FEBRUARY 1968
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PORTABLE FREQUENCY STANDARD

# Wireless World

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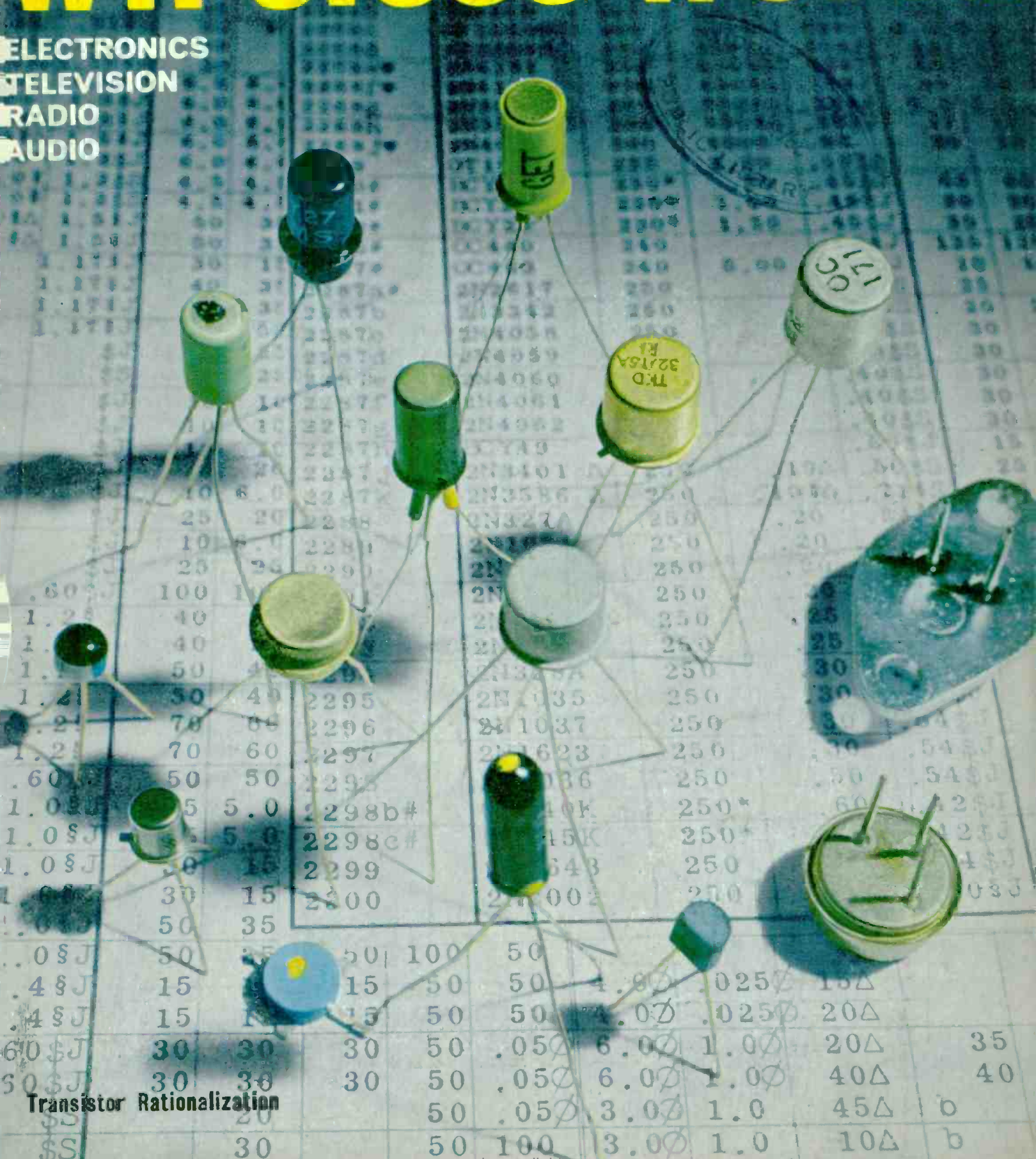

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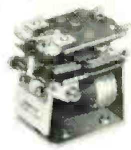

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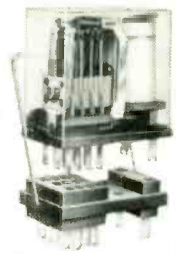

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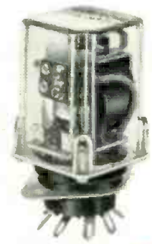

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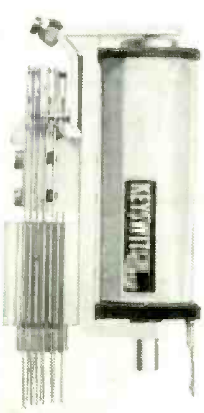

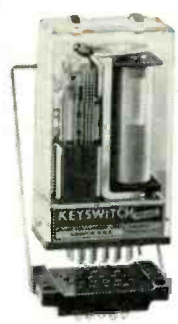

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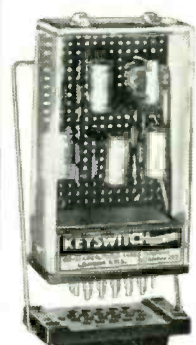

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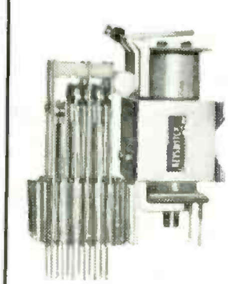

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# Wireless World

ELECTRONICS, TELEVISION, RADIO, AUDIO

## FEBRUARY 1968




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# Wireless World

ELECTRONICS, TELEVISION, RADIO, AUDIO

## Technical Manpower

THE present shortage of scientists and technologists in the electronics industry, and the increasing demand for them, are highlighted in a recently issued study* by the Manpower Research Unit of the Ministry of Labour. This fact is widely known, of course, and is borne out by the enticingly worded display advertisements in the technical and lay press; indeed one company has said that it can cost a year's salary in advertisements to fill one vacancy!

This manpower study was conducted among 36 firms who, between them, have on their payrolls about 70% of the industry's 370,000 or more employees. The 72-page report covers the whole occupational structure of the industry and it is significant that scientists and technologists account for 6%, and technicians 6% of the industry's employees. In the capital goods sector the two categories each account for some 11%. (These figures contradict the usually quoted ratio of four technicians to each technologist.) Moreover, although the estimated total increase in staff over the five years from 1965 to 1970 is expected to be 28% the increase in scientists and technologists in the capital goods sector is foreseen as 49%.

It is obvious therefore that the present situation is unlikely to change for some time to come unless something can be done to encourage young people of both sexes to see a future in engineering. This note was struck forcefully by Major General Sir Leonard Atkinson in his recent I.E.R.E. presidential address. He said "If we [as a nation] are to survive and prosper we must reverse the accent on classical education and turn more to science and engineering. . . . The excitement of creating new tools . . . can only be engendered by stimulating a love of mathematics and physics—not by revering Latin and Greek, which, however commendable in humanistic studies, will never create . . . a transistor. . . . I believe that the newer places of learning should concentrate on courses and degrees in engineering and technology rather than trying to emulate the pattern of degrees in general science which suited the country's needs when older universities were established." This concern is also voiced in the Manpower report which records that several companies have expressed disquiet that some of the technological universities have been developing along more academic lines and losing, or loosening, their links with industry.

Little reference is made in the Manpower report to the question of the "brain drain" but Sir Leonard aphoristically sums up the present situation in the phrase "brains are like hearts—they go where they are appreciated"!

One large organization is quoted in the Ministry's study as saying "We cannot make use of arts graduates as scientists and technologists." However, the report adds, "it seems possible that there is scope for some replacement of scientific and technological manpower by suitable arts graduates, at least in some areas that are not 'technical'". Having elected to take an arts degree, is one to be debarred from making a contribution in a technological industry? After all, the ability to think analytically is not confined to science graduates. The arts graduate would obviously not want to take an engineering degree course, but could not postgraduate reorientation or conversion courses be devised by the colleges of technology which would help to equip the arts man for an engineering post? If this were done we might well find many of the long-standing vacancies in engineering filled.

* "Manpower Studies No. 5: Electronics" H.M.S.O.

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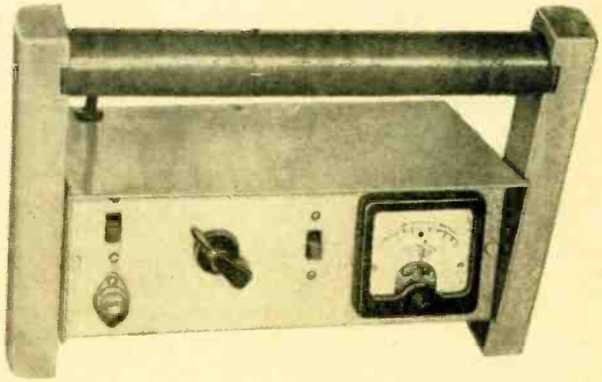
1968

# Portable 1-MHz Frequency Standard



By L. NELSON-JONES, A.M.I.E.R.E.

## Uses crystal oscillator phase locked to 200 kHz B.B.C. Droitwich transmission

THE increasing accuracies being demanded in the generation and measurement of radio frequencies, together with the increasing use of digital frequency measuring instruments, make a frequency standard a necessary part of most laboratories today. The degree of accuracy required will naturally depend on the work in hand, and a number of types of standard are currently employed. These range from simple crystal or tuning fork oscillators to highly stable lenticular or Essen Ring crystal oscillators with elaborate temperature control, and for the very highest accuracies atomic standards are used. In addition, a number of transmitters radiate standard frequency transmissions throughout the radio spectrum, and for a very full treatment of this subject the author would refer readers to the excellent *Wireless World* article by J. McA. Steele*.

The l.f. and v.l.f. transmissions are most suitable for general use as frequency standards, and of these the 200 kHz transmission of the B.B.C. Radio 2 programme from the Droitwich transmitter is in many ways the most useful, since it is a continuous transmission and is not keyed or interrupted as many other transmissions are.

It is possible to use the 200 kHz transmission direct as a standard, with sufficient amplification and successive limiters to remove the amplitude modulation. The author has seen such a specially built receiver which successfully used this method and which "piped" a standard 100 kHz signal through a group of laboratories.

An alternative for removing the modulation from the generated standard frequency is to compare the phase of the standard frequency transmission with the phase of a local oscillator and use the output of the phase comparator to control the local oscillator frequency so that it is locked to the standard transmission. The phase-lock system may then have a sufficiently long response time that it does not respond to the instantaneous phase modulation caused by the amplitude modulation of the transmitted carrier, and so the local oscillator will be free from the effects of this modulation.

The type of local oscillator used is of little importance so far as long term accuracy is concerned since the oscillator is locked to the transmission, but so far as short term accuracy is concerned a crystal oscillator is much to be preferred, for the following reasons: First, because of the narrow resonance bandwidth of the crystal, it will not respond to any but the slowest changes in the frequency control circuit, and it thus assists materially in removing the effects of carrier modulation. Secondly, because of the narrow "pull-in" range of such an oscillator, quite a good frequency standard is still available even if the standard frequency transmission should fail.

The portable frequency standard described uses a 1 MHz crystal oscillator, together with a variable capacitance diode and a blocking-oscillator divider (÷5) in a phase-lock loop. A sampling technique is used rather than a phase sensitive detector. The frequency of the output is that of the crystal (1 MHz) but the output is provided by a non-saturating emitter coupled multivibrator locked to the crystal frequency. The output pulses are of 120 ns width, with fast rise and fall times. The instrument is battery operated. Fig. 1 is a block schematic showing the main functional units of the frequency standard. A complete circuit diagram is given in Fig. 2.

**200 kHz receiver.**—A ferrite rod aerial 8 inches long is contained in the paxolin tube forming the handle above the unit (see photo). This handle also contains the tuning capacitors for the ferrite rod, and the trimmer is accessible through a small hole in the rear of the tube.

The coupling coil of the aerial is connected to the receiver through a coaxial cable. The ferrite rod must, of course, be mounted clear of the case in this way in

* "Standard Frequency Transmissions" by J. McA. Steele, *Wireless World*, Sept. 1967, p. 443.

**Laurence Nelson-Jones**, who is 38, is now a principal engineer with the Data Equipment Division of the Plessey Automation Group at Poole, Dorset, but he has spent the major part of his career (1953-65) with Kelvin Hughes which he joined after National Service in the R.A.F. At Plessey he is working on computer peripheral equipment, having previously spent a short time with S.T.C. at Basildon on p.c.m. repeater design.

order to avoid screening from the case, and instability caused by pick-up from the internal circuitry. The aerial rod used is the type made for the "Contessa" portable receiver, with the medium wave and car coupling coils discarded. (This item together with the other tuning coils, the crystal, etc., may be obtained from Henry's Radio Ltd.) It is important to ensure that, as the tuning and the coupling coils of the ferrite rod are wound over one another, the earthy ends of the two windings are adjacent, or the losses and stray capacitances of the coils will be very serious.

The first two stages of the receiver are conventional grounded-emitter r.f. amplifiers. These stages are, however, run at only about 600-700 μA of collector current, so that their gain is less than the maximum available from such a stage. This reduction of gain ensures a high margin of overall stability in the receiver, and avoids the necessity for neutralization. The 15kΩ damping resistors across the primary windings of both stages are required, not to damp the tuned windings themselves, but to prevent oscillation of the stages at the self-resonant frequency of the primary windings which are very loosely coupled to the main tuned winding. The damping resistors have little effect on the gain at 200kHz.

The third stage of the receiver (Tr3) is also of the

*Fig. 1. Block schematic showing principle of operation of the frequency standard.*

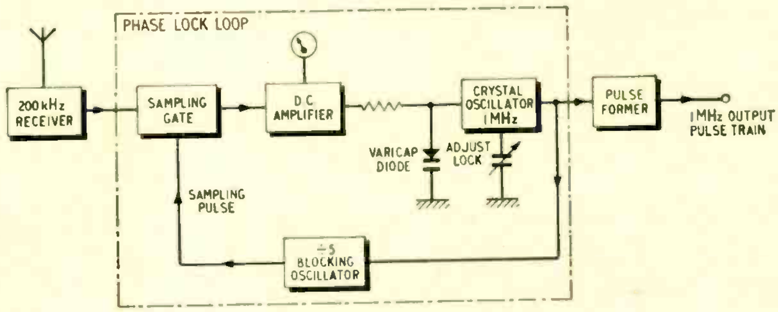
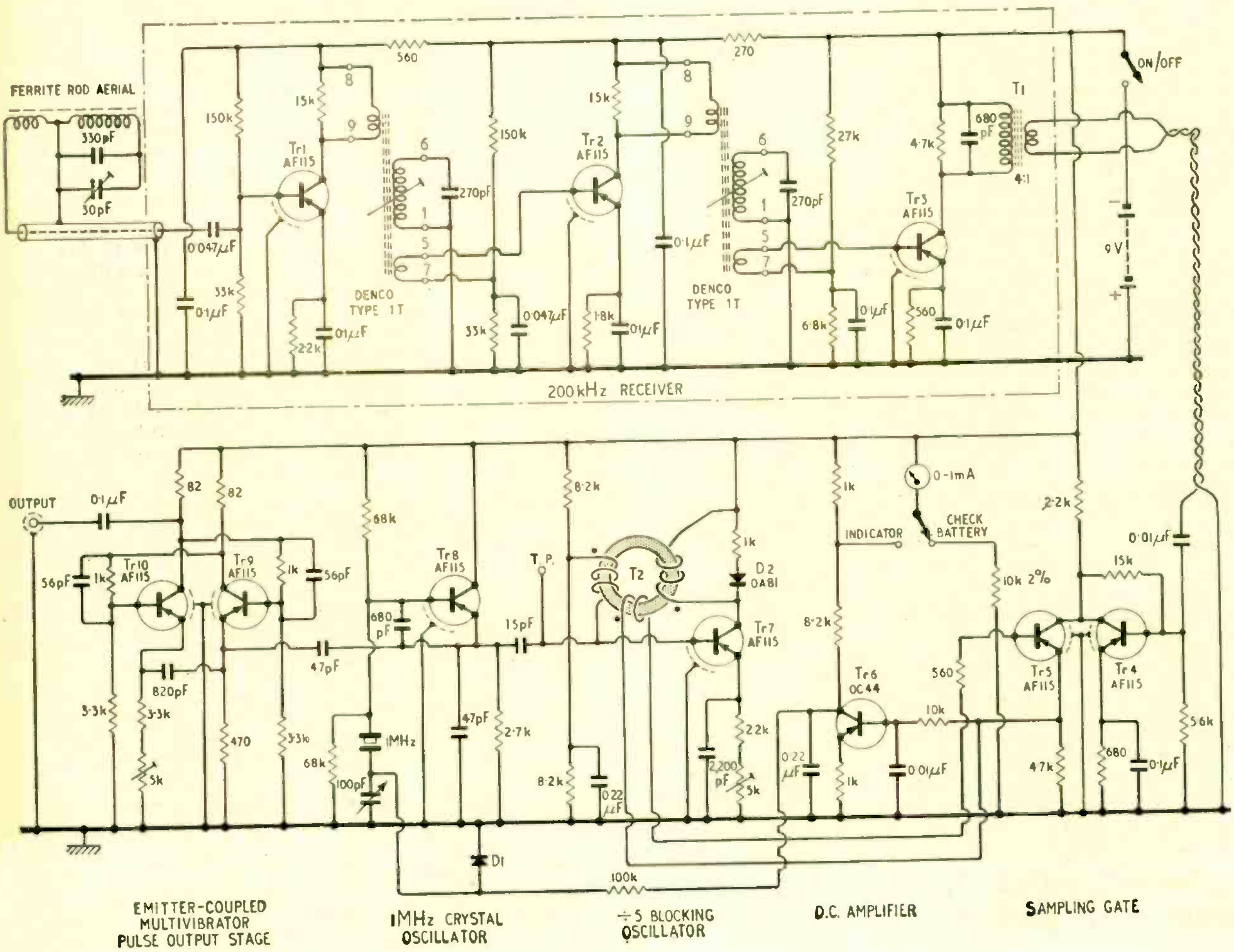



*Fig. 2. Circuit diagram of the instrument. All resistors are ¼ W (10%, unless indicated). All tuning capacitors and 47 pF and 680 pF of 1-MHz oscillator and 820 pF capacitor of multivibrator are silvered mica. 2,200 pF of blocking oscillator is polyester. All other capacitors are ceramic. Values below 100 pF are N750; higher values are HI-K.*



grounded-emitter type, but the load is a tightly coupled tuned transformer connected directly in the collector circuit. No adjustment of the tuning is provided as the working Q of the transformer is 3. The tolerances of the components therefore have little effect on the resonant impedance of the transformer. The secondary of the transformer is coupled by a twisted pair to the driver stage of the sampling gate.

The transformer (T1) is wound on a Denco iron-dust pot core assembly Type 10D. The primary winding, of 160 turns of 40 s.w.g. enamelled copper single silk covered wire, is wound with 100 turns in one of the outer slots and 60 turns in the centre slot of the bobbin. The secondary is wound with 40 turns of 34 s.w.g. enamelled copper wire in the other outer slot. These windings give a primary inductance of 1mH. The iron dust adjusting core may be fitted if desired but, as has been said, it will have little or no effect on the gain due to the low working Q.

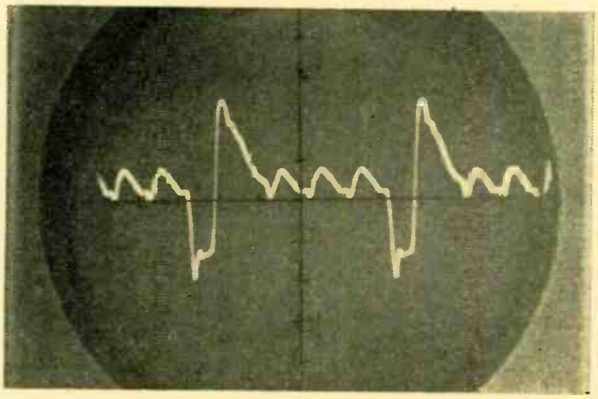


*Fig. 3. Frequency divider waveform. x = 1 μs/div. y = 1 V/div.*

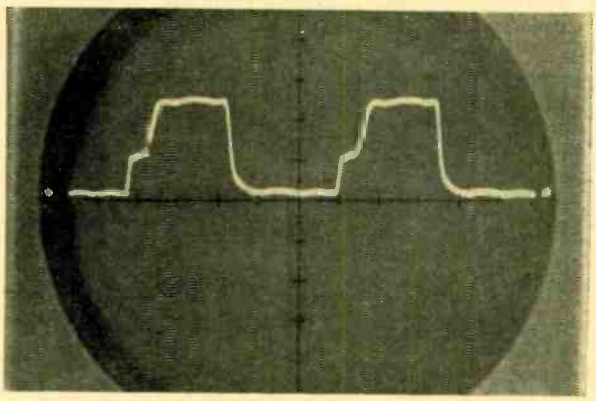


*Fig. 4. Sampling gate waveform. x = 1 μs/div. y = 2 V/div.*

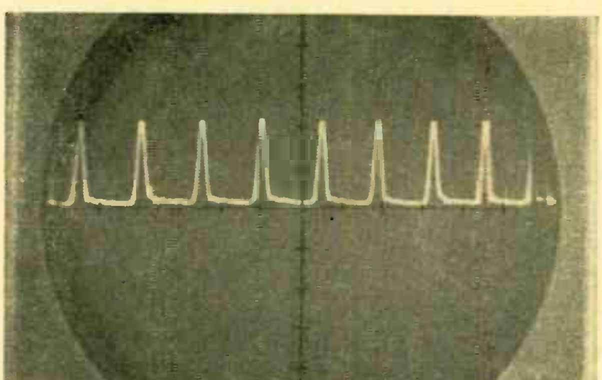


*Fig. 5. Output pulse waveform. x = 0.6 μs/div. y = 0.5 V/div.*

*(On above reproduced photos, div. = 0·5 cm approx.)*

**1 MHz crystal oscillator.**—The circuit operates at the fundamental parallel resonance of the crystal, which is an S.T.C. Type 4044 (AT cut). An adjustable capacitor is included in series with the crystal so that the oscillation frequency may be pulled to exactly 1 MHz. The variable capacitance diode D1 is also connected at this point. The variable capacitance is mounted on the front panel so that the phase-lock may be adjusted.

A number of diode types were tried as reverse biased variable capacitance devices, since no diode specially selected for this purpose was available at the time. Standard diode types range in effective capacitance from the 200-500 pF of the 400 mW zener diodes to only 1-4 pF of such high speed diodes as 1N914 and 1N916. It was found that a diode with a suitable range of capacitance for this application could be found among the smaller rectifier diodes such as OA200, OA202, 1S120 series, and 1S130 series, CV7040, etc. An OA200 was used in the prototype. The electrical Q of such diodes is probably not high, but as the oscillator is fairly tightly coupled the effect of the diode being connected is negligible, nor is the amplitude greatly affected by the amount of reverse bias applied to the diode.

**Blocking oscillator frequency divider.**—A number of locked divider circuits were tried, but that used[2] was found most suitable on a number of counts: (1) It is very stable, and is relatively unaffected by temperature and voltage variations. (2) The variable resistor is at earth potential on one side, making it easier to bring this control out. (3) The use of a blocking oscillator enables a suitable sampling pulse to be generated directly.

The divider is coupled to the crystal oscillator through a small capacitor, and the waveform at the base is available on a socket on the rear panel for adjustment purposes together with the 5kΩ variable resistor of the divider circuit. The waveform is shown in Fig. 3, as it appears when set to the correct division ratio.

The transformer T2 is wound on a Mullard ring core Type FX1593 (obtainable from Henry's Radio Ltd.) or FX308, nylon coated. If the uncoated core FX1593 is used, it should first be covered with a layer of insulation, as the abrasive nature of the ferrite quickly strips the enamel from the wire in winding. In the prototype the core was first wound toroidally with very narrow strips of paper "masking" tape.

The primary (collector) winding is of 25 turns of 34 s.w.g. enamelled copper wire and occupies about a third of the periphery of the core, wound as a single layer.

The secondary (base) winding is of 12 turns of 34 s.w.g. enamelled copper wire, also wound as a single layer adjacent to the primary.

The coupling winding to the sampling gate is of 6 turns of 34 s.w.g. enamelled copper wire, wound in a single layer in the remaining space.

In the prototype a 4 B.A. nylon screw was then passed through the centre aperture and secured in place by a nylon nut. The whole assembly, except for the remaining thread, was then dipped in cellulose enamel to lock the wires in position. (An equally suitable coating would be obtained with one of the polyurethane varnishes.) The excess thread was then used to mount the toroidal transformer onto the chassis with a second nut.

The phasing of the windings, together with the relative position of the windings, is indicated on the circuit diagram (Fig. 2).

**Sampling gate and d.c. amplifier.**—The driver stage of the sampling gate (Tr4) is a conventional grounded emitter stage, with a degree of d.c. feedback since the base bias potentiometer is connected to the collector. This configuration does not result in any great degree of a.c. feedback since the source impedance is low (around 300 Ω). In normal operation in the Bournemouth area, where the 200 kHz signal is none too strong, this stage is driven fully into limiting; indeed full limiting takes place in this stage over nearly the whole of the 360° of rotation of the receiving aerial. Only near the two nulls in the response is there any appreciable reduction in the signal fed to the sampling switch (Tr5).

At full signal the collector potential of Tr4 swings between −2.4 V and −7.4 V. The waveform at this point is shown in Fig. 4.

The notch in one side of the waveform is due to the loading effect of the sampling switch during the sampling period, and is typical of the waveform when phase-lock is established.

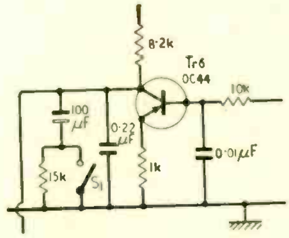
The sampling switch Tr5 is brought into conduction for approximately 1 µs every 5 µs by the sampling pulse generated in the blocking oscillator divider. This pulse is applied through a limiting resistor between the base and emitter of Tr5. During the sampling period, therefore, the emitter circuit of Tr5 is connected to the collector of Tr4. The average d.c. potential at the emitter of Tr5, after smoothing by the RC network feeding this level to Tr6, is approximately a fifth of the potential of the collector of Tr4, and will therefore vary between approximately −0.5 V and −1.5 V, depending on the relative phase of the sampling pulse and the 200 kHz signal at the collector of Tr4. The gain of the d.c. amplifier Tr6 is determined by the ratio of the collector load to the emitter resistor, and with the meter in circuit is approximately eight times. Thus the collector potential of Tr6 will vary from the "bottomed" state which is just reached when the collector is at —1 V up to about —6.5 V at minimum base input.

The potential at the collector of Tr6 is applied to the reverse biased diode D1 through a 100 kΩ resistor to afford isolation between the d.c. amplifier and the crystal oscillator, and to minimize the loading on the crystal oscillator.

**Output pulse generator**[1].—The output pulses are generated by a non-saturating emitter-coupled multivibrator locked to the crystal oscillator frequency through the small coupling capacitor between the emitters of Tr8 and Tr9. The lock-in of the stage is set by the variable emitter resistor of Tr10.

The output pulse at the collector of Tr10 is of approximately 1 V amplitude and is positive-going. An almost identical negative-going pulse is available at the collector of Tr9 if required. The output waveform as viewed on the author's oscilloscope (of 4.5 MHz bandwidth and 80 ns risetime) is shown in Fig. 5. The pulse has, however, been examined on an oscilloscope of 4.5 ns risetime, when the pulse was seen to be rectangular in shape. The risetime (10-90%) was 20 ns, and the falltime 30 ns. There was a slight overshoot on leading and trailing edges. Unfortunately no camera was available at the

*Fig. 6. Modification to d.c. amplifier output circuit for obtaining higher short-term accuracy.*




time to record the waveform. If this pulse is to be conveyed over any distance it should be coupled via 75-80 Ω coaxial cable terminated at the receiving end, or the waveform will be hopelessly mutilated, and the harmonic content greatly reduced.

An effect was observed on the wide-band oscilloscope which confirms the finding of appreciable though small harmonics in the output pulse waveform at 200 kHz intervals. It was observed that if the scope was triggered at a speed which was a multiple of 5 µs then the trace was sharp, whereas if it was triggered at another speed the pulses were very slightly blurred due to a cyclical phase modulation of the 1 MHz crystal oscillator by the blocking oscillator divider operating at 200 kHz. Something of this effect is just about visible in Fig. 5 where the base of each fifth pulse is slightly different.

In practice the effect is of little consequence, the main effect being to give harmonics in the output at 200 kHz intervals in addition to the main ones at 1 MHz intervals. If, however, the effect were felt to be undesirable it could largely be eliminated by placing a buffer stage between the crystal oscillator and the blocking oscillator divider.

The choice of a narrow pulse for the ouput was made in the interests of equality of harmonic levels at the even and odd harmonics. A blocking capacitor is included in the output lead to prevent damage to the 82 Ω collector load from short circuiting of the output terminals.

**Setting-up procedure.**—As will be seen in the photograph on page 666, there are three controls on the front panel. An on/off switch is on the left. A meter switch adjacent to the meter permits a check of the battery voltage in the upper position and connects the meter as a phase-lock indicator in the lower position. (The meter used on the prototype had a right-hand zero.) The large dot on the meter scale merely indicates a suitable setting for the pointer when setting the phase-lock, it being the average of optimum settings at minimum (7 V) and maximum battery voltage. The third, rotary, control is the variable capacitor of the crystal oscillator used to set the phase-lock.

To set up the instrument correctly the knob is slowly turned from left to right when the beat seen on the meter will slowly drop in frequency until at about 1 Hz the beat will cease suddenly. Further movement of the knob moves the pointer of the meter over the scale until at the limit of the phase-lock range the meter suddenly starts beating again, the frequency rising as the knob is further turned. The correct setting is achieved by turning the knob to the position where the oscillations first cease, and then further adjusting the knob until the pointer of the meter is over the centre of the scale (at the dot mentioned above). Normally if this setting is not disturbed the unit can be switched off, and then on again, when it will drop back into correct lock within about 1 second.

**Accuracy.**—The $0.22\,\mu F$ capacitor at the collector of Tr6 provides additional smoothing of the voltage fed to variable capacitance diode D1, but it is of insufficient capacitance to eliminate any residual modulation present in the 200 kHz waveform of the collector of Tr4, and hence present in the voltage of the collector of Tr6. The effect of residual modulation is to cause short-term phase modulation of the 1 MHz output and hence to reduce the short-term accuracy. Since the total pull-in range of the phase-lock loop is only about 2 Hz the effect of this residual modulation (usually less than 10 % peak-peak) is only a fraction of a hertz at the 200 kHz rate, or less than one hertz at 1 MHz.

The accuracy is thus better than one part in $10^6$ over a period of one second (or about three parts in $10^6$ if the signal does not produce full limiting at the collector of Tr4). Over a period of 10 seconds it is one part in $10^7$, over 100 seconds one in $10^8$, and so on. The long-term accuracy is, of course, the accuracy of the transmitted carrier, i.e., five parts in $10^{10}$, with a drift rate of less than one in $10^{10}$ per day[3].

The size of the capacitor at the collector of Tr6 cannot be greatly increased, or it will be found that it is not possible to set the phase-lock loop up initially. However, the circuit of Fig. 6 is suggested for those applications where higher short-term accuracy is needed. The phase-lock is set up with S1 open, when the circuit is similar to that of Fig. 2. After a period of some 30 seconds, to allow for the $100\,\mu F$ capacitor to charge up, S1 is closed, which may cause slight temporary disturbance of the phase lock. After a further 30 seconds or so the phase lock will be steady, and largely free from modulation effects, since the low frequency cut-off of the phase-lock loop is below the lowest modulation frequencies. Switch S1 must be opened again before switching on, or the phase-lock will not re-set. The $100\,\mu F$ capacitor should preferably be of a low leakage type, such as a solid dielectric tantalum or wet tantalum electrolytic. The working voltage of the capacitor should be greater than the supply voltage, which can be up to 10 V with a fresh battery. The majority of users will find that this modification is not necessary.

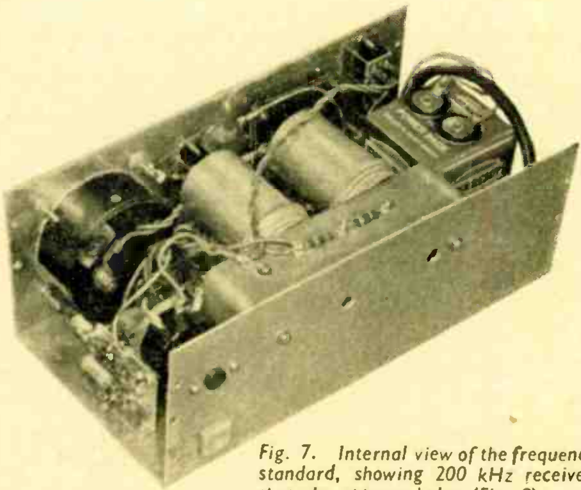


*Fig. 7. Internal view of the frequency standard, showing 200 kHz receiver that also appears below (Fig. 8).*

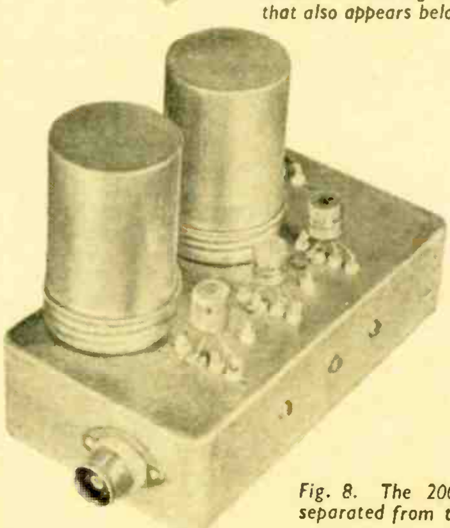


*Fig. 8. The 200-kHz receiver separated from the instrument.*

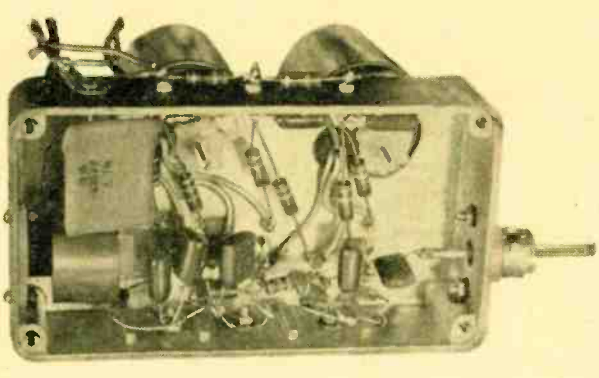


*Fig. 9. Circuit wiring in the 200-kHz receiver.*

**Power supply.**—A standard 9 V dry battery has been used in the prototype, and stabilization of this supply has not been found necessary. The main effect of reduced battery voltage is loss of output pulse amplitude.

If desired it would be a simple matter to build in a mains supply circuit with stabilization (perhaps by a zener diode only). Care should be taken, however, to provide adequate suppression of the mains supply lead, both to avoid the introduction of interference to the unit and to avoid the radiation of interference from the internal circuits, especially as the harmonic content of the output pulses covers a very wide frequency spectrum.

**Constructional notes.**—Figs. 7, 8 and 9 show the construction used in the prototype unit. The packing density is rather high, and if the author were to make a second unit it would be of larger size and use a larger battery than the PP7 shown. Despite its small size this battery gives about 40 hours of intermittent use at the normal load current of 28 mA at 9 V, and is quite adequate for the purpose for which the standard was built, namely as a reference for the calibration of signal generators, digital frequency meters, etc.

Figs. 8 and 9 show the construction of the 200 kHz receiver, which is built in a standard Eddystone die-cast box, Type 896. Screening of the receiver in this way is essential for stability. The screening cans of the coils are the cans in which the coils are supplied, as suggested in the leaflet accompanying them. The numbers on the coils in the circuit diagram are the pin numbers of the coils.

Those readers wishing to modify the circuit to allow use of silicon n-p-n devices should find that the BC108 is suitable, but slight changes of value may be necessary, for instance a reduction in the value of the emitter resistors of transistors 1, 2 and 3 to maintain the value of the collector currents of those stages. It may also be necessary to alter the values of the 56 pF capacitors in the output pulse generator stage Tr9 and Tr10 to obtain a satisfactory pulse shape. If this change is made it will be necessary to reverse the two diodes, the meter and the battery connections. In addition, if the modification of Fig. 6 is incorporated, the electrolytic must be reversed. The output pulse will be negative, but can be made positive by connecting the output capacitor to the collector of Tr9. It should be added that the author has not tried these modifications, but that since the circuit is in no way critical, he sees no reason why the change to n-p-n silicon devices should not be successful.

Layout is not critical, but leads should be kept short. In the unit shown the circuits (other than the receiver) are constructed on small aluminium plates using A.E.I. Polytags Type PT23, which are p.t.f.e. feed-through insulators. The progression of the circuit as shown in Fig. 2 should be followed in the physical layout to avoid unnecessary stray couplings between different parts. The output pulse generator was built on a separate plate and is coupled to the output socket through a coaxial cable.

### REFERENCES


1. Motorola "Switching Transistor Handbook," 2nd edition. Section 8.4, page 276.
2. Mullard Reference Manual of Transistor Circuits, 1st edition. Section 8.4, page 276.
3. *The Radio & Electronic Engineer*, the journal of the Institution of Electronic and Radio Engineers, publishes each month a record of the daily performance of the GBR (16 kHz) MSF (60 kHz), and Droitwich (200 kHz) standard frequency transmissions. (GBR is a standard time transmission and has at present the internationally agreed offset of −300 parts in $10^{10}$. The MSF and Droitwich transmissions have no offset as referred to the basic standard caesium F m (4-0)—F m (3-0) transition at zero field of 9, 192, 631, 770.0 Hz.)


# Further Notes on "VHF Signal Generator"

## By G. W. SUTTON, on his article in the December 1967 issue

**Attenuator piston.**—Since the attenuator drawings were made available Mr. V. J. Cox has pointed out that there is no advantage, and a definite disadvantage, in making the perspex piston as much as ⅞ inch in axial length. It is suggested that this dimension should be reduced to ¼ inch, thus reducing the inductance of each turn of the piston coil to about one third of its previous value. The number of turns on the coil may therefore be almost doubled for the same total coil-inductance as before. The limit to the number of turns is set by the necessity to keep the inductive reactance of the coil well below 75 Ω at the highest frequency generated. As the maximum output voltage was already within the range of a valve-voltmeter there is no particular advantage in raising it by 6 dB or so, but the battery voltage can be reduced, for the same output, to 20 V or less.

**Coaxial cable.**—Good quality 75 Ω cable should be used for the coaxial output of the piston attenuator. A cheap open-mesh braiding is now in almost universal use, but some readers may not be aware of its shortcomings.

**Battery voltage.**—The battery voltage suggested is above the transistor manufacturer's maximum rating. The load current, on the other hand, is only about 1/20th of the rated maximum. The author has carried out tests at considerably more than 36 V, and has used BFY18s and BSY26s in signal generators at 36 V for protracted periods during the past 18 months. At no time has any instability been detected, nor has the output varied. However, if doubt is felt at this point, or more especially, if a germanium alternative is used, the piston turns may be increased to 4 or 6 on the shorter piston mentioned above, and the battery voltage correspondingly reduced. This will still provide a maximum output voltage readable on a valve-voltmeter.

**Additional output.**—For some tests on television sets an r.f. voltage of 1 V or more is needed. An additional, higher voltage, output from the signal generator has been provided by incorporating a pick-up coil coupled to the r.f. oscillator coil. A strip of perspex 4 mm thick was mounted on the rear face of the oscillator coil (see photo on p.575 December issue, and piston attenuator drawings). Four small holes were drilled laterally through the strip and 2 turns of 30 s.w.g. wire were threaded through these holes, fixed in place by squeezing a little cement into each hole, and terminated on a 75 Ω cable socket mounted on the top of the oscillator shield. Two to three volts r.f. are induced in this coil and, provided the leads to the receiver under test are short, can be applied undiminished to a valve grid. The lid of the outer shield has to be removed, but the resulting leakage is of no significance in tests at this level.

**Better shielding.**—The front end of the piston attenuator projects through a circular hole in the inner shield and is connected to it by phosphor-bronze springs. Somewhat better shielding is obtained if a slot of the same dimensions as that in the end of the attenuator is cut in the inner shield instead of a circular hole. The oscillator coil mounting should then be altered to bring the flat side of the coil to within 2 mm of this slot. The springs may be omitted and the attenuator face should be brought also to within 2 mm or so of the outer surface of the inner shield. The two slots should face one another accurately.

**Corrections.**—In the caption to Fig. 7 the reference to graph point 4/7 should read "e.g. 4/7 is the beat with the 7th harmonic of No. 4 crystal. . . ."

In the last paragraph on p.573 the thickness of the coil turn spacing washers is incorrectly given as 0.400 in. This should be 0.040 in.

## A Critique of Class D Amplifiers for A.F.

# 3: DISTORTIONS INHERENT IN P.W.M.

By K. C. JOHNSON, M.A.

THE two previous articles have described the possibility of making power amplifiers of high efficiency using components with wide tolerances by exploiting the class D principle. It has been pointed out that amplifiers of this type may suffer from serious distortion arising from two quite distinct causes. First there is the usual sort of trouble due to the non-linearity present in all electronic systems. This causes the amplitude of the final switching square-wave to have undesirable variations, and also degrades the precise timings of the edges as they pass through the several stages of amplification. These effects are analogous to those which are familiar in the more conventional types of amplifier and to a large extent they can be overcome in the same way—by the use of negative feedback. In a class D circuit this feedback has to be taken from the output of the switching stage and is used to modify the edge-timings at the square-wave generator, but the action is essentially the same as usual.

The second distortion effect is inherent in the class D principle itself. It comes from the fact that the output of a circuit of this type is taken from the powerful square-wave source to the loudspeaker through nothing more than a simple linear filter network. This means that the edge-timings of the square-wave should ideally possess the peculiar property that all its frequency components within the band to be amplified correspond exactly with those of the required signal; whilst the components at other frequencies must be such as to make the total form a square-wave. This very particular requirement is certainly not met by the square-wave from just any circuit that gives a variation of the mark-space ratio. It is true that moderately low levels of distortion can be obtained with a simple square-wave generator circuit if the average switching rate is made substantially higher than the highest output frequency required, and the maximum range of mark-space variation is severely restricted, as was the case in the circuit described last month, but the utilization of the output transistors in such an arrangement is very poor.

Alternatively we can consider more carefully what the exact mathematical requirements are and attempt to devise a generator principle that is nearer to the ideal but yet avoids being too complicated to be practical. This article is concerned with this approach, but, as the reader may suspect from the fact that it is appearing after the amplifier design, there is not going to be any clear conclusion and it seems that any real improvements in the performance of the square-wave generator are likely to be more trouble than they are worth. There is always the hope though, that this assertion will be proved false by some new development.

In order that an amplifier of the class D type shall behave sensibly for input signals of any nature, the switching square-wave cannot be allowed to stop or change drastically in any way. In particular it must run steadily with a near 50:50 mark-space ratio when there is no input applied and change progressively in a smooth manner so as to give the required output when the input is varied. Clearly this is a process of modulation. The zero-input square-wave is an unmodulated carrier which must be generated within the circuit itself, whilst the change, when an input is applied, must follow some well defined modulation law.

Most readers will be familiar with the process of modulation as applied to sinusoidal carrier waveforms in radio practice, a.m., f.m., s.s.b. and so on. In every case appropriate demodulator circuits are necessarily incorporated in the receiver and it is normally possible so to design these that the original modulating waveform can be recovered without any distortion being introduced by the modulation process. The modulation technique that we require for the class D type of amplifier, on the other hand, must work without a demodulator of any sort. Thus if a distortionless output is to be obtained the modulation law must be such as to generate precisely that square-wave which contains the correct frequency components, and no other.

Suppose that we have a carrier square-wave of repetition frequency $f_c$ under our control throughout an interval of time $t$ during which it makes some exact number, $n = t . f_c$ of complete cycles. There will, of course, be $2n$ edges occurring during this time, since there are two per cycle, and in the modulation process each of these edges may be displaced independently by any required fraction of their separation. Thus the system has $2n-1$ degrees of freedom, since one of the edge positions must effectively be used as a reference to measure the displacements of the remainder. But it is well known that in this kind of process the only distinguishable frequency components in the modulation are those which make an exact integral number of cycles during the interval of time $t$ (it is as if this interval were necessarily joined round on itself head-to-tail). These components have the frequencies 0, $1/t$, $2/t$, $3/t$ and so on. Now for the first of these, the d.c. term, there is an amplitude only, whilst the remainder have both amplitude and phase. Thus, provided that the amplitudes are not so excessive that the edges try to cross-over with their neighbours, we can use our $2n-1$ degrees of freedom to determine the values of all the frequency components from 0 to $(n-1)/t$ inclusive. But this upper frequency is $f_c - 1/t$ and, since the argument holds good as $t$ increases to infinity, we therefore find that we can in principle so modulate the edge-timing of a square-wave as to make it have any frequency components of reasonable amplitude that we wish in the band between zero and just less than the carrier frequency itself.

Thus there is no theoretical objection to the use of a carrier which is only just above the highest frequency that we wish to amplify. The edge-timings of such a carrier can be modulated so as to achieve the result we are seeking. In practice, though, there will have to be a decent margin left to allow for the attenuation change of the filter, which must pass the required signal whilst suppressing not only the carrier but also the mass of complicated components that will inevitably be present above it. So far then the prospect is quite encouraging and we have established that the modulation process we are seeking does at least exist. Let us next consider what the available modulation processes can in fact do.

Since a square-wave has both upward and downward edges there can be two distinct forms of modulation applied to it. The first is, of course, mark-space modulation, where the two types of edge are displaced in opposite directions in proportion to the magnitude of an applied signal. When the input signal changes, each displacement is proportional to the input at the instant that the edge is made, rather than to the value at the time from which the edge has been displaced. The magnitude of the modulation will be best measured in this case by the ratio of the displacement to the time of a quarter-cycle of the carrier and this will be called the modulation index, $x$. Clearly this index has strict limits and cannot go beyond the range from plus to minus unity without trouble due to the edges trying to cross over.

The second form of modulation is obtained by displacing all the edges in the same direction, regardless of type, by an amount which is again proportional to the input signal at the instant each edge is made. This is obviously a form of phase modulation and the magnitude can be measured in terms of the phase angle of the carrier that is equivalent to the displacement. This angle will be called $\theta$ and it will normally be convenient to measure it in radians. There is in principle no limit to the value that this angle can have, but as with sine-wave modulation, the value will not normally exceed a radian or so when the mechanism is of the nature of a "phase modulation," but can have vastly greater values when a "frequency modulation" is involved. The distinction between the two is not a rigid one but is convenient and we shall use it here in the usual way.

Now clearly it is possible to generate a square-wave which has either of these forms of modulation, or even both at the same time if required. An analogue computer type of circuit can determine when each edge ought to be formed and then some form of flip-flop can be triggered so as to produce the required square-wave. There is a slight oddity in that it is possible for a sufficiently rapid change of either kind of input to cause an edge to be first made, then reversed, and then made again within a single half-cycle of the carrier, so that a triplet results. But this is nothing to worry about because the input waveforms of practical amplifiers never change sharply enough for this effect to occur. In general these modulation processes work quite well and there is no ambiguity about the square-wave produced for given modulating waveforms.

This is not true in the reverse direction since, in contrast to a sine-wave, a square-wave carries modulation information only at the instants when edges occur rather than continuously. Thus it is not possible to say unambiguously what the modulating waveforms were from an examination of the square-wave produced, and, in particular the same resultant square-wave can be obtained from a variety of different modulating waveforms. But things are not as bad as they may seem, since the ambiguities all result from the effects of reflection of frequency components through the effective sampling frequency. They can thus be eliminated for practical purposes if we consider modulating waveforms whose frequency components are strictly limited to values below the carrier and this limitation will be assumed for the remainder of this article.

It is not unduly difficult then to show that the amplitude $A$ of a square-wave made from a carrier of angular frequency $\omega_c = 2\pi f_c$ by the application of both forms of modulation at the same time can be expressed as a mathematical series as follows:

$$\begin{aligned} A = x &+ \frac{4}{\pi}\cos\left(\frac{\pi x}{2}\right)\cos(\omega_c t-\theta) \\ &- \frac{4}{2\pi}\sin\left(\frac{2\pi x}{2}\right)\cos 2(\omega_c t-\theta) \\ &- \frac{4}{3\pi}\cos\left(\frac{3\pi x}{2}\right)\cos 3(\omega_c t-\theta) \\ &+ \frac{4}{4\pi}\sin\left(\frac{4\pi x}{2}\right)\cos 4(\omega_c t-\theta) + \ldots\ldots\ldots \end{aligned}$$

It will be seen that each term in this series consists of the product of an amplitude modulating factor, which is some function of the mark-space modulation index, and a cosine, which represents a sort of harmonic of the phase modulated carrier frequency. If both $x$ and $\theta$ have steady values then the spectrum consists simply of a series of components on the harmonic frequencies. But if $x$ and $\theta$ are made to vary in response to some applied input waveforms then each of these harmonic components becomes surrounded by a cluster of sidebands. Since the modulation laws involved are not simple even a single incoming tone will normally make each cluster an infinite series of sidebands spaced regularly at multiples of the modulation frequency with amplitudes which tend to decrease at greater distances from the harmonic, but which never actually become zero anywhere in the frequency range. When more than one input frequency is applied there will also be further sets of sidebands spaced from each harmonic by sum and difference frequencies, so that the pattern will be vastly more complicated.

## IDEAL MODULATION SYSTEM

It will be noticed that the zero harmonic, or baseband, term at the start of this mathematical series is a plain unvarnished $x$. Thus if the index of the mark-space ratio modulation is made to follow the input waveform directly, this term alone will provide exactly the correct frequency components that we require for the proper reproduction of the signal. Since the later terms can only contribute components at frequencies which are of the nature of sidebands of the harmonics of the carrier frequency, it is inconceivable that these could also come at the wanted signal frequencies, since the carrier frequency is not in general related to the modulation in either its phase or its frequency. Thus we find that in the ideal system that we are seeking the mark-space modulation must have this simple proportionally to the input, and our problem is reduced to that of finding what function of the input voltage we must use for making phase modulation if we are to achieve the elimination of all the sidebands that fall within the band to be amplified as a result of this amount of modulation of the mark-space ratio.

Fig. 6 shows how this cancellation of the unwanted sidebands by the application of phase modulation can occur in a very simple case. The top diagram (a) shows a half-cycle of a low-frequency sine-wave applied to the amplifier input. Diagram (b) shows the square-wave that corresponds to this if only the mark-space modulation is applied. The next diagram (c), indicates how we can extract an amplitude modulated fundamental component sine-wave from this square-wave, since a 50:50 square-wave plainly has a bigger fundamental component than one of the same amplitude but different mark-space ratio. It will be noticed that this modulated sine-wave is the second term of the mathematical series given previously. Diagram (d) illustrates how the amplitude modulation of this sine wave can be represented approximately by the addition of the two most important sidebands, which are at the frequencies $f_c-2f_m$ and $f_c+2f_m$ where $f_m$ is, of course, the modulation repetition frequency and the usual "spinning vector" method of representation is used. But if we introduce also the amount of phase modulation of the square-wave represented by the "spinning vectors" shown in diagram (e), then the two sidebands at the lower frequency will cancel whilst the important modulation is almost unaffected and no serious extra sidebands are introduced.

It is not very difficult to show from these diagrams that if the original modulating waveform is a simple sinewave of such amplitude that the index for the mark-space ratio modulation is:

$$x = X \cos \omega_m t$$

where $\omega_m$ is the angular modulation frequency, and $X$ is the peak amplitude of sine-wave modulation as a fraction of the limit of the system, then the phase modulation required to eliminate the sideband at $f_c-2f_m$ will be very close to:

$$\theta = \left(\frac{1-\cos(\pi x)/2}{1+\cos(\pi x)/2}\right) \sin 2\omega_m t$$

But this phase modulation only gives approximate cancellation of one only of the sidebands for the very simple case of a single sine-wave at the input, and it is already most unpleasantly complicated. It seems hard to believe that there is not some other better approach whereby the correct phase-modulation to eliminate all the unwanted sidebands for any modulation waveform can be derived, but the author has been unable to find it.

The problem is in many ways analogous to that of producing s.s.b. modulation of a sine-wave, and there are two respects in which the systems will certainly prove to be similar. The first of these is that the extra modulation that must be applied to give the elimination of the unwanted sidebands will be of the nature of a "phase" modulation rather than one of "frequency." Thus in an ideal system the average carrier frequency will be constant regardless of the modulation, and the phase displacements will, in fact, be limited to no more than 90° at the most. Secondly we must expect that in constructing an ideal system we shall have to use the quadrature function of the input waveform. This is a sort of half-way between the integral and the differential waveforms and is similar to them in that every frequency component is separately phase-shifted through a right-angle, but differs in that the amplitudes are left unchanged. It is well known in s.s.b. techniques that this waveform can be obtained only by the use of a filter network whose cost and complexity increases rapidly as the performance is made more accurate and maintained over a wider frequency range. To obtain an output with the phase-shift correct to within say ±10° throughout the audio-band would require a network costing more than most amplifiers, so that our ideal system is hardly likely to be an economic one.

We must never forget that it is not really the ideal that we are seeking but merely some system which is an appreciable improvement over those already known. We have been considering the perfect solution only as a guide to indicate how such an improvement might be obtained. Let us now consider just how serious these distortion effects are in the modulation systems that have been used in published designs of amplifier.

