates—a little less elsewhere) £1,350 starting salary at 23, £1,625 at age 28 or over on entry, rising to £1,810. Within 3 years you could be upgraded, and on a scale rising to £2,050. A few years after that, you could be in the salary bracket going up to £2,375, and there are several higher grades still.

Qualifications: O.N.C. in Engineering, including a Pass in Electrical Engineering; or equivalent standard of technical education.

Send for full details and an application form (which must be returned completed by January 2nd, 1970) to: Civil Service Commission, 23 Savile Row, London, W1X 2AA. Please quote S/207/-.

2697

WW.21.

SENIOR DEVELOPMENT ENGINEER. £1900.

Our clients seek electronics engineer of at least H.N.C. standard with additional qualifications in control or digital techniques preferably around 30 years and living, or prepared to work, in the Hertfordshire area. The applicants should have shown some administrative ability in project coordination, possibly in avionics, military control systems, or high speed digital control circuits.

Please apply in writing and in strict confidence, quoting the above reference to:

ELECTRONICS APPOINTMENTS LTD.
NORMAN HOUSE · 105/109 STRAND · LONDON · W.C.2
TEL · 01-836 5557

89

HENRY'S RADIO LTD.

303 EDGWARE ROAD, LONDON, W.2
HAVE THE FOLLOWING VACANCIES IN THEIR ORGANISATION

SALES ASSISTANTS
Young man with good general knowledge of electronic components required for our retail sales dept. Please telephone 723-1008/9 ext. 1.

SALES ASSISTANTS
Young man with a good general knowledge of HIGH FIDELITY EQUIPMENT required for our retail HI-FI SALES DEPT. Please contact MR. STEVENS, Telephone 723-6963. 2585

An immediate vacancy occurs at

THE WIRELESS COLLEGE
COLWYN BAY, NORTH WALES

for an additional instructor to assist in preparing students for P.M.G./M.P.T. examinations. The primary responsibility will be the practical instruction on modern marine radio equipment. Applicants must hold a P.M.G. Certificate and should have a sound technical knowledge. Recent marine operating and/or teaching experience is desirable but not essential.

Write in the first instance to the Principal. 2776

SPECIAL OPPORTUNITY

Small company in medical electronics development (Richmond, Surrey) offers starting salary £1 300 to keen man suitable early directorship. Founder approaching retirement. Self-contained flat available. Phone 01-940 0865 evenings.

2766

SITUATIONS VACANT

A FULL-TIME technical experienced salesman required for retail sales; write giving details of age, previous experience, salary required to—The Manager, Henry's Radio, Ltd., 303 Edgware Rd., London, W.2. [67

ARE YOU INTERESTED IN HI FI? If so, and you have some experience of selling in the Retail Radio Trade, an excellent opportunity awaits you at Telesonic Ltd., 243 Euston Road, London, N.W.1. Tel. 01-387 7467. [21

CENTRAL AMERICA: Radio Engineer required to install and manage broadcasting equipment at new Radio School to be established at Choluteca, Republic of Honduras. Challenging post for the adventurous, trying to get out of the rut! Volunteer terms: fares, board, lodging, pocket-money, allowances. — Write: CIIR/OV, 38 King Street, London, W.C.2. [2737

CHIEF ELECTRONICS TECHNICIAN required to supervise Electronics Workshops developing and maintaining electronic equipment for use in the teaching and research laboratories of the Departments of Electronics and Physics. Salary £1,510—£1,703 p.a. according to age and experience. Further information and application form from the Laboratory Superintendent, Departments of Physics and Electronics, Chelsea College, Manresa Road, London, S.W.3. [2775

COLOUR TELEVISION. Multi-National Advertising Agency require a Technical Assistant, or Assistant Engineer, to operate and maintain colour television film scanning equipment. Candidates should be between the ages of 22 and 30 and should have "C" and "G" Telecomms. or equivalent, and preferably with experience on this type of equipment. Salary is negotiable. Write to Mr. R. Martin, J. Walter Thompson Co. Ltd., 40 Berkeley Square, W1X 6AD. [2753

ELECTRONICS TECHNICIAN required to assist in the development, construction and installation of electronics instruments used in biochemistry. Applicants should possess O.N.C. or equivalent and be able to construct and test equipment from circuit diagrams. Salary according to age and experience in the range of £1,025 to £1,295 per annum. Supplementary payments for certain qualifications. Superannuation scheme. Good conditions of service. Applications in writing to Departmental Superintendent, Department of Biochemistry, MRC Metabolic Reactions Unit, Imperial College, London, S.W.7. [2778

ELECTRONIC TEST ENGINEERS required for work on a new range of Digital Measuring Equipment using Silicon Transistors and Microcircuits. Fully qualified applicants preferred, although proven experience in electronics would be considered. Prospects for advancement are good. Weekly staff status and salary commensurate with qualifications and experience. We would welcome applications from ex-service personnel or those about to leave the services. Please apply to: The Personnel Manager, Venner Limited, Kingston By-Pass, New Malden, Surrey. Telephone: 01-942 2442. [2760

I.P.C. research and development. ELECTRONIC ENGINEERS AND TECHNICIANS. Advanced optical/electronic systems to process text and pictures for publication are being developed in the Information Science and Technology Unit's laboratory. There are several immediate opportunities for: QUALIFIED ELECTRONIC ENGINEERS to join a team working on the design and development of systems using computer, CRT, TV, and optical techniques. Expert knowledge in at least one of these is essential. Salaries within the Development Officer scale, ranging from £1,500 to £3,500. LABORATORY TECHNICIANS for layout, construction and testing of prototype electronic apparatus. Salary scale up to £1,675. Write for application form to the Director of R & D, IPC Laboratories, Wood Lane, Hemel Hempstead, Herts. [2748

QUALIFIED ENGINEERS considering emigration to Australia 1970 required to join new and vigorous firm of communications consultants. Interviews London and Birmingham. Brief resumé to Box W.W. 2627, Wireless World.

ELECTRONICS TECHNICIANS

this is the business machine explosion

Turnover doubled since 1962—now growing faster in the decimalization rush. Burroughs dominate the U.K. market in the new terminal computers and accounting machines. A wide variety of machines, an expanding market and a policy of promotion from within—all mean exciting opportunities, for trained electronics engineers, to develop their skills into the computer field or into the supervisory grades and beyond. Join the Burroughs boom—and grow with us.

If you are between 20 and 30, with an electronics qualification and want to train as a computer engineer—then there's a job for you with us. With Burroughs, you can find the freedom to develop your talents, open fresh horizons, learn new skills—on the largest third-generation systems in the World—these are the exciting prospects at Burroughs. In return, we're offering you 3 weeks' paid holiday, free life assurance and a contributory pension scheme.

Take a big step now into one of today's development industries—fill in the coupon and send off for one of our application forms. The address is:
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2680

Hampstead High Fidelity
require the services of a qualified

SERVICE ENGINEER

He must be conversant with the repair and service of quality High Fidelity equipment, a useful asset would be experience with CCTV and Colour TV. The man we are seeking must be very conscientious, adaptable and prepared to undertake occasional field work. He will be expected to set up and organise a completely new service department and control a small staff.

Applications are invited in writing giving full details of qualifications, experience, etc., and marked for the attention of P. A. Rispoli, Esq., Hampstead High Fidelity, 91 Heath Street, London, N.W.3. 2746

UNIVERSITY OF ESSEX
DEPARTMENT OF PHYSICS

SENIOR TECHNICIAN

required for maintenance of electronic equipment, supervision of equipment in a teaching laboratory and assistance to research groups. Candidates should preferably have H.N.C. or equivalent qualification in electronics and experience with modern electronic circuitry and equipment. Salary range £1,056-£1,311 with additional allowance for approved higher qualifications.

Applications to the Registrar, University of Essex, Wivenhoe Park, Colchester, Essex.

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We are planning a considerable expansion of our activities and have the following vacancies:

I. A SENIOR ENGINEER
to have control of all aspects of systems design, planning, estimating, installation and commissioning.