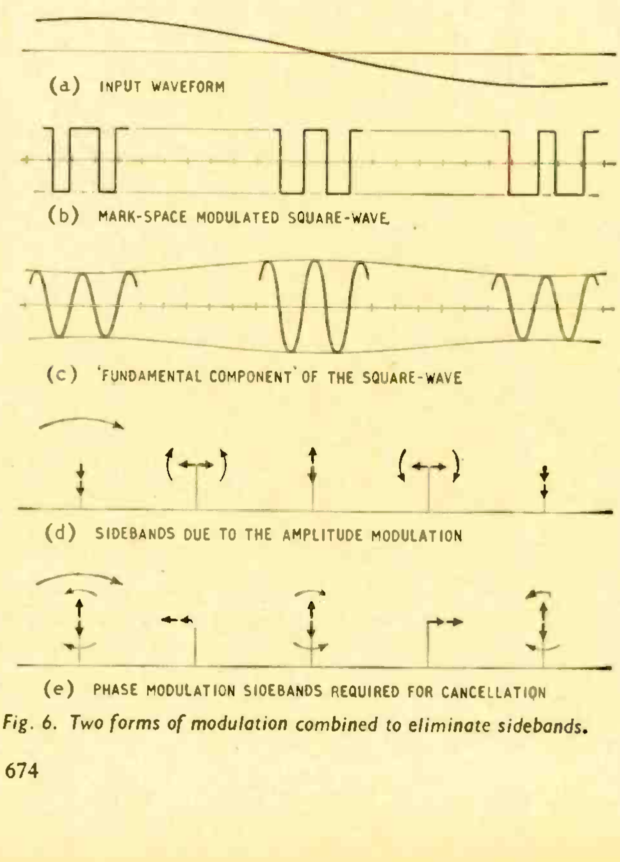


*Fig. 6. Two forms of modulation combined to eliminate sidebands.*

## PRACTICAL MODULATION SYSTEMS

All the practical designs of class D amplifier of which the author is aware employ one or other of two quite distinct systems for the generation of the modulated square-wave. The system [6, 7] that we shall consider first uses a free-running multivibrator arrangement to form a regular triangular waveform which is then compared with the input in a circuit that generates a switching-edge whenever the two voltage levels cross over. The alternative system, which was described with references in the first of these articles and used in the circuit of the second, is the one where a feedback network is used to give a continuous measure of the error of the output of the switching stage and the square-wave is obtained from a flip-flop circuit that is triggered whenever the time-integral of this error reaches either end of a prescribed range. We shall call these two the "pure mark-space" and the "simple feedback" systems respectively.

As the name of the first would suggest the essential action of a circuit of this type is to generate a square-wave which is correctly modulated in its mark-space ratio but has no phase variation at all. In practice amplifiers based on this system suffer from serious distortion due to the absence of negative feedback, but if we assume that the design is so generous that we can ignore the non-linearity effects, then there will still be distortion due to the presence of the sidebands, since no attempt has been made to obtain their cancellation. Notice that with this system there is a well-defined limit to the modulation value that can be obtained. In the theory this is reached when the displacement of the edges is so large that they

| Frequency at which distortion term occurs | MODULATION SYSTEM | | |
|---|---|---|---|
| | Pure mark-space $f'_c = 1$ | Simple feedback $f'_c = (1 - \frac{1}{2} X^2)$ | Improved feedback $f'_c = 1$ |
| $f_m$ | 100 | $100 + 86 f_m^2$ | $100 + 85 f_m^2$ |
| $3f_m$ | 0 | $78 X^2 f_m^2$ | $190 X^2 f_m^2$ |
| $5f_m$ | 0 | $70 X^4 f_m^2$ | — |
| $(f'_c - 2f_m)$ | $38 X$ | $36 X (2f_m)^{-\frac{1}{2}} (f'_c - 2f_m)$ | $38 X (f_c - 2f_m)$ |
| $(f'_c - 4f_m)$ | $2 X^3$ | $17.5 X^3 (4f_m)^{-\frac{3}{2}} (f'_c - 4f_m)$ | $2.4 X^3 (f_c - 4f_m)$ |
| $(f'_c - 6f_m)$ | $0.04 X^5$ | $9.5 X^5 (6f_m)^{-\frac{3}{2}} (f'_c - 6f_m)$ | $0.18 X^5 (f_c - 6f_m)$ |
| $(f'_c - 8f_m)$ | — | $5.6 X^7 (8f_m)^{-\frac{1}{2}} (f'_c - 8f_m)$ | — |
| $(f'_c - 10f_m)$ | — | $3.5 X^9 (10f_m)^{-\frac{3}{2}} (f'_c - 10f_m)$ | — |

*Table shows the percentage magnitude of various distortion terms introduced by the modulation of square waves*

$X$ Peak amplitude of sine-wave modulation as a fraction of the natural limit of the system.
$f_m$ Frequency of the modulation as a fraction of that of the unmodulated carrier.
$f'_c$ Frequency of the modulated carrier as a fraction of that of the unmodulated carrier.

meet and try to cross over, whilst in the actual circuit the corresponding limit is the point when the incoming voltage equals the peak value of the triangular wave. We shall as before refer to the depth of sine wave modulation by the symbol $X$, which is the ratio of the peak value of an applied sine-wave to this ultimate limiting value. With this system the carrier frequency is constant when modulation is applied, so that we need not worry about any change, but it will be convenient to measure the frequency of the applied modulation by the symbol $f_m$, which is the ratio of the value to that of the steady carrier.

The simple feedback system gives a more complicated action in which the amount of mark-space modulation produced is not, in fact, correct, whilst a degree of phase modulation is introduced. This is exactly right to cancel any sideband whose frequency happens to fall very close to zero, the negative feedback and integration ensure that such cancellation must be obtained, but unfortunately the phase modulation produced is incorrect at other frequencies and can even make the sidebands larger than they need have been. Again there is a well defined limit to the input voltage that can be accepted, when the error current from the feedback network falls to zero. In this form of modulator the carrier frequency does change when modulation is applied, so that we must define not only the modulation frequency, $f_m$, but also the actual carrier frequency, $f'_c$, and we can conveniently measure both by their ratios to the unmodulated carrier. It is not difficult to show that the relationship:

$$f'_c \approx a1 - \tfrac{1}{2} X^2$$

holds to sufficient accuracy for our purposes.

Naturally actual circuits working on either of these principles have their own peculiarities and only follow the modulation rules in an approximate manner. Nevertheless it is possible to formulate the rule which an ideal version of each circuit would follow in a purely mathematical form. From this it is possible, in principle, to calculate the exact times at which the switching-edges would be generated under any particular conditions and hence, by a process of Fourier transformation, to obtain the precise frequency spectrum of the square-wave and the magnitudes of all the sidebands.

## CALCULATION OF THE DISTORTION TERMS

It seems that the actual calculation of the spectra by analytical methods, so as to obtain a generalized result, is impossibly difficult in the case of the simple feedback system, whilst it involves the Bessel Functions even in the more straightforward case of the pure mark-space system. Fortunately, though, there is an alternative approach that holds good for any conceivable modulation process and allows different systems to be compared very conveniently. We can use a digital computer to produce both the timings of the edges and the spectrum of frequencies that they represent. The results obtained are necessarily only approximate and apply only to specific levels of modulation, however, it is possible to extract a useful general expression by the comparison of a sufficient number of individual cases. This is the method which has been employed in the production of the results shown in the Table.

There are restrictions in this method in that the modulation waveform used at each computation must not only be a single sine-wave but must also have a frequency related in some comparatively simple way to that of the carrier. This follows from the fact that the calculation must be performed over an interval which contains an exact whole number of cycles of each of the two frequencies, and the time required will become excessive if these numbers are made unduly large. The calculations from which the results given here are taken were made with an interval of 25 carrier cycles, so that modulation frequencies at multiples of 4 % of the carrier could be tested.

There is a further restriction when the action is of a type where the average square-wave frequency changes with modulation, as in the simple feedback system, since it is then only possible to make a fair test at those amplitudes which bring the carrier to a frequency which is again related to that of the unmodulated carrier in this same way. Here the allowable amplitudes were those which reduced the carrier to 96 %, 92 %, 88 % and so on of its initial frequency. This second restriction is much less serious than it might appear as these amplitudes are, in fact, reasonably convenient and the computer was able to work out the values to adequate accuracy very quickly. So far as it was possible to tell, these restrictions on the values that could be calculated have introduced no significant errors into the results. The errors arising in the computation itself were about one part in a million of the amplitude of the main carrier component.

The technique that was used to obtain the generalized form of the results shown in the Table consisted of finding the magnitude of a particular distortion term for a variety of values of modulation amplitude and frequency. These were so chosen that levels for the distortion in the range 0.1 % to 1 % were obtained at frequencies that would be likely to be important in actual use. An approximate expression was then derived for the term in question as a percentage of the modulation amplitude in the form of a constant factor and appropriate powers of the peak amplitude of the modulating sine-wave, the frequency of the modulation, and the frequency of the term itself.

At levels of distortion in the region of 1 % the error in assuming this simple sort of power relationship is not too serious, being perhaps $\pm$ 10 % of the term magnitude, but these results must not be extrapolated to higher levels of distortion where more complicated formulae are needed. Remember also that these results apply only to the rather artificial situation of modulation by a single steady sine-wave, and no estimate of the numerous possible forms of cross-modulation that will arise with more complicated input waveforms has been attempted.

The systems that are being considered have the property of giving the correct components at the output when the amplitude and the frequency of the modulation are both very low. At higher levels of input distortions of various kinds are generated. Since the pure mark-space system has errors only in its phase modulation, the distortion terms that it causes are just unwanted sidebands of which those at $(f_c - 2f_m)$, $(f_c - 4f_m)$ and $(f_c - 6f_m)$ will normally be the most important. Notice that the amplitude of these sidebands is not affected by the frequency at which they are made to occur. In contrast to this the simple feedback system not only generates these sidebands, but also has distortion of the fundamental and introduces harmonics, since its mark-space action is incorrect as well. These distortions rise with the square of the modulation frequency. Notice that the sidebands in this system change their amplitude in a relatively complicated manner with frequency falling to zero when their frequency is zero, and that they are centred on the modified carrier frequency, $f'_c$, so that they will come into the band at lower modulation frequencies as the input amplitude increases.

Both the systems that we are considering have the property of being balanced, meaning that the treatment of positive and negative inputs and also of the upward and downward switching edges are symmetrical. This means that only the odd harmonics of the modulation will be generated, and also that only those sidebands at frequencies $(af'_c \pm bf_m)$ where $(a + b)$ is odd will occur. Needless to say such systems are much to be preferred and unbalanced systems need not be seriously considered unless they have some quite exceptional advantage in another respect.

It will be seen from the table that there is no clear advantage in either of these systems. The freedom from harmonic generation and lower average levels of the sidebands with the pure mark-space modulation compares with the cancellation of sidebands at low frequencies when the Simple Feedback system is used. The choice in practice depends on such factors as the benefits to be obtained from the action of the negative feedback and the fact that the feedback system requires appreciably fewer components.

### POSSIBILITIES FOR IMPROVED SYSTEMS

We now naturally come back to the question of whether it is possible to devise a system which would be a useful improvement over these two, since we have shown that there is no fundamental reason why a vastly better system should not be made. Clearly the principle of feedback should be retained, since it reduces the effects of imperfections in the circuit and also ensures the elimination of any sidebands that come at very low frequencies, but what other features ought we to change? One of the more hopeful possibilities is to say that it is wrong for the carrier frequency to be made to vary, and this leads to the idea of the improved feedback system.

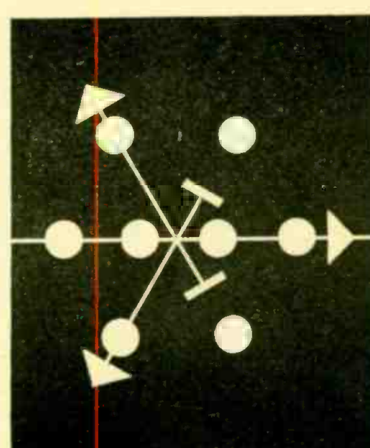
This is similar in most respects to the simple feedback arrangement, but differs in that the triggering limits of the flip-flop are brought closer together (in a symmetrical manner), in proportion to the quantity $(1 - x^2)$, where $x$ is the instantaneous value of the input waveform measured as a fraction of the natural limiting value. This quantity will have to be made by some circuit of the type used in analogue computers, but remember that it is only required to obtain a refinement of the action of a system which already works comparatively well, and so it will not matter too much if the value is not precisely correct. This reduction of the triggering range has been chosen so that the carrier frequency is maintained at a substantially constant value when modulation is applied and thus the excessive sideband amplitudes should be usefully reduced. The actual amplitudes to be expected from such a system have, in fact, been computed, since there is no problem in getting a digital machine to follow such a process with high accuracy, and the results are presented in the third column of the Table.

It will be seen that the effect obtained is more or less as predicted. The amplitudes of the sidebands are indeed a substantial improvement over the values obtained with the two previous systems. The third harmonic generation, however, is considerably worse, though the reason for this increase is not at all clear particularly as the fifth harmonic appears to be much reduced. The overall impression seems to be that these improvements are not sufficient to justify the extra complexity of the circuitry and that if any real improvement is to be obtained some other type of modification to the circuit arrangement will be required to achieve it. They might, for example, be expected to include some rudimentary form of 'quadrature' generating network in addition to arrangements for keeping the carrier frequency at a constant value, since the theory suggested that both these features would be required. But the advantages of the class D system are so small already that any successful improved modulation generator would have to use almost no extra components if it were to remain economic and the chance of such an arrangement being devised seems, unfortunately, to be negligible.

### REFERENCES

6. D. R. Birt, *Wireless World*, Feb., 1963, p. 76.
7. C. Sinclair, X10 and X20 circuits as advertised 1965.

## Physics Exhibition Symbol



*The Institute of Physics and the Physical Society announces the adoption of this symbol for the annual Physics Exhibition. "Based on the weight diagram for the irreducible representation $D^8$ (1,1) that of the SU(3) symmetry which has been so strikingly successful in bringing order to the classification of sub-atomic particles." The exhibition takes place on 11-14 March at Alexandra Palace, London. Tickets are obtainable free from the I.P.P.S., 47 Belgrave Square, London, S.W.1.*

# Log-periodic TV Aerial

## A New look in Band III Arrays

JUST over ten years ago the first frequency-independent aerials were announced in America. The bandwidth of these aerials, which are basically conical or spiral, is limited only by the smallest and largest dimensions of the structure. Change of frequency merely moves the resonant region of the aerial within the structure but does not affect the impedance or radiation pattern. The advantages of the frequency-independent aerial have been combined with those of the Yagi in the logarithmic dipole. However, unlike the Yagi, which normally has only one driven element plus a number of parasitic elements, the log-periodic consists entirely of driven dipoles the lengths and spacings of which increase progressively.

Log-periodic aerials have, of course, been used for some time for h.f. communications and telemetry purposes. The principles were discussed and details given for a u.h.f. television aerial* in our September and October 1964 issues but log aerials for television have not been available commercially in the U.K. until now, although they were introduced in North America a year or more ago.

Antiference have now introduced a series of log-periodic dipole aerials for Band III, having in mind particularly those areas where both I.T.A. and BBC-1 transmissions are radiated on widely separated channels in this band.

To obtain a performance which is basically independent of frequency from a structure composed of a series of resonant dipoles, such resonances must "taper off" so that as the frequency is varied the function of the resonant dipole is smoothly transferred from one dipole to the next. This means that the physical dimensions of the dipoles must be scaled from one to the next in such a way that the desired frequency range is covered by a series of dipoles with overlapping response characteristics. The degree of overlap of any one dipole to its immediate shorter neighbouring dipole must be constant throughout that part of the structure which is within the limits of the desired frequency range.

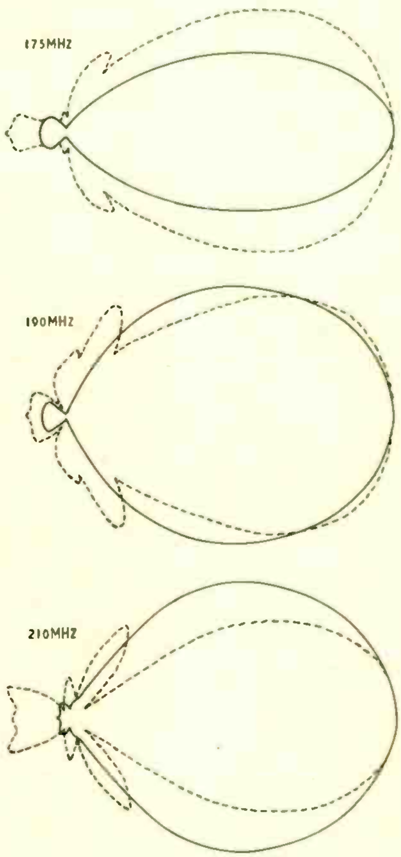
Since the characteristics of the elements are, to a certain degree also determined by their surroundings, such as relative spacing one to another, then these spacings must be scaled also.

The log-periodic dipole aerial is, then, an array of parallel linear dipoles arranged side by side, and both the "tapering off" of the element lengths and the spacing between them, form a geometric progression with a fixed ratio throughout.

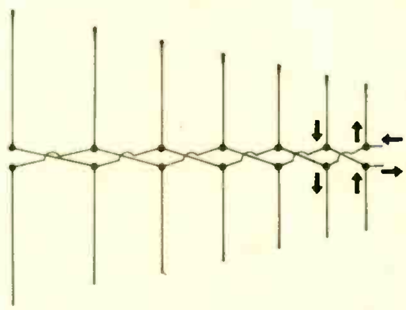
The elements are energized from a balanced, constant impedance transmission line. Adjacent elements are connected to this line in an alternate manner and the operation of the aerial is "end fire" in the direction of the shorter elements with the feeder connected at this end.

In the Antiference log-periodic arrays a double rectangular cross-section boom performs the function of transmission line as well as the support for the elements.

* "Logarithmic Aerials for Bands IV and V" by M. F. Radford.

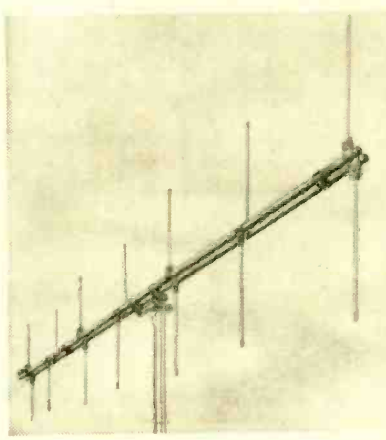



*Polar diagrams for a 7-element log-periodic aerial compared with those for a 5-element double driven Yagi (broken lines).*



*Schematic diagram of log-periodic dipole aerial showing the phasing.*

*The Antiference 7-element log-periodic aerial type LP7.*



# Transistor Rationalization

## How to standardize on a few, easily-available "work-horse" devices

By T. D. TOWERS,* M.B.E., M.A., C.Eng.

HAVING discussed last month semiconductor type numbering and how to find information on the many tens of thousands of device types on the market, we will now take a look at the rationalized selection of a few transistor families which many engineers have come to accept as standards for run-of-the-mill industrial circuit applications.

### CHOOSING BETWEEN SILICON AND GERMANIUM

Every user of transistors is concerned with reliability, but the technique of transistor manufacture has reached a stage where there is little to choose on this score between germanium and silicon.

Semiconductor manufacturers tend to divide their products into three classes: "entertainment," "industrial," and "professional." In the past, reputable manufacturers have produced essentially professional transistors, these are reliable and are guaranteed to meet an exacting specification for Services use. The need for this close tolerancing, multiple testing and quality documentation of professional devices has meant that they are expensive. Semiconductors from the same production line but to a less rigorous specification are fed into the industrial market (high-quality instrumentation and communications field) where reliability is still a prime requirement but the reduced test costs result in lower prices. Finally, the entertainment field (which prudently designs for wide spreads of parameters) gets even more economical devices because with them much of the procedural and testing costs involved in the other fields are avoided.

Over recent years a new situation has emerged. Manufacturers are setting about designing transistors primarily for the entertainment field (in which users cannot afford to pay for even the economical offshoots of the high-quality professional-industrial transistor lines). Thus we see large numbers of plastic-encapsulated transistors at low prices on the market. These are silicon devices, because plastic encapsulations do not suit germanium. Despite some unresolved doubts on the long-term reliability of plastic encapsulated transistors, their low price means that they are finding their way even into the industrial field for less exacting requirements. But as yet they have not been accepted in the professional field.

### L.F. TRANSISTORS

Transistors for low-frequency and d.c. use fall into three distinct groups: *low level*, operating in the region of 1 mA; *mid-level*, around 50 mA; and *high level*, around 500 mA. Each area has its different features.

**L.F. low-level amplifiers.**—The principal requirements in the low-level stages of low-frequency circuits are the obvious ones of low noise and high gain at low currents. In general, in these respects, silicon tends to be superior to germanium and is largely replacing it. Even so, we still see many circuits using time-proved germanium p-n-p devices such as the AC107 and the NKT216. The OC71 and GET106 were progenitors of this breed. There are no germanium n-p-n transistors in common use in low-level circuits.

In silicon, on the other hand, low-noise low-level amplifier transistors tend to be n-p-n. The BC107/8/9 family has become almost a standard for this area. They are characterized by very low-noise levels and by high current-gain at collector currents of around 100 $\mu$A. Many specialized devices in the same category, such as the 2N929/930 (for operation at high voltages and in the microamp current range), the 2N2483/4 and the 2N2604/5, are marketed.

As yet there is no widely accepted common device for p-n-p silicon low-level work. Users have not established any particular type as a standard. I myself design around the 2N3547/8/9/50, which is a good p-n-p complement to the BC107/8/9. Somewhat in the same category fall such devices as the increasingly used BCY70/1/2 and the 2N3250/1.

**L.F. mid-level amplifiers.**—In circuit stages operating from about 10-100 mA, the major requirement on the transistor is that it should have a fairly high and constant current gain over a wide range of current. In germanium, both n-p-n and p-n-p devices are common for mid-level amplifiers. Typical n-p-n units are the AC127 and NKT713 with voltage ratings around 30 V and current gains about 50. On the p-n-p side, there are many devices of which the OC75 and NKT213 are typical. These, too, are characterized by 30-V collector rating and current gains of around 100. Whatever the polarity, this style of transistor has an $f_T$ of around 1 MHz.

When we turn to silicon, n-p-n mid-level amplifier transistors far outnumber p-n-p. Because so much American circuitry has been written around the 2N3053, it has become the best known device in this field. With a 60-V rating, a capability of handling up to 500 mA, and a current gain of around 75, this "maid of all work" still has many competitors such as the 2N696, 2N697, 2N718, 2N956, 2N1420, 2N1613, 2N1711 and 2N1893.

In mid-level n-p-n silicon transistors, the 2N1131/2 is fairly typical with characteristics not unlike the n-p-n 2N3053. It finds many alternatives in the market such as the BFX29/30 and BFX87/88.

**L.F. high-level amplifiers.**—When a stage is required to handle up to 1 A collector current, we have to turn to "beefier" larger-geometry devices. In germanium we find well-tried standards like the AC176 and NKT781 in

* Newmarket Transistors Limited.

n-p-n and the ACY17/8/9/20/1/2 and NKT237/8/9/40/1/2 families in p-n-p. Whatever the polarity, these transistors are basically 30-V transistors (with higher voltage selections), characterized primarily by a high current gain at currents up to 1 A.

In silicon for 1-A amplifications there is no widely used single device. However, the 2N2297 basic transistor, better known in this country under the family numbers BFY50/1/2, BFX84/5/6 and BSX60/1, is representative of n-p-n devices. It has an $f_T$ around 100 MHz, is characterized by a voltage rating of around 60 V, low saturation voltage and a 1-A current gain of 15 minimum. There is as yet no universal 1-A p-n-p device available.

## R.F. AND SWITCHING TRANSISTORS

R.F. amplifier transistors tend either to have a low Cob* for stable low-level amplifier operation or the high Cob which goes with the larger junction for high current carrying capacity in later circuit stages.

**R.F. "low-Cob" amplifiers.**—For many years now r.f. amplifier circuits requiring low feedback capacitance have standardized on the well-known germanium p-n-p AF114/5/6/7 (OC170/1) and NKT674/5/6/7 families of devices. These are a special type of post-alloy diffused transistor, which because of their high gain at low current, and low (2 pF) collector-base feedback capacitance permit gains of around 45 dB per stage in standard tuned 470 kHz i.f. amplifiers. There has been no germanium n-p-n equivalent device in common use.

By contrast, when we come to silicon, there has been no common low-Cob p-n-p transistor. The n-p-n BF115, which can be regarded as a silicon equivalent of the p-n-p germanium AF115, has found many applications. Such devices are all characterized by very small collector-base junctions, but further improvements have been made by what is known as the "Faraday-shield diode" technique. In this, a diode diffused underneath the base overlay bonding pad is connected to the emitter, which is operated at a.c. ground. This diode region is diffused simultaneously with the base during the diffusion cycle. By using this technique the intrinsic feedback capacity of the transistor can be reduced to around 0.1 pF. This, together with the typically 0.4 pF interlead capacitance gives a Cob of the order of 0.5 pF compared with the 2.0 pF of the AF114 family. Typical of this Faraday-shield type of transistor is the BF167.

**R.F. "high-Cob" amplifier.**—For higher level r.f. stages, where the feedback capacitance is not so critical, we find several widely used transistor types. In germanium the most common are p-n-p polarity, such as the 2N1303/5/7/9, the 2N404 and the NKT135. All of these have a Cob of the order of 20 pF, and typical $f_T$ of the order of 5-15 MHz. Smaller geometry devices of the same character with Cob = 10 pF are the well-known OC44/5 and NKT11/12.

The best known n-p-n germanium devices of the same sort are the 2N1302/4/6/8 family which are direct n-p-n equivalents of the p-n-p 2N1303/5/7/9. All these high-Cob germanium transistors are similar in other respects, with voltage ratings of around 20 V, an $f_T$ of typically 7.5 MHz and current gains of 50-100.

Silicon transistors for high-Cob r.f. applications are readily available in both n-p-n and p-n-p. The most commonly used device family is almost certainly the n-p-n 2N2217/8/9/20/1/2 series. These have relatively flat current gain from a few mA to several hundred mA, with typical collector capacitances of 6 pF and $f_T$ of around 350 MHz. Voltage ratings are typically 60 V, i.e., double the corresponding germanium devices mentioned above. Also 80-V versions are available, by contrast with germanium, for which even 30-V selections are rare.

In high-Cob r.f. transistors we also find a common p-n-p family, the 2N2904/5/6/7, which is a close equivalent to the 2N2217 family in its characteristics. Other common devices similar to the 2N2904 family are the 2N3133/4/5/6.

**V.H.F. amplifiers.**—Silicon diffusion techniques lend themselves particularly to u.h.f. transistors. Thus we find the n-p-n type 2N918 with a typical $f_T$ of 900 MHz in everyday use. The 2N2475 and the BSY90, faster versions of the 2N918 with $f_T$ of the order of 1.5 GHz, are tending to replace the 2N918. U.h.f. silicon transistors exhibit relatively low collector voltage ratings for silicon (around 30 V only) and low current gain (typically only 30). They do, however, have low collector capacity, typically 1.5 pF or less. U.h.f. germanium transistors, whether p-n-p or n-p-n, are not in common use industrially.

**L.F. switches.**—For low-frequency switching, manufacturers do not in general produce special families of devices, and we find slow-speed switching generally being done by transistors of the type described above under l.f. mid-level amplifiers or h.f. high-level amplifiers, depending on the current being switched. There is one exception in that the 2N2904 family described above under r.f. high-cob amplifiers is so widespread that it is often used for slow-speed switching in the absence of a common p-n-p equivalent to the BFY50-52 series.

**R.F. switches.**—For r.f. or medium-speed switching, the tendency in the past has been to use r.f. amplifier transistors. Thus with germanium we find the n-p-n 2N1302 family or the p-n-p 2N1303 family widely used, as also has been the OC42 (a selection of the OC44/45).

When we come to the new silicon r.f. switching transistors there is a vast array of transistors specially designed for switching rather than general purpose r.f. amplifier-cum-switching work. The commonest basic device is the famous 2N914, an n-p-n gold-doped switching transistor with a typical $f_T$ of 300 MHz, a 500 mA current capability and a collector capacity of around 4 pF. Other well-known devices of a similar character are the 2N706, 2N708, 2N743/4, 2N753, 2N919/20, 2N2368/9/9A, BSY26/7, BSY38/9 and the ubiquitous BSY95A. Silicon p-n-p r.f. switching transistors are much less common, but the serviceable 2N2904 family again is often used.

**V.H.F. switches.**—For ultra-fast switching, there are no germanium devices in common use, but the last of the v.h.f. germanium switching transistors will still be found in equipment. Typical of these are the p-n-p 2N711B or NKT603F, with relatively low (20 V) collector voltage ratings, maximum currents of 100 mA, current gains of around 50, typical $f_T$ of 125 MHz and Cob of about 3 pF. On the n-p-n side in germanium there never have been any common ultra-fast switches.

In silicon the "daddy of them all" in ultra fast switches is the n-p-n 2N709, with switching times of less than 10 ns. This device has a low collector voltage rating

* Cob ($C_{ob}$)—output capacity with base open to a.c.

(15 V) and will handle up to 200 mA only. On the other hand it has an $f_T$ of 800 MHz typically and a 2-pF Cob. Its current gain is about 50. The 2N709 has proved a very difficult transistor to manufacture and is still quite expensive. There are no p-n-p silicon ultra-fast switches widely available.

### POWER TRANSISTORS

When you want to dissipate more than about a watt in a transistor, you have to leave the small flexible-lead devices described so far. Two main styles of case have become widely used, at least for low-frequency operation. These are the well-known standard TO3 large "diamond-shaped" outline and a miniature version of it. The miniature medium power transistor comes in three different cases: (1) TO66 small diamond; (2) "Continental" small diamond (as Mullard AD161/162); and (3) TO8 (with clamp that makes it similar to small diamond).

**L.F. medium-power transistors.**—In germanium there are only a few medium-power devices on the British market, but these are widely used. For p-n-p requirements, the international standard germanium unit is the 2N1183/4 or NKT302 in TO8 outline with typical voltage ratings of 60 V, current gains of around 50, maximum current around 3A and $f_T$ about 1 MHz. In the n-p-n germanium category there is no corresponding TO8 standard, but the AD161 or NKT871 n-p-n small diamond power devices find wide use. These have a p-n-p exact counterpart in the AD162 or NKT371 (as an alternative in some applications to the 2N1183/4).

In silicon in the medium-power small diamond range there is no p-n-p commonly available, but in n-p-n the 2N3054 is a widely accepted standard device. This is in a TO66 encapsulation and features 90-V collector rating, 4-A maximum current, 25-W theoretical maximum dissipation, typical $f_T$ of 1 MHz, and a current gain around 50.

**L.F. power transistors.**—When higher operating powers of the order of 10-25 W dissipation are called for, the larger TO3 outline is the common encapsulation. In germanium there is a family of TO3 p-n-p devices which has been virtually the standard power transistor for years now. These are the OC28/9/35/6 and NKT401/2/3/4. The most important features of these are current carrying capacities up to 10 A, typical voltage ratings of 60 V, typical current gains of 50 and $f_T$ of around 300 kHz. In the main, germanium p-n-p power transistors of this type still carry the bulk of transistor power applications in this country. There are no n-p-n equivalent germanium power transistors commonly used.

In silicon the standard TO3 high-current power transistor is the n-p-n 2N3055. This features voltage ratings of 60-100 V, current ratings of 15 A, $f_T$ of 1 MHz and theoretical maximum dissipation of 115 W, together with typical current gains of around 50 at 1 A. Whenever the standard p-n-p germanium power transistors described above are replaced by silicon in a redesign, the tendency is very largely to go over to the n-p-n 2N3055. The only major drawback in this silicon transistor is its 7-V emitter rating compared with the 20 V of the OC28 series.

**Other special transistors.**—So far, we have been dealing with "run-of-the-mill" devices. Limitations of space prevent any coverage of special devices such as r.f. power or field-effect transistors. Most semiconductor manufacturers have their own ranges of devices for these, but sufficient field experience has not yet accrued for any particular devices to become accepted as industry standards.

TABLE I

A SELECTION OF WIDELY USED TRANSISTOR TYPES AVAILABLE FROM MORE THAN ONE MANUFACTURER

| | n-p-n | | p-n-p | |
|---|---|---|---|---|
| | Ge | Si | Ge | Si |
| L.F. Low-level Amp. | * | BC109 | AC107 NKT216 | 2N3548 |
| L.F. Mid-level Amp. | AC127 NKT713 | 2N3053 | OC75 NKT213 | 2N1132 |
| L.F. High-level Amp. | AC176 NKT781 | BFY52 | ACY20 | * |
| R.F. Low-Cob Amp. | * | BF115 | AF117 NKT677F | * |
| R.F. High-Cob | 2N1304 | 2N2221 | OC45 NKT12 | 2N2906 |
| V.H.F. Amp. | * | 2N918 | * | * |
| A.C./D.C. Switch | AC176 NKT781 | BFY52 | ACY20 | * |
| R.F. Switch | 2N1304 | 2N914 | OC45 NKT12 | 2N2906 |
| V.H.F. Switch | * | 2N709 | 2N711B NKT603F | * |
| A.C./D.C. Medium Power Amp. | AD161 NKT871 | 2N3054 | 2N1183 NKT302 | * |
| A.C./D.C. Power Amp. | * | 2N3055 | OC35 NKT404 | * |

*No "standard" device commonly available from several manufacturers.

### TABULAR INFORMATION SUMMARIES

To bring into focus all the information detailed above, Table I has been prepared setting out for each circuit function a typical device from the "standard" ranges discussed above, classified as germanium/silicon and n-p-n/p-n-p.

To give some idea of the special characteristic of the various families, Table II sets out critical information on the devices selected as examples in Table I. A study of Table II will reveal most of the differences between n-p-n and p-n-p and between germanium and silicon transistors. For example, you will note in the emitter voltage rating column (headed $V_{ebo}$) that silicon diffused devices have ratings always below 10 V and germanium alloy always above 10 V.

### PLASTIC vs METAL CASE TRANSISTORS

You cannot help but be aware that over the last two years plastic encapsulated silicon transistors at low prices have had a great impact on the transistor market, but there has been controversy about them. Designed primarily for the entertainment market, their most obvious advantage is low cost, but the absence of a metal case can also be an advantage in that they can have lower parasitic capacitances than corresponding metal case units. Also in most silicon hermetically sealed transistors the collector is connected internally to the metal case, so that precautions have to be taken to isolate the case in equipment. With plastic encapsulated devices, no special care is required for this.

Plastic case transistors do have disadvantages, however. Generally the same transistor chip will have lower permissible dissipation than in the corresponding metal-can version. Also there has been much discussion about their long-term reliability when compared with true hermetically sealed devices. As yet, no plastic device has received "CV approval" in this country, and the final verdict on the long-term reliability problem will be given only if and when such approval is obtained.

**Typical plastic-encapsulated transistors.**—Table III sets out for l.f. amplifier applications a selection of fairly common types of roughly equivalent specification, in two classes—n-p-n and p-n-p. The table cross-refers types from several manufacturers to common equivalent metal-case devices.

There is as yet no uniformity in the outlines used for the plastic encapsulations. Difficulties arise because, while some manufacturers supply devices physically interchangeable with standard TO18 or TO5 cans, others produce completely new lead configurations, which are sometimes difficult to fit to boards drilled for standard metal-case devices. However, some manufacturers do provide their devices with the leads pre-dressed to the required TO18 spacing. Also, you can get small plastic mounting pads which do the pre-dressing for you as you draw the transistor down to the board.

It is hoped that the analysis of the various transistor types given above will be helpful to the reader in his assessment of what transistor to use for a specific circuit application. He can find fuller information on details of devices in one of the various sources of information outlined in last month's article.

TABLE III

**REPRESENTATIVE COMPARATIVE SELECTION OF METAL-CASE AND RELATED PLASTIC ENCAPSULATED SILICON TRANSISTORS**

| Metal Case Device | Plastic Encapsulated | | | |
|---|---|---|---|---|
| | Texas | S.T.C. | Ferranti | Fairchild |
| (L.F. Low-level n-p-n) | | | | |
| BC107 .. | BC182L | BC171 | ZTX303 | BC115 |
| BC108 .. | BC183L | BC172 | ZTX302 | BC113 |
| BC109 .. | BC184L | BC173 | — | BC114 |
| (L.F. Low-level p-n-p) | | | | |
| BCY71 .. | 2N3702 | — | ZTX502 | BC154 |
| BCY72 .. | 2N3703 | — | ZTX503 | BC153 |

TABLE II

**CRITICAL DATA ON TRANSISTORS IN TABLE I**

| | Polarity & Material | Fabrication | Case | $V_{cbo}$ | $V_{ebo}$ | $I_c$ max (mA) | $P_c$ max (mW) | $h_{FB}$ | $f_T$ (MHz) | $C_{ob}$ (pF) |
|---|---|---|---|---|---|---|---|---|---|---|
| ACY20 .. .. | P-Ge | Alloy | T05 | 40 | — | 2A | 260 | 100 | 1 | — |
| AC107 (NKT216) | P-Ge | Alloy | T01 | 15 | 5 | 10 | 80 | 50 | 1.5 | 12 |
| AC127 (NKT713) .. | N-Ge | Alloy | T01 | 32 | 10 | 500 | 340 | 100 | 2.5 | — |
| AC176 (NKT781) .. | N-Ge | Alloy | T01 | 32 | 5 | 1A | 700 | 200 | 1.5 | — |
| AD161 (NKT871) .. | N-Ge | Alloy | Special | 32 | 10 | 2A | 4·5W | 100 | 4 | — |
| AF117 (NKT677F) .. | P-Ge | Alloy diffused | T07 | 32 | 1 | 10 | 50 | 150 | 75 | 2 |
| BC109 .. .. .. | N-Si | Diffused | T018 | 20 | 5 | 100 | 300 | 400 | 250 | 4 |
| BF115 .. .. | N-Si | Diffused | T072 | 50 | 5 | 30 | 160 | 100 | 270 | — |
| BFY52 .. .. .. | N-Si | Diffused | T05 | 40 | 6 | 1A | 800 | 125 | 100 | — |
| NKT302 .. .. | P-Ge | Alloy | T08 | 60 | 15 | 2.5A | 13W | 100 | 1 | — |
| NKT603F .. .. | P-Ge | Alloy Diffused | T07 | 40 | 1 | 50 | 80 | 100 | 120 | 3 |
| OC35 (NKT404) .. | P-Ge | Alloy | T03 | 60 | 20 | 10A | 30W | 50 | 0.4 | — |
| OC45 (NKT12) .. | P-Ge | Alloy | T01 | 15 | 12 | 10 | 83 | 50 | 5 | 10 |
| OC75 (NKT213) .. | P-Ge | Alloy | T01 | 30 | 12 | 50 | 125 | 100 | 0.5 | — |
| 2N709 .. .. .. | N-Si | Diffused | T018 | 15 | 4 | 200 | 300 | 50 | 800 | 2 |
| 2N711B .. .. | P-Ge | Alloy diffused | T018 | 18 | 2 | 100 | 150 | 50 | 150 | 3 |
| 2N914 .. .. .. | N-Si | Diffused | T018 | 40 | 5 | 500 | 360 | 50 | 300 | 4 |
| 2N918 .. .. .. | N-Si | Diffused | T072 | 30 | 3 | 50 | 200 | 25 | 900 | 1.5 |
| 2N1132.. .. .. | P-Si | Diffused | T05 | 50 | 5 | 600 | 600 | 50 | 200 | 30 |
| 2N1183.. .. .. | P-Ge | Alloy | T08 | 45 | 20 | 3A | 7·5W | 50 | 0.5 | — |
| 2N1304 .. .. | P-Ge | Alloy | T05 | 25 | 25 | 300 | 150 | 100 | 8 | 20 |
| 2N2221 .. .. | N-Si | Diffused | T018 | 60 | 5 | 600 | 500 | 75 | 350 | 6 |
| 2N2906 .. .. | P-Si | Diffused | T018 | 60 | 5 | 600 | 400 | 75 | 350 | 6 |
| 2N3053 .. .. | N-Sj | Diffused | T05 | 60 | 5 | 700 | 1W | 75 | 200 | — |
| 2N3054 .. .. | N-Si | Diffused | T066 | 90 | 7 | 4A | 25W | 50 | 1 | — |
| 2N3055 .. .. | N-Si | Diffused | T03 | 100 | 7 | 15A | 115W | 50 | 1 | — |
| 2N3548 .. .. | P-Si | Diffused | T018 | 60 | 6 | 100 | 400 | 200 | 200 | 6 |

*NOTE:* Information generally extracted from "Transistor D.A.T.A. Book."

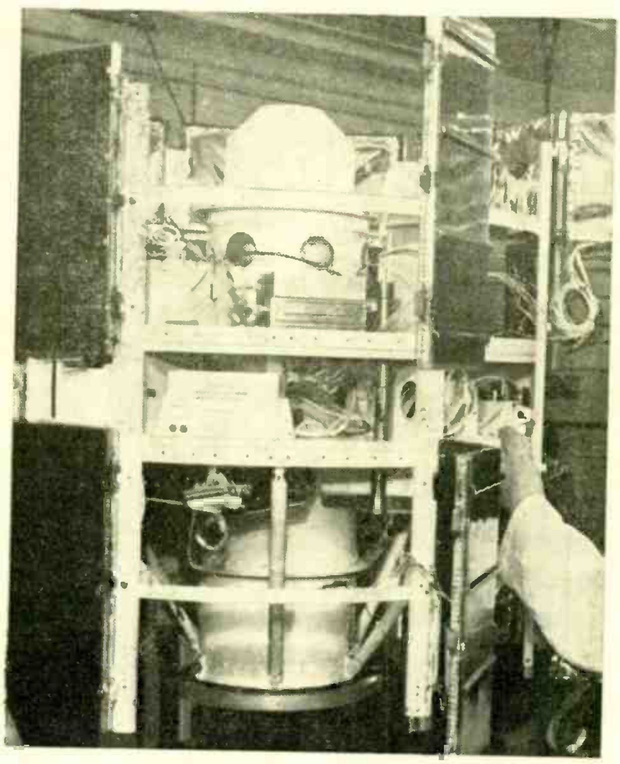
# European Space Research

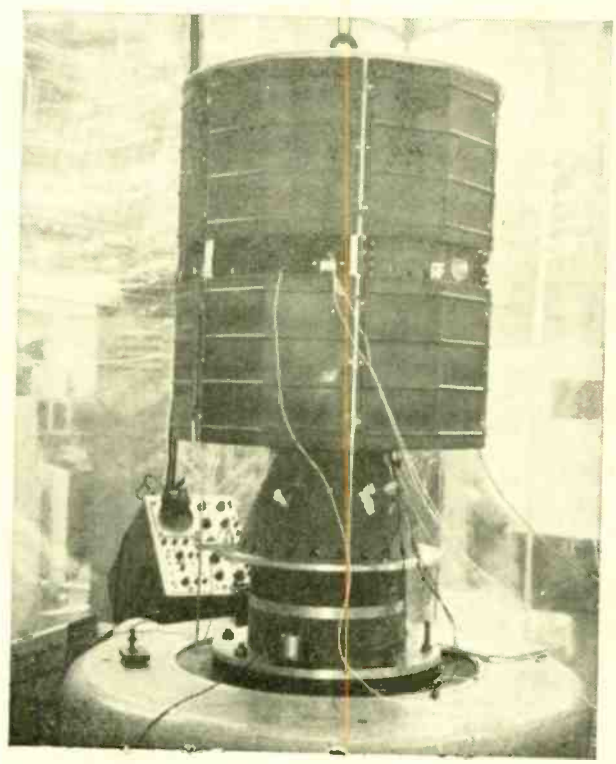
## Setbacks encountered—current programme—satellite situation—uncertainty as to the future

THE satellite programme of the European Space Research Organisation (ESRO) has suffered two major setbacks since it was inaugurated in 1964, although the sounding rocket programme has proceeded very smoothly. The first of these occurred in October 1966 when the premises of the European Space Technology Centre (ESTEC) and the European Space Research Laboratory (ESLAB) situated at Noordwijk in Holland were destroyed by fire together with all equipment, test data and records. The second occurred last May when a failure of the third stage of the four-stage Scout launch vehicle resulted in the first flight model (F1) of the satellite ESRO 2 falling into the Pacific after failing to go into orbit. Telemetry data received from the satellite during the abortive launch showed that all the satellite systems functioned normally.

At the time of this launch the European satellite tracking and telemetry network (ESTRAC) was incomplete and full responsibility for tracking, attitude control, turn-on of experiments, and data acquisition from ESRO 2 (F1) would have been with the American National Aeronautics and Space Administration (NASA). Now the ESTRAC facility is fully operational and the projected launch of F2, in April 1968, will result in a much larger ESRO participation. The design, integration, environmental and flight testing of the satellites is being carried by ESTEC and, apart from the early orbit determination that will be carried out by NASA as part of the launch service, full control of the satellite will be in the hands of ESTRAC.

Some uncertainty now exists as to the future programmes of ESRO following a meeting of member countries held in Rome last year. At this meeting no decision was taken as to the extent of future programmes on the grounds that insufficient information was available at that time. It was agreed, however, to form a programme advisory committee to look into the whole organization; their report is due to be presented shortly. It is envisaged that a further ministerial meeting will be held in late April or early May and a decision as to the magnitude of future programmes will be made, based on the Advisory Committee's Report.





*The left hand photograph shows an experimental unit being installed in ESRO 2 and the right hand photograph shows the same satellite undergoing vibration tests. The main contractor for the project was Hawker Siddeley Dynamics Ltd. with Société des Engins Matra (France) as principal sub-contractors, Ferranti supplying the solar cells. The satellite will be controlled in flight by 36 commands using a tone-digital system on a frequency of 148.25 MHz.*

As has already been mentioned the ESTRAC facility is now ready and in addition ESLAB and ESTEC have been rebuilt and re-equipped forming a sophisticated tool for research, design, environmental testing and tracking of satellites. This has been an expensive process involving the purchase of large amounts of capital equipment; the danger of too small a programme being granted is that these facilities will be only partly utilized. The net result would be a very high unit cost per project and a danger would exist in that scientists may tend to drift away from European Space Research. It is the hope of the organization that the programme will include communication and navigation satellites as well as those carrying scientific experiments currently planned.

The design and development of a satellite or sounding rocket payload is carried out in three definite stages: materials and components, sub-systems and the integrated system. At ESTEC the main task is concerned with environmental testing during the first and third of these stages, the second stage being left in the hands of contractors. The equipment at ESTEC includes comprehensive vibration facilities and large chambers capable of simulating the space environment as far as temperature, vacuum, solar radiation and "blackness" are concerned.

Work is at present proceeding on five projects with the prospect of a sixth "on the horizon." Out of 41 scientific experiments to be carried in these craft, 17 are British. As far as contracts received by British industry are concerned the story is rather different; only a small percentage of the equipment comes from British sources. However, this situation is likely to improve. In the past the organization discovered that in many cases, "space approved" electronic components were not available from European sources and increasing reliance was placed on components of American manufacture, although some were obtained as by-products of the French national space programme.

Briefly the satellites planned by the organization are: **ESRO 1**, a polar ionosphere satellite which will measure energies and fluxes of particles at high altitudes and the effects of particles as manifested by auroral events and the composition of the ionosphere. Studies will also be made of solar proton events which are responsible for polar cap absorption phenomena. To assist in making these measurements, the satellite will be stabilized along the earth's magnetic field lines by incorporating permanent magnets in the structure.

**ESRO 2** is designed to study solar astronomy and cosmic rays and as such its orbit is planned to keep the satellite in direct sunlight for the majority of its design lifetime (1 year). The equipment on board will measure the corpuscular radiation from the sun during solar flares, protons trapped in the inner Van Allen Belt, the electron component of primary cosmic radiation and the modulation mechanism of cosmic rays in interplanetary space.

The highly eccentric orbit satellite **HEOS A** is designed to study interplanetary physics, particularly magnetic fields, cosmic radiation and the solar wind during a period of large solar activity. The orbit apogee will be about 250,000 km and the perigee about 300 km. This orbit, a narrow ellipse, allows telemetry transmissions to be wholly in real time eliminating the need for an internal tape recorder and enabling the satellite to be "seen" for nearly 100% of the time (above 30,000 km) using only two ground stations. These will be the ESTRAC installations at Redu (Belgium) and Fairbanks (Alaska).

The main purpose of the satellite **TD1** will be to study stellar astronomy and cosmic rays and will to this end carry seven experimental installations. It will have a circular orbit at an altitude of 500 km with an inclination of 97.4° to the equator.

TD2 will study solar-terrestrial relationships during a period of maximum solar activity. It is of similar construction to TD1 but will be on an elliptical orbit with an apogee of 1200 km and a perigee of 350 km inclined at 90°.

The previously mentioned sixth satellite "on the horizon" is the **LAS** (Large Astronomical Satellite) on which work, although not suspended, has been reduced to a minimum for financial reasons. This is the largest and most complex of the projected satellites and is expected to be of high optical resolution $10^{-5}$ μm (0.1Å). Design of a three-axis simulator for the satellite was completed and various parts constructed up till the time of the fire at ESTEC; fortunately, some parts had not been delivered and escaped destruction. It has been estimated that some 7.5 man years and 232,000 French francs had been spent on this machine before the fire.

# BOOKS RECEIVED

**The BEAMA Directory 1967/1968.** Compiled by The British Electrical & Allied Manufacturers' Association Incorporated, this directory starts with a pictorial review of the achievement of the British Electrical Industry, the rest of the book being divided into four sections. Section 1—Directory of Manufacturers—gives the names and addresses of manufacturers, a summary of the products manufactured, overseas branches, representatives and agents. Section 2—Technical Information. Section 3—Buyers' Guide—an alphabetical list of products and who makes them. Section 4—Foreign Languages—equivalent expressions in German, Spanish, French, Portuguese and Russian for the English headings found in the Buyers' Guide section. Pp. 556. Price 60s. Pergamon Press Ltd., Headington Hill Hall, Oxford.

**Telecommunications for Technicians,** Vol. 1, by D. Coatesworth. From the Penguin Library of Technology this paper back is the first of three volumes to be published in this series. It introduces some of the basic principles of electricity, magnetism and electronics in a clear and well defined manner without short-circuiting the necessary mathematics. Unusually, in a book of this nature, the properties of semiconductor materials, diodes and transistors are discussed as well as the principles of thermionic emission. Although by no means a full treatment of the subjects it covers, this book provides an excellent introduction to electronics either as a hobby or as an intended career. Pp. 136. Price 10s 6d. Penguin Books Ltd., Harmondsworth, Middlesex.

**Television in Education and Training** by D. A. de Korte from the Philips Technical Library. The object of this book is to provide a general review of the development and scope of television as well as other audio-visual aids in education. Following a discussion of television and the audio-visual concept in general the history and the basic principles of television are broadly outlined together with details of equipment in use. Teaching projects that have been carried out in various countries using television are examined. Final chapters cover film projection and television, teaching machines and television and the production of closed circuit television broadcasts. Pp. 175. Price 41s. Macmillan & Co. Ltd., Little Essex Street, London, W.C.2.

# GaAs Miniature Radar

SMALL, simple and cheap radar sets for burglar alarms, automobile speed measurement, ship docking and other domestic and professional uses have become a practical possibility as a result of a development programme at the Royal Radar Establishment, Great Malvern. They are all based on the gallium arsenide (GaAs) Gunn-effect diode. As is well known, this is a piece of bulk semi-conductor which only requires a low voltage battery to be connected across it to produce oscillations in the microwave region. The diodes are mass-produced in a small plant at R.R.E. Their active part is a 10 $\mu$m epitaxial layer of pure GaAs deposited on a substrate of highly conducting GaAs. This conducting substrate acts as the anode, while a silver contact evaporated on to the epitaxial layer forms the cathode. The completed dice, which are 400 $\mu$m square, are mounted on molybdenum stubs and put into standard diode encapsulations.

R.R.E. were working on gallium arsenide in the early 1960s, before the Gunn effect was discovered. At that time it was thought that this material would be suitable for integrated circuits. A consortium of U.K. firms had been formed to explore the production possibilities of GaAs devices, and it was because of this early work, and successful co-operation between R.R.E. and the consortium, that the development of miniature radar went ahead so fast after the discovery of the Gunn effect. Incidentally the present leader of the R.R.E. team, Dr. Cyril Hilsum, is well known as the author of one of the first papers predicting the possibility of oscillations in GaAs and other bulk semiconductors*.

A further advantage of the Gunn oscillator over the klystrons and magnetrons normally used in radar transmitters is that it can be turned on and off more rapidly, to give extremely narrow pulses. In fact pulses as short as 3ns at 10 GHz have been obtained, and this means that a distance resolution of 0·5 metre is possible at ranges down to 2 metres—a useful facility in, say, the docking of ships.

The two devices illustrated are both Doppler radar systems. One is intended for use as a burglar alarm. The 6in × 4in × 4in box holds a transmitter, receiver and dry batteries, and the radar has a range (on a man) of about 50 yards. When it is operating in a room, any disturbance of stationary conditions, such as the entry of an intruder, causes the lamp on top to light—and, of course, an external alarm could be actuated. The other device is a hand-held, battery-operated Doppler radar for vehicle speed measurement. Its range is 50 yards on a man and 200 yards on a large vehicle, and the speed is read directly on a meter.

A third set, not illustrated, is a high resolution pulsed radar suitable for marine application and has a distance resolution of better than 1 m at ranges down to 2 m. The 10-GHz Gunn-diode oscillator is mounted across a waveguide in a straightforward radar transmitter-receiver system using a circulator, the receiver being blanked by a germanium diode switch during transmission. Switching of the Gunn diode is performed by an avalanche transistor circuit built into a coaxial structure. The best transmitter performance obtained has been pulses of 5 ns (half height) duration and peak power of 1 watt—that is, an energy of about 5 nJ per pulse. The receiver is a crystal video detector followed by a pulse amplifier with 1·2 ns risetime, and a sampling oscilloscope is used to give an A-scope display. It seems likely that this particular set will become available in commercial form.

* "Transferred Electron Amplifiers and Oscillators" by C. Hilsum. *Proc. I.R.E.*, vol. 50, No. 2, February 1962, pp. 185-189.


*(left) Portable radar speedometer being used to measure the speed of a car. The battery-operated microwave Doppler radar set has a range of about 200 yards on a large vehicle.*

*(below) Intruder alarm, showing warning lamp on top. The Doppler radar set inside uses a horn aerial giving a moderately wide beam, and has a range on a man of about 50 yards.*

# Acousto-electric V.H.F. Transmitter

THE simplest v.h.f./f.m. radio transmitter that one could hope to achieve was recently seen by *Wireless World* in operation at the Royal Radar Establishment, Malvern. Consisting of little more than a thin plate of cadmium sulphide with a voltage supply connected across it and an aerial attached, it was being used to transmit audio signals on a carrier frequency of 100 MHz across a room to an f.m. receiver. The power was only a few microwatts. This was in fact just a demonstration to illustrate some of the work of J. D. Maines and E. G. S. Paige at R.R.E. on acousto-electric oscillations in piezo-electric semiconductors, of which cadmium sulphide (CdS) is one. Nevertheless there are obvious practical uses for such a simple and cheap oscillator, which will operate between 30 MHz and 1 GHz, can be frequency modulated by a varying voltage and will generate oscillations in both electrical and mechanical form. In the transmitter, higher power could be obtained by more efficient crystal/aerial coupling.

Acousto-electric oscillations are the result of interaction between ultrasonic (mechanical pressure) waves set up spontaneously in the semiconductor by thermal effects, and the electrons which are caused to drift through the material by the voltage applied across it. Interaction occurs because the successive compressions and extensions of the ultrasonic waves, occurring as they do in a piezo-electric medium, produce electrical potentials within the material and these cause the drifting electrons to collect in bunches which travel with the waves (Fig. 1). If the electron stream is travelling in the same direction as the ultrasonic waves, and faster,

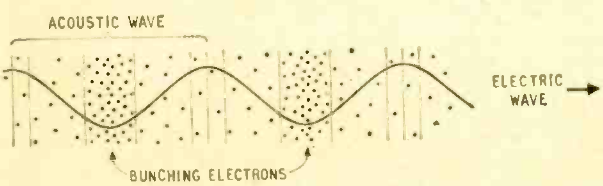



*Fig. 1. Interaction of acoustic and electric waves.*

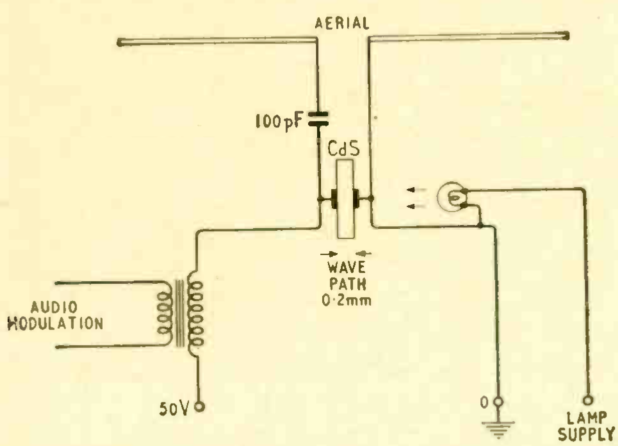
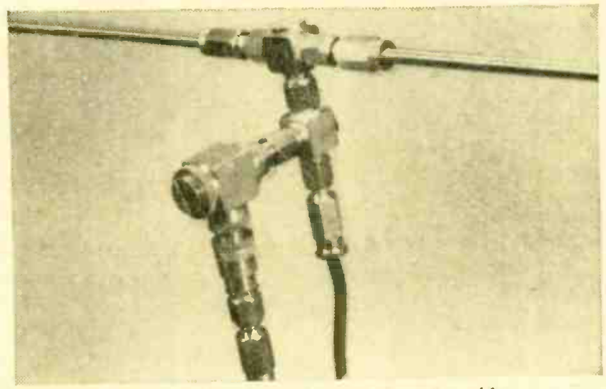



*Fig. 2. Circuit of the v.h.f. transmitter, showing light control.*



*The transmitter, dipole aerial and light source assembly.*

their interaction produces mechanical effects which augment the original waves—a phenomenon which has been used for acousto-electrical amplification in CdS. In the oscillator, however, when the ultrasonic waves strike an end face of the semiconductor they are reflected: the reflected waves are then travelling in the opposite direction to the electron stream and this causes them to be attenuated. After reflection at the opposite face the waves are once more travelling in the same direction as the electron stream, again being augmented by the effects of the electron-bunching, and by the time they have completed a "round trip" a net amplification has been obtained. Non-linear effects reduce the round-trip amplification to unity, and this, of course, is the condition necessary for self-sustaining oscillations.

After several hundred such round trips a steady-state acoustic oscillation on a single frequency is reached, and the electron bunching associated with this is sufficiently large to modulate the d.c. bias current. As a result electrical oscillations are produced in the supply circuit. The thickness of the CdS plate, $t$, determines which wavelengths can be supported ($2t=N\lambda$, where $N$ is an integer) and, through the velocity of sound, which oscillation frequencies are possible ($f=v/\lambda$). If the piezo-electric plate were functioning as a crystal filter or transducer $N=1$, but in the demonstration transmitter $N=21$.

The velocity of the waves is determined by the applied voltage and the conductivity of the material. In CdS 0.2 mm thick, for example, frequencies between 20 and 500 MHz have been generated with applied voltages of 20 V to 100 V. For the 100 MHz demonstration transmitter a supply of 50 V is used. The conductivity of the CdS (typical resistivity $\approx 10^{1}$ ohm cm) is controlled by directing a light source of adjustable intensity on to the plate so that the incident photons liberate electrons in the material. As shown in Fig. 2 a small lamp is included in the v.h.f. transmitter for this purpose.

Since the frequency of oscillation can be varied by altering the CdS supply voltage, it is a simple matter to frequency modulate the transmitter by superimposing a modulating signal on the d.c. bias as shown in Fig. 2. The frequency shift obtained varies with supply voltage and material conductivity but a typical value is 10 kHz per modulating volt and in the demonstration transmitter the modulating voltage range is about 0—2 V.

# WORLD OF WIRELESS

## Satellite vs Cable Communications

WHEN commercial telephone traffic via Early Bird commenced in 1965 the Scandinavian countries had three circuits with New York terminating in Oslo, Stockholm and Copenhagen, and routed via London. It was decided to make a subjective evaluation of whether calls via Early Bird were acceptable to the general public, the idea being to make as close a comparison as possible with existing cable circuits to New York. A total of 1,624 satellite calls were listened to by operators and notes made of the quality of the connections and subscribers' reactions and comments. The same process was repeated on 844 cable calls. In a second stage of these tests subscribers were interviewed immediately after calls, in accordance with an agreed questionnaire. Each of the three terminal stations in Scandinavia made interviews after 50 satellite calls and 50 cable calls, making a total of 300 calls in all. The subscribers had no idea which means of communication they had used and no subscriber was interviewed more than once and, in addition, no publicity was given to the tests.

It is obvious from what has been said that the statistical material obtained was very limited, nevertheless it was thought that investigations over a longer period or with a greater number of circuits would not have produced substantially different results. The main conclusion of the tests is that calls via Early Bird have been generally satisfactory to the Scandinavian public and the results of the objective evaluation of such calls are very much the same as for the cable calls. The tabulated result showed that, based on the operators' report, 84.1 % of the satellite calls were found to be very good as against 76.1 % of the cable calls. Observations of echo, crosstalk and signal level variation showed little difference between systems. Of the interviewed subscribers 46.7% found the satellite and 54% found the cable very good.

## Television-telephone Trials in America

FIELD trials on a visual telephone equipment suitable for use in the office or home will commence next September. Known as the Picturephone and developed by Bell Telephone Laboratories of America, the equipment will be built and evaluated by Westinghouse Electric Corporation. For the trials some 40 sets will be manufactured, 28 will be installed in Pittsburgh and 12 in New York so that the usefulness of the system for both inter- and intra-city communications can be gauged. Providing the trials are a success, the American Telephone and Telegraph Company, Bells' parent organization, said that it hopes to introduce a limited number of the sets into customer service in the early 1970s.

A silicon target camera tube is employed utilizing an electronic zoom system, adjustable focus and an automatic iris resulting in the production of good pictures over a wide range of ambient lighting conditions. A screen measuring 5.5in × 5in is incorporated and this, in conjunction with the wide angle capability of the camera lens system, gives the user considerable latitude regarding side to side movement. To enable larger scenes to be transmitted the camera may be focused at 20ft. Printed matter may also be sent, and for this the camera is focused at 1ft. When this is done a built-in mirror swings to an angle of 45 degrees in front of the lens so that the material may be placed flat in front of the picturephone. When used for normal face-to-face conversation the depth of field is 16 inches centred on 32 inches. A typical installation comprises: dialling unit, control unit, display unit and a service unit. Four push buttons enable the user to initiate a video or voice-only call, to see the picture he is sending out, to prevent his picture from being transmitted—in this case a bar pattern is sent instead, and to select either a normal handset or a loudspeaker for the sound.

The camera tube employed is interesting in that the target consists of a small silicon slice containing over half a million photodiodes. An advantage of this tube is that its performance is not degraded or modified by exposure to bright light or by electron beam bombardment and is does not suffer from optical or raster " burn in."

## Submarine Acoustics

ENGINEERS from Honeywell's Marine Systems Centre at Seattle have started a three-year research programme to study the underwater scattering of sound waves. The object of the programme is to discover whether any consistent patterns emerge so that future marine acoustics instruments may be programmed to take them into consideration. The scattering medium consists of micro-organisms and impurities suspended in the sea that distort the sound paths in such a way as to make signals unreliable or too weak to be detected at all; it is known that air bladders in fish are a real factor in sound deflection. It was formerly assumed that the scattering field could be modelled on the homogenous, densely populated impurities and could be averaged for practical purposes, but this approach is now considered to be insufficiently precise. A 1,600 pound acoustic sensing and transmitting instrument has been set up on the ocean bed in the Strait of Juan de Fuca, British Columbia, where the Pacific Ocean penetrates a protected salt-water labyrinth. The eight-foot high unit will send signals from a depth of 325 ft to Honeywells' research vessel *Neper* and at the same time water current, salinity, dissolved oxygen and temperature will be measured. The experiment is claimed to be the largest company sponsored basic research programme on underwater acoustics ever carried out.

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**The formal opening** of Heriot-Watt University's new Mountbatten Building by Earl Mountbatten of Burma took place on January 3rd. The opening ceremony followed a graduation ceremony at which Sir Alec Douglas-Home, Chancellor of the University, conferred honorary degrees upon a number of dignitaries including a doctorate of science on Earl Mountbatten. The new building was recently completed at a cost £650,000 and accommodates the Department of Electrical and Electronic Engineering and departments of the Faculty of Humanites. The building is T-shaped in plan and it includes a 250-seat conference theatre with adjacent conference rooms, a television suite (see "News from Industry," page 707), two main lecture theatres and a number of well-equipped laboratories—including a language laboratory. Every room is wired for closed circuit television and a comprehensive network connects the TV complex in the Mountbatten Building with the main University building providing direct two-way links.

**To assist listeners** in parts of Scotland who are having difficulty in receiving B.B.C. Radio 2 on 1,500 metres and who do not possess a v.h.f. receiver, low-power repeater stations have been installed in Glasgow and Edinburgh. These stations will provide local reinforcement of Radio 2 by making use of the international common wavelength of 202 metres. The range of stations using this wavelength is restricted by international regulations to only a few miles. In addition the useful range is further limited at night by interference from the other 150 European stations that share this wavelength. The possibility of operating additional transmitters on this wavelength in other parts of Scotland is being investigated.

The **Eddystone Radio essay competition** organized early in 1967 has been won by Bruce Taylor, a 25-year-old student who is engaged on Ph.D. work at Edinburgh University. For his essay describing a new approach to radio receiver design he wins an EA12 Eddystone communication receiver worth £185.

The **Simon Memorial Prize** for 1968 has been awarded by The Physical Society to Dr. K. A. G. Mendelssohn, F.R.S., Reader in Physics in the University of Oxford, in recognition of his distinguished work on superconductivity and the properties of liquid helium.

## ANNOUNCEMENTS

The second **International Broadcasting Convention** is to be held in London from the 9th-13th September. Sponsored jointly by the Electronic Engineering Association, the I.E.E., I.E.R.E., I.E.E.E. and the Royal Television Society, it will include an exhibition and the television conference already announced by the learned Societies. Enquiries should be addressed to the International Broadcasting Convention, Savoy Place, Victoria Embankment, London, W.C.2.

A second conference on **solid state devices** is being arranged by the Institute of Physics and the Physical Society in collaboration with the I.E.E., I.E.R.E. and I.E.E.E. The conference will be held at the University of Manchester Institute of Science and Technology from 3rd to 6th September.

A 98-page prospectus giving details of **full-time and sandwich courses** to be held during 1968 and 1969 at the Borough Polytechnic, Borough Road, London, S.E.1, is now available.

A course on **high-fidelity sound reproduction** will be held each Wednesday evening during February and March at Hendon College of Technology, The Burroughs, London, N.W.4.

A course of three evening lectures on the **science and engineering of elementary particle physics** will be held at University College, Gower Street, London, W.C.1, on Mondays at 5.30 commencing February 26th.

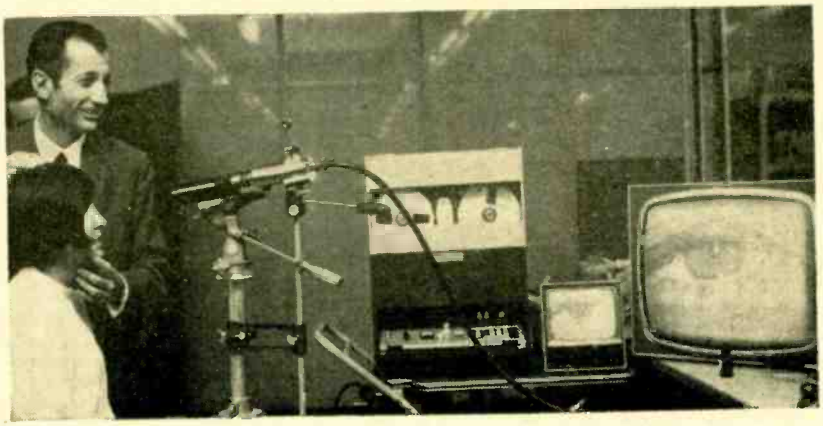
Some 25 American manufacturers of **miniature and microminiature components** are collaborating with the U.S. Department of Commerce to stage an exhibition of the latest products at the United States Trade Center in London, between 14th and 22nd February.

Now available from G. A. Stanley Palmer Ltd. are Type **KS 1 polystyrene film capacitors** manufactured by the German company Ernst Roederstien. The capacitance values range from 5 pF to 0.022 $\mu$F with working voltages of 25, 63, 160 and 630 V and tolerances vary from $\pm 2.5\%$ to $\pm 20\%$. The temperature range is $-10$ to $+70°$C.

The **telemetry system** for Britain's satellite launching vehicle Black Arrow is to be supplied by E.M.I.

For the sum of £150 per day, a complete **closed circuit colour television system** can be hired, with a cameraman and engineer, from Closed Circuit Television Hire, 93 Greenfield Road, London, E.1.

A new service for independent testing of **audio equipment** is available from H. F. Engineering, 3 Willowbank, Sunbury-on-Thames, Middx.



*Professor J. Barraquer, an eminent Spanish eye surgeon, flew into London recently to see a demonstration of EMI's miniature television camera, type BC.930. Professor Barraquer, who specialises in anterior chamber surgery of the eye, required a high quality camera of small dimensions for use in the operating theatre at the Clinica Barraquer in Barcelona. The EMI BC.930 is 1.7 inches in diameter and about the size of a small pocket torch. Using a ½-inch vidicon camera tube, the BC.930 gives high resolution pictures with a very low noise level. After a test of the camera's capabilities, Professor Barraquer returned to Spain the following day with the camera. The picture shows Professor Barraquer using the camera during his evaluation.*

# PERSONALITIES

The B.B.C. has announced that **James Redmond,** F.I.E.E., assistant director of engineering for the past year, is to become director of engineering when **Sir Francis McLean** retires in May. Mr. Redmond, who is 49, served as a marine radio officer before joining

*J. Redmond*

the B.B.C. in 1937 and also during the war. In his early days with the Corporation he was in the Television Service at Alexandra Palace. He became asst. superintendent engineer (film) in 1956; supt. engr. (television recording) in 1960; supt. engr. television (regions and O.Bs) in 1962; for the past year he has been responsible for the operational work of the Engineering Division.

**S. N. Watson,** F.I.E.E., head of the B.B.C. Designs Department for the past four years, is to become chief engineer, television, when **T. H. Bridgewater,** O.B.E., F.I.E.E., retires in April. Mr. Watson joined the B.B.C. in 1933 and after serving at the Newcastle and Birmingham studios he became an engineer in the Lines Department in 1938. He transferred to the Designs Department in 1947 and became head of the television group in 1951.

*S. N. Watson*

**L. A. A. Thomas,** B.Sc., F.I.E.E., F.Inst.P., chief physicist at the G.E.C. Hirst Research Centre, Wembley, since 1961, has been appointed visiting professor in the School of Physics at Bath University of Technology. He will be lecturing to postgraduate students in solid-state physics and will advise the School of Physics on both undergraduate and postgraduate courses. Mr. Thomas joined the Research Laboratories of the G.E.C. in 1935, graduating at the University of London in 1938, and specializing later in the fields of crystallography and magnetism.

**Gerald H. Askew,** B.Sc., M.I.E.E., who has been with Peto Scott Ltd. for the past three years, has become chief engineer and will manage the development laboratory. After graduating at King's College, London University, he joined Kolster Brandes Ltd. in 1945 as a junior development engineer. Seven years later he went to Cinema Television (now Rank Cintel) where he

*G. H. Askew*

became section leader and was concerned mainly with the development of flying-spot telecine equipment. Mr. Askew, who is 42, left Rank Cintel in 1964 to join Peto Scott.

**I. W. Dick,** who resigned last October as managing director of the Marconi Marine Company's Norwegian associates, Norsk Marconikompani A/S, which he joined as general manager in 1962, has been appointed management executive with the parent company. Mr. Dick served as an instructor in air radio in the Royal Air Force during the war, and on leaving the Service in 1946 became an instructor at the Glasgow Wireless College. He later joined the seagoing radio officer staff of the Marconi Marine Company. In 1955 he was transferred to the company's technical shore staff.

**G. C. Briggs,** Grad.I.E.R.E., who joined Marconi Instruments in 1959 as a special trainee after 15 years' service in the Royal Navy from which he retired with the rank of lieutenant commander, has become manager, commercial administration. In 1960 he joined

*G. C. Briggs*

the company's technical sales department and has for some time been field sales manager. He is succeeded in this position by **T. L. Clarke,** B.Sc.(Eng.), M.I.E.E., who has been with Marconi Instruments as senior representative in the Midland Area since 1963. A graduate of King's College, London University, he served his graduate apprenticeship with B.T.H. During his National Service with the R.E.M.E., he served as a staff instructor on radar equipment at the Army School of Electronics at Arborfield, leaving the Service with the rank of captain. He then joined Isotope Developments Ltd., as a senior development engineer, and from 1957 to 1963 was technical sales manager of I.D.M. Electronics Ltd. Marconi Instruments also announce the appointment of **J. H. Buying** to the newly created post of manager, overseas projects. He will be responsible for the

*T. L. Clarke*

smooth running of the Company's overseas manufacturing operations (at present in the U.S.A., Italy and India), whilst also retaining his duties as an export regional manager. Mr. Buying joined Marconi Instruments as an X-ray development engineer in 1948, following service with Philips Electrical Ltd. In 1950 he became a service engineer with General Radiological Ltd. but rejoined Marconi Instruments, as a sales engineer in the Export Department in 1954.

**Leonard T. Perriam,** M.A., who joined Daystrom Ltd., of Gloucester, six years ago as technical sales and service manager of the Industrial Products Division, has been appointed managing director. He has succeeded **A. E. B. Perrigo,** M.Sc., F.I.E.E., who has been managing director since the formation of the company in 1960, and recently took up the appointment of director of the Small Businesses Centre at the University of Aston, Birmingham. Mr. Perriam was for some fifteen years with I.C.I. Ltd., working on instrument development, before joining Daystrom.

*L. T. Perriam*

**Kenneth L. Richardson,** a technical systems supervisor at the London Air Traffic Control Centre, Heathrow Airport, has received a cheque for £500 "in recognition of his suggestion which has led to improvements in the performance of radar displays used by air traffic controllers." The Committee on Awards to Inventors considered that Mr. Richardson had provided an elegant solution to a long-standing problem and had made a significant contribution to safety. Mr. Richardson, who is 43, joined the National Air Traffic Control Service in 1947 and at the time he made the suggestion was engaged on radar maintenance at the London A.T.C. Centre. Now known as Selective Moving Target Indicator, the specification prepared by Mr. Richardson has been developed by Solartron Ltd. who have been asked by the Board of Trade to incorporate S.M.T.I. into five long-range radars at Ash (Kent), Ventnor (Isle of Wight), Clee Hill (Shropshire) and East and West Harrow on a trial basis and it will probably be incorporated in radars at ten civil airports.

*J. Baldwin*

*A. Woods*

*P. Darby*

**John Baldwin,** B.Sc., A.Inst.P., recently joined the I.T.A. as head of the video and colour section of the Experimental and Development Dept. Mr. Baldwin, who is 39, had been chief engineer and research and development manager of Peto Scott Ltd. since 1965. Prior to joining Peto Scott in 1964 he had been for 14 years with Rank Cintel.

**Alfred Woods,** who has joined the I.T.A. as contracts engineer in the Station Design and Construction Dept., was with E.M.I. Electronics from 1958, latterly as commercial contracts officer. Prior to joining E.M.I. he served with R.E.M.E. on a short-service commission.

**Philip Darby,** who joined the I.T.A. staff in 1955 as a senior shift engineer at the Caldbeck transmitting station, is appointed head of the technical quality control section of the Authority's Operations and Maintenance Dept. Mr. Darby, who is 42, became assistant engineer-in-charge at the Emley Moor transmitting station in 1956 and has been engineer-in-charge of the Dover transmitting station since 1959.

**G. Kaye,** M.I.E.E., recently joined ATV Network Ltd. (I.T.A. programme contractors for London and the Midlands) as head of engineering. For the past eleven years he has been with Alpha Television Studios latterly as engineer-in-chief. Mr. Kaye was for two years with the B.B.C. before joining the R.A.F. as a radar mechanic in 1946. After the war he went to E.M.I. Research Laboratories and from 1954-6 was studio manager of High Definition Films Ltd.

## NEW YEAR HONOURS

Among the recipients of awards in the New Year Honours list are the following:—

**Oliver W. Humphreys,** C.B.E., B.Sc., F.Inst.P., F.I.E.E., who was for many years director of the G.E.C. Hirst Research Centre, Wembley, and recently retired as vice-chairman of the General Electric Company and also as chairman of the Conference of the Electronics Industry, has been created a knight bachelor.

**C.B.**

**Captain M. Hodges,** O.B.E., M.I.E.R.E., Royal Navy (retired), lately Under Secretary, Cabinet Office.

**Ieuan Maddock,** O.B.E., F.R.S., M.I.E.R.E., Controller of Industrial Technology, Ministry of Technology.

**C.B.E.**

**B. J. A. Bard,** D.I.C., Ph.D., board member and chief executive (department of applied science), National Research Development Corporation.

**E. L. T. Barton,** O.B.E., M.I.R.E., chief of telecommunications (civil aviation) Board of Trade.

**H. K. Robin,** chief engineer, Diplomatic Wireless Service, Foreign Office.

**O.B.E.**

**E. R. T. Ponsford,** chairman and managing director of Solartron Electronic Group Ltd., for services to export.

**W. H. Storey,** managing director of Unicam Instruments Ltd., for services to export.

**M.B.E.**

**E. A. Beaumont,** superintendent engineer, B.B.C. External Broadcasting.

**G. A. C. R. Britton,** M.I.E.E., lately senior executive engineer, G.P.O. Radio Planning & Provision.

**A. G. German,** M.I.E.E., senior executive engineer, G.P.O.

**C. E. Hutchings,** assistant station radio officer, Government Communications Headquarters, Foreign Office and Commonwealth Office.

**B. B. Learoyd,** co-ordinator, colour familiarisation, B.B.C.

**B.E.M.**

**H. E. Wall,** receiver technician, B.B.C.

# LETTERS TO THE EDITOR

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

## "A Genuine Reject?"

PUTTING spurious type numbers on transistors amounts to giving a false description of goods offered for sale. This is an offence. Unfortunately, unscrupulous vendors are likely to get way with it, because the victims are invariably buyers of small quantities, who cannot afford to go to law.

A reasoned complaint is sometimes effective, but if no redress is obtained the buyer should complain to the magazine in which the goods were advertised. The advertisement managers of reputable magazines always pay attention to reasonable complaints

Magazine publishers do possess the ultimate sanction of refusing to accept further advertisements, thereby depriving a mail order firm of its "shop window", and while this sanction is seldom exercised (perhaps too seldom), a reminder that it exists can curb the excesses of some advertisers.

"Unmarked transistors are in quite a different category to "re-marks". The vendor does not often claim that they meet a standard specification, and in practice they range from straightforward factory rejects (including out-and-out duds) to perfectly genuine transistors which conform exactly to a standard specification. The trouble is that there is no way of distinguishing the sheep from the goats. Unless the supplier is prepared to quote a definite specification the description of such goods as "tested" or "guaranteed" is almost meaningless. Even if a specification is forthcoming, the things it leaves unsaid may be more significant than the things it says. A transistor with $h_{fe}=200$ at $I_c=1$ mA may appear to be suitable for use in low-level a.f. stages, but what about leakage and noise? It may have been rejected on these very counts. Testing transistors thoroughly calls for time and proper equipment, and as the specification of an unmarked transistor is made more rigid so the price rises towards that of the genuine article.

There is a third class of transistors: those marked with type numbers, but not type numbers which appear on any transistor maker's lists. They are sometimes peculiar to a large-scale user, such as a computer maker, who arranges with the manufacturer for a supply of transistors which are a variant on some standard type, but there are other possible explanations, less attractive to the buyer. To my knowledge at least one big manufacturer has been known to mark his own rejects with both non-standard type numbers and the name of an obscure subsidiary company as a 'front' for marketing them.

GEORGE WAREHAM

London, W.C.2

AS ONE of the "home constructors" referred to in your January Editorial, I welcomed your remarks about "reject" transistors. But what can be done about it? A glance through the smaller display advertisements in that issue reveals the following descriptions:

1. "Genuine brand new products."
2. "100% tested transistors."
3. "Fully guaranteed devices."
4. "All guaranteed."
5. "Discount transistors."
6. "First grade, guaranteed."
7. "Transistors—not remakes."
8. "Best quality new semi-conductors."
9. "Brand new, first grade and guaranteed."
10. "No duds: uncoded devices."

And many, many more variations, including those that claim "unmarked" as if it were an advantage.

Nor are these the only snags into which the "home constructor" can run, particularly if components for high-quality audio equipment are needed. Even a simple piece of equipment can involve six suppliers. My efforts to obtain a series of small non-electrolytic capacitors produced an incredible series of replies ranging from "6s each but out of stock" to "£3 each and 26 weeks delivery."

I hate to be able to paint the U.S.A. in a better light, but there one can obtain massive catalogues free and obtain ALL your parts, post free, from one supplier.

GORDON B. NESS

Altrincham, Ches.

## The Future of British Electronics

I DISAGREE with your Editorial in the December issue on two counts. First, electronics is now growing from the *black box* to the *systems* phase. So long as one was concerned with the production of individual "black boxes", the design of the detailed circuits (i.e. the connecting together of selected discrete components) was the aspect on which the designer exercised his skill. But surely the main concern of the equipment designer now is with systems, and he is not interested in the contents of a package provided it gives him the specification he wants. If an equipment designer can call for an i.c. linear amplifier, in terms of gain, bandwidth, distortion and peak-to-peak output voltage, or a logic circuit in terms of fan-in, fan-out, 0 and 1 levels, propagation, time and noise immunity, is not this better than being obliged himself to assign a value to every individual component in such a circuit? L.S.I. might be thought to be a move to extend integrated-circuit techniques from the black-box to the systems phase. But the l.s.i. manufacturer could not sell his wares unless either he had engaged in vertical integration, in the economic sense, so that he had changed from being an i.c. manufacturer to being an equipment manufacturer, or he was manufacturing to the requirements of equipment manufacturers. Presumably it is the former alternative which equipment makers fear.

Secondly, I do not like the protectionist idea of a "Buy British Act." Apart from military projects (to which special strategic considerations apply) products should be bought on the basis not of brand image but of specification, price and delivery. If British made components cannot compete on this basis, there is no hope for them in the long run. But if British purchasing executives place orders irresponsibly (as suggested in your Editorial), it is the business of the managements who employ them to see that they mend their ways. It must be rare for the merits of rival suppliers to be so finely balanced that they cannot be differentiated until one finds a difference in nationality. If the British component manufacturer is consistently inferior to the foreigner, then the British equipment maker cannot afford to buy British; because if he buys his components for non-commercial reasons the equipment he wishes to sell will not remain commercially competitive.

D. A. BELL

University of Hull.

## Identification of Electronic Parts

WE were, of course, extremely interested in Dr. Stanton's letter in the January issue concerning identification of electronic parts under the BS 9000 scheme run by the Institution.

You, sir, have partially given the answer to Dr. Stanton in your Editorial, but it is worth adding a few more facts. The committee co-ordinating the implementation of the Burghard recommendations considered very carefully the question of parts identification. They decided that first priority was to get the specification system going and that it would be better to consider an identification code after some viable specifications were in being. It was felt that, when this stage was reached, the practical implications to which you yourself refer on page 619 would be more easily assessed.

It may be of interest that this co-ordinating committee is comprised of organizations representing the manufacturers of active and passive electronic parts and industrial and Government.

ROHN HOPPER

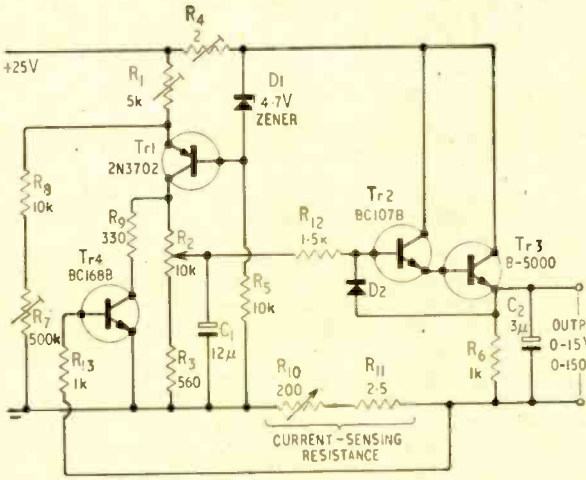
British Standards Institution,
London, W.1.

## Semi-stabilized D.C. Supply

THE term "semi-stabilized" was used to describe my circuit (October 1967, p. 482) because the stabilization is obtained, not by comparing the output voltage with a reference voltage and then applying a correction, as in a conventional series stabilizer, but by recourse to a sort of "dead reckoning" process. With such a system, the degree of perfection attained in the stabilizing action cannot be made arbitrarily large as it can in theory in a series stabilizer by making the loop gain very high.

Nevertheless, the performance is quite good enough for many purposes. Even without load-current compensation the output voltage of my prototype stays within half a volt of 15 V over the range 0-150 mA. The variation can be reduced to less than 0·1 V by using load-current compensation, and improved still further by the methods kindly suggested by Mr. Peter Williams (November, p. 554). The only serious shortcoming is that if the circuit is set up to give optimum performance at one output voltage it does not necessarily provide optimum performance at other output voltages.

In the revised circuit shown here, Mr. Williams' method of compensating for input-voltage variations by means of resistance $R_7$ is incorporated. With careful adjustment perfect compensation can be achieved at any chosen output voltage. A current-limiting circuit (Tr4,




$R_{10}$, $R_{11}$, etc.) has been substituted for the lamp used in the original version. The output current can be limited to anything between about 3 mA and 0·25 A with the values of current-sensing resistance shown. Smoothing capacitor $C_1$ has been retained because the optimum setting of $R_7$ for supply voltage compensation turned out to be different from the optimum value for hum cancellation. This is presumably an indication that the a.c. impedance of the Zener diode differs from its d.c. incremental resistance. With some output transistors a leakage current of several milliamps flows, and for this reason $R_6$ has been reduced to 1 kΩ so that the minimum output voltage off load is kept small.

G. W. SHORT

Croydon

## Variants on the Ring-of-two Reference

FIRST may I apologize for a silly slip in my letter published in the November issue. The bridge action referred to for balancing out the effects of supply changes should not have included the combination $R_2+R_3$, but rather the added compensating resistor $R_7$.

The high performance of the single Zener diode form of the ring-of-two reference described by Mr. May (November "Letters") shows the flexibility of this circuit. I agree entirely with him on the self-starting problems that may exist, and in my original letter (September 1966) had described the circuit as "a complementary bistable with catching Zeners." The single diode circuit is a good example of how, even in these days of massively increasing publication, effort is duplicated. I, too, have used it for some time and referred to it in a letter published in June 1967 (p. 301) without knowing of Mr. May's design. Already I have come across half a dozen individuals who have devised variants on the ring-of-two reference quite independently.

It occurs to me that there may be other readers who have done so, or have seen some published information. Might I ask any such to get in touch with me, as it would help me considerably in a research project I have undertaken. In return I would gladly supply them with a complete list of information received should they wish it.

PETER WILLIAMS

Dept. of Elec. Engg.,
Paisley College of Technology,
Paisley, Renfrew.

# TECHNICAL NOTEBOOK

## Computer Aided Circuit Construction

MUCH design effort in electronics can be saved by using computers to work out problems which are solvable by a systematic, logical routine. At the Royal Radar Establishment, Great Malvern, experiments are being conducted in using a computer to decide the optimum placing of components on printed-circuit boards—in particular the placing of dual-in-line integrated circuit packages on a rectangular matrix. Ultimately the computer programmes will be used in conjunction with a conductor route running programme to provide a complete placing and interconnection diagram. So far, three programmes, based on two algorithms, have been evolved.

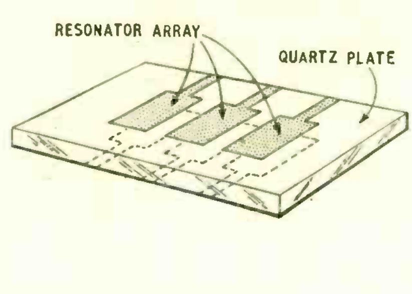
To determine the optimum placing of a package any one of a number of criteria can be used. Two programmes prepared at R.R.E. have as their aims: (1) the minimum number of through connections from one side of the board to the other; and (2) the minimum length of leads between packages. The first programme helps to reduce the number of plated-through holes required on double-sided boards. If two packages are electrically connected the programme will try to place them in either the same row or the same column of a matrix arrangement. The second programme will try to place packages which are electrically connected as close to each other as possible. An alternative version using a square law tries to reduce very long leads.

A random initial placing is assumed in each case, and then pairs of packages are exchanged in the matrix. At each stage all the possible exchanges are considered, then the best one is selected. For practical boards the programmes take into account fixed devices such as plugs and sockets, and for a board containing twelve packages and an edge connector a layout can be produced, using about 3,000 words of computer storage, in approximately 15 seconds. Practical boards usually do not have very well defined "best arrangements," and it is sometimes difficult to decide which of two alternatives is really optimum.

R.R.E. are also using computers to design integrated circuits. In general, the computer does d.c. and transient analyses of a theoretical circuit design and from this produces information for the manufacture of the masks used in fabricating the i.cs. A circuit analysis programme for use in the design of m.o.s. integrated circuits has been written. This can analyse any circuit made up of resistors, m.o.s. transistors and their associated capacitances, and has a simple but flexible input code so that it can be used by a circuit engineer with no knowledge of computer programming. The programme has been applied to the design of a four-stage binary counter, containing 84 transistors on a 0.06-in square silicon chip. Sample devices have been made by using the resulting mask master drawings in Plessey's i.c. manufacturing process. Work has now started on a language for describing integrated circuit layouts to the computer. The stored information will then be used for mask checking, calculation of circuit parameters for use by analysis programmes, and for control of an automatic mask making machine.

## Monolithic F.M. Discriminator

A SMALL quartz plate carrying a simple electrode pattern that will detect narrow-band f.m. signals has been developed by Bell Telephone Laboratories, U.S.A. The device eliminates the need for the second stage converter used in many f.m. receivers and is superior to conventional crystal units with comparable bandpass limits. The discriminators can be produced to operate at frequencies in the range of 10 to 30 MHz with a passband ranging from 0.01% to 0.02% of the desired midband frequency. The discriminator consists of an AT cut quartz plate 0.5in × 0.25in and a triple resonator array formed by depositing gold electrodes on the two major surfaces. The amount of gold deposited sets the frequency of each region; by this means the centre region is adjusted to resonate at the centre frequency and the outer regions above and below this to give the required passband. The resonant frequencies are determined partly by controlling the mass of the gold deposited and partly by the properties of the crystal. The device operates in a similar fashion to electric circuit discriminators except that the resonators and coupling are mechanical. Electro-mechanical conversion is carried out through the piezo-electric effect.




## Picosecond Pulses Observed in Q-switched lasers

TRAINS of light pulses with individual pulse lengths in the picosecond region have been discovered in the outputs of ruby and neodymium: glass lasers Q-switched by a rotating mirror. These pulse trains were previously thought to be a single pulse due to the resolution, or lack of it at these speeds, of oscilloscopes. The discovery, made at Bell Telephone Laboratories, U.S.A., made use of a phenomenon known as two-photon fluorescence to display the pulses. Using this method, pulses of less than a fraction of a picosecond may be seen. The train of light pulses to be observed is directed on to a mirror immersed in a fluorescent liquid and the pulses are reflected back on themselves. Two-photon fluorescence occurs at the points where two pulses overlap, causing bright luminous spots to appear. These are photographed and measured to determine their duration. Using this technique, pulses with a duration of about ten picoseconds in ruby lasers and less than one picosecond in neodymium: glass lasers have been observed. Pulses from two to eight microseconds in duration had previously been produced in a neodymium: glass laser Q-switched with a special dye. At the time it was generally believed that the dye was the agent responsible for the appearance of the short pulses. However, the new observations show clearly that the mechanism for the generation of these pulses is inherent in the laser itself.

# Emitter-coupled, Emitter-timed Multivibrators

## 2: Monostable circuits

By G. B. CLAYTON, B.Sc., A.Inst. P.

LAST month the advantages of emitter-coupled emitter-timed circuits were discussed and the astable multivibrator was looked at in detail. An example of a monostable multivibrator that forms the basis of this month's article is shown in Fig. 13. In the permanently stable state Tr2 is conducting and Tr1 is off. The circuit loop—emitter Tr1—collector Tr1—base Tr2—emitter Tr2—emitter Tr1—is regenerative and if Tr1 is brought into conduction, by a positive pulse applied to its base, a regenerative switching action takes place which switches Tr2 off. The negative step at the emitter of Tr2 is communicated to the emitter of Tr1 by capacitor $C$, diode D2 is reverse biased. The emitter current $I_e$ is transferred to Tr1 and $C$ charges (Fig. 14) causing the potential at the emitter of Tr2 to fall towards earth. After a period $t_p$, Tr2 goes into conduction again and a regenerative action returns the circuit to its permanently stable state.

The waveforms observed in the circuit are shown in Fig. 15. At the end of the timing period the emitter of Tr1 is driven positive and the capacitor $C$ has then to discharge. The discharging current, in addition to the current through $R_4$, passes through Tr2 and is responsible for the overshoot in the collector waveform of Tr2. The overshoot decay and recovery time are governed by a time constant $C(R_3 + R_d + R_i)$. Where $R_d$ is the effective resistance of diode D2 and $R_i$ is the input resistance at the emitter of Tr2. The run down in the emitter voltage of Tr2 during the timing period is non-linear accounting for the slope in the collector waveform of Tr1. The transistors do not saturate and the circuit is capable of producing narrow pulses, Fig. 15 (c) shows a 320 ns. pulse at the collector of Tr2.

A detailed design procedure will not be given since the circuit will operate satisfactorily with a fairly wide range of component values. Care must of course be taken to ensure that the transistor ratings are not exceeded. The following are some useful design equations;

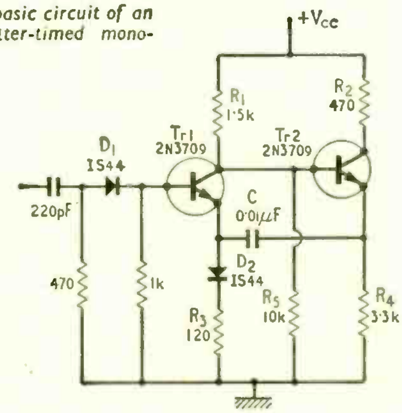
The pulse width is given by the approximate relationship $t_p = CR'(1 - R'/2R_4)$. Where $R' = R_1R_5/(R_1 + R_5)$.

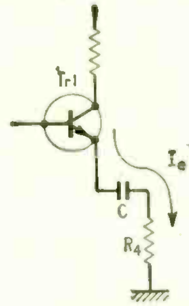
The emitter current of Tr2 in the permanently stable state is given approximately by:

$I_e = V_e'/R_4$, where $V_e' = V_{cc}R_5/(R_1 + R_5)$ is the potential at the base of Tr2 in the permanently stable state.

The output pulse height at the collector of Tr2 is equal

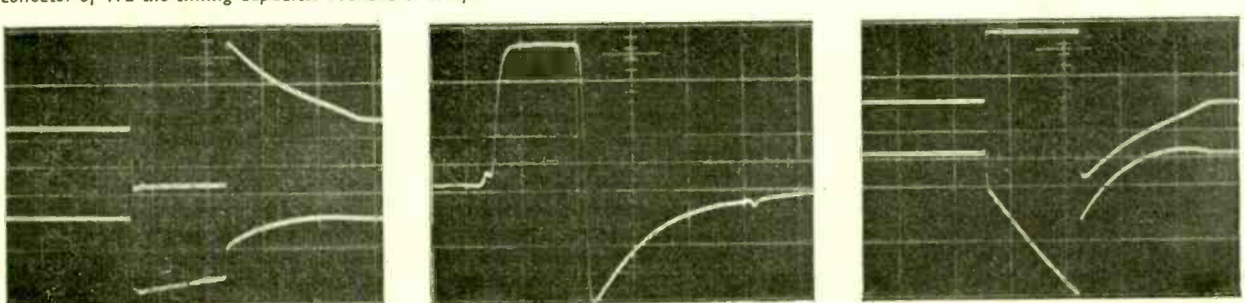
Right, Fig. 13. The basic circuit of an emitter-coupled, emitter-timed monostable multivibrator.




Left, Fig. 14. Charging path of Fig. 13 during the quasi-stable state.

Fig. 15. Waveforms of Fig. 13. (a) The upper trace shows the waveform of the emitter and the lower trace the waveform at the collector of Tr1. (b) The collector (upper) and emitter (lower) waveforms of Tr2. (c) High speed performance of the monostable; a 320 ns pulse at the collector of Tr2 the timing capacitor reduced to 330 p.



(a) upper — 1 V/cm, lower — 5 V/cm. 5 μs/cm.

(b) 2 V/cm. 5 μs/cm.

(c) upper — 2 V/cm. 5 μs/cm. lower — 1 V/cm. 0.2 μs/cm.

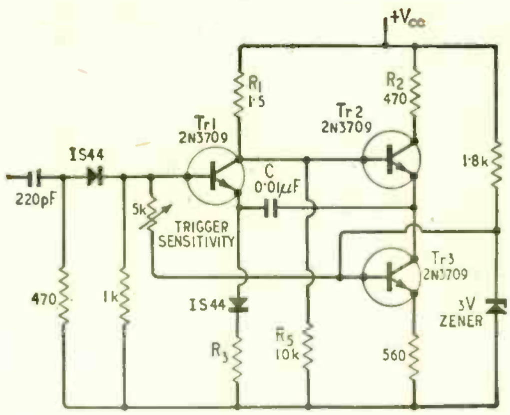



*Fig. 16. An improved emitter timed monostable.*

to $(V_c'/R_4)$. $R_2$. The fastest switching is realised if the transistors are not allowed to saturate, in the case of Tr2 the output pulse height should be made less than $V_{cc} - V_c'$ and for Tr1 $R'$ should be less than $R_4$ if saturation is to be avoided.

It is advantageous to make $V_c'$ as large as possible in order that the pulse width should be reasonably stable against changes in the supply voltage $V_{cc}$ (See appendix). Using the component values shown in Fig. 13 a change in supply voltage from 20 to 30 V was found to change the pulse width by 10 %. The trigger sensitivity of the circuit is low. This is to be expected since the triggering pulse has to supply a forward bias to three silicon p.n. junctions (D1, D2 and the base emitter junction of Tr1) before any current can pass in Tr1. This situation can be improved by connecting a 5 kΩ variable resistor between the positive supply rail and the base of Tr1. When this resistance is reduced below a certain value the circuit free runs.

The performance of the circuit of Fig. 13, as far as the stability of the pulse width is concerned can be improved if the emitter resistance $R_4$ is replaced by a transistor acting as a constant current source.[1] An example of a practical circuit using this modification is shown in Fig. 16. This circuit incorporates a trigger sensitivity control in the form of a variable resistor connected between the base of Tr1 and the stabilized zener voltage upply. The waveforms obtained with this circuit are shown in Fig. 17. The run down in Tr2 emitter voltage is seen to be linear and the bottom of the collector waveform of Tr1 is flat. The steps in the emitter waveforms occurring at the start of the timing period are smaller than those in Figs. 28 and 29. This fact arises from the small forward biasing of Tr1 by the trigger sensitivity control.

An expression for the pulse width may be readily obtained if it is assumed that transistor Tr3 takes a constant current $I_c$. The run down in Tr2 emitter voltage starts at a value $V_3' - V_{be2} - \delta V_{e2}$. $V_c' = V_{cc}R_5/(R_1 - R_5)$ is the voltage at the base of Tr2 in the permanently stable state, $V_{be2}$ is the base emitter voltage of Tr2 in this state $\delta V_{E2}$ is the step occuring in the emitter voltage of Tr2 as it switches off. The run down ends when Tr2 emitter voltage reaches a value $V_c' - I_cR' - V_{be}'$, $R' = R_1R_5/(R_1 + R_5)$, is the effective collector load resistance of Tr1 and $V_{be}'$ is the base emitter voltage of Tr2 when regenerative switching occurs. Capacitor $C$ thus charges through a voltage,
$\Delta V = I_cR' - [\delta V_{e2} + (V_{be2} - V_{be}')]$.

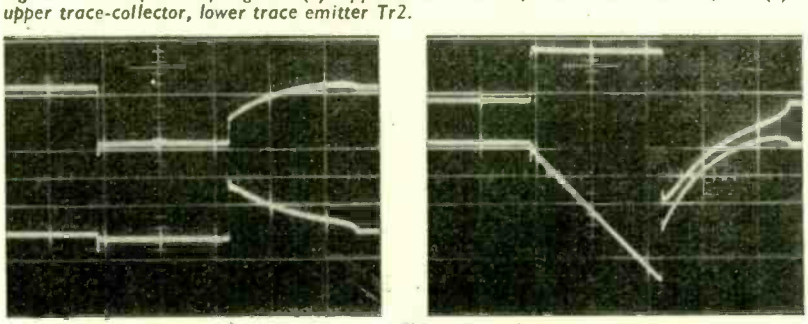
The pulse width,
$t_p = (\Delta VC)/I_c = CR' - C/I_c\,[\delta V_{e2} + V_{be2} - (V_{be}')]$.
If the bracketed terms, which are small, are neglected $t_p = CR'$. Note that the power supply voltage does not occur in this expression for pulse width. In the case of the circuit shown in Fig. 16 a change in supply voltage from 15 to 30 V was found to produce only a 2 % increase in pulse width.

A further modification to the basic circuit can be made in order to eliminate the overshoot in the pulse at the collector of Tr2. An example of a practical circuit in which this modification is incorporated, is shown in Fig. 18. The waveforms produced by the circuit are shown in Figs. 19 (a), (b) and (c).

### SAWTOOTH GENERATOR

In the circuit of Fig. 16 the run down in the emitter voltage of transistor Tr2 is linear enabling the circuit to be used as the basis of a linear sawtooth generator. The collector load resistor of transistor Tr2 is not required and with it omitted from the circuit, the resistor $R_5$ is no longer needed to prevent Tr2 from saturating. A circuit for the saw tooth generator is shown in Fig. 20.

*Fig. 17. Waveforms of Fig. 16 (a) Upper trace-collector, lower-trace emitter, Tr1 (b) upper trace-collector, lower trace emitter Tr2.*



*(a) upper — 5 V/cm, lower 2 V/cm. 5 μs/cm.*    *(b) 2 V/cm. 5 μs/cm.*

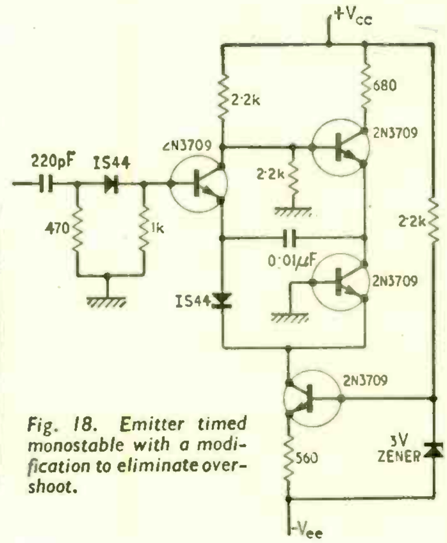
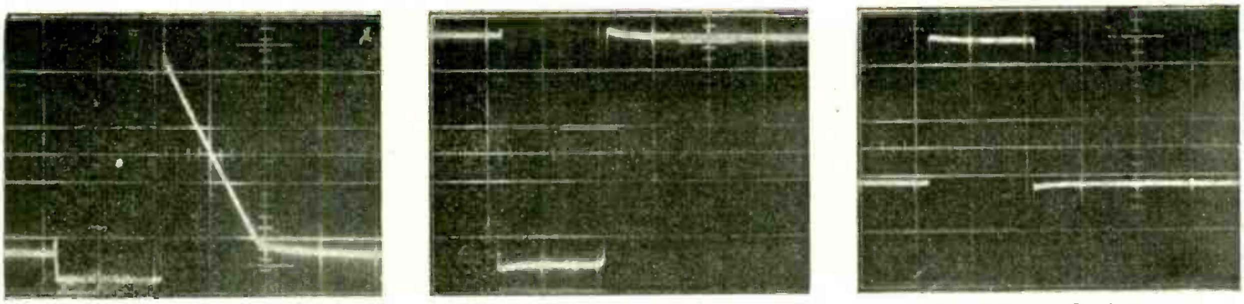



*Fig. 18. Emitter timed monostable with a modification to eliminate overshoot.*



(a) 1 V/cm. 5 µs/cm. (b) 1 V/cm. 5 µs/cm. (c) 1 V/cm. 5 µs/cm.

*Fig. 19. Waveforms encountered in the circuit of Fig. 18 (a) emitter Tr1 (b) collector Tr1 and (c) collector Tr2.*

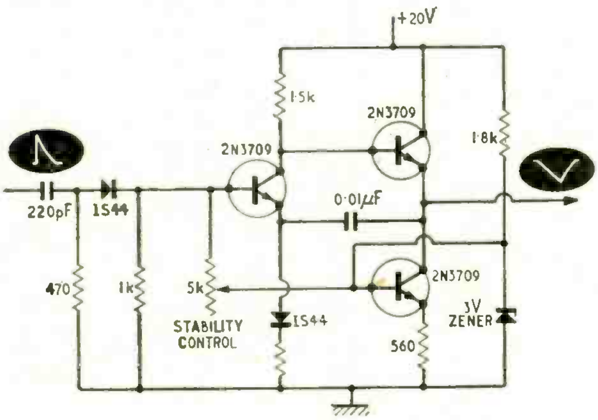



*Fig. 20. A linear sawtooth generator circuit.*

The measurements made on the practical circuits described would appear to confirm that emitter timed multivibrators possess the desirable features outlined in the introduction. Facilities were not available to test the stability of pulse widths against changes in temperature. The analyses given show that temperature changes may be expected to affect the timing periods because of the $V_{be}$ terms that appear in the equations. These terms change by a few millivolts per °C change in temperature but the analysis shows that they only have a small effect on the timing periods. The astable circuits are useful as stable frequency pulse sources and the monostable circuits are suitable for use as high speed pulse generators.[2] The circuits are not really suitable when long timing periods are required as the timing capacitor would need to be excessively large. Base timed circuits are more suitable for low frequencies and long timing periods.

## APPENDIX

Derivation of an expression for the pulse width produced by the circuit of Fig. 13. During the quasi-stable period the charging current into $C$ starts at a value $I_i=(V_c'-V_{be2}-\delta V_{e2})/R_4$ and decays exponentially to a value $I_f=(V'_c-I_cR'-V_{be}')/R_4$ in a time $t_p$.

$V_c'=V_{cc}R_5/(R_1+R_5)$ is the potential at the base of Tr2 in the permanently stable state. $V_{be2}$ is the base emitter voltage of Tr2 in this state. $V_{be}'$ is the base emitter voltage of Tr2 when switching occurs. $\delta V_{e2}$ is the step in the emitter voltage of Tr2 and $R'=R_1R_5/(R_1+R_5)$ is the effective collector load resistor of Tr1. It is assumed that $\alpha_{cb1}+\alpha_{cb2}$.

Now $I_f=I_i\exp.(-t_p)/CR_4$ so that $t_p=CR_4\log_e I_i/I_f$.