II. ENGINEERS
capable of undertaking either:
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Candidates for these appointments must have a good background of practical experience in this field of work, and an up-to-date knowledge of techniques and equipment.

Applications, which will be treated in strict confidence, should be sent to:

BRITISH RELAY

The General Manager,
Special Services Division,
British Relay House,
41, Streatham High Road, S.W.16

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Television Service Management

Applications are invited for vacancies in the North East Region from mature T.V. Service Managers who are experienced in the operation of a large scale rental service organisation.

Applicants must be technically competent and have a strong flair for the solution of organisational, administrative and personnel problems.

An attractive salary will be offered and a car provided.

Applications please to:

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Applications invited for the following post, duties to commence as soon as possible—

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(Grade T.3)—Ref. No. T698/66/2
to take charge of Nuclear Physics/Radiochemistry Laboratory.

Applicants should be over 21 and have qualifications to at least O.N.C. or C. & G. Ordinary Technician standard and previous laboratory experience. 38-hour, 5-day week with generous holiday and sick pay schemes. Opportunities for evening work with additional pay. Permanent posts with superannuation under Local Government conditions of service.

Salary Scale: £930—£1,095. Starting salary dependent upon age, qualifications and experience. An additional £50 or £30 per annum will be paid for appropriate National Certificate and C. & G. qualifications.

Further particulars and application forms (to be returned within fourteen days of this advertisement) from Chief Administrative Officer, Bristol Polytechnic, Ashley Down, Bristol BS7 9BU.

Please quote Ref. No. T698/66/2 in all communications. **2767**

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Customer Services Department

Service Engineers

These appointments will be of interest to electronic engineers who have attained High National Certificate standard.

The Department is responsible for the installation and maintenance of high-power electronic and mechanical equipment, mainly on customer premises, both in the U.K. and abroad.

These monthly staff appointments offer an attractive salary and, in addition, the full use of a Company car.

The Company operates a generous contributory pension scheme, with a holiday entitlement of three weeks per year.

Applications should be made by letter or telephone to the Customer Services Manager.

LTV Ling Altec Limited,
Heath Works, Baldock Road, Royston, Herts.
Tel: Royston 2424

2699

RADIO SCHOOL IN PANAMA: Radio Technician required to operate radio school in Santiago de Veraguas. The school provides an elementary adult education programme and is now unable to function for lack of a technician to take charge. Challenging opportunity to fill a vital need in the development of rural areas. Volunteer terms: board, lodging, pocket-money, fares, allowances. Write CIIR/OV 38 King Street, London, W.C.2. [2770

REDIFON LTD. require fully experienced TELECOMMUNICATIONS TEST ENGINEERS and ELECTRONICS INSPECTORS. Good commencing salaries. We would particularly welcome enquiries from ex-Service personnel or personnel about to leave the Services. Please write giving full details to—The Personnel Manager, Redifon Ltd., Broomhill Road, Wandsworth, S.W.18. [26

SENIOR ELECTRONICS TECHNICIANS are required by the Department of Applied Psychology to support the development of instrumentation for research work. Opportunities available for enterprising Technicians to gain experience in any of the following fields: Electrophysiological recording, magnetic tape systems, analogue computing, digital circuiting and building special peripherals for the departmental on-line PDP 9 computer. Experience and interest in building or maintaining equipment in at least one of the above fields essential. Salary on the scale £1,026 to £1,280 per annum, with supplementary payment up to £80 per annum if approved qualifications held. Five day week. Pension Scheme. Application Forms from the Staff Officer, The University of Aston in Birmingham, Gosta Green, Birmingham 4, quoting reference L/515/W.W. [2739

UNIVERSITY OF SHEFFIELD: CHIEF TECHNICIAN required in Department of Chemistry to take charge of Electronics Workshop, concerned with development and construction of new electronic equipment for research and teaching, and maintenance and repair of wide range of electronic equipment. Experience necessary, qualifications preferable. Salary £1,385-£1,578 p.a. Write, stating age, qualifications and experience, to the Bursar (Ref. B.390), The University, Sheffield S10 2TN. [27411

WE HAVE VACANCIES for Four Experienced Test Engineers in our Production Test Department. Applicants are preferred who have Experience of Fault Finding and Testing of Mobile VHF and UHF Mobile Equipment. Excellent Opportunities for promotion due to Expansion Programme. Please apply to Personnel Manager, Pye Telecommunications Ltd., Cambridge Works, Haig Road, Cambridge. Tel. Cambridge 51351, Extn. 327. [77

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AR88 mains transformers, £2.10.0; 12/24V carbon pile voltage regulator units, 30/-; 40 amp. 4-way terminal blocks, 5/-; Rotax rotary inverters, input 24V dc. output 115V. 3 phase, 400 Hz. 1·8 amps., £7.10.0; 200 amp. terminals, insulated heads, 8/6. Carriage and packing extra. Also, high voltage capacitors and insulators in stock. Westover Electronic Man. Co., Braidley House, St. Paul's Lane, Bournemouth. Tel. 23944. [2771

BRAND NEW ELECTROLYTICS, 15/16 volt, 0·5, 1, 2, 5, 8, 10, 20, 30, 40, 50, 100, 200 mfds. 8d. Carbon Film Resistors ¼ watt 5% E12 Series 10 ohms to 1 Megohm 1/6 dozen, minimum order 7/6, postage 1/-. The C. R. Supply Co., 127 Chesterfield Rd., Sheffield S.8. [2747

BUILD IT in a DEWBOX quality plastics cabinet. 2 in. × 2½ in. × any length. D.E.W. Ltd. (W), Ringwood Rd., FERNDOWN, Dorset. S.A.E. for leaflet. Write now—Right now. [76

CLOSED CIRCUIT TV Mobile Control Room for sale. Purchased January 1969 and built by Ampex. The unit includes 3 Vidicon Cameras by Marconi and full sound and communication facilities. There is also a helican scan V.T.R. unit and an audio tape recorder on board, both built by Ampex. Offers should be made to Television Facilities, Queens Hall, Leeds 1. Loan Finance available. [2738

COPIES of "Wireless World" from 1954 to 1968; offers please.—Grant, The Bungalow, 93 London Road, Hurst Green, Sussex. [2743

DISC RECORDING UNIT complete with Leak stereo amplifier, mod. meters, console, motorised swarf suction unit, spare blank, sapphires, etc., etc. Sugden cutter unit. Good condition. Best offer over £50.—John King (Films) Limited, Film House, 71 East Street, Brighton, BN1 1NZ. [2749

FERRANTI. AF3, AF5, B1, OP2, OPM1(2), OPM5, OPM6, OPM1c, X17, £5 o.n.o. CARRIAGE PAID.—Norwood, May Hill, Ramsey, I.o.M. [2757

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170,000 Valves

The Commissioners of CUSTOMS AND EXCISE are offering for sale by competitive tender approx. 170,000 valves in lots of approx. 1,000.

For further particulars, apply in writing to:

The Officer, Customs and Excise, Queen's Warehouse, Custom House, Lower Thames St., London, E.C.3, before January 2nd, 1970. **2751**

HOW to Use Ex-Govt. Lenses and prisms. Booklets. Nos. 1 & 2, at 2/6 ea. List Free for S.A.E. H. W. ENGLISH, 469 RAYLEIGH RD., HUTTON, BRENTWOOD, ESSEX. [87

ELECTRONIC TECHNICIANS

Ampex Quality Control Department now has vacancies for technicians to be responsible for fault finding and testing a wide range of Professional Audio and C.C.T.V. Magnetic Recording Equipment.

Experience gained in the electronic industry, radio or television servicing would be an advantage or a qualification of O.N.C. standard.

Excellent salaries, three weeks annual holiday, canteen, life assurance, pension and sickness benefit schemes in operation.

Please write or telephone the **Personnel Officer, Ampex Electronics Limited, Acre Road, Reading, Berkshire. Telephone Reading 84411.**

AMPEX

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PRODUCTION TEST ENGINEER

With experience of valve and transistor audio equipments, wanted to join our senior staff. 40 hour week. Salary £1,200 per annum.

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This private College provides efficient theoretical and practical training in the above subjects. One-year day courses are available for beginners and shortened courses for men who have had previous training.