Substitution for $I_i$ and $I_f$ gives:

$$t_p=CR_4\log_e\frac{V_c'-V_{be}-\delta V_{e2}}{V_c'-V_{be}'}\cdot\frac{R_4+R'}{R_4}$$

If $V_c'$ is considerably larger than the other voltage terms we may write an approximate expression for the pulse width.

$$t_p=CR_4\log_e\frac{R_4+R'}{R_4}$$

Expanding the log term gives:

$$t_p=CR_4\left[\frac{R'}{R_4}-\frac{1}{2}\left(\frac{R'}{R_4}\right)^2+\frac{1}{3}\left(\frac{R'}{R_4}\right)^3\ldots\right]$$

$$t_p=CR'\left[1-\frac{1}{2}\left(\frac{R'}{R_4}\right)+\frac{1}{3}\left(\frac{R'}{R_4}\right)^2\ldots\right]$$

provided that $R_4>R'$. If $R_4\gg R'$ then $t_p\approx CR'$.

---

**Correction:** *Amend caption of Fig. 2 to read "below" and caption of Fig. 3 to read "above" (not right and left). The lower end of $R_1$ (Fig. 6) should be connected to the base of Tr2.*



(see advertisement on p.114)

# The Simple Transistor Equivalent Circuit and the Impedance Transforming Node

By R. V. LEEDHAM,* B.Sc.Tech., M.Sc., C.Eng.

THE idea that a transistor may be used in a similar way to a transformer for the conversion of impedance levels in problems of matching loads to generators, and devices to one another, is familiar to circuit designers. This property of impedance transformation is due to a particular arrangement of one of the nodes in the T equivalent circuit of the transistor, and it will be shown how the effect occurs, and how the simple T circuit may be used for approximate circuit analysis by inspection, without the tedious algebra of an exact analysis.

The simple T equivalent circuit for the transistor is shown in Fig. 1. The element $r_c$ has been omitted from the exact circuit, removing the internal feedback, and leaving the transforming node $b'$ in its pure form. The essential elements of the node are shown in Fig. 2 together with an impedance $z$ which includes the emitter resistance $r_e$. The important property of this node is that one node current is a linear function of one of the other node currents. In this case, $\alpha i_e$ is directly proportional to $i_e$. In order to determine the apparent impedance between the terminals shown, assume an input step $\delta v$,

then $\delta i = \delta i_e - \alpha \delta i_e = \delta i_e(1 - \alpha) = \dfrac{\delta i_e}{\alpha_{eb}}$

where $\alpha_{eb}$ is the current gain between base and emitter, and is related to the current gain between base and collector by

$$\alpha_{eb} = \alpha_{cb} + 1$$

The test potential step may be equated to the circuit parameters

$$\delta v = \delta i_e.z = \alpha_{eb}.\delta i.z$$

and the apparent impedance is given by

$$\frac{\delta v}{\delta i} = \alpha_{eb}.z$$

i.e. the impedance $z$ appears to be increased by the factor $\alpha_{eb}$ when seen from the base connection. This impedance transformation works both ways, and Fig. 3 illustrates the effect of an impedance $z$ in the base lead (including $r_{bb}'$). In this case when we apply the test signal $\delta v$ the current drawn from the generator is $\delta i_e$. The current through $z$ however is

$$\delta i_e\,(1 - \alpha) = \frac{\delta i_e}{\alpha_{eb}}$$

and hence the potential difference produced across $z$ is

$$\delta v = z \times \frac{\delta i_e}{\alpha_{eb}}$$

and the apparent impedance is

$$\frac{\delta v}{\delta i} = \frac{z}{\alpha_{eb}}$$

In this case the impedance $z$ has been reduced by the factor $\alpha_{eb}$. This impedance transformation effect is entirely due to the fact that two of the node currents are related by a constant factor. The effect is similar to that of the ideal transformer shown in Fig. 4, of ratio $1:n$. The relationships in this case are well known to be

$$\frac{v_2}{v_1} = \frac{n}{1} \qquad \frac{i_2}{i_1} = \frac{1}{n}$$

and the apparent impedance

$$\frac{v_1}{i_1} = \frac{v_2}{n}.\frac{1}{ni_2} = \frac{z}{n^2}$$

a transformation ratio of $n^2$.

The transformer is a more versatile component than

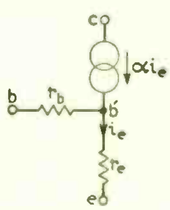



*Fig. 1. Simple T transistor equivalent circuit*

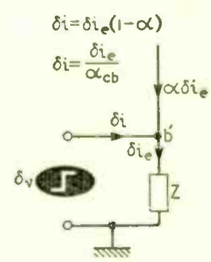



*Fig. 2. Transforming node input on 'base' side*

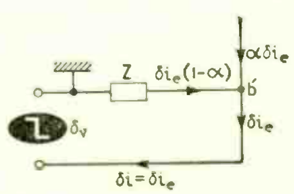



*Fig. 3. Transforming node input on 'emitter' side*

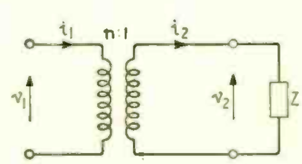



*Fig. 4. Ideal transformer*

* University of Bradford.

the transforming node, since both the current and voltage are transformed in the ratio $n$, whereas in the case of the node the current only is transformed. Using the idea of the transforming node, the input impedance and gain of a transistor circuit may be written by inspection. The method gives no indication of the output impedance of the transistor, but this is not very serious, since the output impedance is high, normally, compared with the load which shunts it. Examples of the method are given below.

### COMMON COLLECTOR

The basic circuit is shown in Fig. 5. It may be seen that the input impedance is given by the sum of $r_{bb}'$ and the effect of the transforming node on $r_e$ and $R_L$.

$$R_{in} = r_{bb}' + \alpha_{eb}\,(r_e + R_L)$$

Fig. 6 shows the circuit for the calculation of output impedance. The impedance is seen to be

$$R_{out} = r_e + \frac{(r_{bb}' + R_s)}{\alpha_{eb}}$$

The voltage gain is seen to be that of an attenuator, from Fig. 5, of

$$\text{gain} = \frac{\alpha_{eb}\,R_L}{r_{bb}' + \alpha_{cb}\,(r_e + R_L)}$$

### COMMON EMITTER

The circuit is shown in Fig. 7 and the circuit parameters of interest may be written down as

$$R_{in} = r_{bb}' + \alpha_{eb}\,(r_e + z_e)$$

The gain is obtained as follows.

Consider the attenuator giving the potential at $b'$. The attenuation factor is

$$\frac{\alpha_{eb}\,(r_e + z_e)}{r_{bb}' + \alpha_{eb}\,(r_e + z_e)}$$

the current $i_e$ is given by the attenuated signal at $b'$ divided by the impedance $r_e + z_e$, and the output signal is $\alpha . i_e$.

$$\text{gain} = \frac{\alpha_{eb}\,(r_e + z_e)}{r_{bb}' + \alpha_{eb}\,(r_e + z_e)} \cdot \frac{1}{(r_e + z_e)} \cdot \alpha . R_L$$

$$= \frac{\alpha_{cb}\,R_L}{r_{bb}' + \alpha_{eb}\,(r_e + z_e)}$$

### COMMON BASE

The circuit is shown in Fig. 8. The circuit parameters of interest are

$$R_{in} = r_e + \frac{r_{bb}'}{\alpha_{eb}}$$

and, by inspection, the voltage gain is

$$\text{gain} = \frac{\alpha . R_L}{r_e + \dfrac{r_{bb}'}{\alpha_{eb}}}$$

In some cases it is possible to include the effect of the component $r_c$, but the effect is often complex due to 'Miller effect' and other feedback aspects. The method is presented as a quick first approximation analysis to facilitate design synthesis, to be followed by exact analysis when the design is completed.

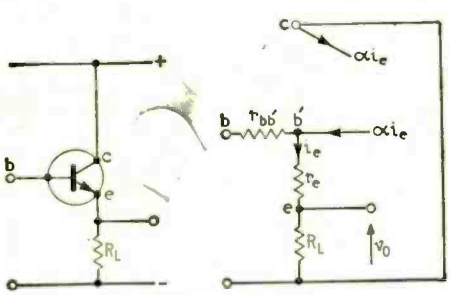



*Fig. 5. Common collector*

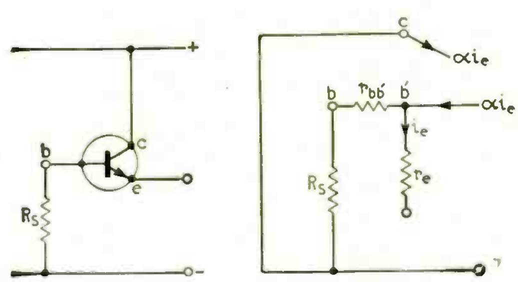



*Fig. 6. Calculation of output impedance*

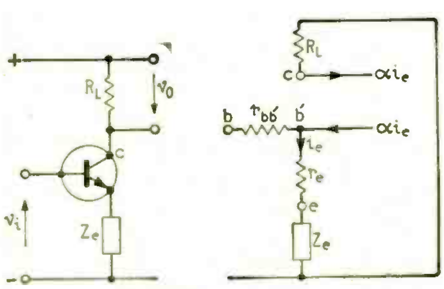



*Fig. 7. Common emitter*

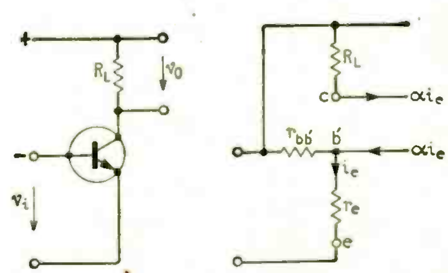



*Fig. 8. Common base*

# WORLD OF AMATEUR RADIO

## *Antique Wireless Association*

MRS. MARION ARMSTRONG, widow of Edwin H. Armstrong, the f.m. pioneer, was guest of honour at the fifth annual convention of the Antique Wireless Association held recently in the Henry Ford Museum, Dearborn, Michigan, U.S.A. Among the historical radio items on display in the Museum are the original rotary gap and condenser used at station NAA (Arlington, Va), the McMurdo-Silver historical collection of valves, early de Forest equipment (including a Syntonizer and a 1907 U.S. Navy "singing arc" radiophone), as well as much early amateur equipment. During the convention Mr. Henry Houck (Major Armstrong's assistant) demonstrated one of the first superheterodyne receivers developed by Major Armstrong. The receiver was later donated to the Museum by Mrs. Armstrong. The call sign of the Antique Wireless Association, an amateur radio organization interested in the history of early wireless, is W2AN. The Association maintains a museum of historical equipment at Holcolmb, New York, the earliest example on display being a replica of the spark transmitter and coherer used by Marconi in his initial tests. Secretary of the A.W.A. is Mr. Bruce Kelley (W2ICE ex-8ACY) of Main Street, Holcomb, N.Y., who also edits *The Old Timers' Bulletin*, published quarterly. Is is not time a similar organization was established in the United Kingdom to document the history of wireless and the work of its pioneers?

**Eye Bank Network.**—Dr. Alson E. Braley (W0GET), Professor of Ophthalmology of the University of Iowa, received the first annual Achievement Award of the Medical Amateur Radio Council for founding the Eye Bank Network in December 1962. The purpose of the network, operated by radio amateurs, is to provide rapid, inexpensive and efficient communication once a day, to make known to participating eye banks throughout the United States of America any emergency requirements for eye tissue and where such tissue is available. The sight of scores of patients has been saved since the network was founded.

**Australian Intruder Watch.**—Nearly 20 years ago the R.S.G.B. set up an organization to report on the presence in "exclusive" amateur bands of broadcast and commercial stations. Known as an Intruder Watch the organization continues to submit regular reports to the G.P.O., who take action, when appropriate, to have the offending stations removed. Since that time Intruder Watch organizations have been established by national amateur radio societies in a number of countries including the U.S.A. Latest addition to the list is the Wireless Institute of Australia.

**Belgium-Netherlands Amateur TV Contact.**—Thanks to having been granted a temporary (three-day) licence by the Belgium authorities, Gaspard de Wilde (ON4ZK) in Dessel (Province of Antwerp) was able to achieve the first two-way amateur television contact on 70 cm between his country and the Netherlands when he worked A.H.M. Lambriex (PA0LAM) in Reethoven, on October 27th, at 19.30 G.M.T., over a distance of 24 km. M. de Wilde has also received amateur television from PA0COB (The Hague) and from G3NOX (Saffron Walden, Essex).

**Reports on Two-metre German Beacon.**—First U.K. reception reports of signals from the German beacon station DL0PR at the Lindau Ionospheric Observatory operating on 145.97 MHz, have reached the R.S.G.B. from R. A. Ham, of Storrington, Sussex. Signals were first heard on November 21st, at readability 5 and signal strength varying from 2 to 5 from 08.30 to 09.30 G.M.T. Further reports will be welcomed by the Society's Scientific Studies Committee, 28 Little Russell Street, London, W.C.1.

**International DX Competition.**—Amateurs throughout the world are invited to participate in the 34th A.R.R.L. International DX Competition for which special certificates of performance will be issued to the top telephony and telegraphy scorers in each country. In addition, plaques will be awarded to continental high scorers—single-operator, telephony and telegraphy. The competition will take place during the weekends February 3/4 and March 2/3 (telephony) and February 17/18 and March 16/17 (telegraphy). The object of the contest is for stations outside the U.S. and Canada to work as many of the 48 United States and Canadian call areas as possible. Further details and log forms can be obtained from A.R.R.L., 225 Main Street, Newington, Conn., 06111, U.S.A.

**A.R.R.L. 1967 DX Contest.**—The leading U.K. station in the 1967 A.R.R.L. Telegraphy Contest was D. Gibson (GI3OQR), Co. Tyrone, N. Ireland, with a score of 1,886,304 points obtained from 2,807 transatlantic contacts made during an operating time of 70 hours. Leading English station was that of C. R. Perks (G4CP), Walsall, Staffs, whose score of 1,446,552 was obtained from 2,199 contacts in a 40-hour operating period. In the Telephony Section the leading U.K. entrant was L. F. Coursey (G4JZ), Birdlip, Glos, who had a score of 1,171,596, obtained from 2,194 contacts in an operating period of 53 hours.

**Top European Memberships.**—The German amateur radio society (D.A.R.C.) recently reported a total membership in excess of 18,000, of whom more than half hold a transmitting licence. As at June 30th, 1967, the total membership of the Radio Society of Great Britain stood at 13,400 (an increase of 115 since the same date in 1966) of whom 7,945 (including a large number of overseas members) held a transmitting licence. At the same date there were 12,308 Class A Sound Licences in force in the U.K. The rapid growth of the amateur radio movement in the Federal German Republic can be attributed, in full measure, to the efforts made by D.A.R.C. to cater for "Der Jungamateur," a section of each issue of *DL-QTC*—the society's journal—being devoted especially to their interests.

**R.S.G.B. President.**—John C. Graham (G3TR), of Crawley, Sussex, was installed as the 34th president of the Radio Society of Great Britain at a recent informal meeting of members at the Kinglsey Hotel, London, W.C.1. Mr. Graham has been a member of the Society for more than 30 years. Professionally he is senior air traffic controller at Gatwick Airport.

**OSCAR News Bulletins** about satellites designed to carry amateur radio equipment into orbit are transmitted by W6ASH on Fridays at 02.00 G.M.T. on 14.03 MHz and at 05.00 G.M.T. on 7.015 MHz. The European OSCAR constructed by the German amateur Karl Meinzer (DJ4ZC) and the Australian OSCAR, constructed by a team of radio amateurs associated with Melbourne University, are both in the U.S.A. waiting to be launched.

**Change of Name.**—The title of the *R.S.G.B. Bulletin*, known throughout the world of amateur radio as "The Bull," has been changed to *Radio Communication*. The official journal of the Radio Society of Great Britain first appeared in July 1925 as the *T & R Bulletin*. It remained the title until July 1942, although the Transmitter & Relay Section of the Society ceased in December 1926. The T & R Section came into being during September 1923 to safeguard the interests of the transmitting amateurs, many of whom considered too much attention was being given by the Society to broadcasting matters and to the interests of broadcast listeners; broadcasting having commenced in the United Kingdom in November 1922.

JOHN CLARRICOATS, G6CL

# Pin-board Construction

A simple, beginners' circuit-building technique employing a circuit diagram as a guide to layout

By G. W. SHORT*

IT is very difficult for the beginner or young constructor to perform the mental contortions necessary to turn a theoretical circuit into a practical layout, and even if he manages this feat, or has it done for him, useful working concepts, such as the idea of signals flowing from left to right, or the positive line always being at the top, are destroyed, unless one uses an inordinate quantity of terminal blocks.

The practical difficulties are manifold. First, screw-down terminal blocks are not very reliable as a means of making connections, at least not in the hands of a young constructor. The actual connection is hidden away inside the block, and so cannot be inspected. Dimensions of the blocks impose limitations on the components which can be used with them. Epoxy-encapsulated transistors with half-inch leads have to be mauled in order to make them span three adjacent terminals. Short-lead second-hand resistors and capacitors are likewise awkward, and the assembled circuit often looks clumsy. Certain educational circuit-construction techniques were considered, but were rejected because of their high cost. However, from these, and demonstration circuits seen at exhibitions, the simple constructional technique discussed here was developed. The main problem was the method of making joints. If the ends of leads can first be wrapped round a fixed, rigid post even an eleven-year-old can then solder them. Suitable posts can be provided by hammering ordinary domestic electro-plated pins (which solder well) into a piece of wood and then cutting off their heads with wire snippers, leaving about a quarter of an inch of stem showing.

Suitable materials for the baseboard are hardboard, soft wood, and the "sandwich board" which has an inner core of softwood and outer skins of veneer, even plywood can be used if not too hard. Whatever is used, it must be dry. If thin materials such as hardboard are used, the points of the pins come through, and should be filed off to avoid scratching surfaces on which they are laid.

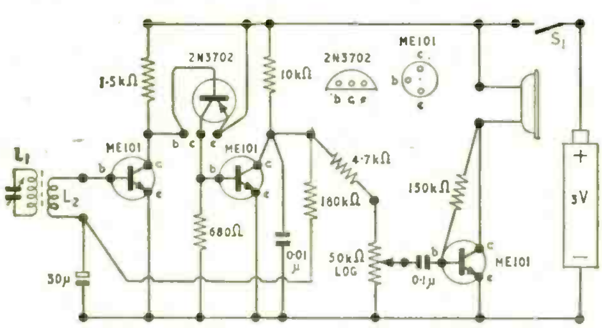



*Fig. 1. The circuit diagram is drawn in the usual way, except that the transistor electrode connections are positioned so as to correspond with the transistor header. In this circuit the only transistor which requires special treatment is the 2N3702, which has its leads in a straight line with the collector in the middle.*

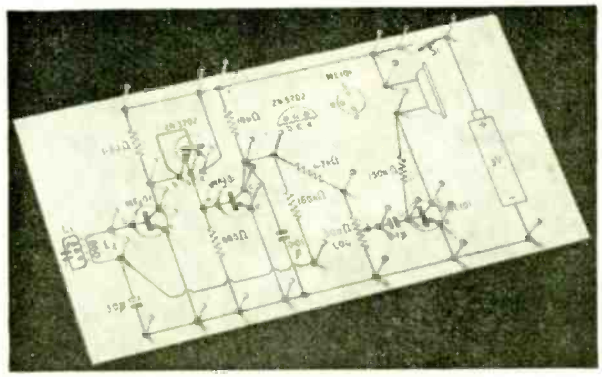


*Fig. 2. Ordinary household pins are hammered in at every connecting point.*

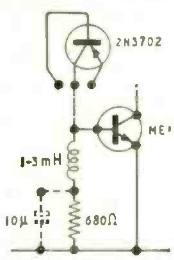



*Fig. 3. Adding a choke increases r.f. gain. By-passing the 680-ohm resistor to a.f. reduces noise.*

The layout problem is solved by working directly from a circuit diagram, drawn out large, so that the actual components can be laid over their symbols on the paper. Transistors are drawn both symbolically and physically, so that the connections are quite clear (Fig. 1). This circuit diagram is placed on the baseboard, and pins are knocked in at every junction point (Fig. 2). The lines and symbols then form a direct guide for wiring-up. Errors will be at a minimum, and are easily checked by inspection, and soldered joints can be inspected. Straight connections which do not cross other wires are first put in using bare wire, and soldered. Crossing-over wires are next put in, with insulated wire. The passive components come next, and finally the transistors. Variable capacitors, volume controls, and earphones are at first connected by long leads, then, when the equipment is working, they can be accommodated on a front panel.

Pinboard construction is very simple and adaptable. If for example, the leads of a resistor prove to be too short to span the gap between a pair of pins, it is a simple matter to drive in an extra pin and complete the connection with ordinary wire. Modifications are easily made, because the layout is necessarily open and accessible. Testing is likewise easy. Apart from its cheapness and simplicity, this method has the great advantage that the beginner is not tied to very elementary circuits. There is no reason, for example, why his first radio receiver should not be something more than a mere toy.

The accompanying diagrams show how the basic radio receiver of the pin-board (Fig. 1) can be gradually im-

*Amatronix Ltd.

proved. Adding a choke (Fig. 3) increases the r.f. gain substantially. It then becomes apparent that the signal-to-noise ratio is poor (because the wide-band r.f. amplifier generates a.f. noise). Adding an a.f. bypass capacitor across the resistive part of the load of 2N3702 takes care of this, but if its capacitance is too large, l.f. relaxation oscillations may occur, because of the phase shifts round the d.c. feedback path over the first three stages. The easiest way to add reaction (improving selectivity) is to connect a wire to the live side of the aerial tuned circuit, and place the other end somewhere near the collector load (680 Ω) of the second transistor 2N3702 (Fig. 1). The audio output can be progressively increased by means of the amplifier circuits of Figs. 4 and 5.

Although the pin-board method was devised for the beginner, it is also useful for experimental circuits, since it is very quick, and the chances of making a wiring error are small. Quite compact layouts are possible, and a number of circuit "cards" can be stacked in a complete equipment. The usual type of pin, known as a "standard short white," is one inch long, strong and easy to handle. The cut ends are rather sharp, however, and if this is considered a serious hazard it is better to use shorter pins and leave the heads on. The type known as "lills," which are half an inch long are suitable.

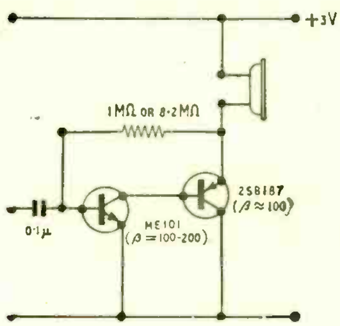



*Fig. 4. Simple two-stage class A amplifier. The current drain is 8-35 mA, depending on the speaker impedance. A power output of about 10 mW is delivered to a load of 20-40Ω and loads up to 200Ω may be used without change of component values. For higher loads, or headphones, the bias resistor is 8.2 MΩ, and the current taken is 1.5 mA.*

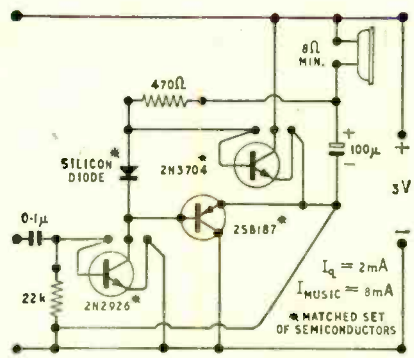
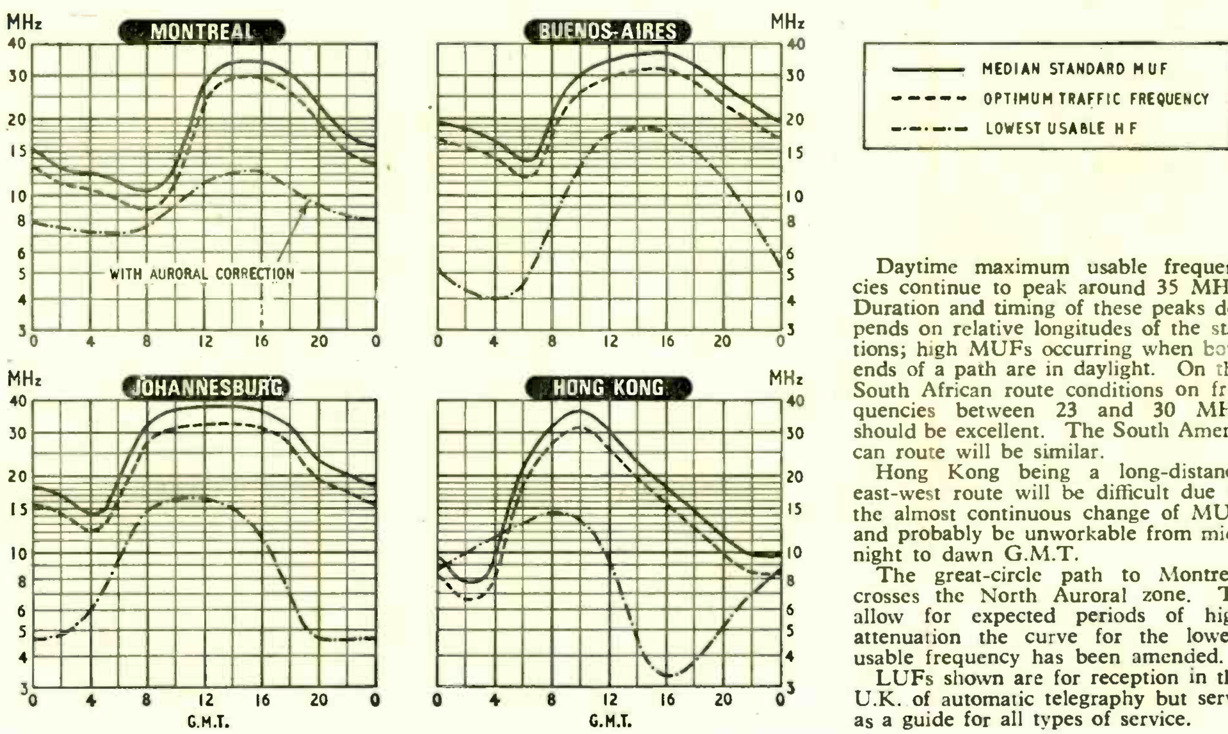



*Fig. 5. Complementary a.f. amplifier. With sine-wave drive this delivers 60 mW to an 8Ω load. Speakers of any higher impedance may be connected.*

## H. F. PREDICTIONS — FEBRUARY




Daytime maximum usable frequencies continue to peak around 35 MHz. Duration and timing of these peaks depends on relative longitudes of the stations; high MUFs occurring when both ends of a path are in daylight. On the South African route conditions on frequencies between 23 and 30 MHz should be excellent. The South American route will be similar.

Hong Kong being a long-distance east-west route will be difficult due to the almost continuous change of MUF and probably be unworkable from midnight to dawn G.M.T.

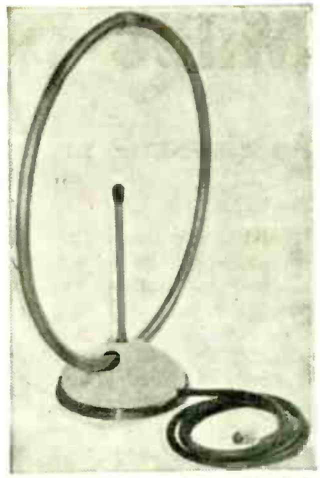
The great-circle path to Montreal crosses the North Auroral zone. To allow for expected periods of high attenuation the curve for the lowest usable frequency has been amended.

LUFs shown are for reception in the U.K. of automatic telegraphy but serve as a guide for all types of service.

# Ferrite Aerial Receivers

## Setting up known fields in a loop aerial for receiver alignment

By
R. S. ROBERTS*
M.I.E.R.E.



*The stub indicates the centre of the loop from which the receiver coil should be spaced axially 24 in.*

RECEIVERS designed for use with outdoor aerials are, of course, tested or aligned by injecting a modulated signal into the aerial terminal from a signal generator, and a suitable indicating device is used to measure the a.f. output.

However, receivers that use a built-in ferrite aerial pose two problems. How should the signal-generator voltage be injected, and how can the final sensitivity be assessed?

The first problem is usually overcome by using a little ingenuity in devising a loop of wire which, when connected to a signal-generator, can set up a field in the vicinity of the ferrite aerial. Such a field can be adjusted by varying the position of the loop with respect to the aerial rod, and alignment can be carried out quite satisfactorily using this method for injecting a test signal. But what of the final sensitivity? It is not possible to know whether the overall sensitivity of the aligned receiver is up to standard. The performance cannot be related in any way to the signal generator output setting.

Many transistor receivers that use a built-in ferrite aerial have provision for connecting an external aerial. It is a convenient way of using a portable receiver with, say, a car aerial. A signal generator test signal *can* be injected into the aerial socket of such a receiver, but the results will, generally, be meaningless in terms of receiver sensitivity. The coupling provided in the receiver between the ferrite tuned circuit and the aerial socket can be carried out in a number of possible ways, none of which provides a clear relationship between the signal generator output setting and the sensitivity of the receiver to a known field strength.

It is possible, however, to set up a known field by using a signal generator to drive a current round a suitable loop aerial. The resulting field in the vicinity of the loop can be determined, and the receiver aerial can be positioned in the field.

By passing a current through a loop, a magnetic field, $H$, is produced. This field can be related to an equivalent electric field component, $E$, by the relationship $E = ZH$, where $Z$ is the impedance of free space ($Z = 377\,\Omega$).

The magnitude of the field strength produced by a single-turn circular loop is given by

$$E = \frac{60\,\pi\,r_1^2\,I}{(d^2 + r_1^2 + r_2^2)^{3/2}}\sqrt{1 + \left(\frac{2\,\pi\,d}{\lambda}\right)^2} \quad \ldots \quad (1)\dagger$$

where

- $E$ = equivalent free-space field strength (V/m)
- $r_1$ = radius of tranmitting loop (m)
- $r_2$ = radius of receiving loop (m)
- $d$ = axial spacing between loops (m)
- $I$ = transmitting loop current (A)
- $\lambda$ = wavelength (m).

The magnitude of the field is substantially independent of frequency up to about 10 MHz if the spacing, $d$, is kept low. Useful fields can be generated up to about 30 MHz.

† National Bureau of Standards Circular 517, December 1951.

Examination of equation (1) suggests that a few simplifications and expedients can be adopted to assist in turning it into practical form:—

(a) Making the transmitting loop 10 in (0.254 m) dia.
(b) Determining $d$ as 24 in (0.6 m).
(c) Ignoring $r_2$. The radius of most receiver aerial coils using ferrite rod cores is, generally, about 0.5 cm.
(d) Ignoring the last part of the equation, under the root sign.

Re-writing equation (1) in these terms gives

$$E \approx 13.12\,I \quad \ldots \quad (2)$$

Using a three-turn loop, equation (2) becomes

$$E \approx 39.36\,I \quad \ldots \quad (3)$$

If this loop is driven from a signal generator, the current $I$ is conveniently determined by placing in series with the loop a resistance which is large in value compared with the loop reactance. This resistance value is particularly useful if it is about 390 ohms. If the loop is then driven by, say, 1 V from a low-impedance generator, the current through the loop is then $\approx 1/390$ A and, from equation (3), the field $E$ is 0.1 V/m. In other words, the generated field strength in V/m will be $-20$ dB on the signal-generator output voltage setting.

The loop requires screening in order to minimize "vertical effect" and is, preferably, driven from a balanced source. The device is easily constructed, and the photograph shows one version. The three turns of insulated wire are threaded into a loop which is made from 3/8 in diameter aluminium tube. The loop is split at the top by means of an insulating sleeve. and is secured in a suitable base that houses the 390-Ω series resistor and the end of the feeder cable.

The model shown is unbalanced, and the feed cable is a length of 75-Ω coaxial. The cable length is not very significant when the device is used in the m.f. and l.f. bands but, if it is to be used up to 30 MHz, the length should not be an appreciable fraction of a wavelength. Although the device is not a precision instrument the fields generated on the long- and medium-wave broadcast bands are surprisingly accurate, with increasing errors up to 30 MHz, where the error is about 2 dB.

The author thanks the directors of Antiference Ltd. for permission to publish this article.

* Northern Polytechnic, London.

# Miles-per-Gallon Meter

## An electronic motoring aid

By D. J. GROVER, B.Sc.

THE meter described here indicates continuously miles per gallon when installed in a car; it makes use of facilities already available to obtain the necessary information, namely, distance and fuel flow. The rate of petrol flow is measured by using pulses obtained from an electric petrol pump. Unfortunately the quantity obtained at each stroke varies with the rate of pumping due to inertia of the liquid, distortion of the diaphragm and valve leakage. However, over the practical operating range this variation is nearly linear with speed and may easily be compensated for electronically. A measure of distance is obtained from the odometer which contains a mechanism which reciprocates at the rate of one cycle per 32.5 yds. It is a simple matter to mount an insulated contact which is shorted for approximately half the cycle of this lever. It would have been preferable to have a contact which was shorted to ground for a very small time compared with the cycle time, but this was difficult to achieve in practice so as near a 50 : 50 ratio as possible was chosen.

The circuit generates a voltage which is proportional to the number of strokes of the petrol pump over the distance indicated by the odometer contactor. This voltage is stored and fed to a meter while the calculation for the next distance period is being carried out. The "working" stroke of the petrol pump generates a positive going 12 V pulse which is fed to a diode-transistor pump formed by $C_1$, $C_2$, Tr1, D2 via capacitor $C_1$ (Fig. 1). Capacitor $C_2$ therefore assumes a potential proportional to the number of pulses entering $C_1$ until it is reset to zero by switch P. Tr2 is an emitter-follower whose function is to buffer $C_2$ from the storage capacitors $C_3$ and $C_4$. Assume that Q is in the position shown and that X is open and Y closed. The meter, M, will now be deflected if there is any charge in capacitor $C_4$. $C_3$ will follow the potential on $C_2$ until a reset pulse is imminent. When this pulse arrives Q changes over and P momentarily shorts $C_2$ to earth. Y opens and X closes so that the voltage stored in $C_3$ now feeds the meter. $C_2$ again assumes a voltage proportional to the number of strokes of the petrol pump and Tr2 charges $C_4$ until a reset pulse is again imminent. When this occurs the

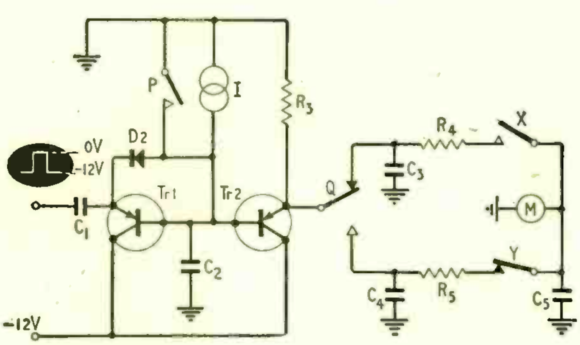



*Fig. 1 Illustrating the computing method employed.*

**D. J. Grover** graduated in physics and mathematics at University College, London, in 1953. After several years of circuit development work in this country he spent three years in the U.S.A. Returning to the U.K. in 1963 Mr. Grover joined Marconi Instruments and later went to Cossor Electronics as a senior systems engineer.

process repeats itself. It is evident that the meter deflection will be proportional to the number of strokes of the petrol pump between operations of the reset switch P. The current generator I compensates for leakage etc., in the petrol pump and capacitor $C_5$ smooths the drive to the meter.

Contact K of the petrol pump (Fig. 2) assumes earth potential during each activation stroke. A connection is easily made to this to provide the required 12 volt pulse. The quantity of petrol per stroke varies with the rate of pumping as shown in Fig. 3. At low pumping rates pump efficiency is poor due to leakage past the inlet valve. At higher rates of pumping the efficiency is increased due to the inertia of the liquid and the pump armature. The characteristic over the range of interest, between 0.4 sec./stroke and 4 sec./stroke, is sufficiently linear for a simple correction to be applied electronically. It is shown in the appendix that the characteristic of Fig. 4 is equivalent to a discharge of 3.23% per sec.

A four pole four way relay is controlled by the contact in the odometer so that it is energized and de-energized every 32.5 yds, with a ratio of approximately 50:50. The spacing of the contacts A-H is indicated diagrammatically in Fig. 4. The moving contacts B & C are connected together and adjusted to give a make before break action between A & D. A & D are therefore shorted momentarily each time the relay operates. F & G are connected together and adjusted to give a break before make changeover between E & H. The contacts were further adjusted so that the break of FG occurred before the make of BC in both directions. The effect is to short D momentarily to earth while FG is travelling between E & H.

### CIRCUIT DESCRIPTION

The circuit diagram is shown in Fig. 2. The 12 V pulses from the petrol pump enter via diode D1, this eliminates the negative spike occurring when the pump coil is open-circuited. $R_1$ discharges $C_1$ to −12 V after each pulse. $C_1$, $C_2$, Tr1, D2 form the diode-transistor pump, a silicon diode D3 providing some compensation for the emitter-base voltage drops of Tr2 and Tr3 or Tr4. The current generator for compensating for petrol pump leakage is provided by $R_2$. The switch J is the contact in the odometer; imagine that this contact is open (relay not energized) the contacts FG are switched on to E, and BC to A. $C_3$ assumes the voltage applied

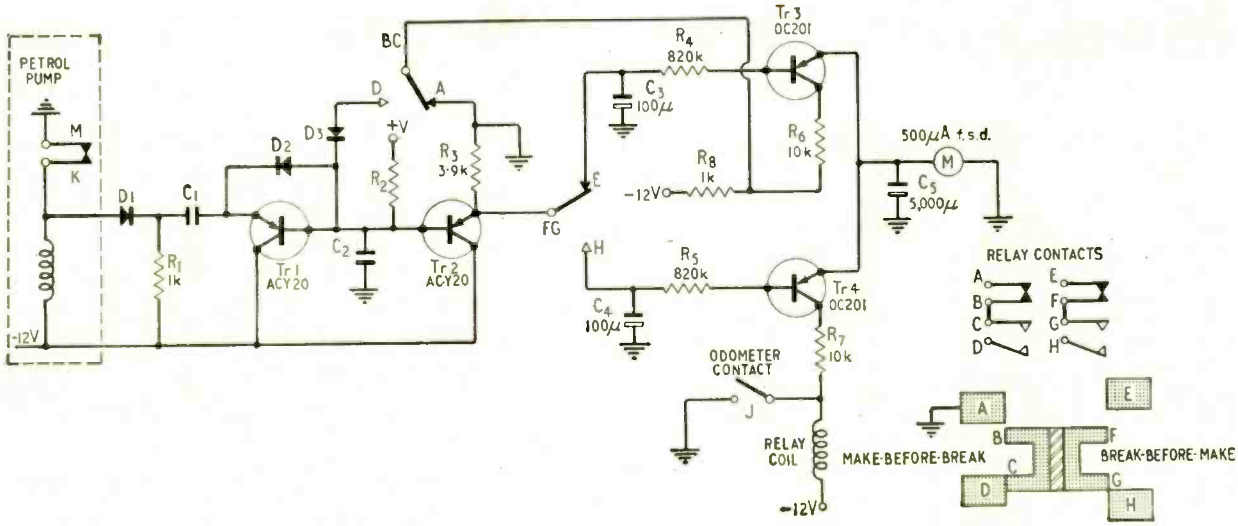



*Fig. 2. Circuit diagram and the method of adjusting the relay contacts.*

to $C_2$ via the emitter follower Tr2. The function of switch X (Fig. 1) is performed by grounding the collector of Tr3 via $R_4$; since BC is shorted to A which is at ground. Silicon transistors are used for Tr3 and Tr4 and since their emitters are limited to the order of 100 mV by the meter, the grounding of the collectors prohibits transistor action even in the inverted mode. The potential on $C_4$ feeds current to the base of Tr4 which amplifies it to drive the meter.

The closing switch J energizes the relay and BC switches to D and FG to H. D is grounded during this transition and discharges $C_2$ via D3 to ground. BC approaches −12 volts enabling Tr3 to amplify the current from $C_3$ and D3 is reverse biased. $C_4$ now assumes the charge across $C_2$ and Tr4 is immobilized by grounding its collector via $R_7$ to switch J. It is necessary that resistors $R_4$ and $R_5$ be sufficiently large to prevent appreciable discharge of $C_3$ and $C_4$ when feeding the meter. Tr3 and Tr4 must be matched, any slight variations in gain being compensated for by adjusting the value of $R_4$ and $R_5$. The resistors $R_6$ and $R_7$ protect the meter in the event of one of the transistors going short circuit and also safeguard Tr4 from the inductive voltage spike generated by the collapsing field across the relay coil when J opens.

### CALIBRATION

It is shown in the Appendix that the ratio of close/open periods of the relay has a secondary effect provided the periods are nearly equal. The ratio may be checked in a number of ways. A lamp or counter, switched by a relay contact, forming a suitable indicator, the number of counts being recorded over a known distance. Fig. 4 shows an alternative method for measuring the open/close distance ratio; it can also be used for measuring the relay shorting period. The capacitor $C$ is alternatively charged and discharged between earth and −12 volts. Provided the time constant associated with $R_2$ and the meter resistance is sufficiently large, compared with the relay period, then the voltage across capacitor $C$ remains essentially constant at $V$. Then:

$$\frac{T_{12}}{T_0} = \frac{V}{12-V} \qquad \left(\begin{array}{l} T_{12} \text{ is time A is at 12 V} \\ T_0 \text{ is time A is at 0 V} \end{array}\right)$$

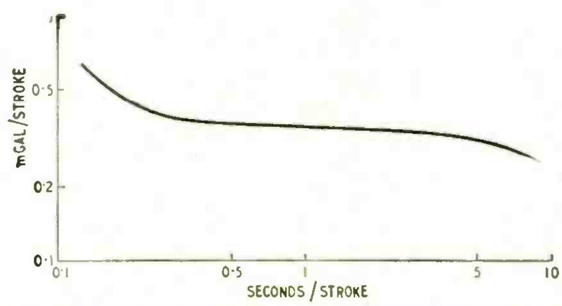
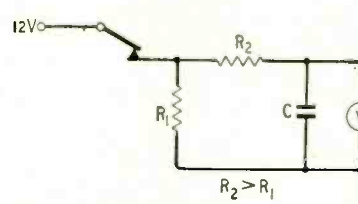



*Fig. 3. The characteristic of the petrol pump in the writer's car.*

*Fig. 4. The circuit employed for period ratio measurement.*




The close/open distances in the author's case were 11.5 millimiles and 7.3 mmls giving a ratio of 1.55:1.

The meter is calibrated by simulating normal operating conditions. The pulses from the pump are simulated by grounding the input diode D1 with a switch or bell-push (S1). The car is moved until contact J is open and a second switch (S2) wired in parallel. The quantity of petrol corresponding to a pulse at D1 is known and the average distance travelled, for J to be switched, is also known. Hence by switching S1 $n$ times for every throw of S2 (at a rate which is within the normal operating range) until the meter reading is steady, the deflection for a known rate of consumption is obtained. The deflection for an integral number of m.p.g. is readily interpolated if a scale is retained on the meter for this purpose.

As explained in the appendix a correction is necessary if the relay does not operate on a 50:50 duty ratio. For the ratio quoted (1.55:1) the meter drive will be 5% higher when caused by the manual means described than when created by normal operating conditions.

The variation of battery voltage between charging and discharging is sufficient to give an unacceptable error. Accordingly the power supply to the circuit must either be stabilised with a zener diode or the calibration performed with the battery on charge.

The choice of the ratio of capacitors $C_1$ and $C_2$ is a compromise between generating a voltage step large enough to make semiconductor junction variations negligible and the probability of the voltage on $C_2$ approaching the supply voltage thereby saturating transistors Tr1 and Tr2. A ratio of 1:5 was chosen to give steps of approximately 2 V. Six pump strokes in a distance of 11.5 mmls at 10 m.p.h. corresponds to 5.4 m.p.g. The heaviest consumption occurs at lowest speeds during acceleration where the decay of the capacitor voltage permits seven steps without saturation. The maximum time between resets will depend on the lowest speed at which a measurement is desired. At 10 m.p.h. the time to cover 11.5 mmls is approximately 4 seconds. The potential on $C_2$ will vary by 5 % of 2 V in this time if the leakage current is 2.5 $\mu$A. Since this leakage may be compensated for in the value of $R_2$ (the system can be calibrated empirically) leakage can vary by this amount. The time constants $C_3$ $R_4$ and $C_4$ $R_5$ must also maintain the stored potential within acceptable limits. The decay will be less than 5 % in 4 seconds if the time constant exceeds 80 seconds. The value of $C_5$ will depend on the conditions of use and the response time required.

$R_3$ must discharge $C_3$ or $C_4$ during the shortest summing time. 7 mmls at 70 m.p.h. corresponds to 0.36 seconds. It is unlikely that consecutive sums will differ substantially, however, for a time constant of 0.39 sec., $C_3$ or $C_4$ will discharge to 40 % of the initial value in 0.36 sec. The base current of Tr2 if significant, will cause a variable discharge of $C_2$, however it may be used to supplement $IR_2$, particularly if $R_3$ is taken to + V.

## APPENDIX

Suppose the petrol pump to have a linear characteristic extending from a stroke of period 0 seconds to the range of interest. (In practice, only that portion of the characteristic which coincides with the actual pump characteristic between 0.4 seconds and 4 seconds will be used.)

Let $Q\gamma$ be the quantity of petrol pumped per stroke of period $\gamma$, then for a linear characteristic:

$$Q\gamma = Q_0(1 - k\gamma) \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

From Fig. 4. when $\gamma = 0.4$, $Q_{0\cdot 4} = 0.356$ mgals/stroke
when $\gamma = 4.0$, $Q_4 = 0.315$ mgals/stroke

$$\text{Then: } \frac{3.56}{3.15} \quad \frac{1 - 0.4k}{1 - 4.0k} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

$$k = 0.032$$

For each stroke of the petrol pump a pulse is applied to the diode transistor pump, which raises its potential by $V$ volts. The voltage $V_n$ after $n$ strokes is therefore $V_n = nv$.

The leakage of the petrol pump may be simulated, over the working range, by a current generator which discharges the storage capacitor $C_3$ at a constant rate. Let this rate be $K_v$ volts per second. If $C_3$ is partially discharged over the period $n\gamma$, then $V_n$ reduces to $V'_n$ where $V'_n = nV(1 - K\gamma)$.

In order for the quantity of petrol pumped at a rate $l/\gamma$ to be equivalent to the voltage of the diode pump: $V'_n = nQ\gamma$. i.e. $nQ_0(1 - k\gamma) = nv(1 - K\gamma)$ where $v \equiv Q_0$ and $K \equiv k$.

Let the minimum number of strokes that can occur in time $T$ be $n$, then the number of strokes in a period $T$ will vary between $n$ and $(n + 1)$ depending on the random timing of the pump strokes and the reset mechanism. Let us suppose that the reset occurs just before the $(n + 1)$th pulse, then $t = T - n\gamma$. Hence $n$ pulses will be counted if $T - n\gamma < t < \gamma$ i.e. over a variation of $t_1$ of $[(n + 1)\gamma - T] = \Delta t_1$. $(n + 1)$ pulses will be counted if $0 < t < T - n\gamma$.

i.e. over a variation of $t$ of $[T + n\gamma] = \Delta t_2$.

The probabilities will be proportional to these times since the events are random with respect to each other.

i.e. $P(n) \propto \Delta t_1$
$P(n + 1) \propto \Delta t_2$

where $P(n) + P(n + 1) = 1$

$$\therefore \frac{1 - P(n)}{P(n)} = \frac{\Delta t_2}{\Delta t_1} = \frac{T - n\gamma}{(n - 1)\gamma - T}$$

$$\text{whence } P(n) = \frac{(n + 1)\gamma - T}{\gamma}$$

$$P(n) + 1) = \frac{T - n\gamma}{\gamma}$$

The mean potential $\bar{V} = V_n P(n) + V_{(n+1)} P(n + 1)$

$$\therefore \bar{V} = \frac{nv[(n + 1)\gamma - T]}{\gamma} + \frac{(n + 1)v(T - n\gamma)}{\gamma} = \frac{Tv}{\gamma}$$

The mean potential, after discharge over the period $T$, will be $V' \dfrac{Tv}{\gamma} - TKv = \dfrac{v'T}{\gamma}$ where $v'$ $v(1 - K\gamma)$.

Suppose that alternate summing periods are of lengths $T_1$ and $T_2$, where $T_1 \approx T_2$.

Then $Q_1 = (v'T_1)/\gamma$ and $Q_2 = (v'T_2)/\gamma$

The quantity $Q$ over period $T_1 + T_2$ is

$$Q = Q_1 + Q_2 \frac{v'}{\gamma}(T_1 + T_2)$$

The nature of the relay reset and storage system makes it difficult to ensure that it alternates with a 1 : 1 duty cycle. Suppose that the cycle time is $T$, where $T_1 + T_2 = T$ and $T_1 = \alpha T$,
so that $T_2 = (1 - \alpha)T$,

then $V_1 = \dfrac{\alpha T v'}{\gamma}$ and $V_2 = \dfrac{(1 - \alpha)Tv'}{\gamma}$

The voltage $V_1$ accumulated over period $T_1$ is applied to the meter circuit for period $T_2$, and the converse applies for $V_2$. The charge received by the meter over the period $T$ is therefore proportional to

$$\frac{\alpha T v'}{\gamma}(1 - \alpha) + \frac{(1 - \alpha)Tv'\alpha}{\gamma}$$

i.e. meter charge over period $T = q_T = 2\alpha(1 - \alpha)v' \dfrac{T}{\gamma}$

The effect of a non 1 : 1 duty cycle for the relay is more apparent if we substitute $\epsilon = 0.5 - \alpha$
then $q_T = 2v'T(\frac{1}{4} - \epsilon^2) = v'T(0.5 - 2\epsilon^2)$.

In the system described $\alpha = 0.41$, $\therefore \epsilon^2 = 0.012$. The error which is readily compensated for reduces the meter reading by 4.8 % from that obtained with a 1 : 1 duty ratio. It is apparent that $\alpha$ need not be measured very accurately provided it is near to 0.5.

# Point-to-Point Review, 1967

By DAVID WILKINSON,* B.Sc., M.I.E.E.

DURING the year h.f. conditions continued to improve due largely to the increase in values of sunspot number and ionosphere index (IF2). The predicted value of the latter for December was 129, compared with 66 for the same month in 1966. The increase in solar activity, however, continued at a much slower rate than at the same phase of the previous sunspot cycle and there was little change in the monthly provisional number from and including September. Should the present trend continue, it would seem that the forecast of Professor Waldemeir, of Zurich, that the approaching maximum would be in the region of 100 may be fairly accurate.

The Greenwich provisional monthly mean sunspot number for the first eleven months of 1967 was 103.2 compared with 50.4 for the previous year. Forty-one sunspot groups of area equal to or greater than 500 millionths of the visible solar hemisphere were reported. Eight of these were of area of 1,000 millionths or greater, the largest (reaching 2,200 millionths — approximately 2,570 million square miles in area) did not produce any significant ionospheric disturbances during its passage across the sun's disc from July 21st to August 4th.

Considering that the predicted sunspot maximum is only a few months distant, 1967 was notable for the remarkable inactivity of the sunspot groups reported on the disc. Only 45 sudden ionosphere disturbances were reported up to mid-December (46 during 1966). Many were of a minor nature and had little effect on h.f. operation. Most of the activity occurred during February, March and May with 10, 9 and 12 fades respectively. From the end of May only 9 were reported.

So far, during the present cycle, reports of complete "blackouts" associated with intense solar flares have been conspicuous by their absence.

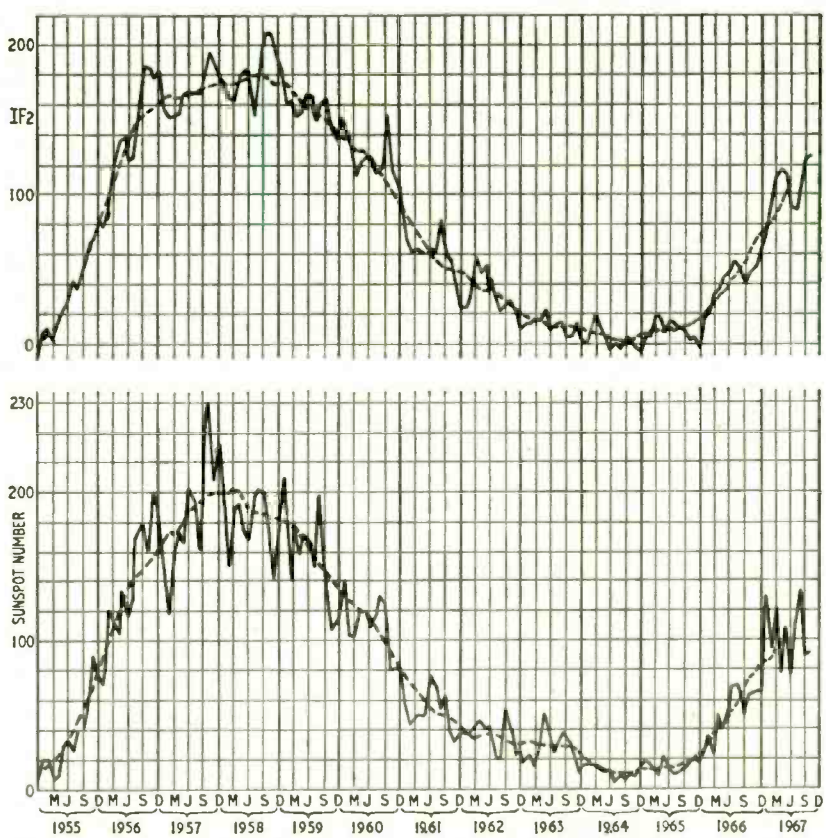
There was a slight increase in the level of magnetic activity during the year, the monthly mean Hartland "C" value† for 1967 being 0.62 compared with 0.57 for 1966. Apart from a severe magnetic storm from May 25th-31st, during which a "C" value of 2.4 was attained on the 26th, there were few disturbances of note. On a number of occasions increased magnetic activity occurred during periods when there were no groups of notifiable size (500 millionths or greater) on the sun and there was some evidence that the disturbances were of the M region (27-day recurrence) type.