Write for details to: The Secretary, London Electronics College, 20 Penywern Road, Earls Court, London, S.W.5. Tel.: 01-373 8721. 84

Bath University of Technology

A TECHNICIAN

is required in the School of Mathematics to assist mainly in servicing and developing ANALOGUE AND DIGITAL COMPUTING devices.

Candidates should have experience in electronics, should possess a basic qualification and be competent in elementary workshop skills.

Salary in the range of £773—£1,077 per annum, according to age, experience and qualifications.

Further details and application form from Registrar (S), The University, Bath, BA2 7AY, quoting ref. 69/83.

2754

RADIO OPERATORS

There will be a number of vacancies in the Composite Signals Organisation for experienced Radio Operators in 1970 and in subsequent years.

Specialist training courses lasting approximately nine months, according to the trainee's progress, are held at intervals. Applications are now invited for the course starting in September 1970.

During training a salary will be paid on the following scale:

Age 21	£800 per annum
„ 22	£855 „
„ 23	£890 „
„ 24	£925 „
„ 25 and over	£965 „

Free accommodation will be provided at the Training School.

After successful completion of the course, operators will be paid on the Grade 1 scale:

Age 21	£965 per annum
„ 22	£1025 „
„ 23	£1085 „
„ 24	£1145 „
„ 25 (highest age point)	£1215 „

then by six annual increases to a maximum of £1,650 per annum.

Excellent conditions and good prospects of promotion. Opportunities for service abroad.

Applicants must normally be under 30 years of age at start of training course and must have at least two years' operating experience. Preference given to those who also have GCE or PMG qualifications.

Interviews will be arranged throughout 1970.

Application forms and further particulars from:

Recruitment Officer, Government Communications Headquarters, Oakley, Priors Road, CHELTENHAM, Glos., GL52 5AJ.

Telephone No. Cheltenham 21491 Ext. 2270.

92

TRANSFORMERS

Working Foreman

for small shop producing transformers, 20vA-10KvA. Must be fully experienced, all stages of production. Commencing salary about £1,200.

Also Young Assistant with testing experience

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2761

INTERNATIONAL AERADIO LTD
TELECOMMUNICATIONS INSTRUCTOR

Applicants should possess a recognised qualification in telecommunications, e.g. City & Guilds. ONC. HNC with electronics. These are desirable qualifications but personnel with a sound basic and applied radio theory capability would be considered.

Ex-Services/Civilian personnel who have completed an instructional technique course and have had instructional experiences in the field of telecommunications would be preferred.

A liking and aptitude for this work is essential together with general experience of UHF, VHF and HF communications equipment providing fixed and mobile services. Applicants should also be familiar with Radio Navigational Aid equipment as installed at airports for use by air craft and ATC personnel. It is inherent that applicants will have a knowledge of solid state techniques.

This is a permanent and pensionable position at our Radio Training School outside Southall which address is in easy access of surrounding areas. The post offers good career prospects. Starting salary will be in the region of £1500. Benefits also include membership of an excellent contributory pension and life assurance scheme and substantial rebates on holiday air fares, after a year's service.

To apply for this position write to

IAL **Personnel Officer (Recruitment)**
INTERNATIONAL AERADIO LIMITED,
HAYES ROAD, SOUTHALL, MIDDLESEX. Tel: 574 2411

THE HANNAH DAIRY RESEARCH INSTITUTE AYR
ELECTRONICS TECHNICIAN

ASSISTANT EXPERIMENTAL/EXPERIMENTAL OFFICER required for duties in the Department of Physiology, including servicing of electronic and electrical equipment, construction of special instruments, devising and construction of electrophysiological apparatus. Previous experience in a physiological laboratory desirable, but not essential.

Qualifications: a degree, H.N.C., N.H.C., Grad. I.E.E.E. or equivalent in electronics engineering, applied science or applied physics.

Salary: A.E.O. up to £1,208 in a scale to £1,454;
E.O. in a scale £1,190 to £2,006.

Further particulars may be obtained from the Secretary of the Institute, to whom applications, with the names of two referees, should be submitted by 17th January, 1970.

2734

WE OFFER A
YOUNG ENGINEER

the opportunity of working in an up-to-date tape recorder service department on Uher recording equipment.

The applicant should be familiar with the latest transistorised circuitry as well as being able to carry out mechanical work on such equipment.

We offer a good salary, non-contributory pension scheme, subsidised canteen facilities and some local transport.

If you are interested, please write giving brief details about your qualifications and experience to:

The Personnel Manager,
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NEW FULL SPECIFICATION DEVICES. Integrated Circuits complete with data: GE PA230 Audio Preamplifier 18/6 each; GE PA234 1W Audio Amplifier 17/6 each; GE PA237 2W Audio Amplifier 32/6 each; MEL 11 Photo Darlington Amplifier 9/6 each; high quality low cost plastic transistors: GE 2N5172 NPN 200mW Transistor 1/9 each; ME 0412 PNP 200mW Transistor 3/9 each; Westinghouse guaranteed plastic rectifier: IN4820 1·5A 400V Si Rectifier 2/6 each. GI W005 1A 50V Full Wave Bridge Si Rectifier 7/6 each. C.W.O. P. & P. 1/- per order. JEF ELECTRONICS, York House, 12 York Drive, Grappenhall, Warrington, Lancs. Mail Order Only. [2750

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VHF RADIO TELEPHONE
comprising one Base Station F27AM 25 watts output, and two 'CAMBRIDGE' mobile units type AM10D. Latest transistorised design—as new and in perfect order. Cost over £500.
Offered at £320 the lot.
H.P. terms available.
For demonstration call Mr. K. M. V. Crump, Baldock, Herts. Tel. 3196. 2752

UHF KITS and T.V. SERVICE SPARES. Suitable for Colour: Leading British Makers dual 405/625 six position push button transistorised tuners £5 5s. 0d., 405/625 transistorised sound & vision IF panels £2 15s. 0d. incl. circuits and data, P/P 4/6. Basic dual purpose 405/625 transistorised tuners incl. circuit £2 10s. 0d., P/P 4/6. UHF list available on request. UHF tuners, PLESSEY incl. valves 55/-, P/P 4/6. EKCO/FERRANTI 4 position push button type, incl. valves, leads, knobs £5 10s. 0d., P/P 4/6, SOBELL/GEC UHF tuner kit incl. valves, right angle slow motion drive assy, leads, fittings, knobs, instructions £5 18s. 6d., P/P 4/6. SOBELL/GEC 405/625 IF & output chassis incl. circuit 32/6, P/P 4/6. Ultra 625 IF amplifier plus 405/625 switch assy incl. circuit 25/-, P/P 4/6. New VHF tuners, Cyldon C 20/-, Ekco 283/330 range 25/-, Pye CTM 13 ch. incremental 25/-. P/P 4/6. Many others available incl. large selection channel coils. Fireball tuners, used good cond. 30/-. Push button tuners RGD 612/619 type used good cond. 30/-, P/P 4/6. LOPTs, Scan coils, Frame output transformers, Mains droppers etc., available for most popular makes. TV signal boosters transistorised PYE/Labgear B1/B3, or UHF battery operated 75/-. UHF mains operated 97/6, UHF masthead 85/-, post free. Enquiries invited, COD despatch available. MANOR SUPPLIES, 64 GOLDERS MANOR DRIVE, LONDON, N.W.11. CALLERS 589B, HIGH ROAD, N. FINCHLEY, N.12 (near GRANVILLE RD.). Tel. 01-445 9118. [60

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I seek a firm or individual of proven competence to design and produce prototype important invention (provisional pat.) involving op.-to-electronics, R.F., logic, control circuits and small high speed electro-magnetic mechanism (from specialists) Box No. 2635.