By the choice of suitably lower operating frequencies at critical times the effect of the disturbances was generally masked and h.f. communication was seldom seriously affected.

The increase in sunspot activity and values of IF2 (shown by the smoothed values in the graphs) resulted in higher maximum usable frequencies (MUFs) and the influence of sporadic E on circuit operation was less marked. On many long-distance point-to-point circuits opportunity was taken to move up in frequency to the 23-25 MHz band for daylight operation. It was noted that, on many occasions, v.h.f. reception was possible over long distances.

Most h.f. circuits showed an increase in efficiency compared with 1966 and the monthly average percentage efficiency on four representative circuits using ARQ (automatic error detection and correction) and received in this country was 94% as against 92.9% for the previous year. These are equivalent to efficiencies of 99.3% and 99.1%, respectively, without the use of ARQ.

There was considerable activity in the higher frequency bands, especi-




*Monthly figures and smoothed values of the IF2 and of the sunspot numbers for the pas thirteen years.*

* Cable & Wireless Ltd.
† The mean of the "K" values recorded every three hours at Hartland, Devon.

ally in the field of satellite communications. As reported last year,‡ the first (F1) of the Intelsat II satellites suffered a failure of the apogee motor when launched in November 1966, and did not reach synchronous orbit. However, F2 and F3 were successfully launched in January and March 1967, and are now positioned respectively over the Pacific and Atlantic Oceans. In addition, because of the rapid growth of traffic, F4 in the Intelsat II series was also launched, in September, and is now in use in the Pacific Area. Intelsat I (Early Bird) continued to operate, having been in continuous use for 32 months by the end of the year.

The communication system in support of the NASA Apollo project was set up. This involves, in addition to the two stations on the U.S. mainland at Andover (Maine) and Brewster Flats (Washington), stations at Ascension Island, Canary Isles, Carnarvon (Western Australia) and two shipborne. Additional temporary stations were set up to provide public service channels between Thailand and the Philippines, and the U.S. mainland. Stations were completed at Fucino (Italy) and Buitrago (Spain), and the station at Moree (Australia) was almost finished. Stations in Argentina, Bahrain, Brazil, Chile, Hong Kong, Mexico, Peru, Philippines, Thailand, and at a number of other locations were under active discussion or being constructed. All these will employ 85-foot, or larger, paraboloids in order to meet the full requirements of the I.C.S.C. (Interim Communications Satellite Committee) for standard earth stations.

Work on the Intelstat III satellites continued. It is expected that the first of this new generation will be launched in the Summer or Autumn of 1968. These 1200-circuit satellites will considerably increase the capacity available in the Atlantic and Pacific Oceans and will also, for the first time, give Indian Ocean coverage, permitting U.K.-Australia and U.K.-Japan circuits to be set up. Also, a full-time television service should be possible without the need to cut off part of the telephone service, as is necessary at present.

‡ *Wireless World*, March 1966, p. 135.

# Literature Received

Racal RA 217 series solid-state h.f. **communications receivers** are described in a four-page brochure received from Group Publicity, Racal Electronics Ltd., "The Elms," 26 Broad Street, Wokingham, Berks.
WW 332 for further details

The performance characteristics and the applications of **dry reed switches** are discussed in a 41-page booklet issued by the Publicity Department, The M-O Valve Company Ltd., Brook Green Works, Hammersmith, London, W.6.
WW 333 for further details

The results of a two-year **reliability study** on Motorola plastic encapsulated transistors are contained in report No. RD 104 published by Motorola Semiconductor Products Inc., York House, Empire Way, Wembley, Middlesex.
WW 334 for further details

We have received a set of pamphlets from **Aero Electronics Ltd.**, Gatwick House, Horley, Surrey, that include details of a range of television signal generators, portable aerial masts for one- and two-man erection, quartz crystals, radiotelephones and educational equipment. Also included is a CV type valve equipment guide.
WW 335 for further details

**Lasky's Radio Ltd.**, who recently celebrated their 35th birthday, have sent us a copy of their 12-page colour pictorial catalogue. Their headquarters are at 3-15 Cavell Street, Tower Hamlets, London, E.1, and they have five branches in London.
WW 336 for further details

**Semiconductor Polarizing Filter for Infra-Red** is the title of a leaflet on Siemens semiconductor i.r. filters and polarizers available from Cole Electronics Ltd., 7-15 Lansdowne Road, Croydon, CR9 2HB.
WW 337 for further details

Facilities for all aspects of **printed circuit design and production** offered by S.C.E.E. Ltd., Reddicap Trading Estate, Sutton Coldfield, Warwicks, are described in the five-page leaflet PCB 10-1.
WW 338 for further details

A **multi-channel carrier frequency system**, that can be used with wire or foil strain gauges (half or full bridge connected), rotary transformers and transducers for the measurement of torque, load, displacement, vibration, acceleration, and pressure, is described in a leaflet from the Vibro-meter Corp., Haletop Civic Centre, Wythenshawe, Manchester 22.
WW 339 for further details

Received from the **British Industrial Measuring and Control Apparatus Manufacturers' Association** the 1967/69 edition of its handbook which describes the association, what it does, its members and their products. This 112-page publication will be sent free to branches and subsidiaries of industrial organizations at home and abroad, to Government departments, public authorities, public technical reference libraries and technical college libraries. The address is 23/24 Margaret Street, London, W.1.
WW 340 for further details

Aim Electronics Ltd., have just published their first short-form catalogue, **Advanced Instrumentation Modules.** Within its 20 pages, modular units available in each of three spheres of waveform technology are described. The same units may also be obtained either ready-assembled into complete systems or for assembly by the user. The three divisions in which systems are available are signal recovery and analysis, pulse generation and waveform sampling. The booklet ends with basic explanations of phaselock techniques, waveform sampling techniques and lock-in amplifiers. Copies are available from Aim Electronics Ltd., 71 Fitzroy Street, Cambridge.
WW 341 for further details

A new **comprehensive guide to five product** ranges of particular interest to industrial electronics engineers and designers has been published by Newmarket Transistors Ltd. The 20-page guide described as a "Products Portfolio" gives in tabular form details of semiconductors, including industrial germanium and silicon devices, packaged circuits and film attachment devices. A special section is devoted to the company's customer-oriented microcircuit building service. Free copies for buyers, engineers and designers can be obtained from the Sales Office Manager, Newmarket Transistors Ltd., Exning Road, Newmarket, Suffolk.
WW 342 for further details

**Electro-magnetic pick-ups** that convert mechanical motion into an a.c. voltage without physical contact or external power are described in the 6-page Bulletin F-8 available from Ampex Electronics, Seminole Division, P.O. Box 8488, Fort Lauderdale, Florida 33310.
WW 343 for further details

The latest position regarding the preparation of **metric standards** is given in the B.S.I. publication PD 6286, "Metric standards published and in progress." Section 1 lists more than 800 standards already written in metric units. Some 250 standards independent of any system of units such as glossaries and colour codes are listed in Section 2. Sections 3 & 4 give details, under industry headings, of the 500 or so standards now being revised or awaiting revision in metric terms. The information in this 82-page booklet is complete to 31st August, 1967. B.S.I. Sales Office, Newton House, 110 Pentonville Road, London, N.1. Price is 10s.

# NEWS FROM INDUSTRY

## ADVICE ON MATERIALS TECHNOLOGY

THE United Kingdom Atomic Energy Authority (U.K.A.E.A.) has set up a Materials Technology Bureau at the Atomic Energy Research Establishment at Harwell. The purpose of this bureau is to stimulate enquiries on materials from industry and research organizations and to share knowledge accumulated by scientific and technological staff in the Authority. It is also intended to provide an advice consultancy service and to encourage visits between Authority staff and industrial firms. This may lead to the use of Authority facilities on specific problems either by visiting technologists or U.K.A.E.A. staff. Information services of a general nature will be provided free although a charge will be made for consultancy work and for the use of experimental facilities. Most of the knowledge acquired by the U.K.A.E.A. during the course of their work, relates to materials—particularly conventional materials for unconventional use. The experience includes the use of modern techniques for the fabrication and preparation of metals and ceramics, including high-frequency and electron beam melting and casting, hydrostatic extrusion, planetary swaging, hot pressing, isostatic pressing (hot and cold) and vibro-compaction of powders. Other examples are the ultrasonic machining of glass and ceramics, together with the various jointing processes including electron beam and friction welding, roll-bonding and the brazing of metals to ceramics. Interested readers should contact the head of the Bureau, Mr. H. Lloyd, M.B.E., Ceramics Division, Building 35, A.E.R.E., Harwell.

## COMPUTERS–A NEW CONTENDER

INITIALLY producing a range of three medium sized computers for the European market Philips Computer Industries are to be officially opened on June 14th at Apeldoorn in the Netherlands. The first production models of these general purpose machines will be absorbed by Philips for their own use, however, deliveries to outside customers are expected to start in the beginning of 1969. At present the staff at Apeldoorn numbers a thousand although throughout the Philips concern about 6,000 people are either directly or indirectly employed on computers. Philips started research into computers in 1950, which led to the construction of a number of machines, some for use within the company. Among these were PETER, PASCAL and STEVIN. Later this research led to the production of machines for military applications, air traffic control, fire control and defence purposes.

In the Netherlands some 2,200 are employed on research whilst in other countries another 1,500 reinforce these activities. Work is proceeding on memories in the United Kingdom, peripheral equipment in Germany and multilayer circuit boards and software in Belgium.

The new range of machines will be called the P1000 series. They will use integrated circuits and will feature a fast memory. It will be a fairly simple matter to translate programmes written for other computers for use on these machines.

## CAR DRIVING SIMULATOR

A NEW car driving simulator, the Drivotrainer, has been developed by the Raytheon Company, Massachusetts, U.S.A., which is capable of training up to 32 students simultaneously. In essence, it consists of 32 "cars," a large cinema screen, a control computer and an instructor's monitoring console. The student "drives" in response to the changing road conditions indicated by a colour film projected on the screen (which includes the rear mirror view), the film having previously been taken through the windscreen of a camera-equipped car. The film carries a sound track and binary coded information indexing all the proper driving responses that match the actions seen on the screen. The computer scans each car and in the event of a student acting incorrectly, lights a message indicator informing the student of what he should do to correct his action. The cars can even run out of petrol and will stall if the student allows the petrol gauge to indicate zero. Another task of the computer is to keep a score for each student and to print out a detailed account of the student's actions compared to what they should have been. Advanced films prepare the student for handling emergency situations and enable them to drive in rain, snow, fog and ice in complete safety

*Drivers on the London Transport Victoria line and its Brixton extension will be able to communicate directly with other trains using a v.h.f. radio link. So far Nelson Tansley Ltd., 144 Holland Park Avenue, W.11, have received orders for about 170 communication systems as shown in the photograph. These, in addition to inter-train communications, offer passenger address and cab-to-cab intercom facilities.*

## ELECTRONIC CONTROL OF LOCOMOTIVES

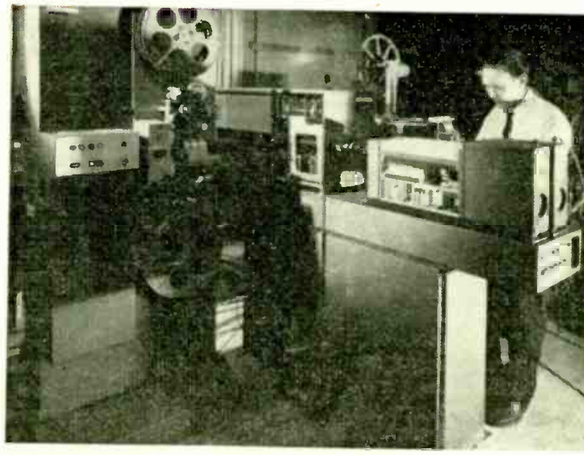
THE combined use of a radio link and digital control equipment has allowed freight trains to be operated more economically in America by enabling more trucks to be incorporated in a train. For instance, using the system, a typical train would consist of three 3,600 horse-power diesel units followed by as many as 300 trucks and three slave diesel units of similar horse power. The system, designated Locotrol, translates commands of an engineer in the lead locomotive and transmits them to the slave locomotives. Each message comprises 50 bits, transmitted over a 200 ms period, and includes address code, control information and an error check code. Each command contains an algebraic problem which must be solved for zero by the addressed locomotive before the order is accepted. If the result is something other than zero the slave requests that the message be repeated thereby ensuring the fidelity of the radio link. The equipment is manufactured by Radiation Inc.

An advanced **educational television studio** has been opened at Herriot-Watt University, Edinburgh, which it is hoped will substantially increase the effectiveness of teaching and strengthen the university's ties with industry. Although equipped with black-and-white cameras (Marconi V322Bs) and ancillary equipment at the present time, the design of the studio renders it suitable for colour television use. Equipment includes a telecine system that will accept 16 or 35 mm film or slides and seven cameras with seven-inch electronic monitor/viewfinders. The studio is linked with lecture theatres, laboratories and staff rooms throughout the university. The studio control room design is in agreement with the latest in broadcasting philosophy, consisting of an array of four 14-in monitors, a nine-inch preview monitor and a comprehensive vision and sound control console.

Land reclaimed from the river Itchen, Southampton will be the site of a **new colour television centre** to be built for Southern Independent Television at a cost of £500,000. The prime contractor is the Marconi Company who will provide a substantial proportion of the equipment and will assist Southern Television with the planning and installation. The equipment will include a comprehensive control switching system to allow television to be fed in and out of the I.T.A. broadcasting network. Some of the fifteen colour television cameras to be supplied are destined for outside broadcast units currently under construction. The cameras will be supplied complete with colour balance equipment correcting for variations in colour temperature. A large number of distribution amplifiers will be installed for routing signals to monitors throughout the centre. A Marconi designed switching system will carry signals from Video tape recorders and Rank Cintel telecine equipment to the studio control rooms for integration into the programme.

A new Product Division has been formed at Basildon, Essex, within the Marconi Company which is known as **the Electro-Optical Systems Division.** This new division will exploit the growing use of electro-optics to extend human capability. This can be achieved either directly by extending human operator faculties or indirectly by using the system to train him more effectively. The division has been formed by combining the activities of two groups, the Closed-Circuit Television Division and Project Martel—a team producing the television guidance system for the Anglo-French missile Martel. The two activities represent a turnover in excess of £3M.

**Johnson Matthey Metals Ltd.** have introduced a new line, gold inlaid beryllium-copper, that should be of interest to manufacturers of plug and socket components, particularly those for use with printed circuit boards. The minimum dimensions of the 5% nickel-gold inlay are 0·25 in wide by 0·0002 in thick; in all cases the thickness of the inlay must exceed 3% of the total thickness of the strip.



*A new telecine system announced by Marconi is capable of making fast (50 ns) cuts between any of four programme sources. Two versions are available, one for black-and-white reproduction only, using a Mk. VI camera, and one for colour or black-and-white built around the Mk. VII camera. Inputs can be from 35 mm or 16 mm cine projectors and/or a dual slide projector. A variable density filter in between the lamp-house and the film compensates for variations in film density whilst electronic circuits compensate for film dye imperfections. The system has been designed by Marconi with the exception of the film projection mechanisms which are of well-established professional manufacture. A sync. interlock drive motor is employed which allows precise registration of separate magnetic sound followers. The equipment is intended for use with a Westrex sound follower unit, but other units may be employed providing minor modifications are made.*

An **exhibition of small American computers** is to be held in various places throughout Britain early in the new year. The exhibition will open at the U.S. Trade Center and then go on tour in seven specially fitted British Rail display coaches. Places at which the exhibition will be held are:

London, U.S. Trade Centre, Jan. 16 to 19.
Birmingham, Moor St. Station, Jan. 25 to 27.
Manchester, Victoria Station, Jan. 29 to 31.
Newcastle, Central Station, Feb. 1 to 3.
Glasgow, Stobcross Freight Dept. Feb. 5 to 7.

In all, 16 exhibitors will show machines ranging from simple electronic calculators to complex process control computers.

**A Norwegian firm, Nera Bergen A/S,** has been awarded a contract by the Norwegian Director-General of Telecommunications worth 21.6M Norwegian Crowns (just over £1M) for microwave equipment to be used internally. The contract is for 1800 channel broadband equipment for the routes between Tromsø and Hammerfest; Stifjell and Rassegalvarre, Oslo and Bergen, in addition to equipment for 27 300-channel local branch links from the main network. The equipment has been developed by Nera Bergen and production has already begun. The expansion is the foundation for further work that will lead to a fully automated telephone network and it is hoped to link the more northerly districts of the country to the national telephone network in 1969.

The Central Treaty Organization have ordered seven **meteorological radar systems** from Plessey Radar which will be installed in Iran, Turkey and Pakistan early in 1968. The equipment, which is worth £131,000, consists of four windfinding radars type WF2 and three type 42 weather radars.

After winning a **colour television contract,** the Marconi Company succeeded in delivering, installing and commissioning the equipment in Bangkok within six weeks. The contract, worth £160,000, was to supply and install, in an outside broadcast van supplied by the Bangkok Broadcasting and Television Corporation, two Mk. VII colour cameras, monitors, sound and vision mixing equipment and a video tape recorder. Thailand commenced live colour televison broadcasts last November.

B. H. Morris & Co. (Radio) Ltd., of 84/88 Nelson Street, London, E.1, have been appointed sole U.K. distributors **for the Trio Corporation,** of Japan. The Trio product range consists of audio equipment and communications receivers. Featured in the range is a double conversion superhet crystal controlled communications receiver (Model JR500SE) that has a recommended retail price of about £60. It incorporates a crystal controlled b.f.o. and an S meter and covers 3.5 to 29.7 MHz.

An American manufacturer of precision components for the **focusing, deflection and control** of electron beams in cathode-ray tubes has appointed Walmore Electronics, 11-15 Betterton Street, Drury Lane, London, W.C.2 as their U.K. Agents. The firm, Constantine Engineering Laboratories, of New Jersey, produce a short form catalogue illustrating specialized applications that is available from Walmore.

The contract to provide the **solar cells for the ESRO satellites** TD1 and TD2 (see page 683) has been won by Ferranti Ltd. The satellites will carry a sun-oriented array of 11,520 silicon solar cells worth over £300,000. Ferranti solar cells are also being used on ESRO 2 and Ariel 3.

# DEMONSTRATING RECTIFIER ACTION IN SLOW MOTION

By T. PALMER,* B.A., Assoc.I.E.R.E.

VERY often it is useful to be able to clarify points of theory with a slow motion demonstration. The writer has previously described methods for demonstrating series circuits in phase-shift oscillators[1] and a.c. theory[2] in slow motion. This third article applies similar techniques to rectifier action, in particular illustrating one aspect that is difficult to show on an oscilloscope.

The demonstration comprises three separate stages. In stage one the output of a v.l.f. signal generator operating at about seven cycles per minute is applied to three meters: $A_1$ and $A_2$ swing in step with $V_1$. Adjust the output voltage of the signal generator to give a peak reading of, say, one volt on $V_1$. Then set $R_1$ to give a peak reading of 100 $\mu$A on $A_2$.

For stage two a diode is inserted (OA81) as shown. Now when meter $V_1$ gives a reading on the right of zero $A_1$ and $A_2$ follow, and when $V_1$ swings to the left $A_1$ and $A_2$ read zero. The peak forward current is now less than 100 $\mu$A because of the forward resistance of the diode; restore this current to 100$\mu$A by re-adjusting $R_1$—note the amount by which $R_1$ is reduced. This reduction corresponds to the forward resistance of the diode (although it would be truer to say that it represents the forward resistance when a forward current of 100 $\mu$A is flowing).

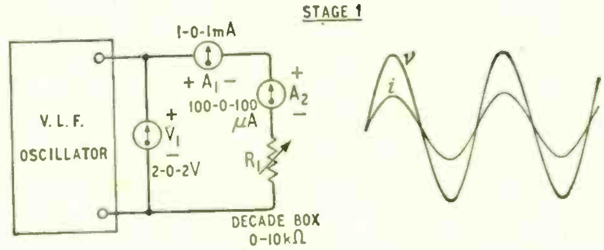
Proceeding to stage three, capacity $C_1$ is added. This was originally made up of 20 separate 100$\mu$F tantalum capacitors but ordinary low voltage electrolytics should do. Eventually the circuit will reach a state of equilibrium where in each cycle the charge flowing into D1 is equal to that flowing out of $C_1$ through $R_1$. When this happens it can be clearly seen that the diode passes current for only a small fraction of the positive half cycle as indicated by the brief pulse of current shown on $A_1$ when $V_1$ has almost reached its maximum positive value. This is about the same as the peak current on $A_3$ and is around half a milliamp.

After the pulse $C_1$ discharges through $R_1$ and the readings on $A_2$ and $A_3$ are equal (as $C_1$ is discharging $A_3$ reads to the left of zero). Until the equilibrium condition is reached more charge flows into $C_1$ through D1 than leaks out through $R_1$ in the intervals between pulses. The first pulses of current may have a peak value of 0.8mA. As $C_1$ becomes more and more charged in successive cycles this diode current diminishes until it reaches a value 0.5mA and the duration of the pulse decreases correspondingly.

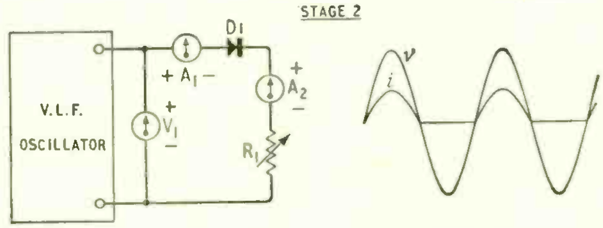
The peak value of the diode current should be the sum of the peak current on $A_3$ and the current through the resistor. If the meters $A_2$ and $A_3$ are heavily damped this may not be suggested by the meter readings; but the meters used originally did support the equation.

It is easy to extend this technique to other rectifier circuits—a bridge, for instance. It is recommended in this case to have a meter in series with each of the four diodes and one for the a.c. current and one for the d.c. current; six meters in all. It is a good idea for provision to be made for shorting out individual meters as the sight of six pointers swinging simultaneously at early stages in the demonstration can be confusing, to say the least.

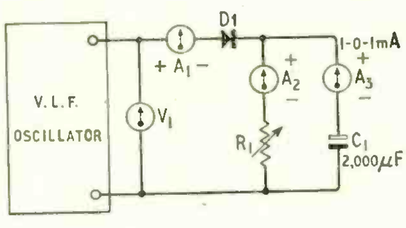
STAGE 1

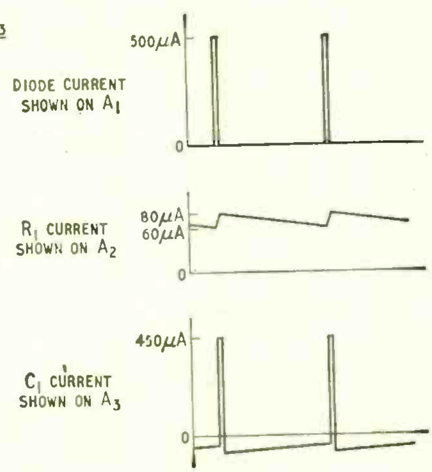



STAGE 2




STAGE 3



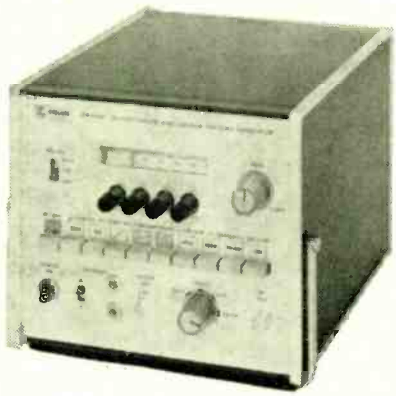

* Acton Technical College.
1. "Demonstrating a.c. theory," by T. Palmer. *Wireless World*, October 1963.
2. "Demonstrations at v.l.f.," by T Palmer. *Wireless World*, June 1966.

NEW

# PRODUCTS

## Colour TV Pattern Generator

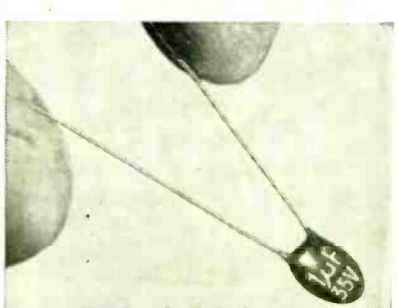
THE adjustment and servicing of colour television receivers is simplified by the Philips pattern generator, type PM5506. It will be available in Britain from the M.E.L. Equipment Company Ltd., and will cost £245. The instrument takes full advantage of the "self checking" properties of the PAL system which enable a receiver to be adjusted using the picture tube as the only indicator. This is said to almost eliminate the need for an oscilloscope, but if one is used it can be synchronised by line and field sync pulses from the generator. The generator delivers ten pattern signals which are selected by ten push-buttons arranged in logical sequence across the front panel as follows: (1) black and white checkerboard of $6 \times 8$ squares for checking tuning, scanning, amplitude and linearity, (2) blank raster with constant white content for purity check, (3) blank raster with constant red content for purity check, (4) eight-step staircase for grey-scale tracking, (5) dots, $11 \times 15$, for adjustment of static and dynamic convergence, on 625 lines only, (6) crosshatch, $11 \times 15$ lines, for adjustment of static and dynamic convergence, on 625 lines only, (7) four colour bars for delay line phase and amplitude adjustment, using tube as indicator, (8) four colour bars for demodulator phasing, using tube as indicator, (9) four colour bars for matrix check, using an oscilloscope, and (10) eight colour bars similar to the B.B.C. signal for general check. The standard is PAL 625 lines, and the range covered is 470 to 850 MHz, frequency being selected by push-buttons and continuous tuning. Outputs are 10 mV at u.h.f. (continuously variable) and 1 V at video, both into 75 ohms. Burst amplitude is variable for checking colour killer and a.g.c. The sound carrier can be modulated internally, unmodulated or switched off. Complete solid state construction has been used, and the generator measures $10\frac{3}{4} \times 8\frac{1}{4} \times 7\frac{1}{2}$in. The weight is 10lb. M.E.L. Equipment Co. Ltd., Manor Royal, Crawley, Sussex.



WW 301 for further details

## Solid Tantalum Capacitors

LOW COST, epoxy encapsulated, solid tantalum capacitors, designated Kemet "E" Series capacitors, are now available from Union Carbide U.K. Ltd., Electronics Division. "E" Series capacitors have been designed for commercial and high quality electronics applications, e.g., in communication equipment, where high capacitance values are required in small space, for coupling, decoupling and timing circuits. The devices have a high volumetric efficiency, low leakage current, and reverse voltage capability. The capacitance tolerance is $\pm 20\%$ and the capacitors are designed for continuous operation between $-55°$C and $+85°$C. Kemet "E" Series capacitors are available from 3 V to 35 V, at 0.1 to 100 $\mu$F. Electronics Division, Union Carbide U.K. Ltd., 8 Grafton St., London, W.1.



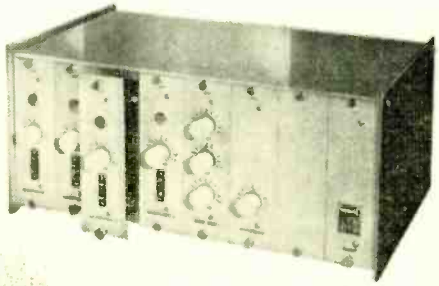
WW 302 for further details

## Tape Recorders

TWO tape recorders have been added to the Truvox range of sound recording and reproducing equipment. The new models, the R52 (two-track) and R54 (four-track), have an entirely new three-speed ($7\frac{1}{2}$, $3\frac{3}{4}$ and $1\frac{7}{8}$ in/sec) Truvox deck. Known as the Series 50 models, they incorporate many other significant departures from previous designs. The combination of twin acoustically matched $7 \times 4$-inch speakers mounted in a wood cabinet is said to result in exceptionally good sound quality. The case, controls and mechanism have been designed for both flat and vertical operation of the unit. The Series 50 recorders have linear frequency characteristics from 30 Hz to 17 kHz at $7\frac{1}{2}$ in/sec, with wow and flutter of less than 0·14%. Oscillator frequency is 90 kHz. With calibrated VU meter, tone control, full monitoring facilities, mixing and (on R54 only) dual play provision, the new units come within the definition of hi-fi equipment. Total output is 6 W. The three-figure digital counter has a push-button reset. Unbreakable control keys and key switches themselves are also of a new type, ensuring light yet positive action. Controls are interlocked and there is pause control, automatic tape-end stop, push-on spool retainers and an accessory storage compartment. Truvox decks have a large robust motor mounted below a solid aluminium deck plate with anodised lettering to identify controls. Micro-gap recording heads are used, and the solid-state electronics include selected matched silicon transistors. Low-noise, moulded-track potentiometers are also employed. Both models take 7-inch spools, giving $8\frac{1}{2}$ hours and 17 hours of play respectively on double-play tape. Both are supplied complete with a moving-coil microphone, one 7-inch reel and 1,200 ft of tape. They weigh 25 lb (11·5 kg) and measure $13\frac{1}{2} \times 15 \times 7$ in ($34 \times 38 \times 18$ cm). The price is 56 gns for both models. Truvox Ltd., Hythe, Southampton.

WW 303 for further details

# Modular Sound Systems



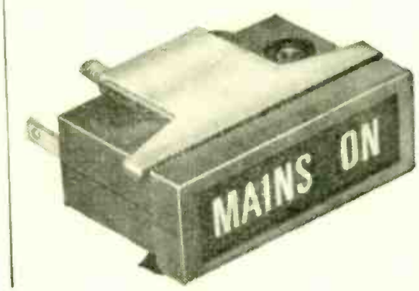
THE ASTRONIC A1700 Series of modular amplifying equipment has been designed to enable particular requirements to be met by building up a system using standard units, thereby keeping the cost of otherwise non-standard equipment down and reducing delivery delays. The 75 W power amplifier is intended for large p.a. installations, its output circuit incorporating current sensing diode networks which render it short-circuit proof. The amplifier can be racked up in multiples for parallel operation to give higher power outputs up to 750 W. Silicon transistors are used throughout all units and transformers are vacuum impregnated and dipped. Using either a 10 W, 25 W or 75 W power amplifier, up to seven input and control modules may be fitted to the main frame, any unwanted position being filled by a blank panel. Thus, a five-way microphone mixer with a music input and master gain control, or a two-way microphone with tape, gram and radio input modules together with master gain, can be constructed. A variety of standard modules are available. All input and control modules are constructed on etched aluminium front panels with suitably marked controls and components are marked on printed circuit boards. The pre-stages amplifier of both the 25 W and 75 W power amplifier are also on printed circuits boards, the main chassis being equipped with edge connectors into which these boards are plugged, alignment being ensured by guides. The modules are retained in the main frame by captive screws. Input, output and mains connection are situated at the rear of the case. The amplifier is constructed on a rigid sheet plated steel chassis and provided with adequately ventilated removable steel covers when used as a free standing amplifier. For rack mounting these covers become optional and the case end plates are changed to provide standard 19 in G.P.O. rack fixing. The inputs are: microphone, low impedance 15-50 Ω balanced with a sensitivity of 50 μV; tape, high impedance 270 Ω unbalanced, sensitivity 150 mV; gram, high impedance 2 MΩ unbalanced, sensitivity 120 mV; radio, high impedance 270 kΩ unbalanced, sensitivity 150 mV. The controls consist of microphone module: bass filter, gain control, tape, gram, radio modules: treble control ±15 dB at 10 kHz, bass control ±12 dB at 100 Hz, gain control. Distortion is less than 1% for full output on 10 W, 25 W and 75 W models. Response for microphone is ±2 dB 50 Hz—10 kHz and music ±2 dB 40 Hz—12 kHz. Noise on microphone is better than 50 dB and on music it is better than 60 dB. The dimensions are: standard free-standing unit 16½×7×10 in deep; rack mounting model 19×7×10 in deep. Associated Electronic Engineers Ltd., Dalston Gardens, Stanmore, Middlesex.

WW 304 for further details

# LEGEND INDICATOR

USING a bright-glow neon lamp, the miniature Bulgin mains legend indicator is operated directly from 200-250 V. The power consumption is approximately 1 W, with negligible temperature rise. Connections are by 110 Series push-on tags equally suitable for direct soldering. The two styles of legend available are black characters on lit amber background, or lit amber characters on a black background. This component will fit into a panel cut out to 1.32 in × 0.512 in. A. F. Bulgin & Co. Ltd., Bye-Pass Road, Barking, Essex.

WW 305 for further details




# Flat-Lens Photodevices

TWO MINIATURE silicon planar photodevices from SGS-Fairchild Ltd., the BPY66 and BPY67, are said to entirely eliminate cross-talk and cross-light problems in photoelectric reading systems for punched card and punched tape equipment. Contained in hermetically sealed cylindrical Kovar cases only 2 mm diameter by 4.5 mm long, they feature a coaxial flat-lens construction that enables them to be mounted absolutely flush in the reading head so that each device receives light only from its associated source. Mounting can be achieved without the need for critical alignment, thus simplifying manufacture and maintenance of the equipment. Both devices are manufactured from specially diffused silicon chips which, despite the unusually small device dimensions, have a very large base surface to trap the maximum number of photons. Their planar construction guarantees an inherently low dark current and a high light-to-dark current ratio, enabling them to be used at very low light levels. The BPY66 is a sensitive photo-transistor capable of providing a photocurrent of 0.3 mA minimum in a light level of only 10 mW/cm². As it operates efficiently with tungsten lighting, it can be employed in optically coupled circuits, coding equipment, character recognition and process control. The BPY67 is a photo-diode which, in the reverse-bias mode, features good photocurrent linearity. In the photo-voltaic mode, its open-circuit voltage varies in a logarithmic manner suitable for servo-type applications such as horizon detectors and proportional followers. A prime attribute of the BPY67 is speed; it is at least 10 times faster than a photo-transistor permitting detection of laser beam modulation up to several MHz.

WW 306 for further details

# Feed-through Terminal

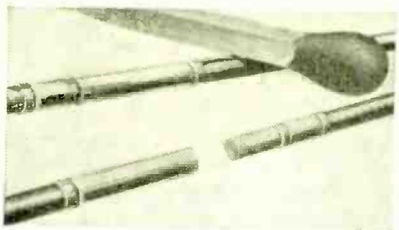
A MINIATURE feed-through terminal engineered for insertion into panels 0.320in thick is available from Sealectro. Designated press-fit part no. FT-160-TUR, the new feed-through has a 0.148in minor diameter measuring 0.500in long. When installed in a 0.125in or thicker panel, the insertion hole is 0.144in ± 0.002 diameter with a 60° countersink to a diameter of 0.174in + 0.010 − 0.002. It features a gold over copper-plated brass lug, rated for 5.5 A continuously. Sealectro Ltd., Walton Road, Farlington, Portsmouth.

WW 307 for further details

## Micro-miniature Coaxial Connector

SUITABLE for matched impedance coupling of 50 Ω lines, an r.f. micro-miniature coaxial connector by Thorn Special Products Ltd. has overall dimensions of 0.625 in length and 0.103 in diameter. Its low-loss characteristics result in a voltage standing-wave ratio of less than 1.16 at a frequency of 3.5 GHz. With simple push-pull coupling, the connector allows rapid assembly or servicing of miniaturised u.h.f. equipment. Contact resistance is less than 4 mΩ and the operating temperature range is −55°C to +200°C. Made of gold-plated copper alloy, with crimped connections, the connector is internally insulated with p.t.f.e. The disengaging force of a mated connector is in excess of 4.4 *N* (16 ozf), while cable retention in each half of the connector is greater than 44 N (10 lbf). The micro-miniature connector is supplied as a completed cable assembly, the pin and socket each being assembled with a 12-in length of 50 Ω Teflon jacketed coaxial cable (RG.178BU). Alternative lengths are available to order. Thorn Electrical Industries Ltd., Thorn House, Upper Saint Martin's Lane, London, W.C.2.

WW 308 for further details



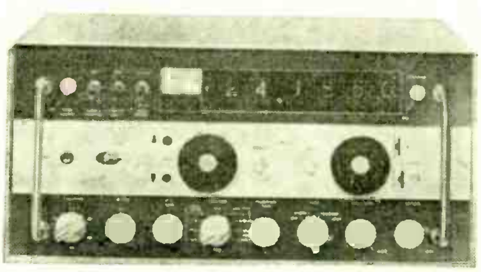
## I.C. Audio Amplifier

AUDIO amplifier type PA 222 is an encapsulated eight-lead dual-in-line integrated circuit by General Electric (U.S.A.). It is intended for consumer and light industrial applications with a 1-watt output rating. The supply voltage required is 25V, the power gain is said to be 72dB with a 22Ω load; with one watt output the noise figure is −55 dB. This unit has a frequency response of ±3 dB over the range 55 Hz to 15 kHz. Price is £1 16s 0d and data sheets are available. Jermyn Industries, Vestry Estate, Sevenoaks, Kent.

WW 309 for further details

## H.F. Communications Receiver

A NEW communications receiver (RC410/R) with a built-in frequency synthesizer has been introduced by G.E.C. (Electronics), replacing their BRT 400 range which ran to eight marks over the course of 20 years. The receiver covers 2-30 MHz and has facilities for s.s.b. reception (upper or lower sideband) as well as c.w., m.c.w. and d.s.b. The signal frequency is displayed digitally on a bank of in-line cold cathode tubes, the display being locked to the frequency synthesizer. Unusually the receiver is single-knob-tuned in 1 kHz or 100 Hz steps and has the "feel" of a conventional free-tuning receiver; frequency stability is quoted as being 5 Hz at 30 MHz. A f.e.t. is employed in the front end to provide a good cross- and inter-modulation performance. Crystal filters are incorporated for A1, A2 and A3 modulation and a sideband filter for A3a and A3j is included. Sensitivity for 12 dB (signal-noise)/noise at the output in the A2, A3 mode is 2.5 $\mu$V and in the A1, A3a, and A3j better than 0.5 $\mu$V. The audio stage provides 1 W into 3 Ω or 10 mW into a 600 Ω balanced load. Image response is greater than 60 dB below signal response and other spurious responses are at least 70 dB down on the signal. Second- and third-order intermodulation selectivity is better than 60 dB below signal response. A notch filter with a 6 dB bandwidth of 800 Hz tunable 4 kHz about a centre frequency of 100 kHz providing a rejection of at least 30 dB is incorporated. A three-position switch selects a.g.c. attack times of 10, 20 or 30 ms and a.g.c. performance is such that the audio output level will not vary more than 6 dB for an input level variation of 90 dB referred to 1 $\mu$V. G.E.C. (Electronics) Ltd., Communications Division, Spon Street, Coventry CV1 3AZ.

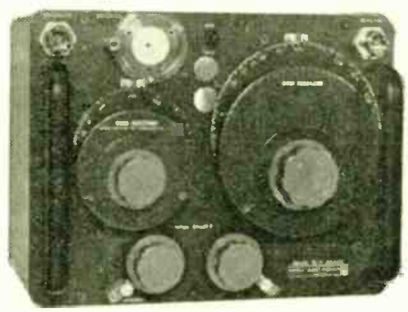


WW 310 for further details

## R.F. Bridge

AN IMPEDANCE bridge for accurate measurements in the 400 kHz to 60 MHz range is now available from General Radio Co. (U.K.) Ltd. The 1606-B radio frequency bridge is adaptable to coaxial connectors, and in particular the GR900 precision coaxial connector, for convenience in making highly repeatable measurements on devices fitted with such connectors. The GR900 coaxial connection also simplifies calibration of the bridge with precision resistance and capacitance standards. The screw-type terminals on the basic instrument can be adapted to GR900 coaxial connectors with the 1606-P2 adaptor kit, and to other coaxial systems with appropriate adaptors. The resistance range of the bridge is 0 to 1 kΩ, and the reactance range is ±5 kΩ at 1 MHz (at other frequencies the reactance reading must be divided by the frequency in megahertz). General Radio Company (U.K.) Ltd., Bourne End, Buckinghamshire.

WW 311 for further details



## High Current Vacuum Variable Capacitor

A NEW high-current small-size ceramic vacuum variable capacitor, the CAQA-200, by ITT Jennings is available from S.T.C. This new variable capacitor utilizes high efficiency ceramic and copper materials with vacuum dielectric. The overall length is only 3.75in with a diameter of 1.31 in. The CAQA-200 is capable of handling 50 A r.m.s. at 16 MHz. The temperature rating is 120°C by actual current testing. Capacitance range is 10 to 200 pF. Peak voltage is 3 kV at 60 Hz. Design of compact transmitter tank circuits is possible with the CAQA-200. Typical uses are as tank capacitors on medium power fixed frequency and pre-selected frequency transmitters. STC Components Marketing Division, Edinburgh Way, Harlow, Essex.

WW 312 for further details

## INSTRUMENT RECORDER

A 7-CHANNEL instrumentation tape recorder-reproducer, weight 30 lb, and small enough to be stowed under an aeroplane seat, is now being marketed in the U.K. by Consolidated Electrodynamics. The Model 417 recorder can, in laboratory applications, be operated from 110/220 V a.c. In the field it runs off its own built-in, rechargeable batteries. It is equipped with a low mass differential capstan drive which is said to ensure good performance under difficult operating conditions. Other features include dynamic braking, low power consumption (maximum 12 W), and a switchable reproduce channel for field monitoring of all record channels. Frequency response of the model 417 is 200 Hz to 100 kHz direct and d.c. to 10 kHz f.m. The ½-in head arrangement is IRIG (Inter Range Instrumentation Group, U.S.A.) compatible. A choice of four new speed combinations is offered within the range 1⅞ in/s to 30 in/s. Optional facilities include remote control, voice track, continuous-loop adapter, end of tape sensor, and footage counter. Size of the Model 417 is only 14 in wide × 15$\frac{3}{16}$ in deep × 6$\frac{3}{4}$ in high. Consolidated Electrodynamics, 14 Commercial Road, Woking, Surrey.

WW 313 for further details

## Resistance Boxes

RESISTANCE box Series 1200 by D.S. Controls gives a selection of 72 values of resistance from 1 Ω to 8.2 MΩ in a 10% tolerance preferred value range with two selector knobs. The ranges are ×10; ×100; ×1k; ×10k ×100k; ×1M, and resistance types are high stability carbon film. Ratings available are 1200, 0.5 W; and 1201, 0.25 W to 4.7 MΩ and 0.5 W from 5.6 MΩ up. The size is 8×5×5 in and the weight is 3½ lb. Prices are 1200, £15 10s 0d, and 1201, £19 10s 0d. D. S. Controls, 24 Broughton Road, Orpington, Kent.

WW 314 for further details

# DC Servomotors

DIRECT current servomotors capable of reaching 1200 r.p.m. from zero in one millisecond are available from Honeywell. First model in the series, the HSM 30 servomotor, has very low armature inertia (0.00035 N cm s$^2$), extremely rapid acceleration characteristics, (278,000 rad/s$^2$ initially at 24 V), a mechanical time constant (inertial) of 2.4 ms and a rated torque of 21 N cm (30 ozf in). Design of the servomotor represents a complete break from conventional motor design geometry in that all the rotating iron has been removed, leaving a moving coil, shell-type rotor configuration. Coils are encapsulated in a hollow, cylindrical shell of special high-temperature material, and a four-pole permanent magnet circuit is employed, using extremely high flux densities. In use the HSM 30 will start or stop in less than half the time of other motors of comparable frame size (4.0 in dia × 3.6 in long). It can be directly coupled to the load for inertia match, so that gearing and belts can be eliminated, and can replace motor-brake or motor-clutch combinations, with the added advantage, in many cases, of solid state control. The new servomotor is suitable for use with tape capstan drives, intermittent motions, machine tool drives, drafting machines, digital and analogue positioning, computer printers, readers, memory disc packs, etc. Honeywell Controls, Ltd., Brentford, Middx.

WW 315 for further details

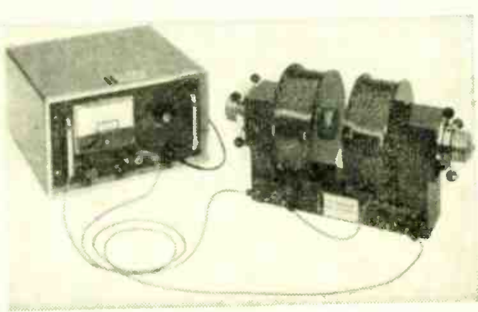
## RESONANT GATE TRANSISTOR

A NEW solid-state device called a resonant gate transistor (r.g.t.) is now available in evaluation quantities from Westinghouse Electric Corporation. The r.g.t. is a frequency selective device capable of providing Qs from 20 to 200, and its availability offers a solution to the problem of building tuned circuits without inductors. The operation of the r.g.t. results from a mechanical resonating beam or "tuning fork" of minute proportions actuated by electrostatic forces. A signal voltage, when superimposed upon a larger constant polarization voltage, sets the resonating beam in motion. Vibration of the beam is sensed by a conventional m.o.s. field effect transistor for which the beam serves as the gate electrode. The frequency range of the r.g.t. is at present limited to about 3 kHz - 30 kHz but higher frequencies can be obtained by using an overtone mode of vibration. Westinghouse Electric International, 1-3 Lr. Regent St., London, S.W.1.

WW 316 for further details

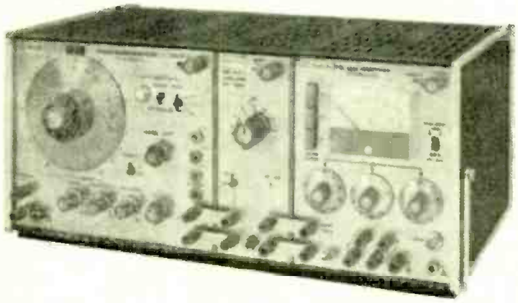
# Biaxial Field Electromagnet

THE SCIENTIFICA 2 inch electromagnet has features that make it suitable for both research and advanced teaching. Either standard plane pole caps or ones with an axial bore hole through them can be used. The magnet is therefore supplied with two sets of pole caps, one being plane with optically polished faces, while the other pair are similar, but have in addition an axial hole of 1 in diameter. This enables additional experimental investigations to be carried out. In order to ensure maximum field homogeneity for all field settings, the pole ferrous caps are precision machined and the pole faces are ground and polished to a flatness of 0.001 inch. A typical value for field homogeneity with an air gap of $\frac{1}{4}$ in and field strength of 2.4 × 10$^5$ A/m (3,000 gauss) is 1 part in 10$^6$ over a volume of 0.1 ml. The magnet is therefore suitable for use in a low resolution nuclear magnetic resonance spectrometer or an X-band electron spin resonance spectrometer. An all solid-state power supply has been designed for the 2 inch magnet, the control circuitry of which takes the form of an error actuated loop system. Feedback in this circuit compensates for variations in both load resistance and supply voltage such that a 100% change in load will result in only a small percentage change in magnet current. Scientifica & Cook Electronics Ltd., 148, St. Dunstan's Avenue, Acton, London, W.3.



WW 317 for further details

## Low Frequency Measuring System

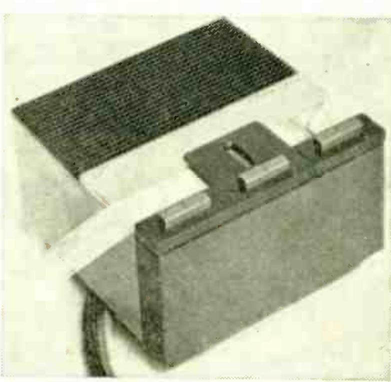


THE PHILIPS low frequency measurement system consists of a compatible family of solid state generators, amplifiers, attenuators and other equipment designed to meet new needs of measurement. The first six instruments in the range are now in quantity production and a further six are already planned and in the design stage. Others are envisaged for the future. Each instrument is self-contained and can be used singly or in combination with others in the system. Complete test sets can be assembled in minutes for special purposes and dismantled when no longer required and the individual units put to other work. A valuable feature of the system is the extension of the frequency range at both ends of the spectrum well beyond the ordinary concept of low frequency, the new frequency range extending from 0.0005 Hz to 1 MHz. This considerably increases possible applications and widens the appeal of the equipment. Typical applications include frequency amplitude response, gain measurement, gain response, gain response of attenuators and filters, two-tone tests, transmission tests, servo and process control measurement, medical electronics and education. Instruments now available include Type PM 5160 wide-band oscillator covering the range 1 Hz to 1 MHz. Features include capacitance tuning giving high resolution and a buffer amplifier to isolate the oscillator from the load. Type PM 5168 function generator is a function generator with some unique features. Simultaneous outputs give sine, triangular and square waveform signals at a fixed amplitude. One of these waveforms is also available simultaneously from a fourth output but with adjustable amplitude and d.c. shift. A "hold" facility enables all waveforms to be held static at will. A mark/space ratio switch effectively provides ramp facilities. Single shot and external trigger facilities add to the versatility of the instrument. Frequency coverage is from 0.0005 Hz to 5 Hz. Like the PM 5168 function generator, this instrument also has sine, triangular and square wave outputs but the PM 5162 has an internal oscillator which can be switched on to three different sweeping ratios. Both the sweep frequency and sweep width are adjustable up to a maximum of 1:10,000. Additional features are single cycle sweep, external frequency modulation, and a frequency analogue output. The latter facility provides an output voltage proportional to the logarithm of the frequency. M.E.L. Equipment Co. Ltd., Manor Royal, Crawley, Sussex.

WW 318 for further details

## Paper Tape Reader

PAPER tape reader GNT 24, made in Denmark, is a motor-driven reader that can accept 5, 6, 7 or 8 channel tape or edge punched cards. Tape/card transportation is accomplished with a feed rake rather than the conventional sprocket wheel, and the equipment will read at up to 50 characters/sec step-by-step or 70 characters/sec continuous running. Sensing is mechanical and the motion of sensing pins is transferred to set reed switches in a contact unit. The switches remain set until the next reading action takes place. The dimensions of the reader are $6\frac{1}{2}$in × $6\frac{1}{2}$in × $3\frac{1}{2}$in and it is normally supplied as a free standing unit. A panel mounting version and spooling facilities will be available soon. Great Northern Telegraph Works, 5 St. Helen's Place, London, E.C.3.



WW 319 for further details

## THYRISTOR-DIODE KIT

A THYRISTOR-diode kit has been introduced by International Rectifier, Hurst Green, Oxted, Surrey. The new kit is complementary to the IR zener "40 Plus" Semiconductor Kit which was designed for the circuit designer, development engineer and laboratory technician. The new kit provides all the semiconductor components required to set up single-phase and three-phase circuits for use in such applications as motor speed control, solid state switching, voltage control, temperature control, controlled battery chargers, light dimmers and flashers. The kit costs £12 and includes a design handbook, a thyristor slide-rule calculator, a selection of useful circuits, 15 thyristors and diodes with p.i.v. ratings from 50 V to 800 V and current ratings of 600 mA to 8 A, and a 2N2160 unijunction transistor. International Rectifier, Hurst Green, Oxted, Surrey.

WW 320 for further details

## Optical Increment Encoder

OPTICAL increment encoders by Moore Reed Ltd., are housed in a 3.062in diameter frame. The electrical output consists of 1,000 on-off square waves for one shaft revolution. A second output, of the same resolution but displaced relative to the first by a quarter cycle, provides means of direction sensing. Complement signals of both outputs are also provided to facilitate doubling the number of cycles by means of an EXCLUSIVE OR gate. Thus 4,000 "edges" per shaft revolution can be realised. A fast rise time of under 2 $\mu$s can be obtained and thus the square wave can be maintained from effectively zero (shaft speed) up to 6,000 r.p.m. (100 kHz) with little change in mark/space ratio. A marker pulse occurring once per shaft revolution is also provided. Two additional outputs give "lamp healthy" or "lamp failed" signals. Long lamp life is achieved by a factory soak test to eliminate early mortalities, and under-running the lamp by 20% to 30% of its capacity. An additional feature is an easily interchangeable lamp and lens assembly. The amplification, squaring and buffer circuits are self-contained. Accurate control of shaft and spigot dimensions, shaft run-out and squareness, enables the encoder to be used where high precision is needed in the relationship between pulse output and shaft rotation. Moore Reed & Co. Ltd., Walworth, Andover, Hants.

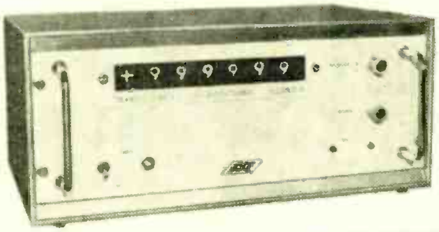
WW 321 for further details

# DOUBLE BALANCED MIXERS

BROADBAND double-balanced mixers from Hewlett-Packard are housed in a compact package (1·63×0·70×0·43 in) for mounting directly on printed circuit boards or in strip-line circuits. The 10514B, retains the characteristics of the 10514A but is in a more compact package, and is offered at a lower price. The frequency range of the 10514B is 0·2 to 5000 MHz at the local oscillator and signal ports; the third port is d.c. coupled. The frequency range of the 10534A, with BNC connectors, and the companion printed-circuit mounting Model 10534B, is 50 kHz to 150 MHz. As suppressed carrier modulators deriving sum and difference products of two input frequencies, the double-balanced mixers serve either as up-converters or down-converters with appropriate band filtering at the output. D.C. coupling at the X port enables them to serve also as phase detectors. Conversely, the X-port can be used as the input for a signal that modulates a signal applied to either of the other ports. These broadband, untuned mixers are thus useful as pulse modulators, capable of high carrier suppression between pulses, as current-controlled attenuators, as a.m. modulators, and also as spectrum or comb generators. Of particular importance, the i.f. noise specified for all the H P mixers is claimed to be very low (less than 0·1 $\mu$V per root cycle at an output frequency of 10 Hz). Mixer conversion loss (single sideband) of the 0·2–500 MHz Model 10514B is less than 9 dB over the full input frequency range, and less than 7 dB, typically 6 dB, in a frequency range of 0·5 to 50 MHz. Mixer conversion loss of the 0·05–150 MHz Models 10534A and 10534B is less than 6·5 dB, between 0·2 and 35 MHz, and less than 8 dB throughout the rest of the range. Other performance data and comprehensive specifications for these mixers are given over a wide environmental range. By the use of hot-carrier diodes in the diode-bridge modulator circuit, these double-balanced mixers have high carrier suppression. Intermodulation products are also exceptionally low. All of the double-balanced mixers are designed for and specified in 50 Ω systems. Prices of the double-balanced mixer family for single unit purchases are Model 10514B 0·2 to 500 MHz PC mixer £57; Model 10514A 0·2 to 500 MHz BNC mixer £69; Model 10534B 50 kHz to 150 MHz PC mixer £23; and Model 10534A 50 kHz to 150 MHz BNC mixer £29: Hewlett Packard Ltd., 224 Bath Road, Slough, Bucks.