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STEREO GENERATORS: 1 Ohmatsu LSG/230, £25; 1 Heathkit, £35; 14 volumes "Radio and TV Servicing" until 1962. Offers considered.—H. F. ENGINEERING, 3 Willowbank, Sunbury-on-Thames, Middlesex. Telephone 83232. [2756

(1) Mullard Double Beam Oscilloscope, L.101. Excellent general condition but may possibly need recalibrating. £80. (2) Marconi BFO, type TF195L. £30. (3) Avo model 7, £15. (4) Evershed Bridge Megger 500 volt, £20.—Burgess Lane & Co. Ltd., Thornton Ave. Chiswick, London W.4. [2638

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HRO Rx5s, etc., AR88, CR100, BRT400, G209, S640, etc., etc., in stock.—R. T. & I. Electronics, Ltd., Ashville Old Hall, Ashville Rd., London, E.11. Ley. 4986. [65

NEW GRAM AND SOUND EQUIPMENT

CONSULT first our 76-page illustrated equipment catalogue on Hi-Fi (6/6). Advisory service, generous terms to members. Membership 7/6 p.a.—Audio Supply Association, 18 Blenheim Road, London, W.4. 01-995 1661. [27

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IF quality, durability matter, consult Britain's oldest transfer service. Quality records from your suitable tapes. (Excellent tax-free fund raisers for schools, churches.) Modern studio facilities with Steinway Grand.—Sound News, 18 Blenheim Road, London, W.4. 01-995 1661. [28

TAPE to disc transfer, using latest feedback disc cutters; EPs from 22/-; s.a.e. leaflet.—Deroy, High Bank, Hawk St., Carnforth, Lancs. [70

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VALVE cartons by return at keen prices; send 1/- for all samples and list.—J. & A. Boxmakers, 75a Godwin St., Bradford, 1. [10

VALVES. To clear Large quantity ex Admiralty. CV2127, CV455, CV4055, CV4024. 3/- each, 6 for 12/-. Post paid.—GREENE, Fieldings, Poulner, Ringwood, Hants. [2740

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FOR hire CCTV equipment including cameras, monitors, video tape recorders and tape—any period. —Details from Zoom Television, Amersham 5001. [75

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LEAK Dynamic Moving Coil Pick-up for L.P. Records. Parts acceptable.—S.B., 167 South Avenue, Southend-on-Sea. [2744

WANTED, all types of communications receivers and test equipment.—Details to R. T. & I. Electronics, Ltd., Ashville Old Hall, Ashville Rd., London, E.11. Ley. 4986. [63

WANTED: Bruel & Kjaer automatic frequency response recorder type 3308 (2305/1022) 20 Hz-20 KHz (or earlier model). Details please to Mr. C. Heinlein, CTH ELECTRONICS, Hoddesdon, Herts. Phone Hoddesdon 64798. [2772

WANTED, televisions, tape recorders, radiograms, new valves, transistors, etc.—Stan Willetts, 37 High St., West Bromwich, Staffs. Tel. Wes. 0186. [72

WANTED: Wireless World 1938 Communication Receiver. Condition immaterial. Box WW 2773 Wireless World.

VALVES WANTED

WE buy new valves, transistors and clean new components, large or small quantities, all details, quotation by return.—Walton's Wireless Stores, 55 Worcester St., Wolverhampton. [62

SCRAP R.F. Heating and Transmitting Valves wanted. TY5-500, TY6-800, TY7-600, ESA 1500, BR 1126. May be interested in other types. Good price paid for valves still under vacuum. Electronic Heat Co. 01-654 7172. [2606

CAPACITY AVAILABLE

AIRTRONICS, Ltd., for coil winding, assembly and wiring of electronic equipment, transistorised sub-unit sheet metal work.—3a Walerand Rd., London, S.E.13. Tel. 01-852 1706. [61

ELECTRONIC and Electrical Manufacture and Assembly. Prototypes and short production runs. East Midlands Instrument Co. Ltd., Summergangs Lane, Gainsborough, Lincs. Tel. 3260. [88

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

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TECHNICAL TRAINING IN Radio, TV and Electronics through world-famous ICS. For details of proven home-study courses write: ICS, Dept. 443, Intertext House, Stewarts Road, London, S.W.8. [24

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KINGSTON-UPON-HULL Education Committee. College of Technology. Principal: E. Jones, M.Sc., F.R.I.C.
FULL-TIME courses for P.M.G. certificates and the Radar Maintenance certificate.—Information from College of Technology, Queen's Gardens, Kingston-upon-Hull. [18

BOOKS, INSTRUCTIONS, ETC.