WW 322 for further details

# Bi-directional Counter



A BI-DIRECTIONAL solid-state pulse counter (by A & R Design Ltd.) has a six-digit wide-angle view neon indicator display and direction sign, and is available either enclosed (as illustrated in photograph) or in open form for standard 19in rack mounting. Designed primarily for use with optical gratings using the moiré fringe effect for either linear or radial position indication, these counters can be driven by other transducers or signals. Driven by an optical grating transducer of sufficient accuracy, the counter can read position to within 1 $\mu$m (0.00004in) linear or within 30sec of arc radially. Alternatively, the counter can be driven by any sine or square wave or pulse input at speeds up to 100 kHz, and because of its bi-directional nature if 2 inputs are employed that are 90° out of phase the direction of the count can be reversed by changing the phasing of the inputs, giving true bi-directional counting. The standard counter is fitted with a sign change at zero and the direction of the count is also reversed at zero, giving a true zero with upward count in either direction with sign change clearly indicating direction of count. The counter can be supplied with transducers and can also be supplied with predetermining counters, for sequence operations; with print-out units recording individual and total counts, for measuring, inspection or statistical analysis; and with automatic zeroing and remote control and print-out facilities. Power supply 200/250 V 50Hz, 110V, 60Hz, or 24V d.c. to special order. A & R Designs Ltd., 1 Vineyards, Bath, Somerset.

WW 323 for further details

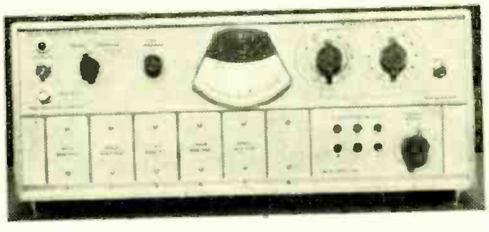
# Driver Transistor

A SILICON planar transistor, type BSW70, by Mullard, is primarily intended for driving cold-cathode numerical indicator tubes. It has a $V_{CEO}$ of 60 V and therefore adequately meets the "off" requirements of the number tube's cathodes—an essential condition for good visual performance. The BSW70 will become part of the company's "Practical Planar" range. Brief data is as follows:— $V_{CBO}$max. 100 V, $V_{CEX}$ (at $I_B$ 10$\mu$A, 25°C) 75 V, $V_{CE}$sat. (at $I_C$ 2mA) 0.5 V, $h_{FE}$ (at $I_C$ 2mA, $V_{CE}$ 5 V) 50 min. $P_{tot}$ continuous is 250 mW. Encapsulation TO-18. Mullard Ltd., Mullard House, Torrington Place, London, W.C.1.

WW 324 for further details

# White Noise Test Set

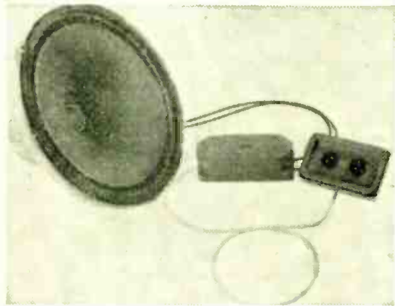
THE Marconi Instruments white noise test set is an equipment used in the measurement of noise interference in wideband telecommunications systems. The test set comprises a noise generator, with bandwidth extending from below 12 kHz to above 12·388 MHz, and the noise receiver. The latter, connected to the receiving end of the link system, is switch-tuned to the centre frequency of a quiet test channel, and the noise breakthrough into the quiet channel is measured in terms of relative or absolute power. It is fitted with an internal standardising noise source, so that its sensitivity can be set up independently from the noise generator This feature is necessary when the receiver is to be used for out-of-band testing, utilizing the traffic as the noise source. A pW scale has been added to the attenuator calibration to facilitate measurement in terms of absolute power per unit bandwith. Provision is made for adjusting the sensitivity on each reception channel independently, so that the sensitivity of the receiver can be equalised over its working range.



The price of the TF 2092A noise receiver is £415. The price of the OA 2090A white noise test set comprising the noise generator and receiver is £787. Marconi Instruments Ltd., St. Albans, Hertfordshire, England.

WW 325 for further details

# Adjustable Loudspeaker

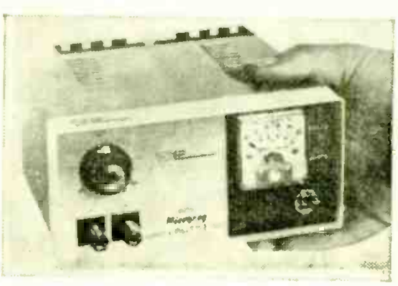


TO enable adjustments to be made for specific acoustic conditions desirable in recording, broadcasting and television studios, the Tannoy Monitor Gold speaker has a panel accommodating the treble roll-off and treble energy controls. The roll-off control permits extreme treble response to be attenuated while the energy control reduces the treble response from the cross-over point upwards. Of interest to general users is that the impedance of 8 Ω now available in this type of speaker (dual concentric) is held to within close limits making this unit particularly suitable for use with solid-state amplifiers. The mass of the l.f. diaphragm assembly has been increased in order that the bass response will be better maintained in smaller enclosures. The 15 in unit h.f. diaphragm has been modified to use a lighter voice coil yielding an improvement in high frequency response. The crossover has been modified on the three units in this range, the "15," "12" and "IIILZ," resulting in reduced intermodulation and smoother response. The frequency response, power handling capacity and cross-over frequencies for the "15," "12" and "IIILZ" are respectively, 23 Hz to 20 kHz; 25 Hz to 20 kHz; 27 Hz to 20 kHz; 50 W, 30 W, 15 W; 1 kHz; 1 kHz; 1.2 kHz. Tannoy Products Ltd., West Norwood, London, S.E.27.

WW 326 for further details

# Variable Power Supply

VARIABLE power supply Type 300 incorporates regulation and control circuits. The unit has been evolved to cater for educational, laboratory, test, circuit development, production and component evaluation applications. Voltage and current output monitoring is effected by a 2% dual scale (volt/ammeter) with a clearly calibrated continuously variable voltage control spanning from true zero to 25 V with a setting resolution of 0.2%. To ensure an interference-free supply of regulated power under the worst conditions of supply line or load change, spurious transients are held to less than 250 mV while transient recovery time does not exceed 10 μs. The unit is protected against possible semiconductor and capacitor breakdown should a reverse polarity voltage be applied. Further safety provisions include automatic current limiting and a "short-circuit proof" facility, with automatic "reset." As load and line regulation is typically held to within 0.1% and ripple and noise do not exceed 1 mV peak to peak, the unit meets the requirements of most sophisticated applications. Because of its ambient temperature operating range (0-50°C), initial "turn on" drift is kept to a minimum and can be ignored for most practical purposes. This unit can be used singly or stacked in parallel or in series to meet higher voltage or multirail requirements. The output is 0 to 24 V d.c. 0.5 A from the following inputs: 105-125 V or 200-250 V a.c. 50/60 Hz. Weir Electronics Ltd., Durban Road, Bognor Regis, Sussex.



WW 327 for further details

# D.C. Transducer

SOMETIMES known as a "d.c. transformer," a direct current transducer is especially applicable to the measurement of d.c. in high voltage circuits. The device operates entirely from the magnetic field resulting from the d.c. The insulated current carrying conductor that passes through an Airpax d.c. transformer serves as a half-turn d.c. signal input winding to a toroidal magnetic core. This core is excited from an a.c. supply. Interaction of the two magnetic fields produces an output signal which, after rectification and filtering in a solid-state network, is linearly proportional to the measured current. The d.c. transformer produces no loading on the current carrying circuit because of loose coupling. An internal resistance limits the excitation current. Response time of the magnetic circuit is of the order of ten milliseconds. The Airpax high sensitivity d.c. transducers produce full-scale outputs from as little as 1 mA d.c. signal levels. The transducer fully isolates the output (meter) circuit from the input (metered) circuit in a manner similar to the isolation provided by instrument transformers used in metering a.c. circuits. With the d.c. transducer, d.c. in high voltage circuits can be measured to an accuracy of ±1.0% of full-scale. The internal circuit is designed for continuous operation and long life. The instrument is claimed to retain its accuracy from 0°C to +50°C and with a ±5% variation in the 115 V a.c. supply. The excitation is 60 Hz (50 Hz available on special order). Overloads in the input current line do not damage the unit, nor do short circuits in its output circuit. Airpax Electronics, Seminole Division, P.O. Box 8488, Fort Lauderdale, Florida 33310, U.S.A.

WW 328 for further details

# DIGITAL CLOCK

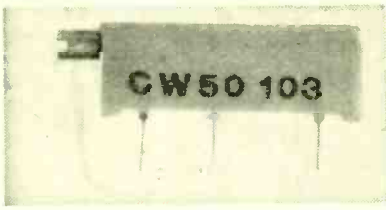
TIME indication by the Racal integrated circuit digital clock Type 812, is in hours, minutes and seconds. Display is through six in-line numerical indicator tubes. Timebase facilities offered include an internal standard derived from a 1 MHz crystal oscillator or 50 Hz mains power frequency. The crystal oscillator has a short-term stability of ±1 part in $10^6$ because of cyclic oven control; long term stability is typically within three minutes of nominal setting over a period of a year. The 50 Hz stability is dependent on the mains supply. Also available are external standard frequencies of 1 MHz, 100 kHz, or 1 Hz, at a level of 1 V r.m.s. Other features of this clock include a timebase failure alarm and the following controls: (1) initial time setting, (2) clock start and synchronization, (3) time adjustments during operation, and (4) zero reset; and time interval measurements (stop watch application). The electrical output of information is 4 line b.c.d. weighted 1248 code per display unit, "0" state logic. Options available are higher stability timebases (two) and an alternative power supply. Racal Instruments Ltd., Dukes Ride, Crowthorne, Berkshire.

WW 329 for further details

## R Trimmer

A MINIATURE rectangular trimmer by Reliance Controls Ltd., although a discrete component, is intended for use with integrated circuits or where space is at a premium. The trimmer, Type CW50, is 0.75 in long, 0.165 in wide, 0.28 in high, and has been designed for printed circuit applications with pins on the standard 0.1 in matrix. Operating torque is 2.1 N cm (3 ozf in). The resistance range is 100 Ω to 20 kΩ. Temperature range is −65° to +125°, and the power rating is 1 W at +40°C.

WW 330 for further details




## 4-channel f.e.ts

EIGHT new 4-channel f.e.t. switches, the G125F to 132F, are available in the Siliconix line of multi-channel f.e.t. switches and drivers, now available in this country from U.E.C.L. These n-channel junction devices, packaged four to a TO-84 can, are designed primarily for switching applications; however, they are also useful in amplifiers and voltage-controlled-resistor and constant current applications. The series offers a choice between separate or common-drain configurations, four $r_{ds}$, and two $V_P$ ranges in each configuration. Maximum pinch-off voltages are 5 and 10; maximum "on" resistances are 500, 250, 90 and 45Ω. The f.e.ts have low $I_{GSS}$, 0.1 and 0.2 nA max. depending on device type, and 0.05 and 0.1 nA max $I_{D(OFF)}$ and $I_{S\ (OFF)}$. N-channel junction f.e.ts provide several advantages; very low "on" resistance per unit capacitance, trade-off between $V_P$ and $r_{ds(on)}$ to lessen the drive swing requirement and low leakage. On special order, Siliconix will package any of its junction f.e.ts in a flat package. Ultra Electronics (Components) Ltd., Microelectronics Division, 35-37 Park Royal Road, London, N.W.10.

WW 331 for further details

# FEBRUARY MEETINGS

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

**LONDON**

1st. I.E.R.E.—"Satellite communication systems and the diverse engineering techniques which they require" by C. F. Davidson at 6.0 at 8-9 Bedford Sq., W.C.1.

2nd. I.E.E.—Colloquium on "MOSTs for analogue switching" at 2.30 at Savoy Pl., W.C.2.

5th. I.E.E.—"Future trends in the design of subscribers' telephone instruments" by F. E. Williams, F. A. Wilson and K. A. T. Knox at 5.30 at Savoy Pl., W.C.2.

6th. I.E.E. & R.Ae.S.—"Automatic landing of aircraft—control techniques in all-weather aircraft operations" by K. Smith at 5.30 at Savoy Pl., W.C.2.

7th. I.E.E.—"A new electrostatically focused and deflected vidicon" by Dr. H. G. Lubszynski, N. Barford, Dr. B. Mayo and J. Wardley and "Beam separation and low-noise read-out in isocons" by P. C. Ruggles, Dr. N. A. Slark, D. P. Mouser and P. H. Batev at 5.30 at Savoy Pl., W.C.2.

7th. I.E.R.E. & I.E.E.—Colloquium on "Fluid logic in peripheral equipment for computers" at 6.0 at the London School of Hygiene and Tropical Medicine, Keppel St., W.C.1.

8th. I.E.E.—"A system for transmission and display of weather information" by R. H. D. Hardy at 5.30 at Savoy Pl., W.C.2.

8th. Inst. Electronics.—"Measurement and control in the wire and cable industry" by P. Baxter at 6.45 at the School of Hygiene & Tropical Medicine, Keppel St., W.C.1.

9th. I.E.E.—"Evanescent mode filters" by G. F. Craven at 5.30 at Savoy Pl., W.C.2.

9th. R.T.S.—"A comparison of wired and wireless broadcasting for the future" by R. P. Gabriel at 7.0 at I.T.A., 70 Brompton Rd., S.W.3.

13th. I.E.R.E.—"The MOST integrated circuit" by P. Cooke at 6.0 at 8-9 Bedford Sq., W.C.1.

14th. I.E.E.—"Stimulus or constraint? The interplay of computer design and use" by F. J. M. Laver at 5.30 at Savoy Pl., W.C.2.

15th. I.E.E.—Colloquium on "Direct digital control of systems and processes" at 2.0 at Savoy Pl., W.C.2.

16th. I.E.E.—"A position fixing aid to marine surveying" by J. K. V. Lee at 5.30 at Savoy Pl., W.C.2.

21st. I.E.R.E.—Symposium on "Integrated harbour radar systems" at 6.0 at 8-9 Bedford Sq., W.C.1.

23rd. R.T.S.—"Data presentation by visual displays" by R. A. Ward and M. H. Cufflin at 7.0 at I.T.A., 70 Brompton Rd., S.W.3.

27th. I.E.E.—Colloquium on "Developments towards a computer-based information service in physics, electrotechnology and control" at 2.30 at Savoy Pl., W.C.2.

28th. I.E.E.—"Measurement as an aid to archaeological research" by Dr. E. T. Hall at 5.30 at Savoy Pl., W.C.2.

28th. I.E.R.E.—"Ultrasonic delay lines and their uses in television" by R. Gibson and S. M. Edwardson at 6.0 at 8-9 Bedford Sq., W.C.1.

**BASINGSTOKE**

8th. I.E.R.E.—"High voltage pulse techniques in fusion research" by Dr. N. R. McCormick at 7.30 at the Technical College.

**BIRMINGHAM**

20th. R.T.S. & I.E.R.E.—"Colour is our future" by Bill Ward at 7.0 at A.T.V. Ltd.

**BRIGHTON**

13th. I.E.R.E.—"Radio astronomy" by J. M. H. Hill at 6.30 at College of Technology.

**BRISTOL**

5th. I.E.R.E. & I.E.E.—"Computer control systems for materials handling plans" by J. P. Coley and W. J. Castens at 6.0 at the University, Queens Building.

13th. R.T.S.—"Colour TV receivers—general design problems" by B. J. Rogers at 7.30 at B.B.C., Whiteladies Rd.

**CAMBRIDGE**

1st. I.E.R.E. & I.E.E.—"Recent developments in wideband aerials" by M. F. Radford at 8.0 at the University Engineering Laboratories, Trumpington St.

29th. I.E.R.E. & I.E.E.—"The theory of oscillators" by P. J. Baxandall at 8.0 at the University Engineering Laboratories, Trumpington St.

**CARDIFF**

9th. S.E.R.T.—"Field effect transistors" by E. F. Munroe at 7.30 at Llandaff Technical College, Western Ave.

14th. I.E.R.E.—"Electronic techniques in electro-physiology" by D. P. Nelligan at 6.30 at University of Wales Institute of Science and Technology.

14th. R.T.S.—"Techniques for 'pop' music recording" by D. Heelis at 7.30 at Broadcasting House, Llandaff.

**CHESTER**

14th. I.E.E.T.E.—"The laser" by Dr. P. T. Andrews at 7.0 at College of Further Education, Eaton Rd.

**CHESTERFIELD**

5th. S.E.R.T.—"U.H.F. reception" by B. M. Goodwin at 6.30 at College of Technology, Infirmary Rd.

**COVENTRY**

5th. I.E.R.E.—"Post Office towers and trunks" by J. C. Billen at 7.15 at Lanchester College of Technology, Priory St.

**DUNDEE**

7th. I.Prod.E.—"An introduction to integrated circuits and methods of manufacture" by J. T. Brown and C. Turner at 7.30 at Queen's Hotel, Nethergate.

**EDINBURGH**

13th. I.E.R.E. & I.E.E.—"The use of satellites for long-distance telecommunications" by H. Stanesby at 6.0 at Carlton Hotel, North Bridge.

23rd. S.E.R.T.—"Colour television" by J. C. Allen at 7.30 at Napier Technical College, Colinton Rd.

**EVESHAM**

27th. I.E.R.E.—"Slow motion video disc recording" by C. R. Webster at 7.0 at B.B.C. Club.

**FARNBOROUGH**

22nd. I.E.R.E.—"Electrical interference in electronic systems" by D. Harrison at 7.0 at Technical College.

**GLASGOW**

12th. I.E.R.E. & I.E.E.—"The use of satellites for long-distance telecommunications" by H. Stanesby at 6.0 at University of Strathclyde.

21st. I.E.E.T.E.—"Cybernetics in management" by W. A. Gay at 7.0 at University of Strathclyde, Montrose St.

**GRANGEMOUTH**

22nd. S.Inst.Tech.—"Gas lasers and their applications" by H. Foster at 7.0 at Leapark Hotel, Bo'ness Head.

**GREENOCK**

2nd. S.E.R.T.—"Colour television" by J. McMaster at 7.30 at Watt Memorial College.

**HALIFAX**

8th. I.E.R.E.—"Machine tool control transducers" by D. Mather at 7.0 at Percival Whitley College of Further Education, Department of Engineering, Francis St.

**HORNCHURCH**

20th. S.E.R.T.—"Automatic landing systems" by F. J. Sullings at 7.0 at Havering Technical College, 42 Ardleigh Green Road.

**LINCOLN**

6th. S.E.R.T. "U.H.F. reception" by B. M. Goodwin at 7.30 at Technical College, Cathedral St.

**LIVERPOOL**

21st. I.E.R.E.—"Electronic standards conversion" by D. Stebbings at 7.0 at Regional College of Technology, Byrom St.

**LOUGHBOROUGH**

20th. I.E.R.E. & I.E.E. "The 57 effects of electric current" by Dr. G. S. Brosan at 6.30 at University of Technology.

**MANCHESTER**

22nd. C.E.I.—"Our present knowledge of the universe" by Sir Bernard Lovell at 6.30 at Renold Building, Manchester College of Science and Technology, Altrincham St.

**NEWCASTLE-UPON-TYNE**

7th. S.E.R.T.—"Interference" by T. Boast at 7.15 at Charles Trevelyan Technical College, Maple Terrace.

14th. I.E.R.E.—"Automatic landing—some design aspects of high integrity autopilots" by R. Bishop at 6.0 at Institute of Mining and Mechanical Engineers, Neville Hall, Westgate Rd.

22nd. S.Inst.Tech. — "Integrated circuits" by W. L. Clough at 7.0 at the Rutherford College of Technology.

**OLDHAM**

8th. S.E.R.T.—"Stereo broadcasting" at 8.0 at The Technical College.

**PLYMOUTH**

20th. I.E.E., I.E.R.E. & R.T.S.—"Concorde electronics" by H. Hill at 7.0 at College of Technology.

**READING**

13th. I.E.R.E.—"On-line control" by Dr. R. C. Butchart at 7.30 at J. J. Thomson Physical Laboratory, The University.

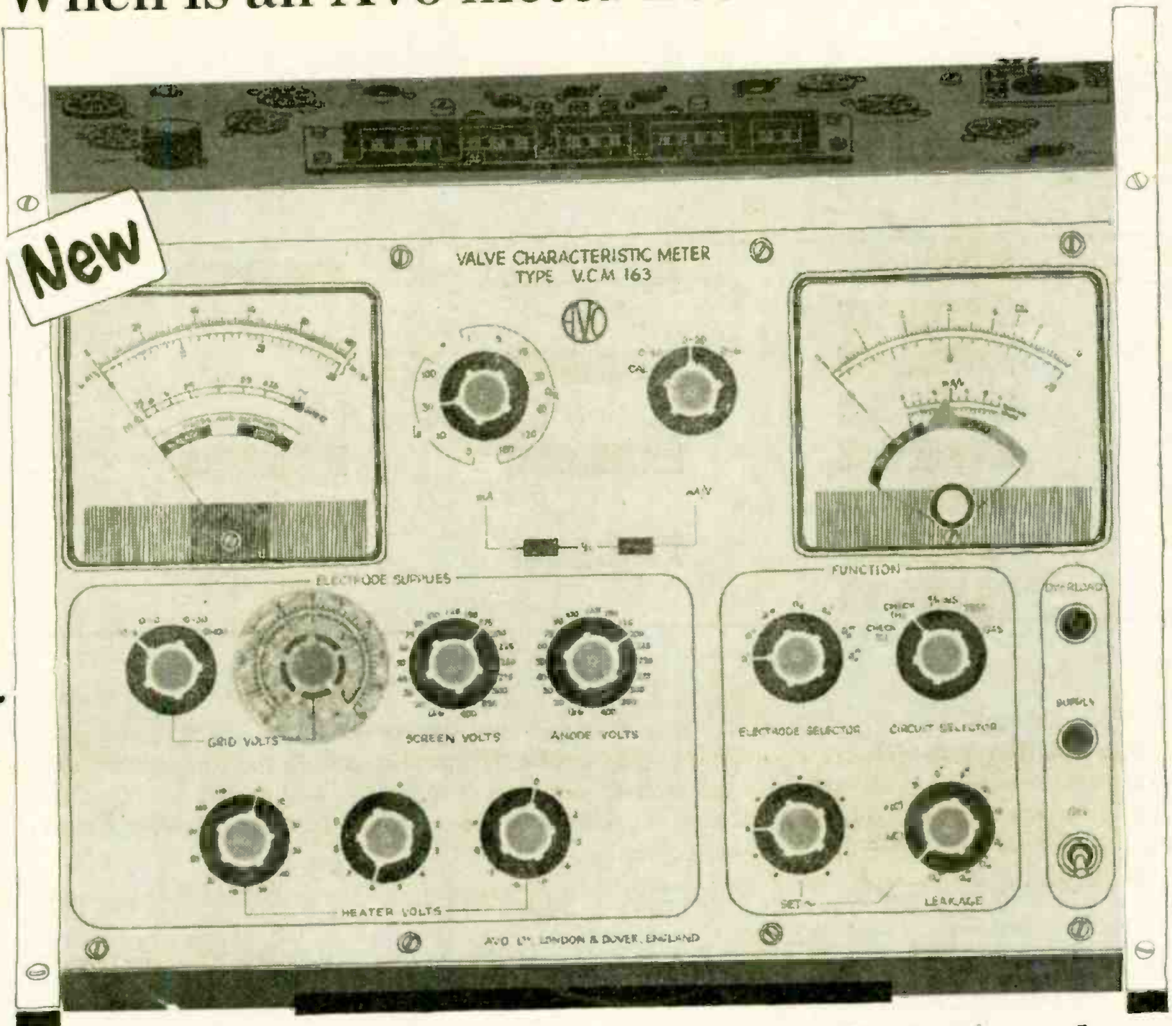
**STOKE-ON-TRENT**

16th. S.E.R.T.—"Sony video tape recorders" at 7.30 at North Staffs College of Technology, College Road.

**WAKEFIELD**

29th. I.E.E.T.E.—"The application of thyristors in industry" by E. J. Pepper at 7.0 at Adult Education Centre, Queen Street.

# When is an Avo meter not an Avometer?




## When it tests nuvistors, compactrons & 13-pin valves

The new Avo VCM163 Valve Characteristic Meter is one of the most versatile valve testers ever developed. With facilities for testing valves with as many as 13 pin connections (and 2 top caps), plus recently introduced types such as nuvistors and compactrons, the VCM163 provides both rapid fault diagnosis and comprehensive static/dynamic characteristics data. Nevertheless, it is even simpler to use than previous models – no backing-off is required. A separate meter displays mutual conductance values continuously during testing, and there is pushbutton monitoring of screen parameters. The full range of h.t. voltage – 12.6V to 400V – can be applied to anode and screen, heater voltage is adjustable in 0.1V steps from 0 to 119.9 and grid voltage may be varied continuously from 0 to 100V (calibrated). Get complete information about the VCM163 from your local dealer or Avo Ltd, Avocet House, Dover, Kent. Telephone Dover 2626. Telex 96283.

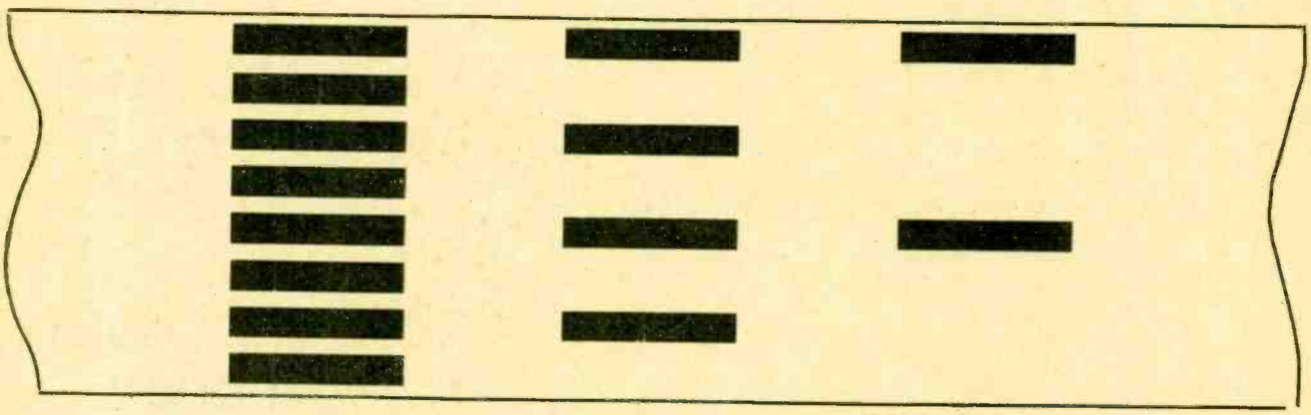
AVΩ MEANS BASIC MEASUREMENTS ALL OVER THE WORLD

WW—003 FOR FURTHER DETAILS

A

# 8 TRACKS

## ON 1/4" TAPE



**8/8** **4/8** **2/8**

The ever-increasing application of digital techniques to data acquisition has prompted Marriott Magnetics to investigate track density in ¼ inch wide magnetic tape. The possibility of using readily available and comparatively cheap tape and tape transport mechanisms opens up new and attractive avenues of approach to many applications which hitherto have been dismissed on cost grounds. This 8/8 head is a valuable newcomer to our standard range which now includes 4/8 and 2/8 in addition to the 4/4—2/4 and 1/4 configuration.

Combination Record/Playback/Erase heads to the above configuration are available for some of the above types.

Marriott Magnetics were the very first company in the world to mass-produce miniature heads, and in 1959 Marriotts scooped the world by mass-producing a four-track head. Well over 5 million heads have been sold since then, and it is the company's firm intention to continue leading the world in the design and manufacture of Magnetic Recording Heads.

**RESEARCH AND DEVELOPMENT**

Marriott Magnetics' research and development activities are directed towards continuously improving the mechanical and electrical characteristics of their heads through the use of many new ideas, engineering approaches and manufacturing techniques.

Much research and development effort is applied to the development of heads with unique configurations for many special and unusual instrumentation applications. A highly efficient pre-production group works closely with research and development to provide a fast service of prototypes, small quantity production and special heads.

**MANUFACTURING**

Marriott Magnetics maintain a complete facility; fully equipped with the machines, tools, optical equipment and electronic test instruments for mass production of precision heads. Machinery, assembly, test and inspection operations are performed by operators experienced in close tolerance and precision assembly work.

Material handling methods are used to permit cost reduction and quick delivery of Standard Heads. Assembly, test and inspection procedures are carried out under most controlled conditions.

**ENGINEERING**

Marriott Magnetics' engineering staff has extensive experience in application of design, manufacturing and test techniques to head production problems, and taking a new design through the prototype stage to quantity manufacture. The ability to analyse and to provide answers quickly to engineering problems peculiar to precision heads results in a quality product with superior operational characteristics and very uniform production runs.

**QUALITY CONTROL**

Continuous piece part inspection and evaluation of each Sub-Assembly are the two basic points of Marriott Magnetics' quality control system. Incoming materials and parts are closely inspected to ensure that mechanical and electrical specifications are met. All completed heads are vigorously inspected and performance tested to ensure complete customer satisfaction.

**MARRIOTT MAGNETICS LTD.**

WATERSIDE WORKS PONSHARDEN PENRYN CORNWALL

*Telephone: Penryn 3591-3363*

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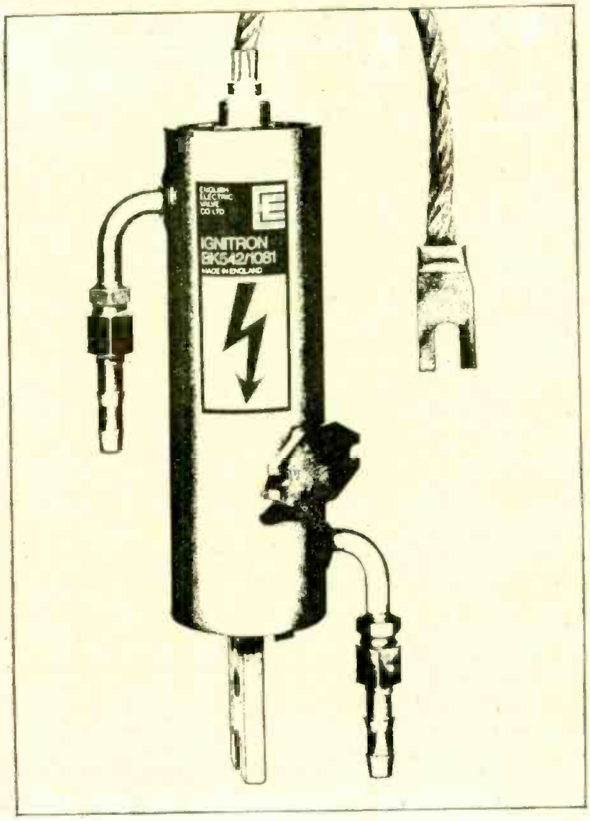


This looks like
a 'B' size Ignitron

but it controls
65% MORE POWER
and saves money

# The new EEV Mini 'C' Ignitron

It's well-known that 'B' and 'C' Ignitrons are often used for applications which call for something in between. You can either overwork a 'B' or underwork a 'C'. Whatever you do wastes money. To cut out this waste EEV has developed a new Mini 'C' Ignitron which has a standard international 'B' size envelope, but can handle 65% more KVA than the 'B' size. The new tube has a number of advantages. Take-over voltage is low to minimise misfiring at low current conditions, which in turn increases ignitor life. When used in place of a standard 'B' size ignitron, you will find that the Mini 'C' lasts nearly twice as long. The cooling water is in direct contact with the vacuum envelope, and the inlet has been streamlined for better water flow. This adds up to better cooling, especially at hot spots, and reduced clogging by sediment. Both water connections are of the quick release type. Plastic coating is optional. The Mini 'C' fits standard 'B' size sockets, so that you can use it to uprate existing equipment to provide new intermediate types. Makers of welding equipment will see in the Mini 'C' a means of extending their range, as there is no need for a new socket size calling for radical design changes. Use the Mini 'C' in place of an overworked 'B' size for longer life, or to replace an underworked 'C' size for lower running costs. In both cases it will save you money.

EEV's new Mini 'C' Ignitron is available from stockists throughout the country.

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

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

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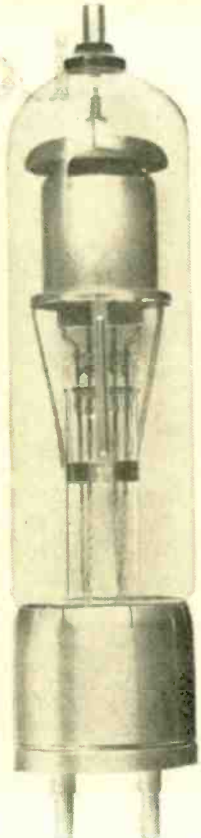
WW—005 FOR FURTHER DETAILS



# Mercury Vapour Rectifiers

## DATA

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

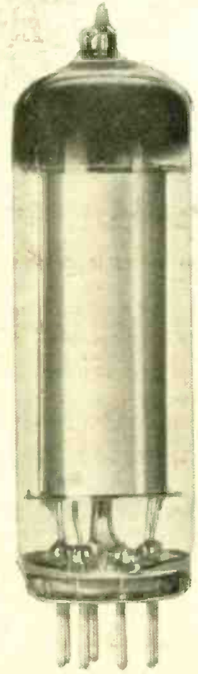
*Full wave rectifier.

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

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

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

**WW—007 FOR FURTHER DETAILS**



# Voltage Stabilisers

## DATA

| Type | Service type | Operating voltage approx. (V) | Striking voltage (V) ○ | Striking voltage (V) ● | Tube current range (mA) | Regulation max. (V) | Base |
|---|---|---|---|---|---|---|---|
| OA2 | CV1832 | 150 | 185 | 225 | 5-30 | 6.0 | B7G |
| OA2WA‡ | CV4020 | 150 | 165 | 225 | 5-30 | 5.0 | B7G |
| OB2 | CV1833 | 108 | 133 | 210 | 5-30 | 3.5 | B7G |
| OB2WA‡ | CV4028 | 108 | 133 | 210 | 5-30 | 3.0 | B7G |
| OC2 | CV8766 | 75 | 115 | 145 | 5-30 | 4.5 | B7G |
| QS75/20 | CV284† | 75 | 110 | 160 | 2-20 | 6.0 | B7G |
| QS75/60 | CV434 | 75 | 117 | — | 5-60 | 5.0 | B8G |
| QS92/10 | CV188†† | 92 | 140 | — | 1-10 | 5.0 | Br.4-pin |
| QS95/10 | CV286 | 95 | 110 | — | 2-10 | 5.0 | B7G |
| QS108/45 | CV422 | 108 | 120 | — | 5-45 | 5.0 | B8G |
| QS150/15 | CV287 | 150 | 170 | — | 2-15 | 5.0 | B7G |
| QS150/45 | CV395 | 150 | 170 | — | 5-45 | 5.0 | B8G |
| QS1202‡ | CV4052 | 108 | 133 | 210 | 2-15 | 3.0 | B7G/F |
| QS1203‡ | CV4053 | 150 | 180 | 225 | 2-15 | 4.5 | B7G/F |
| QS1215 | CV5173 | 90 | 115 | 115 | 1-40 | 8.0 | B7G |

‡ A rugged and reliable type ○ In normal lighting ● In total darkness †† Also CV1070 (operating voltage 100V) † Also CV5083 (operating voltage 70V)

This range of cold cathode Voltage Stabilisers is available from your local EEV stockist. English Electric Valves production methods ensure the reliability and performance you are looking for and prices are competitive.

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

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

WW—009 FOR FURTHER DETAILS

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

## NEW! 12+2W TRANSISTOR STEREO AMPLIFIER Model TSA-12

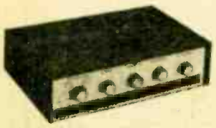
**Luxury performance at lowest possible cost**

Attractive low-silhouette styling in compact sizes 3¼" x h15¾"w x 10" deep.

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

Kit £30.10.0 (less cabinet) Ready-to-use £42.10.0
Beautiful Walnut cabinet £2.5.0. extra

## LOW-COST TRANSISTOR STEREO AMPLIFIER, TS-23



Incorporates all the essential features for good quality sound reproduction from record, radio and other sources ● 16 transistor, 4 diode circuit ● Good frequency response ● 3 watts r.m.s. (15 ohms) each channel ● 6 position selector switch easily handles your record, radio or tape inputs—stereo or mono ● Separate controls provide bass boost, treble cut, amplifier balance and volume ● Printed circuit board construction ● Compact, slimline styling ● Measures 3⅞in. high x 13in. wide x 8in. deep ● Beautiful walnut veneered cabinet (optional extra) ● Attractive Perspex front panel.

**KIT £17.15.0** (less cabinet) **KIT £18.19.0** (with cabinet)
Walnut veneered cabinet £2/5/- extra.

## TRANSISTOR AM-FM STEREO TUNER, AFM-2

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

**TOTAL PRICE KIT £32.7.0 incl. P.T.**
Optional extra: Walnut veneered cabinet £2/5/- extra

## TRANSISTOR FM STEREO TUNER, TFM-1S

(Mono version TFM-1M available)

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

**TOTAL PRICE KIT (Stereo) £20.19.0 incl. P.T.**
**TOTAL PRICE KIT (Mono) £24.18.0 incl. P.T.**
Optional extra: Walnut veneered cabinet £2/5/- extra.

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

## BERKELEY SLIM-LINE SPEAKER SYSTEM

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

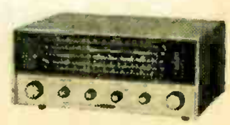
**KIT £19.10.0 Ready-to-Use £24.0.0**

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

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

**KIT £11.17.6 (less legs)**

## LOW-COST SHORTWAVE RECEIVER, GR-64E



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

**KIT £22.8.0 Ready-to-Use £27.8.0**

## GENERAL COVERAGE RECEIVER, GG-1U (not illustrated)

●Powerful 10 transistor, 5 diode circuit ●Tunes 580 to 1,550 kc/s and 1.69 to 30 Mc/s in five bands ●Bandspread on all bands ●Fixed-aligned ceramic IF transfilters for best selectivity ●Pre-assembled and aligned "front-end" for fast, easy assembly ●Built-in 6in. x 4in. speaker ●Tuning meter for pin-point tuning ●Completely self-contained for portability.

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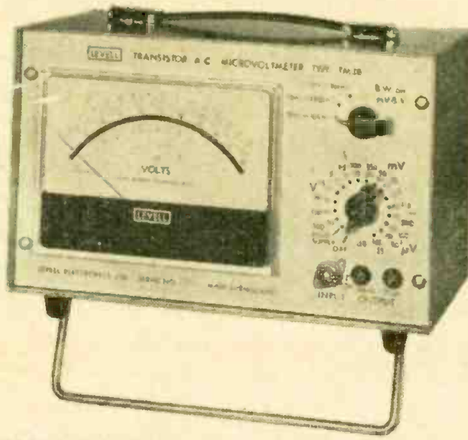

**TYPE TM3B**

**£63**

Complete with battery and input lead.

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

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

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

**FREQUENCY RESPONSE**
Above 500μV: ±3dB from 1Hz to 3MHz.
0·3dB from 4Hz to 1MHz.
On 500μV: ±3dB from 2Hz to 2MHz.
On 150μV: ±3dB from 4Hz to 1MHz.
On 50μV: ±3dB from 7Hz to 500kHz.
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**AMPLIFIER OUTPUT**
150mV at f.s.d. on all ranges. Will drive a load of 200kΩ and 50pF without loss.

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

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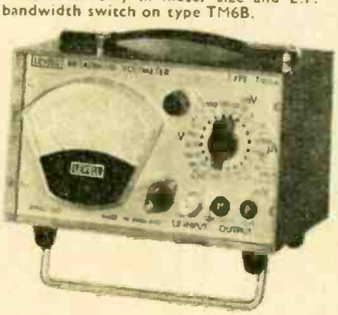
As A.C. Microvoltmeters plus H.F. probe to extend response to 450MHz. Two versions differ only in meter size and L.F. bandwidth switch on type TM6B.



**TYPE TM6A**

**£85**

Complete with battery and input lead.

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

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

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

**L.F. RANGES**
As TM3A and TM3B except for the omission of 15μV and 150μV.

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

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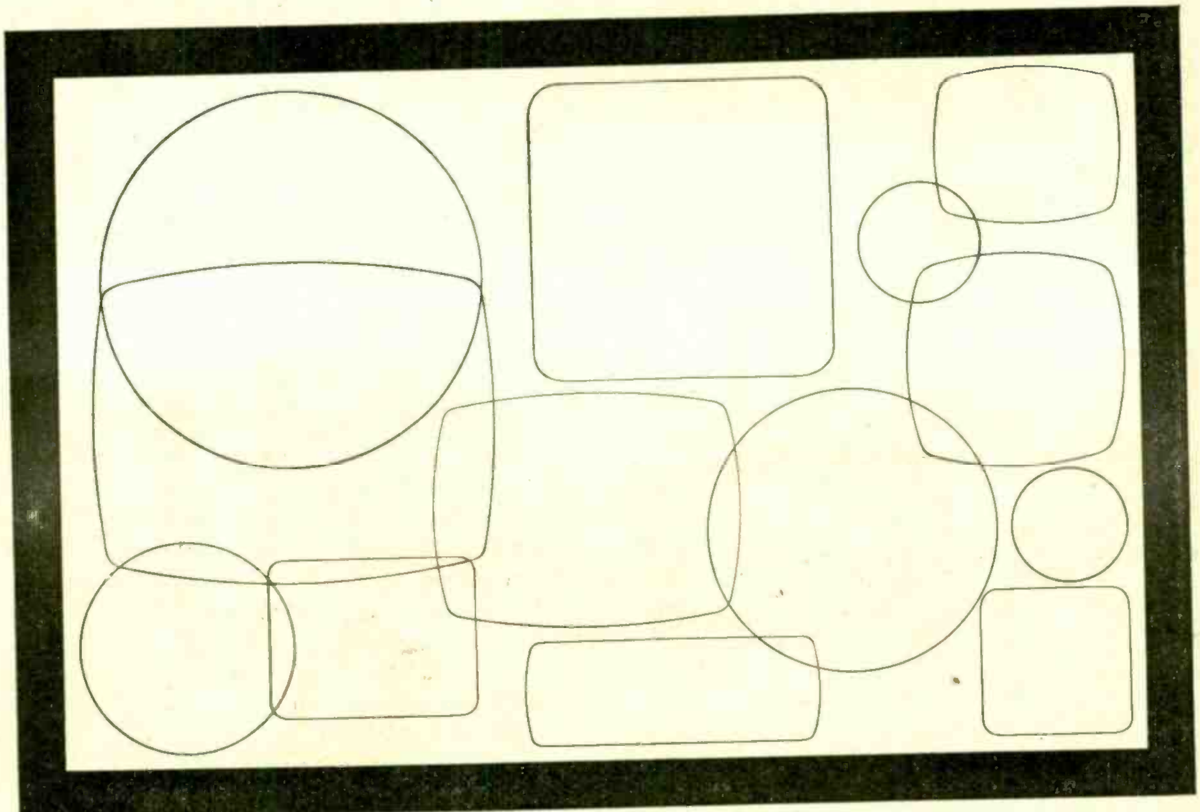


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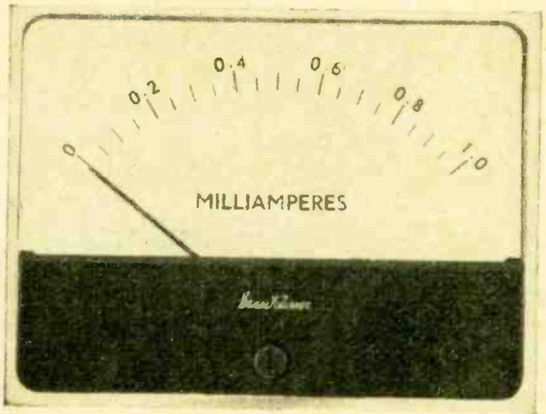


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A feature of the instrument is that the selected output voltage can be continuously varied over the ranges $\pm$5% and $\pm$0.5%, with meter indication.

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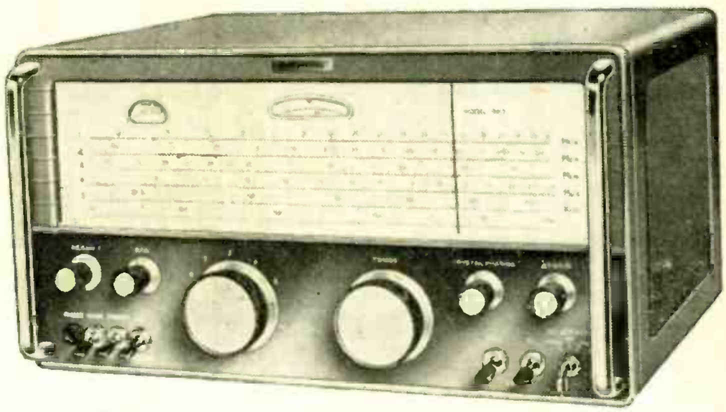

### 770R Mark II

for reception of c.w, a.m narrow and broadband f.m signals in the range 19 MHz to 165 MHz in six bands. Selectivity automatically adjusted to suit signal mode. Twenty valves and two germanium diodes are used in a highly sensitive circuit with push-pull audio output and provision for a 2.5-ohm speaker, 600-ohm balanced line or high resistance telephones. Power requirement 100/125V and 200/250V a.c 40—60 Hz.

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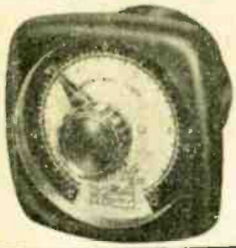

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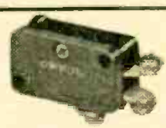

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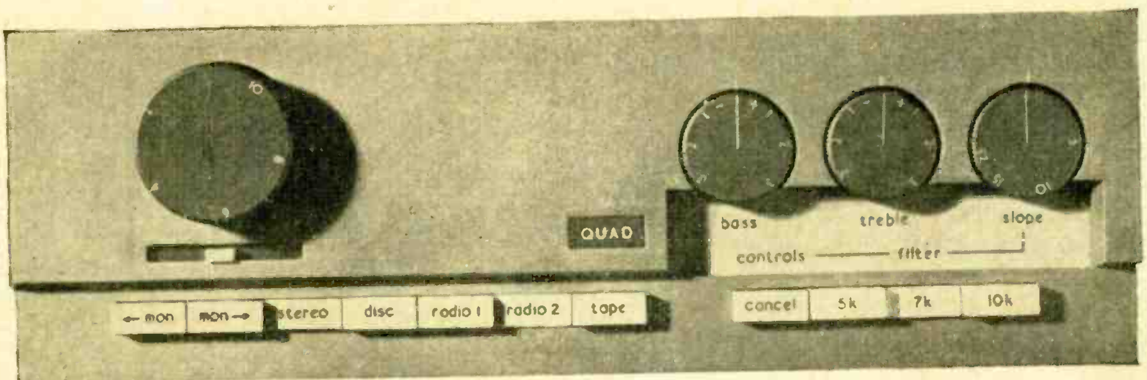


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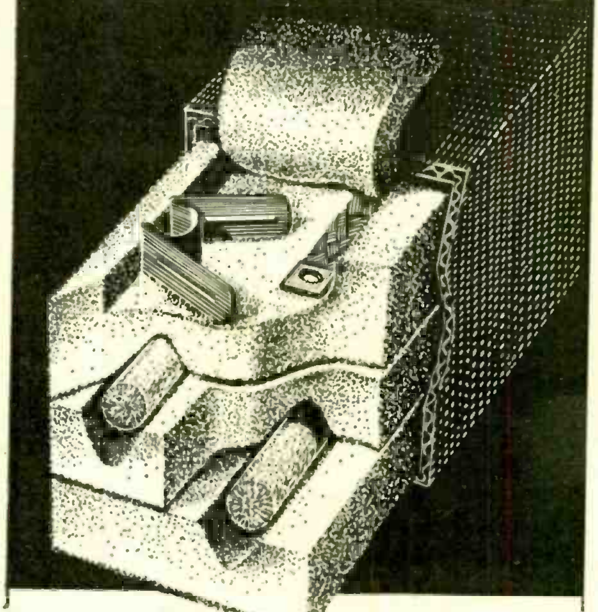

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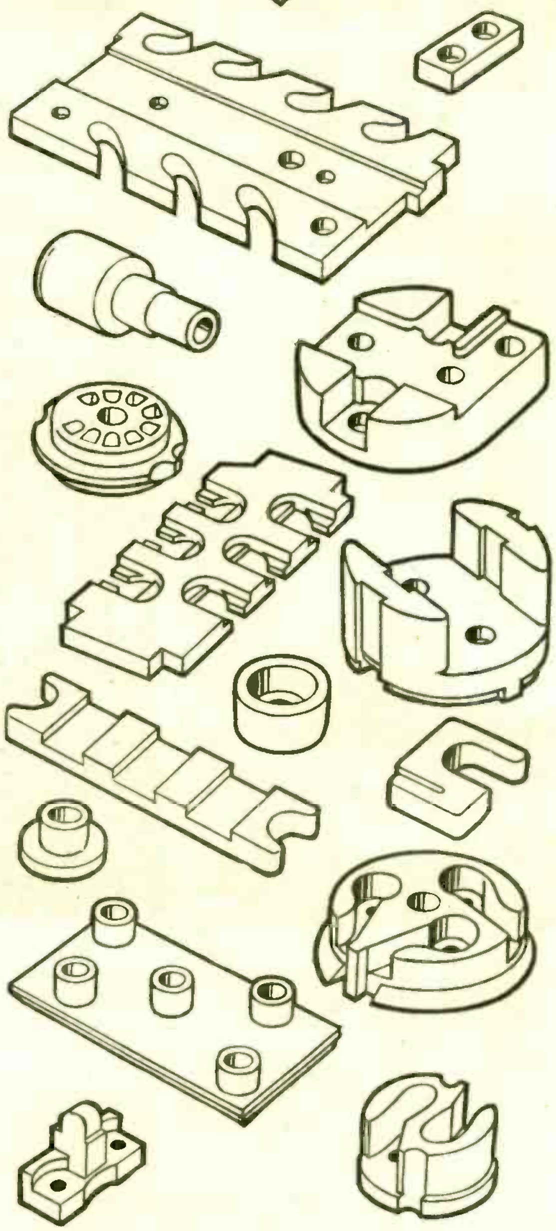

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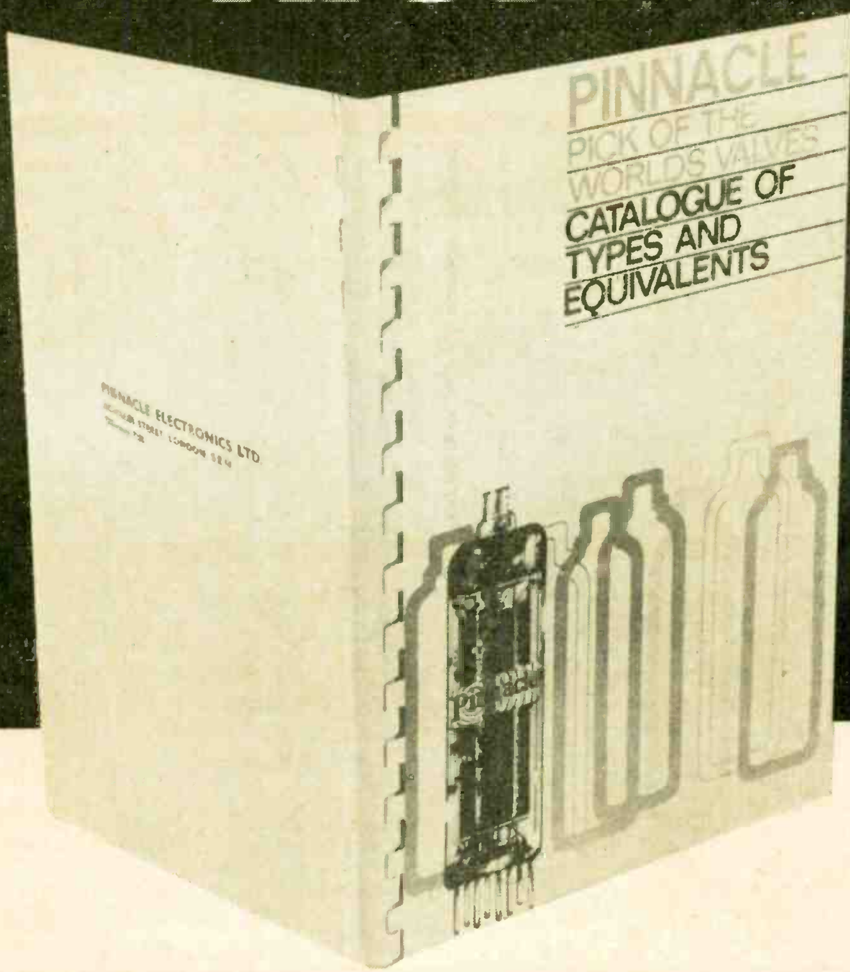


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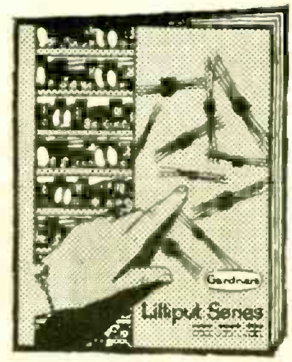
# The Lilliput Series

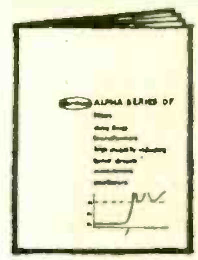




**ULTRA MINIATURE, INVERTER, WIDE BAND, CARRIER MATCHING, DRIVER AND PULSE TRANSFORMERS, A.F. AND SMOOTHING INDUCTORS**

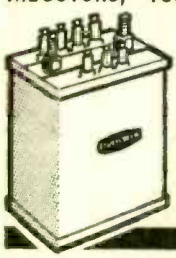
Gardners Lilliput series of Ultra Miniature transformers has been specifically developed for compatibility with other wired-in modules used on printed circuit boards. Exceptional performance has been achieved by a unique form of construction incorporating extremely thin (down to 3:2 microns) high permeability core materials and a very short length of coil turn. Transformers in this new series are particularly suitable for pulse and switching circuits with rise times of 10 nanoseconds or less

**GT 12A.** *Describes the Lilliput series of Ultra Miniature transformers and gives useful information and data on their application in transistor converter/inverter, wide band communication and high speed pulse circuits.*

# The Alpha Series



**FILTERS, DELAY LINES, TRANSFORMERS, MODULATORS, HIGH STABILITY INDUCTORS, TUNED CIRCUITS, OSCILLATORS**



A range of custom built components from simple or hybrid transformers and modulators to highly complex multi-section filters or complete active networks of exceptional stability hermetically sealed to DEF. 5214 Humidity Class H1.