MANUALS, circuits of all British ex-W.D. 1939-45 wireless equipment and instruments from original R.E.M.E. instructions; s.a.e. for list, over 70 types.—W. H. Bailey, 167a Moffat Road, Thornton Heath, Surrey, CR4-8PZ. [66

REQUIRED 1937 Jones Radio Handbook. Litherland, G8CFB, 11 Birch Grove, Chippenham, Wiltshire. [2742

REDIFFUSION

COLOUR TELEVISION FAULTFINDERS & TESTERS

We have a number of vacancies in our Production Test Departments for experienced faultfinders and testers.

Knowledge of transistor circuitry and experience with Colour Receivers together with R.T.E.B. Final Certificate or equivalent qualifications required.

These will be staff appointments with all the expected benefits.

Applications to:

Works Manager,
Rediffusion Vision Service Ltd.,
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Phone: 01-397 5411

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AIR FORCE DEPARTMENT
RADIO TECHNICIANS

Starting pay according to age, up to £1,189 p.a. (at age 25) rising to £1,500 p.a. with prospects of promotion.

Vacanies at RAF Sealand, Near Chester and RAF Henlow, Bedfordshire

Interesting and vital work on RAF radar and radio equipment.

Minimum qualification, 3 years' training and practical experience in electronics.

5-day week—good holidays—help with further studies—opportunities for pensionable employment.

Write for further details to:
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London, W.C.1.

Applicants must be UK residents.

2685

FOR

ANNECY (FRANCE)

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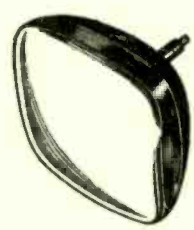

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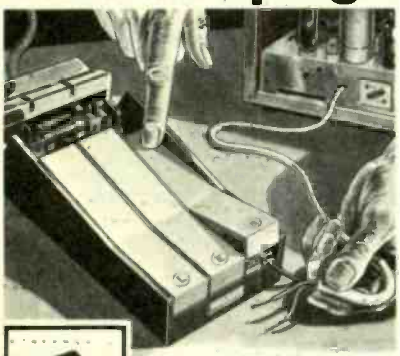

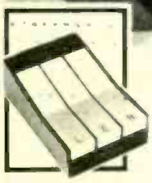

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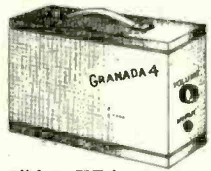

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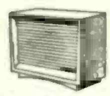

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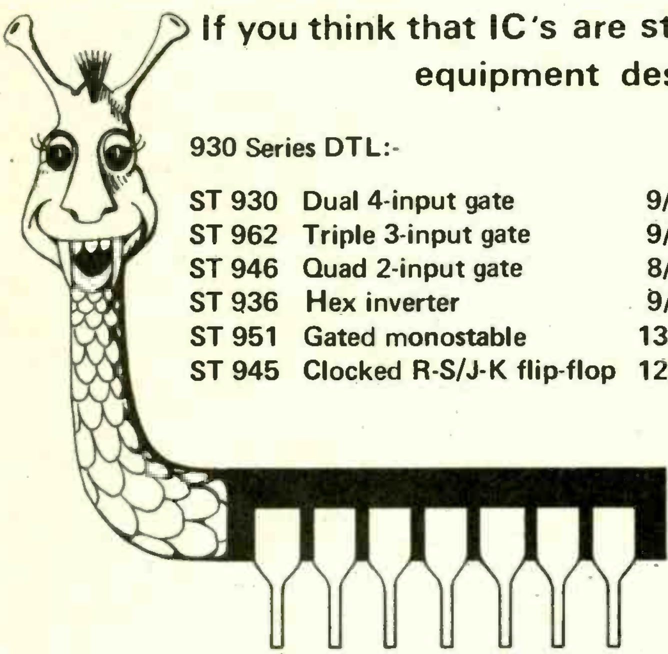

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