**GT 16.** *Gives a general description of the Alpha series assemblies and describes their suitability for wound components where a high degree of stability is required.*

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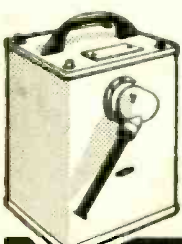

A comprehensive range of conventional double wound and auto transformers for applications in industry and in the home. Nearly 200 types are available in six different styles and with outputs from 6 volts to 240 volts and from ·5VA rating to 2 kilowatts. All types are normally held in stock in reasonable quantities for immediate delivery.

**GT 17.** *Everyone in the electronics industry uses low voltage, isolating and auto transformers at some time or other and this booklet describes the complete Gardner range of this type of transformer in a convenient and presentable form.*

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**Gardners Transformers Ltd., Christchurch, Hampshire**
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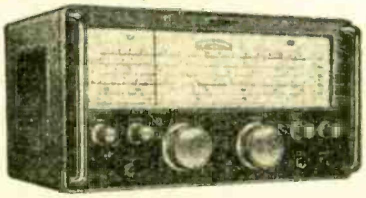

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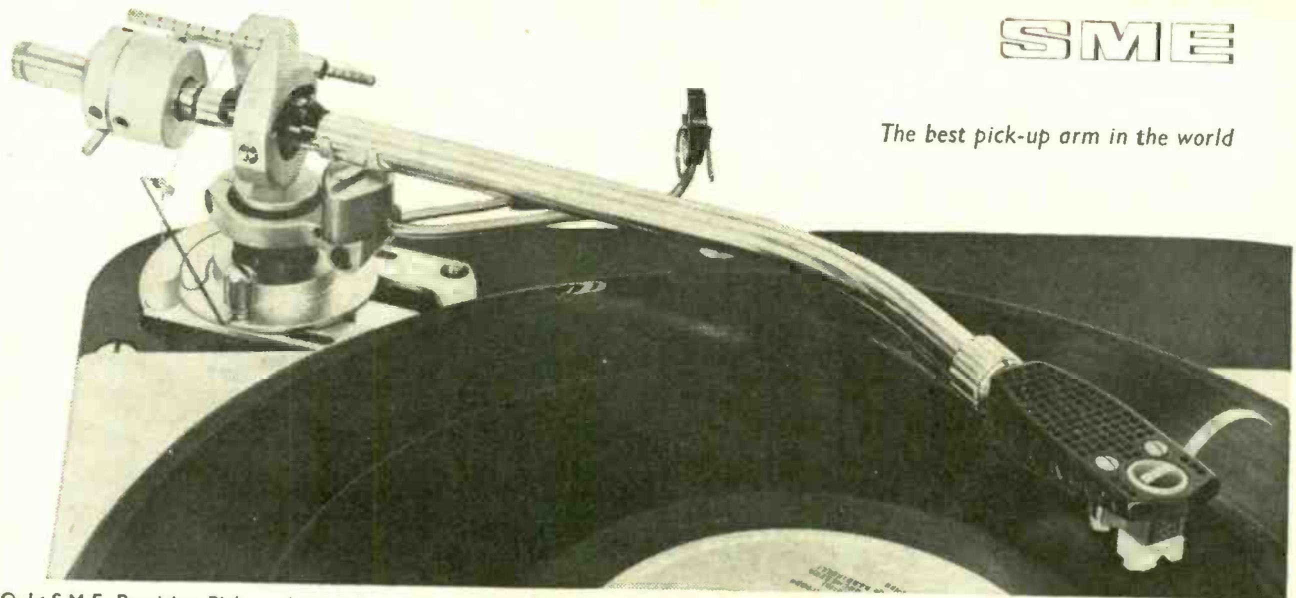

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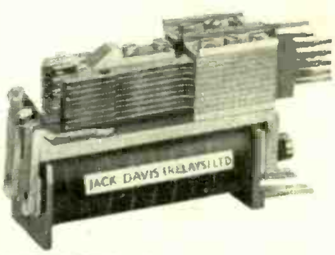
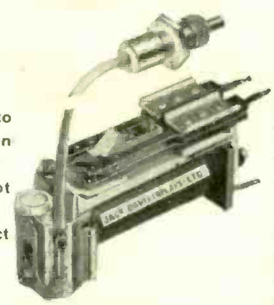



Twin coils and armatures. Two completely independent relays in one. A space and money saver!

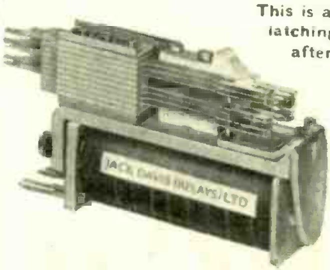
## MECHANICAL RELAY LATCH

Enables the P.O. 3000 type relay to be held in the closed position when the coil is de-energised and until manually released. Does not impair the versatility of the contact arrangements, nor affect the normal mounting position.



RELAYS

## THE REMANENCE RELAY




This is a 3000 type relay capable of latching in the energised position after the supply is removed until a suitable releasing current is applied in the opposite direction. This releasing current is controlled with a single coil, by reducing the operating current in reverse or with a double coil, via a pair of contacts employed on the relay to energise the second coil.

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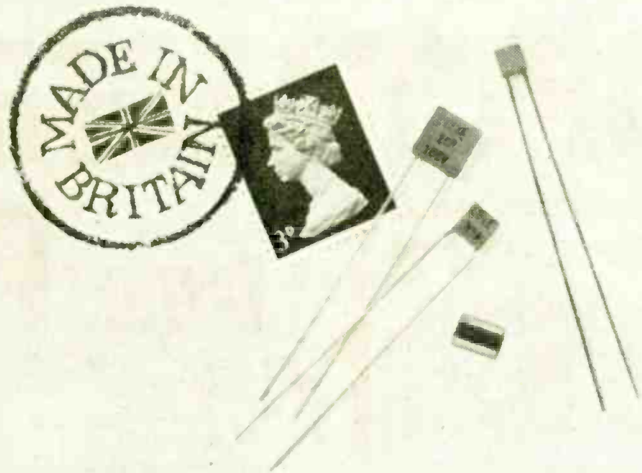


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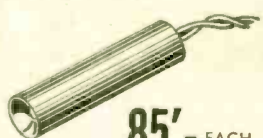

## MSP3

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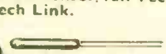
## 31F2



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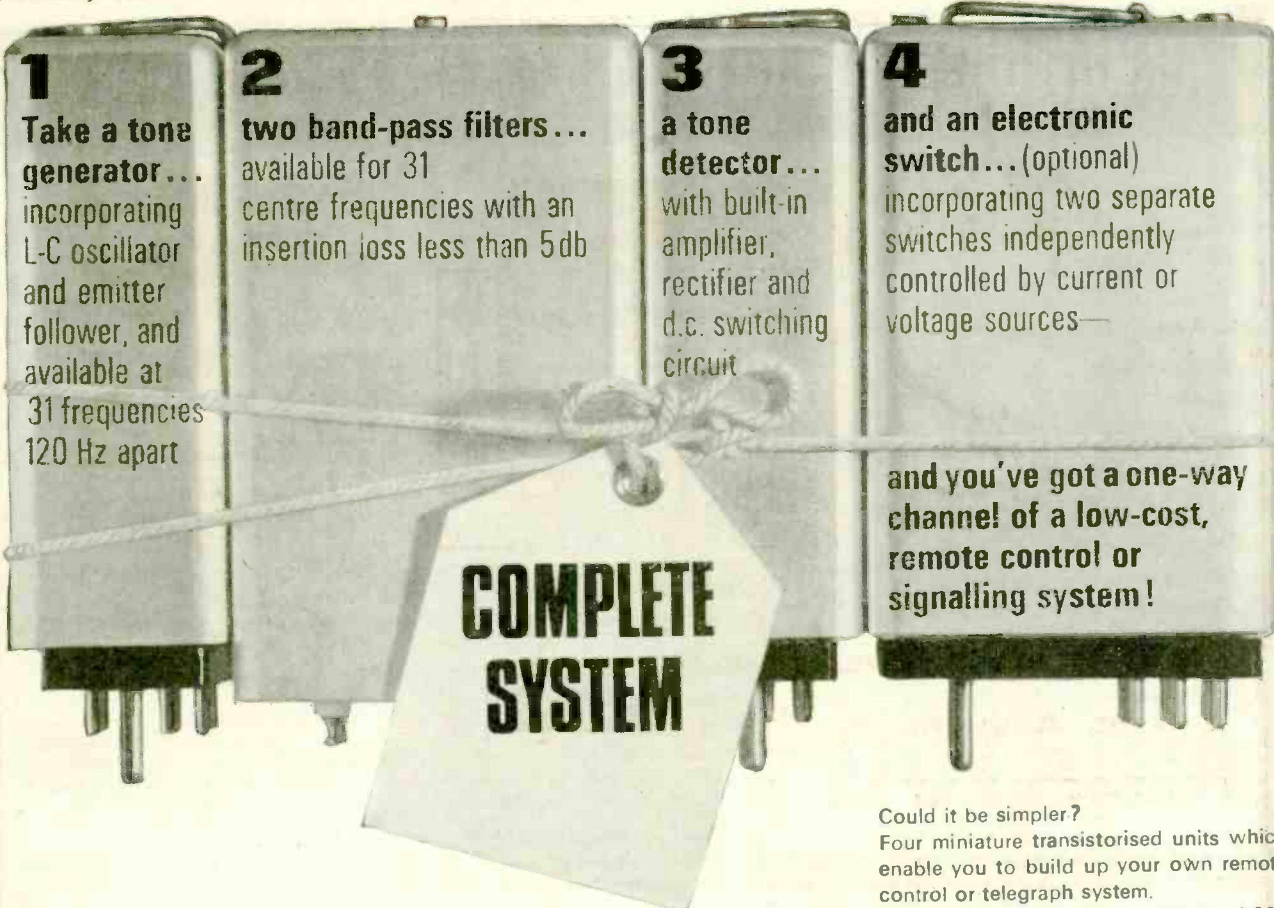


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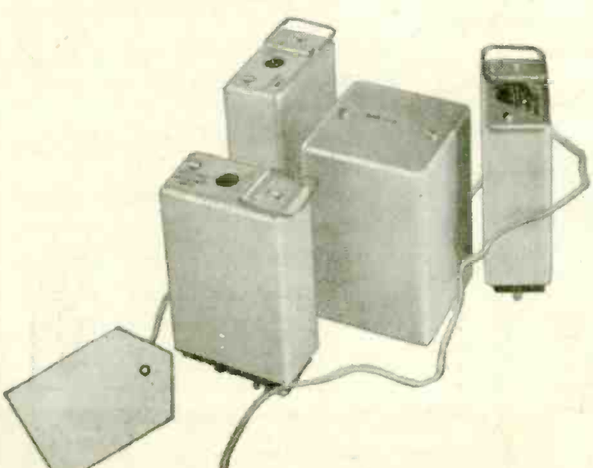

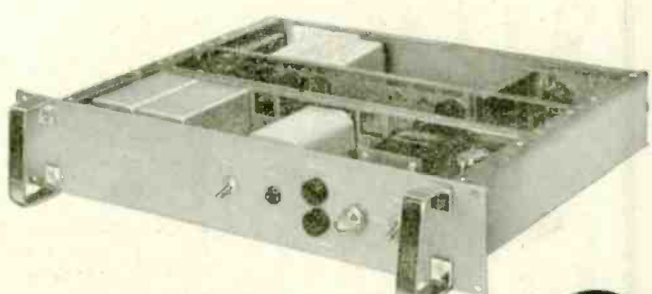

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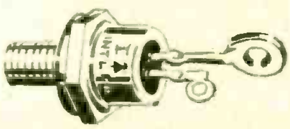

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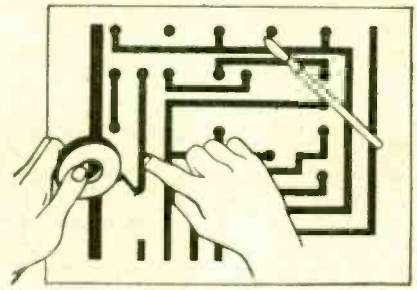

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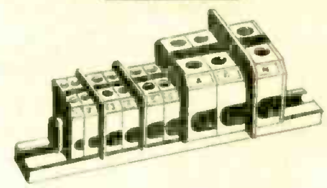

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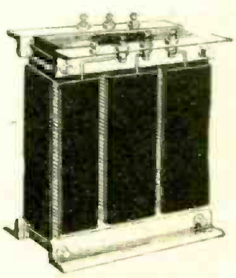

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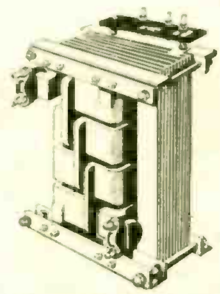

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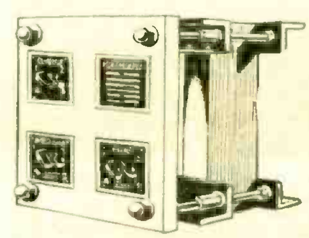

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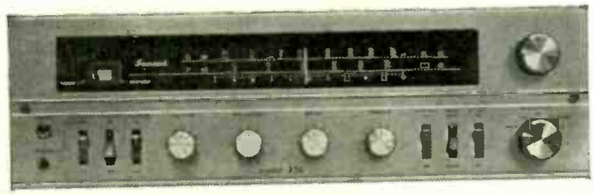
**AM/FM Multiplex Stereo Tuner Amplifier**

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

**MODEL 500A**
**AM/FM Multiplex Stereo Tuner Amplifier**

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



**MODEL 250**
**AM/FM Multiplex Stereo Tuner Amplifier**

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

## Other equipment in the superbly styled Sansui range

MODEL 3000A—Solid-state AM/FM Multiplex Stereo Tuner Amplifier. RMS power: 48/48 W. ± 1 dB.

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MODEL AU-777—Solid-state Stereo Control Amplifier. RMS power: 30/30 W.

MODEL AU-70—Stereo Control Amplifier. RMS power: 12/12 W.

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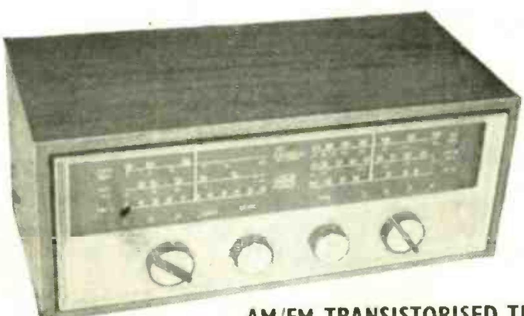
# NOW MADE BY RESLOSOUND

# Chapman Stereo Tuners

**VHF/FM TRANSISTORISED TUNER**
type FM.1000A/B FM. 80 - 108 Mc/s. only. **£28.** + P.T. £5.12.7.



**AM/FM TRANSISTORISED TUNER**
type FM.1005A/B. Long, Medium and two Short wavebands. FM. 80-108 Mc/s. **£48.** + P.T. £9.13.0.

**AM/FM VALVE TUNER** type S6BS/FM MK.II. The finest Tuner in the Chapman range. Medium and two Short wavebands, also six bandspread ranges on 11, 13 16, 19, 25, 31 metres. FM. 80-108 Mc/s. FM. Stereo Decoder optional extra. Much in demand overseas for its exceptionally good short wave reception. **£64.** + P.T. £12.17.5.

The Chapman range of High Fidelity Tuner units can be optionally fitted with multiplex decoders for stereo broadcast reception. Models FM.1000A/B and FM.1005A/B are also available in chassis form for fitting in owner's cabinet.

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Tel: ROMFORD 61926 (3 Lines)

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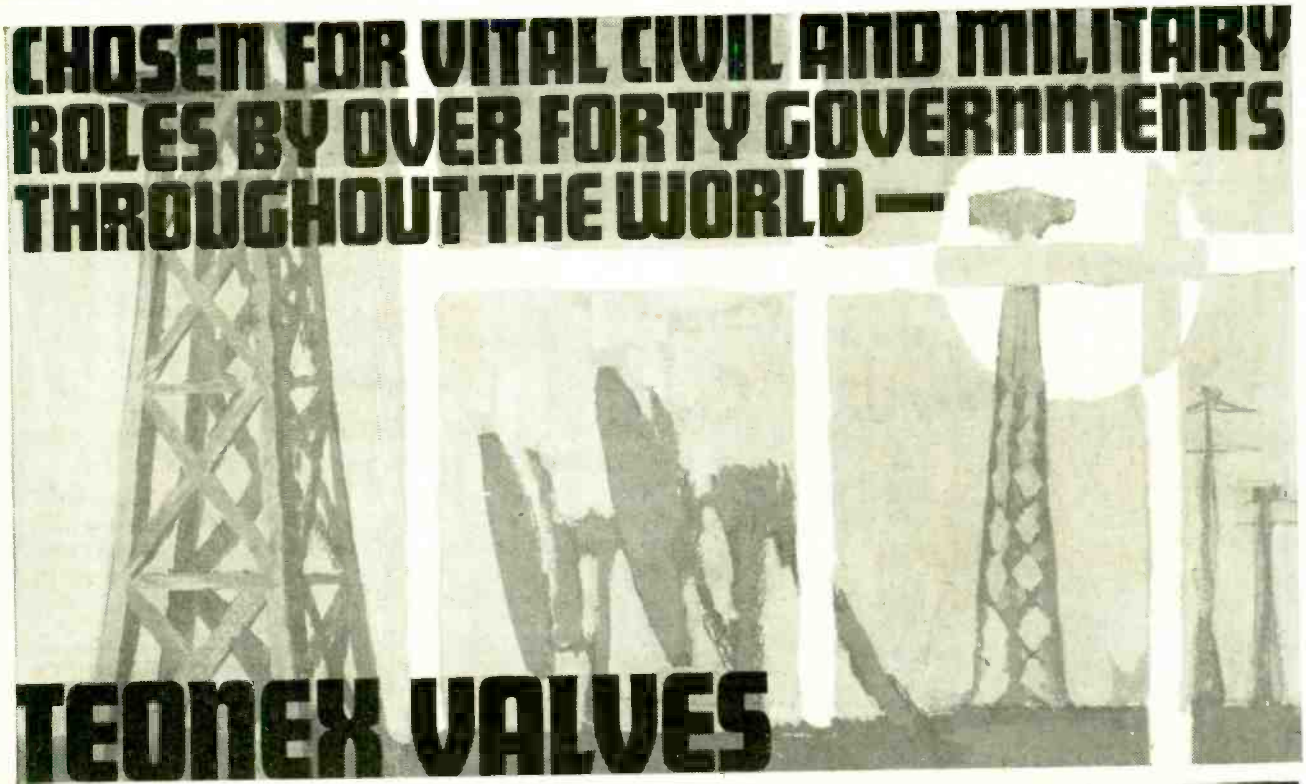
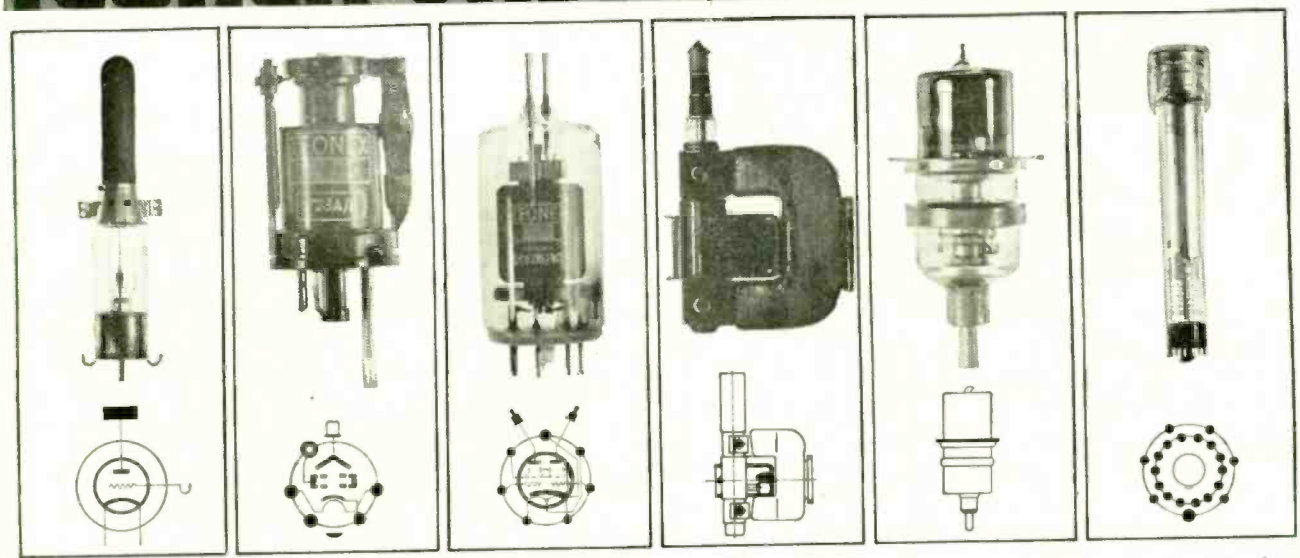
*RESLO also manufacture a complete range of public address equipment, including amplifiers; reflex horns, cabinet and line source loudspeakers; ribbon and dynamic microphones.*



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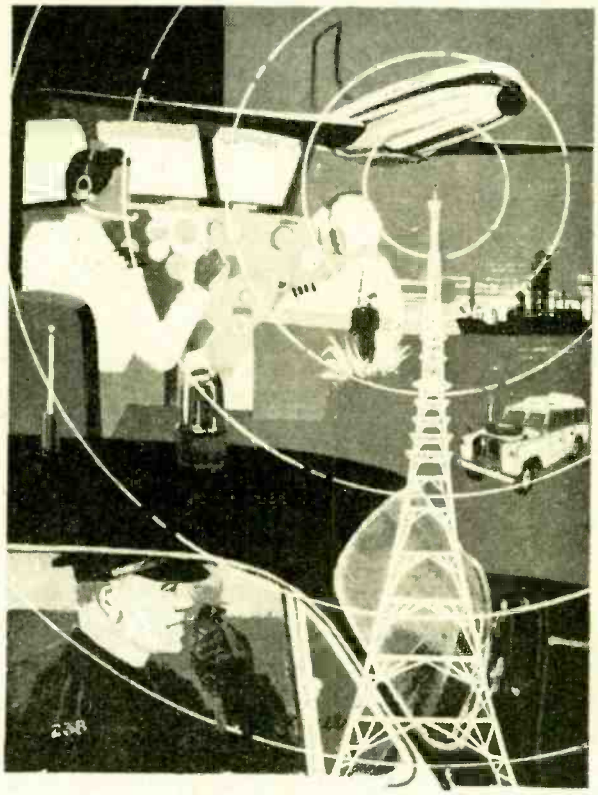
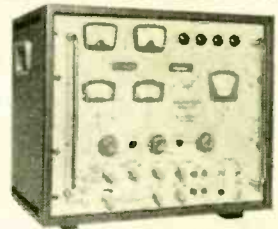


# 331.C FREQUENCY METER AND STANDARD SIGNAL GENERATOR



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**FANFLOW EXTRACTOR FANS.** Undoubtedly to-day's greatest bargain for domestic or industrial use. For 200/250 volts A.C. 7,500 cu. ft. per hour. Easily installed, fitted weatherproof louvres which open when motor is switched on and closed when off. Only 6½in. dia. Our nett price only **£6/15/-** (despatch 4/6).

**ELECTRIC FANS** (Papst), for extracting or blowing. The most exceptional offer we have yet made. 200/250 v. A.C. Induction motor—silent running. 2,800 r.p.m. duty 100 C.F.M. Only 4½in. square and 2in. deep. Ideal for domestic or industrial use. Easy mounting. **£3/5/-** (des. 3/6).

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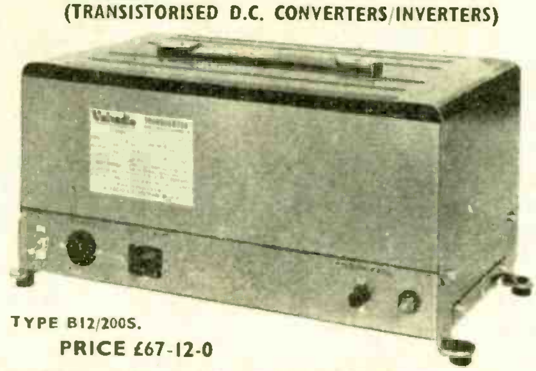
**(TRANSISTORISED D.C. CONVERTERS/INVERTERS)**



TYPE B12/200S.

**PRICE £67-12-0**

INTRODUCING THE VALRADIO "B" SERIES
SINEWAVE output 200W (120W also available).
FREQUENCY: 50 c/s ± ½ c/s (60 c/s to order).
OUTPUT V.: 115-230 v. ± 10%.
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★ FREQUENCY REGULATION OF ± .005% WITH ADDITIONAL "RESONATOR".
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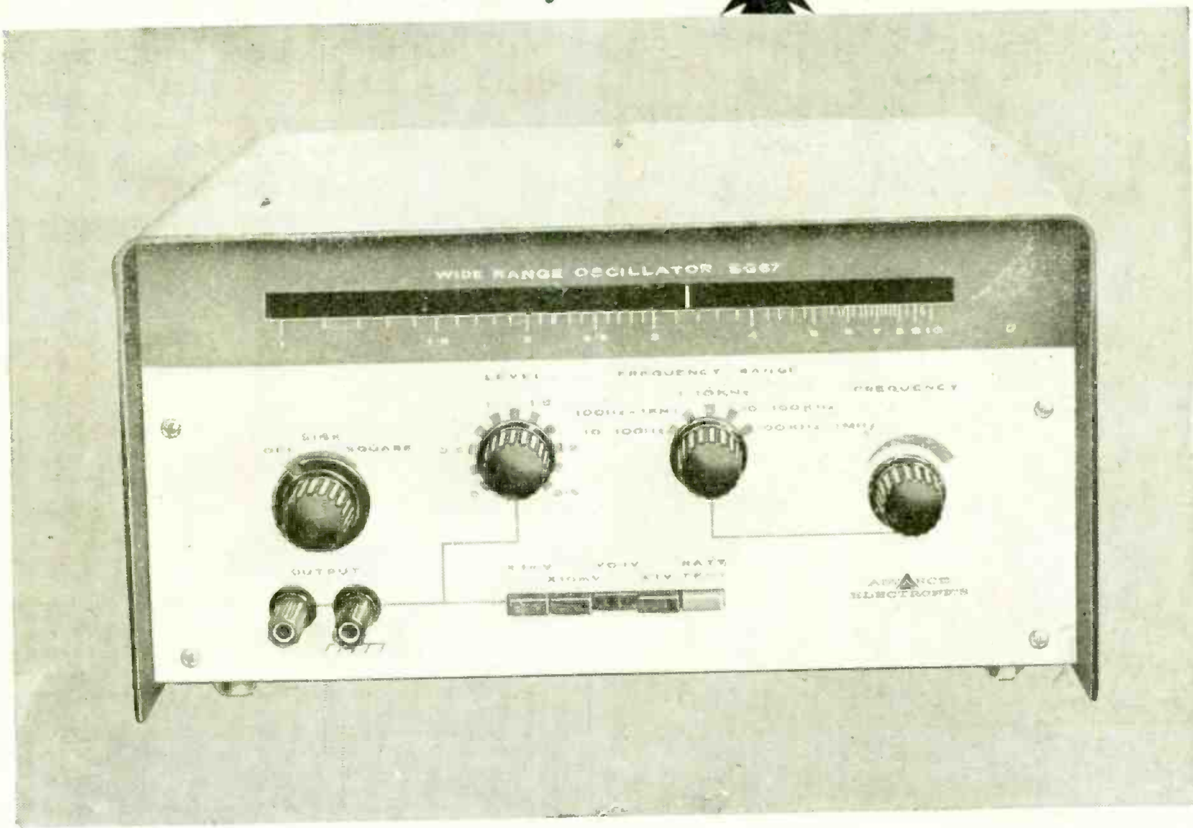


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# Wide Range Oscillator SG67

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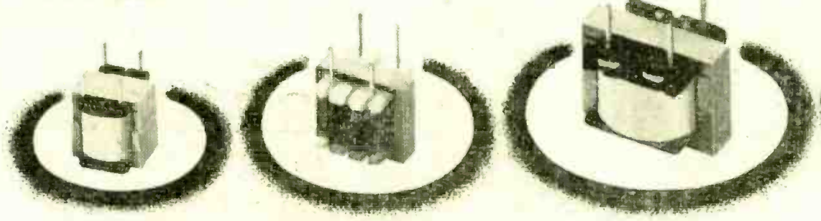

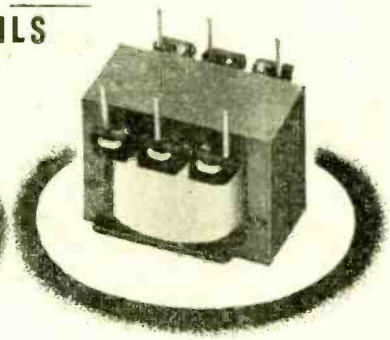

I. F. TFR. COUPLING TFR. O. P. TFR. MAINS TFR.

*(ILLUSTRATIONS—ACTUAL SIZE)*

**THE BELCLERE COMPANY LIMITED**

**COWLEY ROAD, OXFORD, ENGLAND. Tel. Oxford 77266**

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# RE-CREATES THE FINER SHADES OF ORIGINAL SOUND

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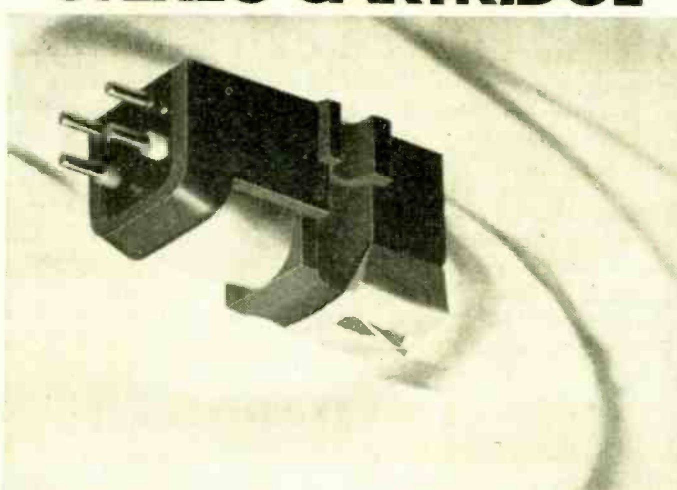
## GOLDRING '800' FREE FIELD STEREO CARTRIDGE



**GOLDRING "800" FREE FIELD STEREO CARTRIDGE £12.7.6** tax paid

SPECIFICATION

| | |
|---|---|
| Type | Magnetic—(Free Field) |
| Frequency Response | 20 Hz—20 kHz |
| Sensitivity | 1 mv. per cm/sec. |
| Separation | 25dB at 1kHz and nowhere less than 15dB |
| Load | 100k—47k/ohms |
| Compliance | 20 x 10—6 cm/dyne |
| Stylus | 0.0005" diamond replaceable |
| Effective Tip Mass | 1 mg. |
| Tracking Weight | 1—3 grms. |
| Head Weight | 8 grms. |
| Vertical Tracking Angle | 15° |

Mu Metal Shield for hum protection.

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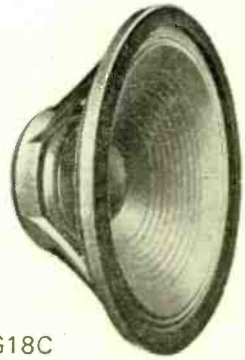
MF1000



G18C

Celestion POWER loudspeakers for the perfectionist

## —for guitars and organs

*Write for Catalogue No: RCS162*

## Rola Celestion Ltd.

Ferry Works, Thames Ditton, Surrey, England.
*Telephone:* 01-398 3402 *Telex:* 266135

GD972

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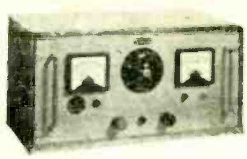
## VARIABLE—HIGH CURRENT SMOOTHED POWER SUPPLIES WITH ACCUMULATOR PERFORMANCE FROM A.C. MAINS



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

**PRICE: £131:5.0**

**FEATURES.** Type 250VRU 30/20. 0-30 v. Continuously Variable up to 20A.

**RIPPLE CONTENT.** Negligible. IMPEDANCE and REGULATION equivalent to accumulator performance SILICON RECTIFIERS. Inadvertent "SHORT" protection.

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**FIXED OUTPUTS** ALSO AVAILABLE. Smoothed 12 or 24 v. up to 24A.

**APPLICATIONS OPERATING AND SERVICING.** Transistorised equipment e.g. 12-24 v Mobile Radio Telephone. D.C. motors, etc., direct from AC—WITHOUT THE USE OF ACCUMULATORS.
AVOID THE EXTRA EXPENSE OF SUPER REGULATION YOU MAY NEVER NEED.

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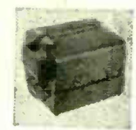

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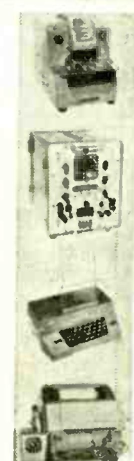
Picture Telegraph, Desk-Fax, Morse Equipment; Pen Recorders; Switchboards; Converters and Stabilised Rectifiers; Tape Holders, Pullers and Fast winders; Governed, Synchronous and Phonic Motors; Teleprinter Tables and Cabinets; Silence Covers; Distortion and Relay Testers; Send/Receive Low and High Pass filters; Teleprinter. Morse, Teledeltos Paper, Tape and Ribbons; Polarised and specialised relays and Bases; Terminals V.F. and F.M. Equipment; Telephone, Carriers and Repeaters; Multiplex Transmitters; Diversity Frequency Shift, Keying Equipment; Line, Mains Transporters and Suppressors; Racks and Consoles; Plugs, Sockets; Key, Push, Miniature and other Switches Cords, Wires, Cables and Switchboard Accessories; Teleprinter Tools; Stroboscopes and Electronic Forks; Cold Cathode Matrics; Test Equipment; Oscilloscopes; Miscellaneous Accessories and Spares.



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Celestion Studio Series loudspeakers for the perfectionist

HF1300 Mk. 2

CX2012

## —for high fidelity

*Write for Catalogue No: RCS 2002*

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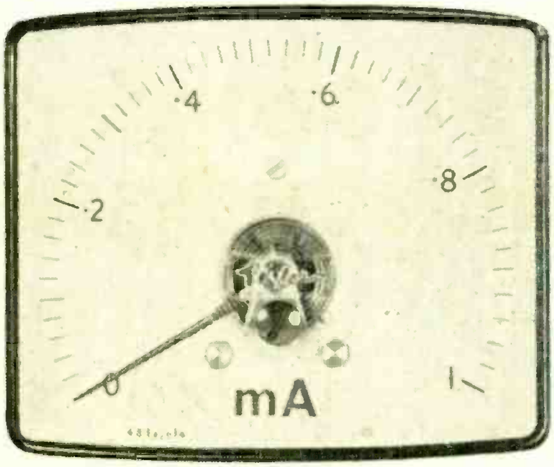


# 240°andfyne

The outlook is always favourable when you specify panel meters from the 'Wide Angle' range of Taylor Fynelines. These new Fynelines feature clear visibility of a precisely-marked full 240° scale. You get shadowless readings and the proven Taylor moving-coil movement with a standard accuracy of ±2% f.s.d. (±1% f.s.d. available). So set your course fair with 'Wide Angle' Fynelines.

Lance or 'knife edge' pointers are fitted and mounting arrangements are identical with existing Fyneline and Vista panel meters.

Complete technical and price details from **Taylor Electrical Instruments Ltd, Montrose Avenue, Slough, Bucks. Telephone: Slough 21381. Telex 84429.**

Taylor

T5

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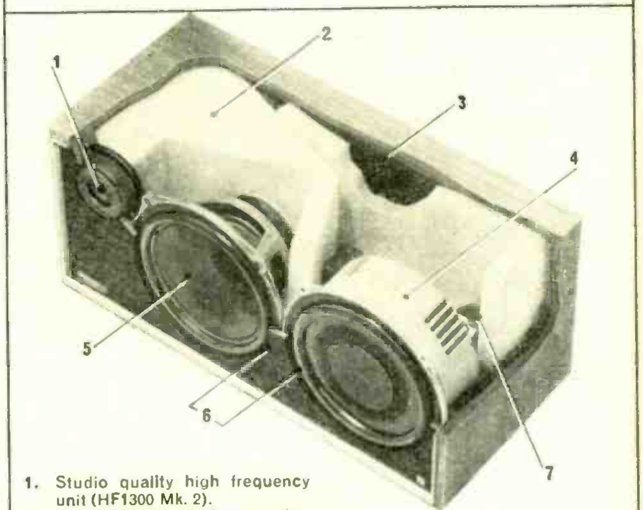
# Just what *is* this ABR, that makes such a vital difference to the 'DITTON 15'?




1. Studio quality high frequency unit (HF1300 Mk. 2).
2. Anechoic cellular foam wedge and lining eliminates standing waves.
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4. Auxiliary Bass Radiator (ABR) —plastic foam diaphragm giving high rigidity and low mass; double roll suspension allowing excursions up to 1" with minimal distortion.
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7. Full L-C half-section Crossover network.

**It's an interesting story – and worth enquiring about.**

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GD 997

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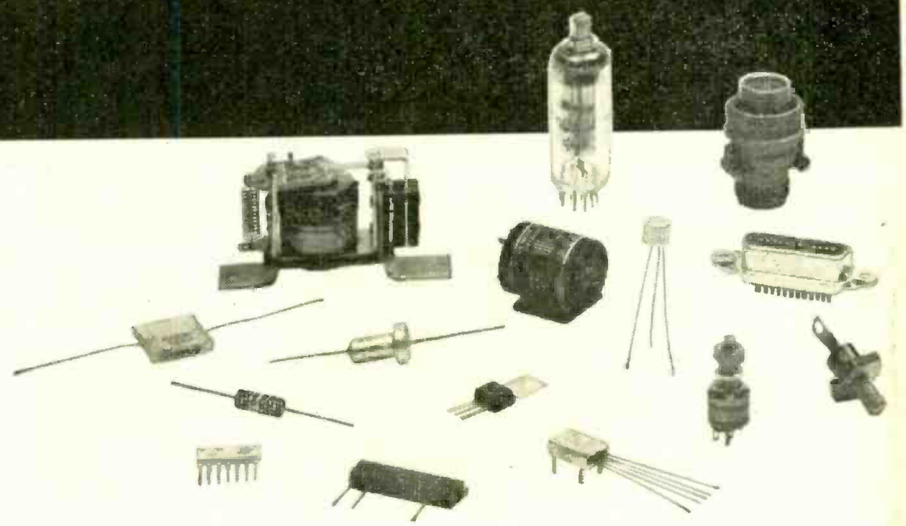
# Electronic components from the U.S.A.

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36 pages packed with detailed information on the widest range of variable transformers made by a single manufacturer in Europe. All listed standard models are in stock for immediate delivery from our trade counter or by mail order, and are backed by a year's guarantee and a first class repair and replacement service.

Ask for list MT/625 (3rd Edition) NOW!

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60B

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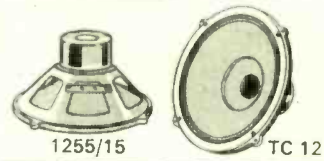
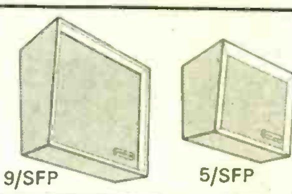
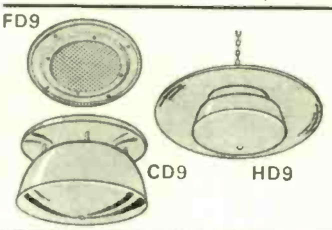
# LOUDSPEAKERS for every purpose




**High Flux**
high quality, wide frequency, highly sensitive Cone units.

**Cabinet speakers**
contemporary styling —painted and oak veneer types

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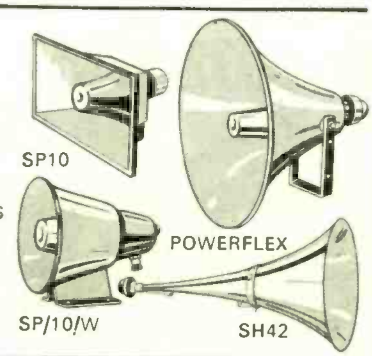
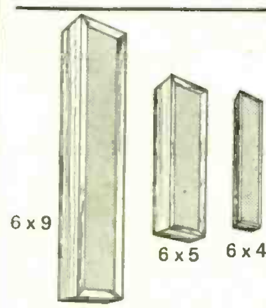
surface, flush and suspension types

**Projector loudspeakers**
Re-entrant and Exponential types for fixed and mobile use




**Column loudspeakers**
wood-cased and fibre glass types for indoor and outdoor use.

*Grampian* SOUND EQUIPMENT
*—integrity that you hear*

*Send for leaflet giving full details—*

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## AUDIO LABORATORY INSTRUMENTS

### LOW DISTORTION OSCILLATOR (Series 2)

An instrument of high stability providing very pure sine waves, and square waves, in the range of 5 Hz to 500 kHz. Hybrid design using valves and semiconductors.

**Specification**

| | |
|---|---|
| Frequency coverage: | 5 Hz-500 kHz (5 ranges) |
| Output Impedance: | 600 Ohms. |
| Output Voltage: | 10 Volts r.m.s. max. |
| Output Attenuation: | 0-110 dB continuously variable. |
| Sine Wave Distortion: | 0.005% from 200 Hz to 20 kHz increasing to 0.015% at 10 Hz and 100 kHz. |
| Square Wave Rise Time: | Less than 0.1 microseconds. |
| Monitor Output Meter: | Scaled 0-3, 0-10, and dBm. |
| Mains Input: | 100 V.-250 V. 50/60 Hz. |
| Size: | $17\frac{1}{4} \times 11 \times 8$in. |
| Weight: | 25 lb. |
| Price: | £125. |

Rack mounting version available.

### DISTORTION MEASURING SET (Series 2)

A sensitive instrument for the measurement of total harmonic distortion, designed for speedy and accurate use. Capable of measuring distortion products as low as 0.002%. Direct reading from calibrated meter scale.

**Specification**

| | |
|---|---|
| Frequency Range: | 20 Hz-20 kHz (6 ranges) |
| Distortion Range: | 0.01%-100% f.s.d. (9 ranges) |
| Sensitivity: | 100 mV.-100 V. (3 ranges) |
| Meter: | Square law r.m.s. reading. |
| Input Resistance: | 100 kOhms. |
| High Pass Filter: | 3 dB down to 350 Hz.<br>3 dB down to 35 Hz. |
| Frequency Response: | ±1 dB from second harmonic of rejection frequency to 250 kHz |
| Power Requirements: | Included battery. |
| Size: | $17\frac{1}{4} \times 11 \times 8$in. |
| Weight: | 15 lb. |
| Price: | £90. |

Rack mounting version available.

### VOLTMETER (new item)

A transistor operated voltmeter satisfying the requirements for audio frequency measurement.

**Specification**

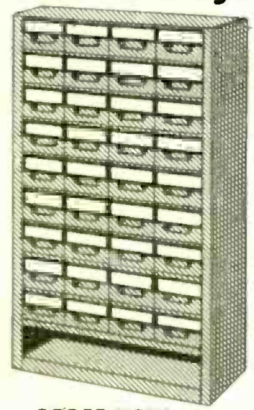
| | |
|---|---|
| Sensitivity: | 1 mV.-300 V. f.s.d. (12 ranges) |
| Calibration Accuracy: | 2% f.s.d. |
| Frequency Response: | ±1 dB. 10 Hz-500 kHz. |
| Input Impedance: | 1 MOhm. 1 mV.-300 mV.<br>10 MOhm. 1 V.-300 V. |
| Meter Scaled: | 0-3, 0-10, and dBm. |
| Power Requirements: | Included battery. |
| Size: | $11\frac{1}{2} \times 6\frac{1}{2} \times 6$in. |
| Weight: | 7 lb. |
| Price: | £35. |

**RADFORD LABORATORY INSTRUMENTS LTD**

Ashton Vale Road
Bristol 3

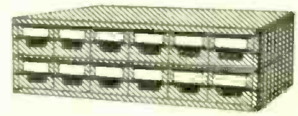
WW—084 FOR FURTHER DETAILS

# Those transistors cost money! Protect them!!



**36A SPACESAVER DRAWER UNIT** 42″ high, $24\frac{1}{2}$″ wide, 12″ deep. 36 drawers each 3″ high, $5\frac{1}{4}$″ wide, $10\frac{7}{8}$″ deep, with identification cards.

(CARRIAGE FREE ON MAINLAND) **£12.0.0 BRAND NEW**



**12A POPULAR DRAWER UNIT** 9″ high, 35″ wide, 12″ deep. 12 drawers each 3″ high, $5\frac{1}{4}$″ wide, $10\frac{7}{8}$″ deep, with identification cards. Ideal for shelf or table-top.

**£4.15.0 BRAND NEW**

**ORDER NOW**
Send for FREE catalogue of our complete range of storage equipment.

**N.C.BROWN LTD**
INDUSTRIAL SALES DIVISION
pacesetters in storage equipment

Eagle Steelworks, Heywood, Lancs. Tel: 69018
London: 25/27 Newton St. WC2. Tel: 01-405-7931

Please send ☐ 36A Spacesaver Drawer Unit
☐ 12A Popular Drawer Unit

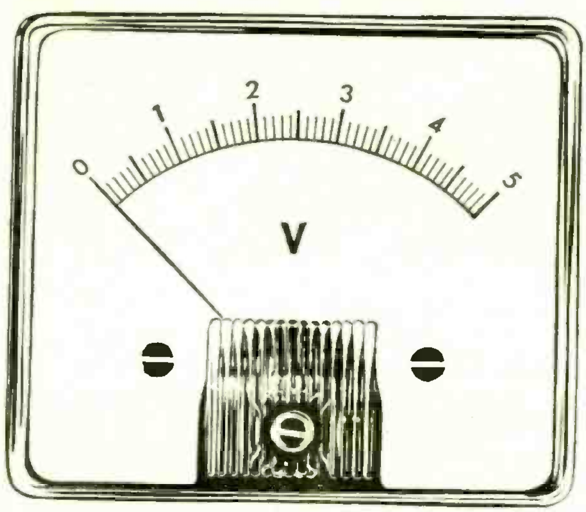
Tick where applicable and send cash with orders under £5

NAME ........................................

ADDRESS ........................................ E29

WW—085 FOR FURTHER DETAILS

# METER PROBLEMS?




A very wide range of modern design instruments is available for 10/14 days delivery.

Full information from:

**HARRIS ELECTRONICS (London) LTD.**
138 GRAYS INN ROAD, W.C.1 Phone: 01/837/7937

WW—086 FOR FURTHER DETAILS

# The new JT makes you wonder how small a connector can get

No connector could be more appropriate to modern space-saving requirements than the new JT. It's lighter, shorter and considerably more compact than anything of its type at present available. Simply designed (with fewer components) and precision made, the JT sets an entirely new standard in reliability for connectors. It is at home in conditions ranging from cryogenic to high temperature, offering much greater freedom to designers in many different fields.

AVAILABLE NOW – with up to 128 contacts in less than $1\frac{1}{2}''$ diameter.

**Already in use on over 80 international projects.**

| | |
|---|---|
| JTA – general duty types. | JTC – Pressurised styles. |
| JTG – for RFI protection. | JTH – Hermetically sealed. |
| JTP – for potting. | JTRE – Crimped contacts. |
| JTS – for high temperatures. | JTL – 100% scoop proof. |

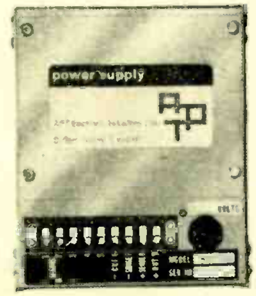
**There is a Thorn connector for every purpose!**

**THORN SPECIAL PRODUCTS LIMITED** Great Cambridge Road, Enfield, Middlesex. 'Phone: 01-363 5353; Telex: 263201-2-3
A SUBSIDIARY COMPANY OF THORN BENDIX LIMITED

AP11

WW—087 FOR FURTHER DETAILS

# This is an illustration of sixty-two different power units




Concealed behind this $4\frac{3}{8}'' \times 5\frac{1}{8}''$ front panel is a standard range of parts manufactured in large quantities, resulting in low production costs. The saving is passed on to you without affecting the superior performance and high reliability. For example, you can have a pre-set unit in the range 11 to 28 volts at 4 amps for as little as £34.

The 62 units in the new Series 30 range cover voltages from 0 to 500 with output currents up to 10 amps, depending on the voltage. A choice of protection circuits is available including 'crowbar' for your integrated circuits.

For complete details of this new approach to power supply design send for Series 30 full-colour folder and price list.

A.P.T Electronic Industries Ltd. Chertsey Rd., Byfleet, Surrey. Tel: Byfleet 41131.

WW—095 FOR FURTHER DETAILS

# Wireless World

ELECTRONICS TELEVISION, RADIO, AUDIO

## FEBRUARY 1968



## SHORT ITEMS



## REGULAR FEATURES



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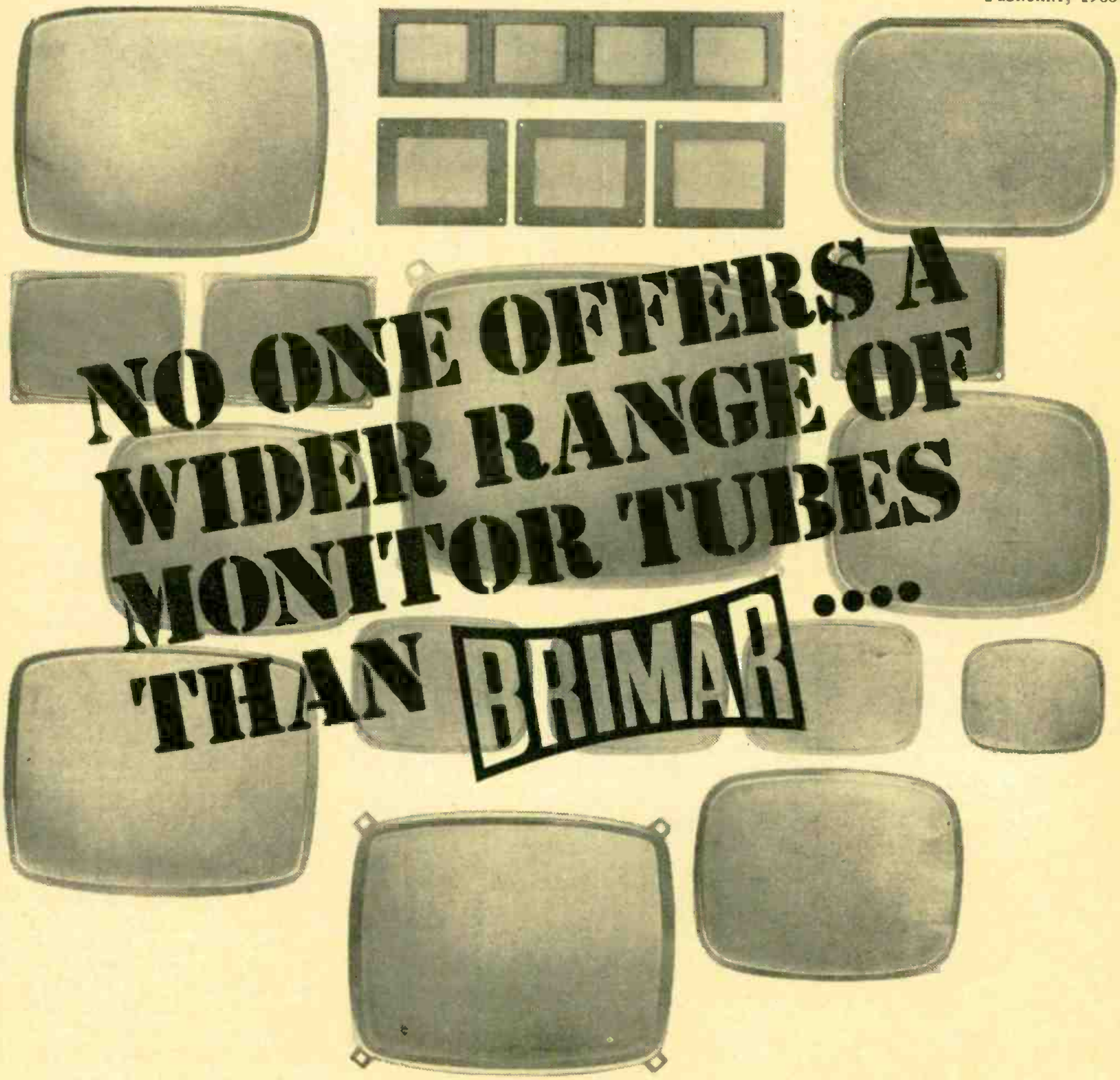



BRIMAR offers the most comprehensive range of monitor tubes in the country, together with the widest selection of phosphors.

**The tubes** range in size from 5" to 23". They can be used for television camera viewfinders, studio quality monitors, data displays and closed circuit television – twenty tubes in all! They have been designed to give maximum resolution under high ambient lighting conditions.

A variety of mounting and implosion protection methods, including self protection bonded glass faces are available from BRIMAR who are Britain's leaders in implosion protection.

Common features include magnetic deflection, electrostatic focus and aluminised screens.

**The phosphors.** In addition to the standard type for television, a wide selection of others is available offering varying degrees of persistence and colour.

# ....OR A MORE PERSONALISED SERVICE!

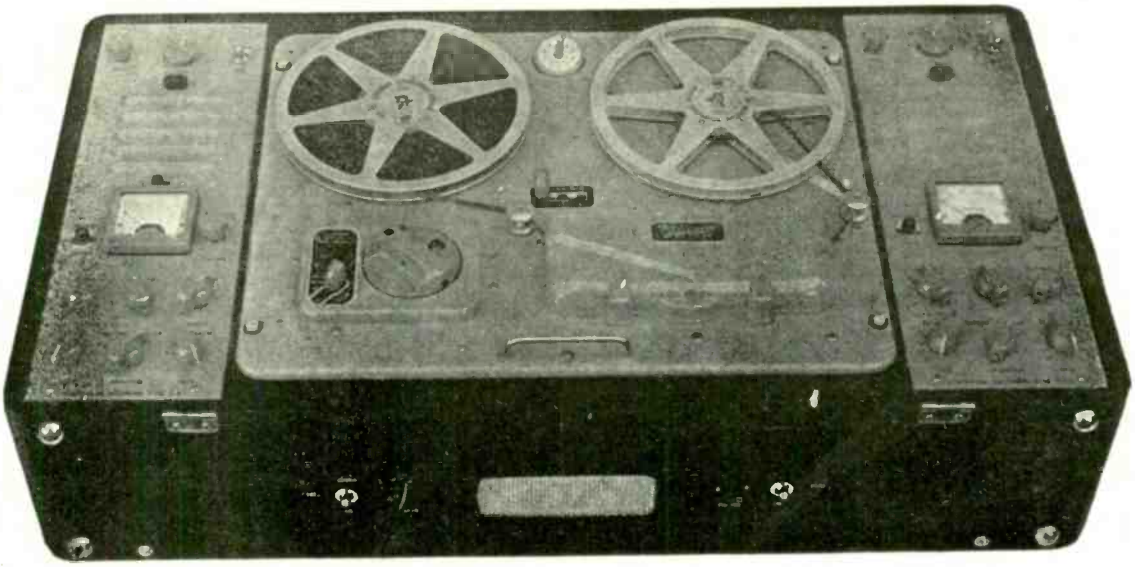
Every BRIMAR tube is backed by a first-class technical service and assistance on any type of problem involving its use in monitors – from special characteristics to circuit design. BRIMAR engineers are always available – contact is on a personal basis. Please telephone or write for full details.

**Thorn-A.E.I. Radio Valves & Tubes Ltd.**
7 Soho Square, London W1. Telephone: 01-437 5233

TA 6959

# *Vortexion* quality equipment

# TYPE C.B.L. TAPE RECORDER



Here is a versatile stereophonic recorder which has no equal in its price group.

IT CAN record monaurally or stereophonically with its own mixed inputs from Gram, Radio or other sources and from high grade low impedance balanced line microphones. With good microphones, etc., the result is a suitable master for disc manufacturers. " Before and After " monitoring is provided together with adjustable metered bias for perfection.

IT CAN also make a recording on one track and then transfer it to the other track while measuring and listening to it and adding one or two more signals also metered. A special PPM type meter is now used.

IT CAN repeat the process and transfer this combined signal to the first track with one or two more signals. Composers use it for this purpose. One track may have music or commentary and the other cueing signals or commentary and either may be altered without the other.

IT CAN play back stereophonically or monaurally with its own amplifiers of $3\frac{1}{2}$ watts each.

Speeds $1\frac{7}{8}/3\frac{1}{4}/7\frac{1}{2}$ i.p.s. Price **£172 0s. 0d.**
Speeds $3\frac{3}{4}/7\frac{1}{2}/15$ i.p.s. Price **£180 0s. 0d.**

The Vortexion W.V.B. is a high quality monaural machine with " Before and After " monitoring. The recording inputs are a high sensitivity socket for moving coil or ribbon microphone and a high impedance socket for radio, etc., either of which can be selected by a switch. Superimposing and echo work can be done and the playback has reserve gain for abnormal requirements. This model cannot be converted for stereo playback, but it is a thoroughly reliable machine for the engineer specialising on monaural work.

Speeds $1\frac{7}{8}/3\frac{3}{4}/7\frac{1}{2}$ i.p.s. Price **£115 10s. 0d.**
Speeds $3\frac{3}{4}/7\frac{1}{2}/15$ i.p.s. Price **£128 0s. 0d.**

The Vortexion W.V.A. is a monaural machine which has a performance equal in sound quality to the other models. It possesses all the features of the W.V.B. except for " Before and After " monitoring, Dubbing and Echoes. The recording being made can be heard on the internal loudspeaker as in the W.V.B. and C.B.L. The controls are uncomplicated.

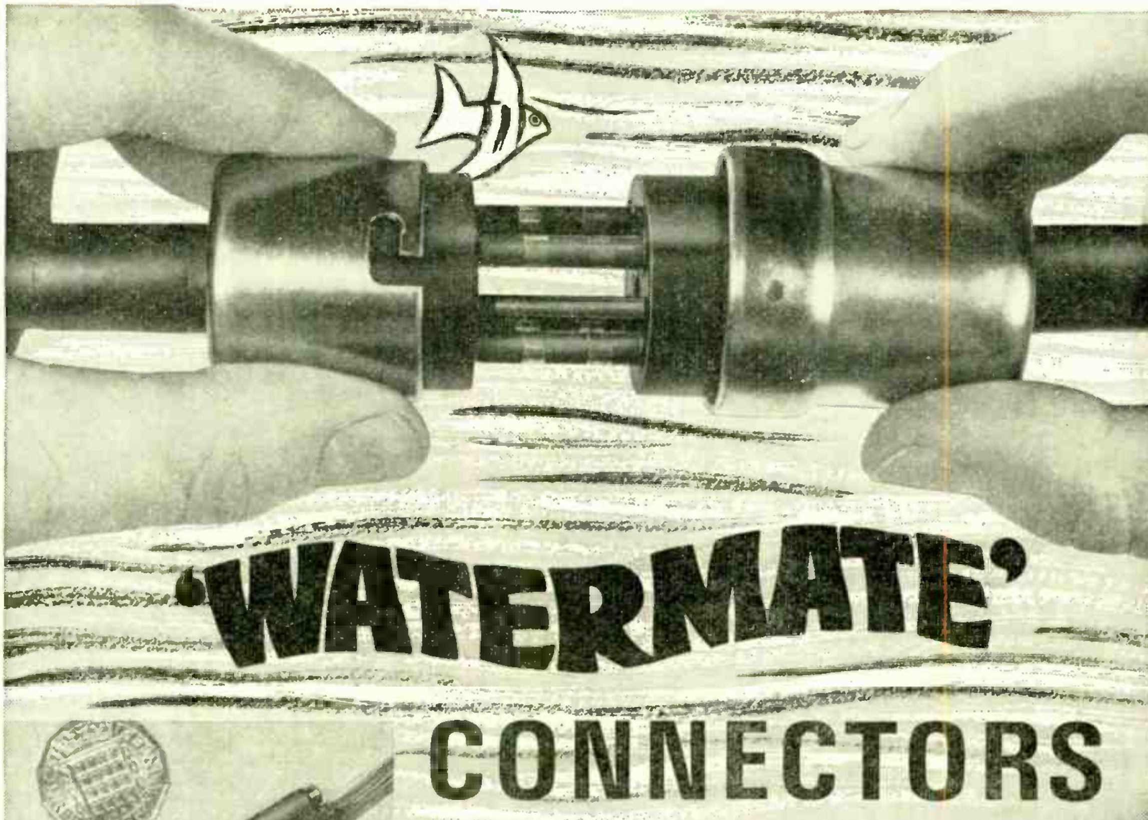
Speeds $1\frac{7}{8}/3\frac{3}{4}/7\frac{1}{2}$ i.p.s. Price **£96 7s. 0d.**
Speeds $3\frac{3}{4}/7\frac{1}{2}/15$ i.p.s. Price **£107 3s. 0d.**

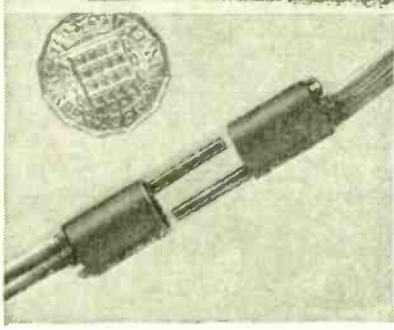
All tape recorders have adjustable bias controls, low impedance mic. inputs for unlimited lengths of cable, highly accurate position indicators and meters to measure recording level and bias.

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

Telephone: 01-542-2814 and 01-542-6242/3/4 Telegrams: "Vortexion London S.W.19"

WW—100 FOR FURTHER DETAILS



Depicted here are typical examples of a range of Waterproof Connectors of unique design enabling electrical circuits to be connected or disconnected even when under water. The range caters for electrical loads of 440 volts a.c. 175 amps. down to the signal current levels associated with instrumentation and similar arrangements.

The basic design incorporates a patented principle referred to as "Watermate". Both plug and socket are moulded of a specially compounded neoprene rubber with unusually high insulation resistance and non-wetting surface. As mating occurs water, salt deposits, sand and other foreign matter are wiped from the sockets and ejected from a duct in the socket to form a leak-proof seal. The wiping action assures a dry connection at the moment of contact resulting in a leakage resistance of not less than 100 megohms WHEN MATED UNDER WATER.
They are pressure balanced and will not block up under high pressures. There are no glands or threads to seize up in water and the method of moulding to the associated neoprene jacketed cable provides an extremely robust and simple connector for both Military and Civil applications.
For full details of these Connectors and a new Underwater Reed Switch Assembly, please write or telephone to the Technical Sales Department.

**McMURDO**

McMURDO INSTRUMENT CO. LTD., RODNEY RD, FRATTON, PORTSMOUTH, Tel: Portsmouth 35361 Telex: 86112
LUGTON & CO. LTD., 209/210 Tottenham Court Road, London, W.1. Tel.: Museum 3261.
SASCO. P.O. Box No. 20, Gatwick Road, Crawley, Sussex. Telephone: Crawley 28700 (also: Chipping Sodbury 2641. Cumbernauld 25601. Hitchin 2242).
**ARGENTINA:** Corte & Mon S.R.L., Salta 1325, BUENOS AIRES. **AUSTRALIA:** McMurdo (Australia) Pty. Ltd., 15 Edinburgh St., Huntingdale, VICTORIA. **AUSTRIA:** Lipschitz & Co. Biberstrasse 22, VIENNA I.

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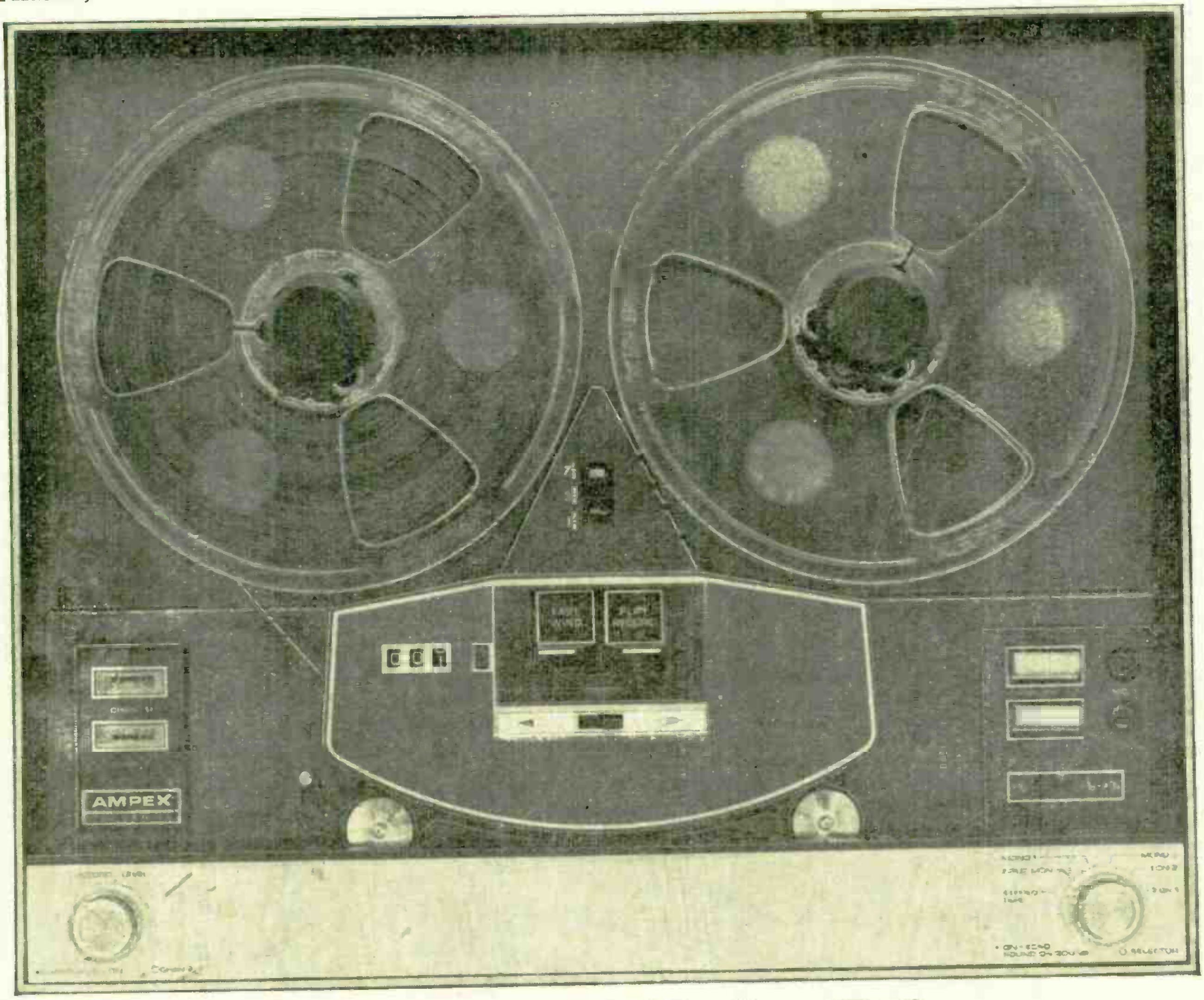



# It's Ampex. It's 91 gns

The new Ampex 753 Tape Deck (complete with pre-amplifiers) gives you these important new features:
☐ **off-tape monitoring** ☐ **sound-on-sound**
☐ **sound-with-sound** ☐ **echo control**

The 753 is specially engineered for sound-on-sound recording and monitoring. You can mix narration with music tracks—add sound and music to your home-produced programmes. You get the famous Ampex stereo fidelity too. Precision engineering. And better performance than any price-range competitor. Plus ☐ **rigid block construction**—tapes align with heads to one thousandth of an inch, and the 753 finds every sound on the tape. ☐ **deep-gap heads** give three years' peak performance—few other makes give more than one year. ☐ **stereo 4-track** ☐ **dual-capstan drive** ☐ **3 speeds** ☐ **digital counter** ☐ **fast wind** ☐ **solid state throughout** ☐ **vertical or horizontal operation** ☐ **available in teak case.**

For further information and list of dealers in the U.K. send coupon below, or write to: Ampex Great Britain Ltd., (Dept WW2 Acre Road, Reading, Berkshire.

*Please send me 753 details and dealer list.*

Name ____________________

Address ____________________

____________________

____________________

____________________

AMPEX

CA-9 WW2

WW—102 FOR FURTHER DETAILS

# MST SUCCESS

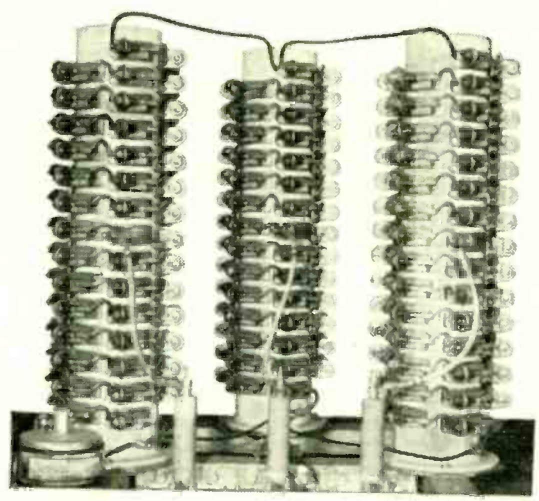
## SALES NOW EXCEED £10,000,000

More and more countries are buying Marconi Self-Tuning h.f systems . . .

and one good reason is:

## INCREASED RELIABILITY

- Wideband and distributed amplifiers simplify and reduce the number of moving parts, which are to the highest engineering standard, thus minimising mechanical failure.
- Silicon diode rectifiers, vacuum variable capacitors and extensive use of solid-state techniques give optimum reliability.
- MST receivers are all solid-state, eliminating mechanical variable capacitors and telegraph relays.



## and other good reasons are:

### Reduced capital outlay
MST designs reduce demands for space and need for standby equipment. Installation costs are decreased.

### Economy of manpower
High equipment reliability together with full remote control facilities permit unmanned station working. Complete h.f systems can be controlled by one man.

### Traffic interruption reduced
Frequency changes and retuning accomplished in less than one minute without loss of traffic.

### World-wide acceptance
30 countries throughout the world have ordered more than £10,000,000 worth of MST equipment to improve their communications services.

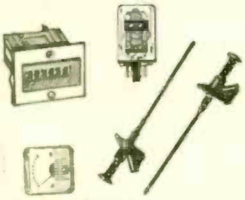
**Marconi** telecommunications systems

The Marconi Company Limited, Radio Communications Division, Chelmsford, Essex, England

LTD/H78

AN 'ENGLISH ELECTRIC' COMPANY

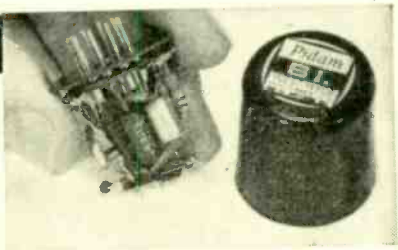
# CONTIL AND PIDAM SYSTEMS



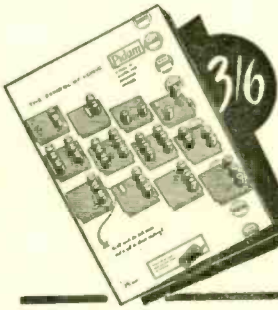
**ACCESSORIES**
A full range of accessories are available for PIDAM. Shown are the meter, scaled 0-9, at 35/6. Test prods insulated and flexible with fine steel clips at the tip, red or black at 13/-. High speed resetting counter including bezel and socket, with speed of over 40 operations per sec. 165/-. Plug-in Octal relay 24v. with two changeover at 17/6. Not shown: 8 range test meter, 42/-. Oscilloscope made for us by Advance, £25.

**PIDAM** (Plug-in Digital and Analogue Modules) perform all the usual logic functions, but, unlike other units, can be plugged in, using their B9A bases and can be quickly connected to the required configuration. To help learning, the module covers are easily removable for circuit examination and sets of components are available.
The 16 modules have an enormous range of use, from a single MONO for a tachometer, to over 300 units in a computer interface; nevertheless, their greatest asset is extreme simplicity. Design time is cut and elaborate breadboards superseded and any reader of "Wireless World" could, with **PIDAM**, build up a low cost system for his own needs.

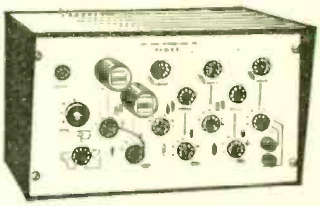
**PIDAM PLUG-IN MODULES, PRICES**
per module range from 9/6 to 28/- and all necessary accessories are supplied. A complete starting kit is only £19/19/-. (normally £22/16/-).



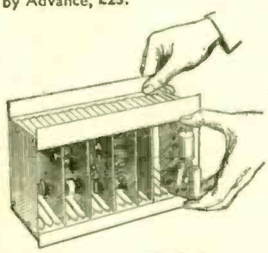
**BI** (Bistable) module shows B9A base for ease of connection, Pins 7, 8, 9 are always power connections.

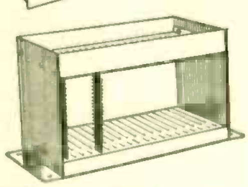


**PIDAM BROCHURE**
Send for this complete explanatory booklet showing detailed examples of use and circuit diagrams of all modules. Examples and circuits given include voice-operated switch alarms, flashers, tachometer, timers, batch counters, etc. 3/6 post free.



**PIDEC**
(Plug-in Digital Educational Circuit.) This Pidec unit allows seven modules to be interconnected for demonstration or mock-up without soldering. Including internal power supplies, 370/-.





**PRINTED CIRCUIT CHASSIS**
Printed circuit chassis type "P" which fits into 1277 or 16127 case, or type "Q" which can be mounted on an aluminium chassis. Both types take up to 20 boards and connectors on ½" centres. Prices from 45/6 down to 37/- for quantities.

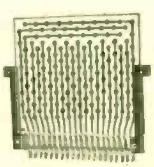
## CONTIL CASES

Contil cases are mass-produced to give the lowest prices yet. In 21-gauge steel. Finished hammer blue, with 18-gauge front panel supplied with easy-to-strip protective covering for easy marking out. For ease of ordering Contil cases are described by their dimensions, i.e. 755 is 7"×5"×5". Individually packed, inc. feet and screws.

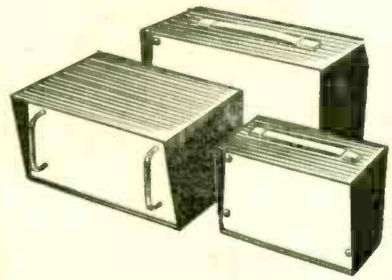
Range of chromium-plated and Delrin handles available with matching chassis, spare panels, etc.

| | ONE | FIVE |
|---|---|---|
| 755 | 45/6 | 44/- |
| 867 or 975 | 47/6 | 46/- |
| 1277 | 53/- | 51/- |
| 16127 | 98/6 | 96/6 |
| 191010 | 133/- | 130/- |

Kit £11/19/- (normally £14/12/).

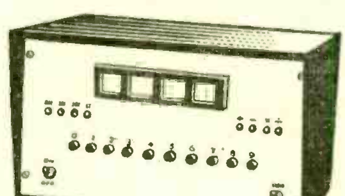


"A" board shown plugged into "M" 20-way connector with "S" board supports. Note: Power supply rails at right angles to signal rails "A" boards, 8/6 each. 20-way "M" connector 9/-. "S" supports 3/- pair. Less for quantities.



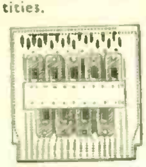
**"BRIGHTLIFE" NEONS**
25,000 hr. average life with high intensity and resistor in housing; either ⅜" or ½" dia. Standard units 160-250v. with 6" lead variants. 10 at 2/6 each with 10 different caps. In quantity down to 1/7 each. Neon only, down to 6½d each.

**SUB-MINIATURE NEON**
The smallest yet. Type "Q" overall dia. $\frac{3}{16}$", body length $\frac{7}{16}$". With resistor for mains, 3/9 each. Minimum quantity 10. Down to 2/6 each.

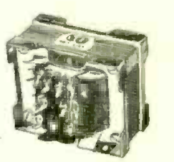


**DIGITAL COMPUTER MODULES**

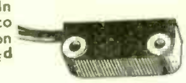
Digital computer modules are available including bistables, flip flops, comparators (coincidence gate), neon driver, 5NOR, 2NOR×2, 5NAND, and RESET. Also available are neons for driv by transistors, display boards, divide boards, together with escutcheons that only require round holes



**DIVIDE BOARD**
The Contil divide board can be used for decoding from 9 bistables giving a count up to 512. Includes resetting and decoding diodes and switches. Type "R" at 78/- each.



**TRANSFORMERS**
Two West Hyde transformers are available for transistorised equipment one at 2 amps, giving 6, 10, 15, 18 and 30v. i.e., 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 24 and 30 with 12-0-12 and 15-0-15. The second at 1 amp. 6, 10, 18v. taps. Price 34/- and 25/-.



**REED SWITCH**
The West Hyde Reed Switch works at up to 2,000 times a second for more than fifty thousand million operations. Ideal for: over and under speed monitors, counting, timing, switching, rev. counting, etc. Hermetically sealed and moulded. Prices from 14/- each to 7/6 each per thousand.

**CONTIL LOW COST PRINTED CIRCUIT BOARDS**

| | ONE | TEN | FIFTY |
|---|---|---|---|
| Standard transistor board | 8/6 | 7/6 | 7/- |
| Half board B9A | 7/- | 5/6 | 4/6 |
| B7G or B9A boards inc. their four respective bases | 9/6 | 8/6 | 8/- |
| Connectors, 20 way | 9/- | 8/6 | 8/- |
| 10-way | 5/- | 4/6 | 4/- |
| "P" chassis to fit 1277 Contil | 39/6 | 37/6 | 37/- |

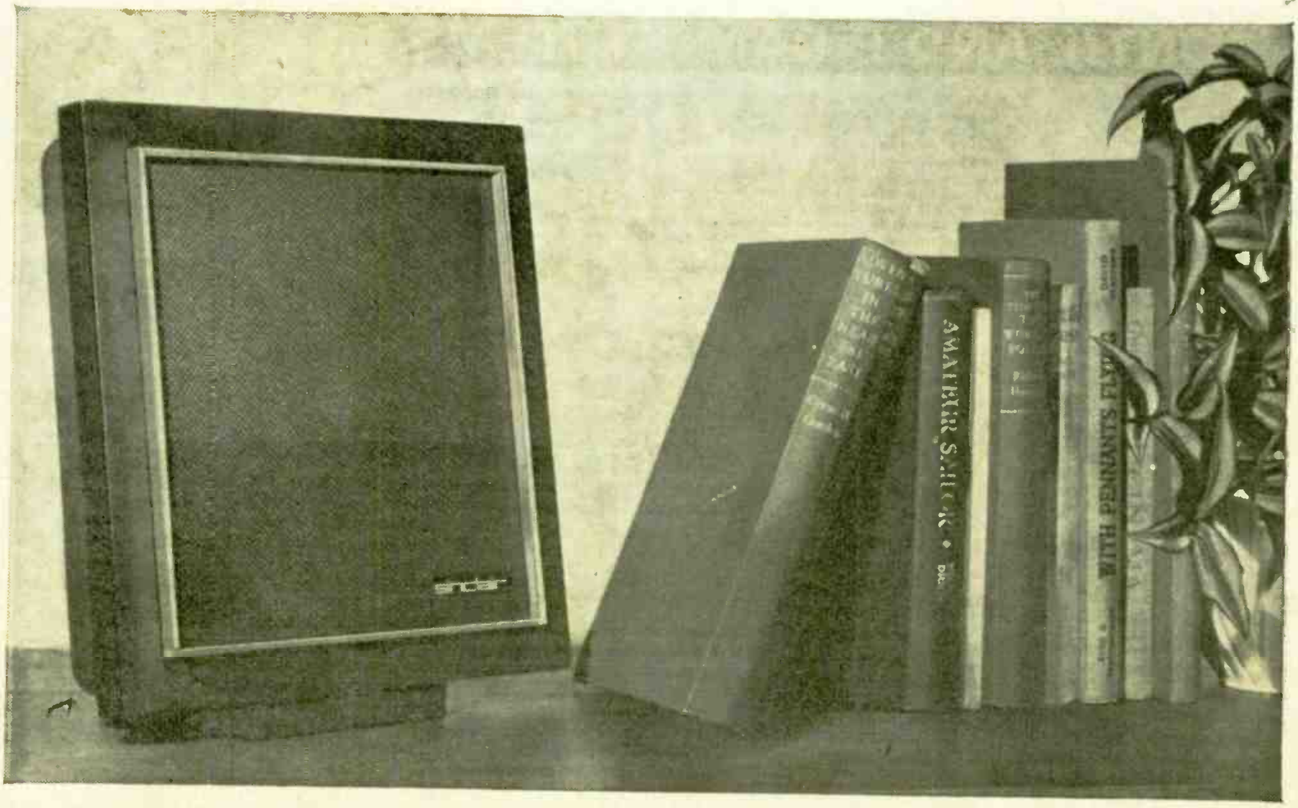
Printed circuit kit: including case, normally £14/8/6 for only £11/19/6.

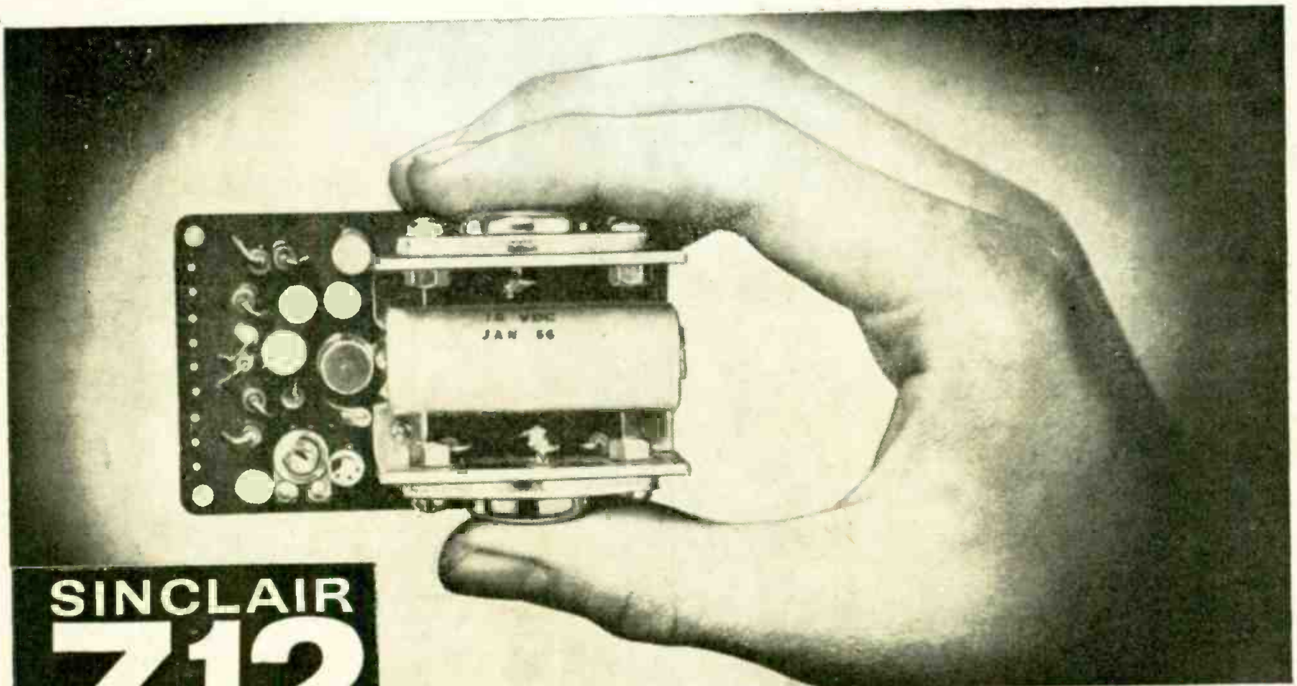
**PLEASE NOTE**
All products ex-stock for normal quantities. Return of post service. No S.A.E. Minimum order £1. Fully detailed leaflets available. All prices include postage and packing.

W H WEST HYDE

**WEST HYDE DEVELOPMENTS LTD.**
30 HIGH STREET, NORTHWOOD, MIDDLESEX
Tel: Northwood 24941

WW—105 FOR FURTHER DETAILS






# SINCLAIR Z.12

## COMBINED 12 WATT HI-FI AMP AND PRE-AMP

# Fantastic power & versatility

- 12 Watts R.M.S. continuous sine wave. (24 w. peak.)
- 15 watts music power (30 w. peak.)
- Ultralinear class B output
- Input —2mV into 2 K/ohm
- Output suitable for 15, 7.5 and 3 ohm speakers. Two 3 ohm speakers may be used in parallel
- 15-50,000 c/s ±1dB
- Ideal for battery operation
- 3" x 1¾" x 1¼"

BUILT, TESTED AND GUARANTEED

**89/6**

The Z.12 proves beyond all question that high-fidelity can be combined with very low price. No other integrated amplifier system so successfully meets such a wide range of requirements. The Z.12 will operate from any power supply between 6 and 20 v. D.C. The output is suitable for any impedance between 1.5 and 15 ohms, and consequently for any loudspeaker including, of course, the Sinclair Q.14. This remarkable amplifier has facilities for matching to any types of conventional inputs, details of which are given in the Z.12 manual supplied.
Included amongst popular applications for the Z.12 are mono and stereo high fidelity systems (two are needed for stereo), guitars, electric organs, car radios and P.A. and intercom systems, etc. It is also of great value in experimental work where dependable standards are required.

***"All you claim for it"***
"The Sinclair Z.12 is all and more that you claim for it. Its performance is outstanding. Thank you for your prompt service."—S/Sgt. R . . . ., B.A.O.R.

***"Performance excels that of many systems"***
"I have built a stereogram employing 2 Z.12 amplifiers and a PZ.3. I am delighted with the reproduction which is better than some I have heard costing over double the price. It has also silenced some of the old brigade who stubbornly believe that nothing can beat valves." —R.H., Argyll.

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For use with two Z.12s or any hi-fi stereo system. Frequency response 25 c/s to 30 kc/s ±1dB. Switched inputs for P.U., Radio, Microphone, etc. Equalisation correct to within ±1 dB on RIAA curve from 50 to 20,000 c/s. 6¼in.×2¼in.×2¼in. plus knobs. BUILT, TESTED AND GUARANTEED **£9.19.6**

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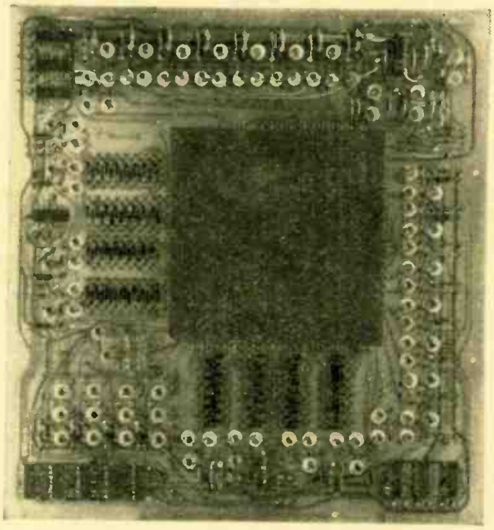

MEASURING 11" × $10\frac{1}{4}$" × $1\frac{1}{8}$"

This model is one of a range of Core Stores offering a variety of word/bit combinations.

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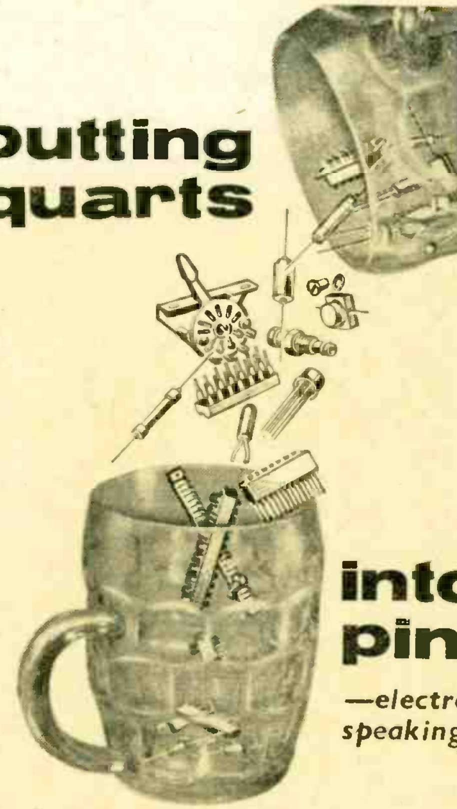

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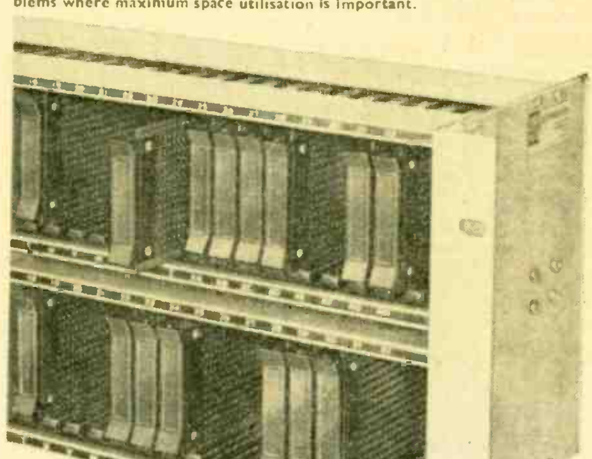

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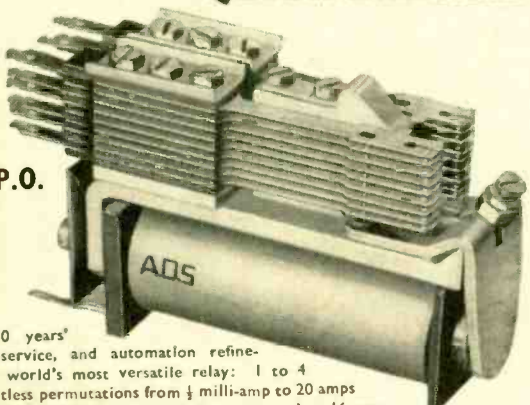


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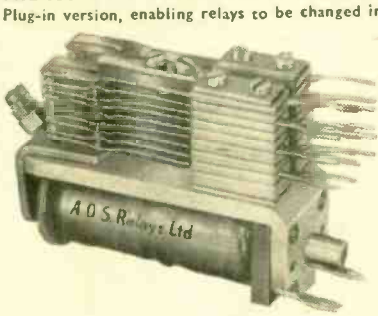


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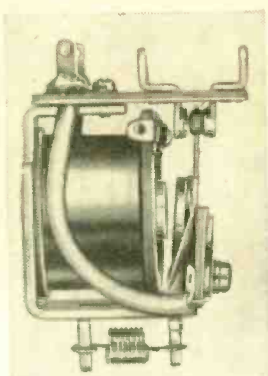

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# NEW SWITCHED ATTENUATOR

Type 687E


## *600 ohms impedance

The new Hatfield type 687E Switched Attenuator extends the present range of 50 and 75Ω impedance models (Types 687A and B), features 600Ω input and output impedance and frequency range D.C. to over 1 MHz. All three models provide precise switched attenuation from 1-100 dB in 1 dB steps and are housed in die-cast aluminium boxes only 5½ x 1⅝ x 2¼in., fitted with two B.N.C. coaxial sockets.

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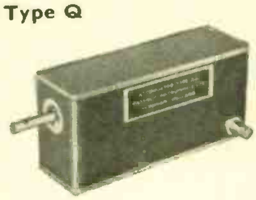
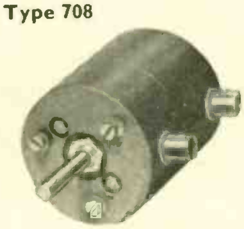


Impedance levels 50 or 75 ohms. Available for the ranges 0–1.1dB up to 50 MHz, 0–11dB in 1dB steps or 0–110dB in 10dB steps, frequency range D.C. to 500 MHz.

Type 708



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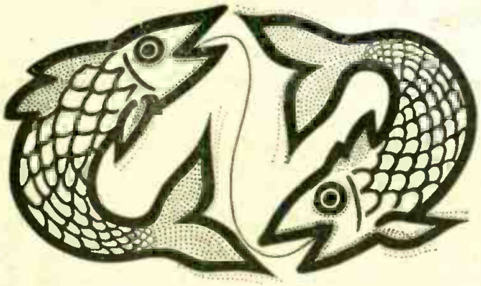

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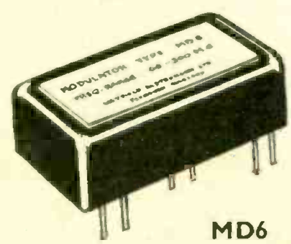
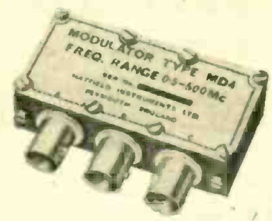


MD6



MD4

Recent additions to the Hatfield range of Attenuators, Hybrids, and Modulators include:

TYPE MD4, a compact V.H.F. Double Balanced Modulator using " Hot Carrier " Diodes, capable of very good performance as an amplitude modulator, mixer, phase detector or current controlled V.H.F. Attenuator. Input and output frequency range is 0.5-300 MHz.

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## HATFIELD BALUN

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# for acoustic hoods

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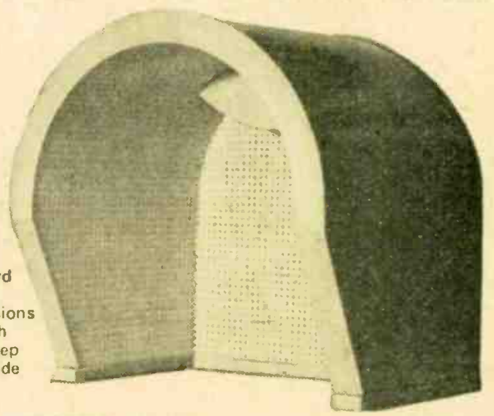
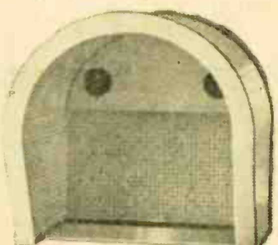


Standard Hood Dimensions
25" high
$20\frac{1}{4}$" deep
$24\frac{1}{2}$" wide

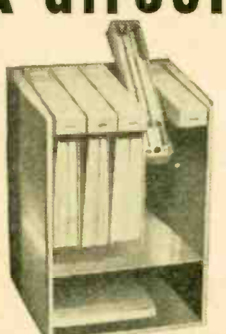


Fitted with loudspeakers

Fitted with doors for outdoor use

*Also available with internal light and/or a storage shelf below hood*

# & directory holders



These attractive, and extremely functional directory holders will hold five directories neatly and securely, in individual swivel holders permitting easy identification and reference. The lower shelf provides additional storage space. The units are of cast alloy and are finished in an attractive grey epoxy resin enamel and constructed to strict G.P.O. design specifications.

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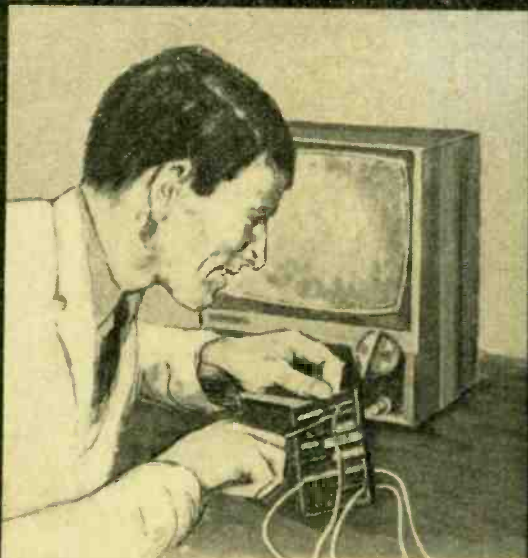

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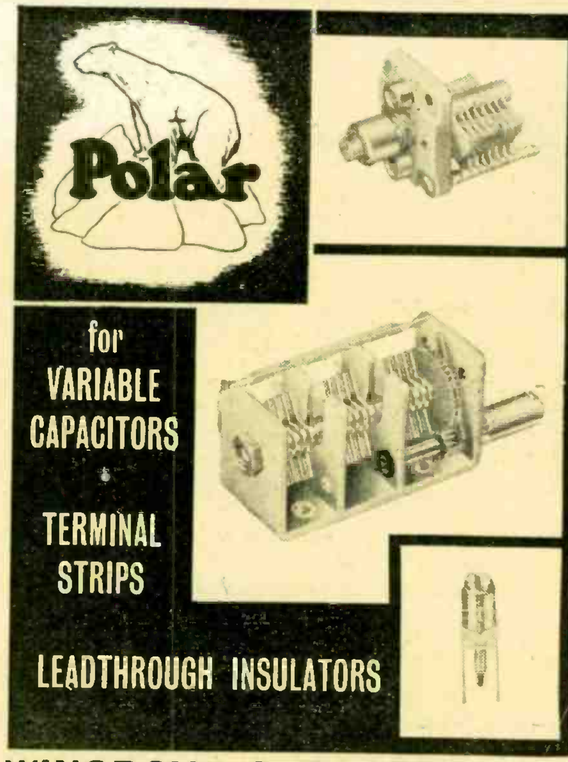


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# AERIAL HANDBOOK
## By G.A. BRIGGS with R.S. ROBERTS
C.Eng. M.I.E.R.E. Sen M.I.E.E.E. as Technical Editor


**Second Edition PUBLICATION DATE 26th JAN. 1968**

176 Pages, Fine Art Paper. 144 Illustrations (including 50 new to this Edition and 14 Cartoons).
Price 15/- (16/- post free), Semi-Stiff cover.
22/6 (24/- post free), Cloth bound Library Edition.
The first edition of *Aerial Handbook* was published in Oct. 1964 and the 5,000 copies were sold out in just over a year.
This second edition has been delayed until the plans for Colour Television & Multiplex Stereo had matured and could be dealt with from the angles of Transmission and Reception.
The activities of the B.B.C. and I.T.A. are well covered. Relay Systems, Eurovision, World Satellites and Colour Conversion, Post Office Tower, etc., also receive attention in non-technical terms.

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Double beam. Time base 2 c/s. to 750 kc/s. Band width up to 5 Mc/s. Calibration markers at 100 kc/s. and 1 Mc/s. Operates from A.C. mains 100 to 250 volts. A completely reliable quality instrument. Supplied fully checked with circuit £22/10/-. Carr. 30/-.

## HRO MODEL 5T £30

The octal valve version. In mint condition. Complete with all nine general coverage coil sets covering 50 kc/s. to 30 Mc/s. Instruction Booklet and circuit, but less external power supply. Carriage 30/-. Complete manual available at 30/- extra.

**PRICES NOW REDUCED CINTEL EQUIPMENT. ELECTROLYTIC CAPACITANCE AND INCREMENTAL INDUCTANCE BRIDGE No. 36601**
A modern instrument, all solid state, which accurately measures the capacity of electrolytic condensers from 0.1μF to 1,000μF under operating conditions. Leakage current and polarizing voltage are separately metered. Inductances from 100 mH to 100 H can also be measured with current up to 100 mA. A.C. mains operation. Unused with handbook. List Price £220. Our Price £70.
**WIDE RANGE CAPACITANCE BRIDGE. No. 1864.** A matching instrument to the above. All solid state. Mains operation. Measures from 0.002pF to 100μF. Unused with handbook. List Price £250. Our Price £75.

## MARCONI TEST EQUIPMENT

**PORTABLE FREQUENCY METER TYPE TF.1026 SERIES**
TF.1026/4 2,000/4,000 Mc/s., TF.1026/5 1,800/2,200 Mc/s., TF.1026/6 3,800/4,200 Mc/s., TF.1026/7 1,700/2,100 Mc/s., TF.1026/9 2,425/2,525 Mc/s. £40 each.

**WIDE BAND MILLIVOLTMETER TYPE TF.1371**
100μv to 300 mv in five ranges. 30 c/s. to 30 mc/s. £45.

**VACUUM TUBE VOLTMETER TYPE TF.1300**
A.C. measurement 0.05 to 100 v., 20 c/s. to 300 Mc/s. D.C. measurement 0.1 to 300 v. Each over 5 ranges. Will also measure ohms, 50Ω to 5mΩ in 2 ranges. £45.

**SENSITIVE VALVE VOLTMETER TYPE TF.1100**
100μv to 300 v. A.C. in 12 ranges. 10 c/s to 10 Mc/s. Can also be used as a wide-band amplifier. £50.

**DELAY GENERATOR TYPE TF.1415.**
Provides sweep-delaying facilities when used in conjunction with the TF. 1330 (series) or similar oscilloscope. Alternatively, it may be used independently as a general purpose delay generator. £35.

| | | |
|---|---|---|
| TF.867.A | Standard Signal Generator | £200 |
| TF.890.A/1 | R.F. Test Set | £150 |
| TF.1020.A/2 | R.F. Power Meter | £50 |
| T.F.1066.B/2 | U.H.F. F.M. Signal Generator | £200 |
| TF.1067 | Hetrodyne Frequency Meter | £65 |
| TF.1102 | Amplitude Modulator | £40 |
| TF.1221 | Hetrodyne Unit | £125 |
| TF.1274 | V.H.F. Bridge Oscillator | £40 |
| TF.1275 | V.H.F. Bridge Detector | £40 |
| TF.1350/1 | Power Unit for TF.1346/1 | £40 |
| TF.1400 | Double Pulse Generator | £100 |

Detailed technical specifications supplied upon request. Offered BRAND NEW at fraction of original cost.

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**PORTABLE OSCILLOSCOPE CT.52.**
A compact general purpose instrument with many unusual features. Size 9in. high, 8in. wide, 6½in. deep. Time base 10 c/s. to 40 kc/s. Y plate sensitivity 40 v. per cm. Tube 2¾in. Frequency compensated amplifier up to 38 dB gain. Bandwidth up to 1 Mc/s. Single sweep facilities. Operates from A.C. mains 100-250 volts, 50 c/s. Complete with all test leads, metal transit case, instruction book and circuit diagram. BRAND NEW. Tested and guaranteed. £22/10/-. Carr. 10/-.

**SIGNAL GENERATOR CT-218 (FM/AM). MARCONI TF 937.**
Covers 85 Kc/s. to 30 Mc/s. in 8 switched ranges. Effective length of film scale is 50ft. Output level variable in 1 dB steps from 1μV to 100mV (75Ω). Also 1V Outputs down to 0.1μV from an outlet at 7.5Ω. Int. mod. at 400 c/s., 1 Kc/s., 1.6 Kc/s. and 3 Kc/s. FM at frequencies above 394 Kc/s. Variable mod. depth and deviation. Crystal calibrator 200 Kc/s and 2 Mc/s. Monitor speaker for beat detection. Fully metered, blower cooled, Panclimatic. A.C. mains 100 to 150 and 200 to 250 volts, 45 to 100 c/s. 17 × 20½ × 17½in. Weight 117 lbs. Fully tested and guaranteed. Fraction of original cost. £65. Carr. 50/-.

**T.C.C. METALPACK CONDENSERS.** 0.1 mfd. 500 v. D.C. wkg. at 70°C. Brand new, polythene wrapped, 7/6 doz., or £2 per 100.
**T.C.C. METALMITE** 350 v. D.C. wkg. 0.1 mfd. (CP37N); 0.05 mfd. (CP35N); 0.91 mfd. (CP.32N) all at 5/6 doz. or 32/6 per 100.
**SPRAGUE METAL CASED CONDENSERS** 0.01 mfd. 1,000 v. D.C. wkg., 5/6 doz., or 32/6 per 100.

**T.C.C. VISCONAL CONDENSERS.** 8 mfd. 800 v. D.C. wkg. at 71°C. CP 152 v. Size 3×1¾×5in. high. BRAND NEW (boxed), 8/6 each. **DUBILIER.** 4 mfd. 600 v. wkg. CP 130T or similar. 1¾ × 1¾ × 4¾in. high. BRAND NEW (boxed), 4/6 each. All post paid.

**STANDARD TRANSFORMERS**
Vacuum impregnated, interleaved, E.S. screen, universal mounting. Size 4×3½×2½in. ALL BRAND NEW. 24/- each. Post 4/6.
**Type 1.** 250-0-250 v. 80 mA. 6.3 v. 3.5 a., 6.3 v. 1 a., tapped at 2 a.
**Type 2.** As above but 350-0-350 v. 80 mA.
**Type 3.** 30 v. 2 a., tapped at 12, 15, 20 and 24 v. to give 3-4-5-6-8-9-10 v., etc.
**Type 5.** 0-6-9-15 v. 4 a. Ideal for chargers.

**LOW CAPACITANCE BRIDGE MARCONI TF. 1342.** Range 0.002 pF. to 1,111 pF. Accuracy 0.2%. Three terminal transformer ratio arm bridge allows "in situ" measurements. Internal oscillator frequency 1,000 c/s. 12 × 17 × 8½in. Weight 15¾ lbs. A.C. mains 200 to 250 and 100 to 150 v. 40-100 c/s. With leads and handbook. **ABSOLUTELY BRAND NEW.** List Price £120. Our Price £45.

# LIND-AIR (ELECTRONICS) LTD

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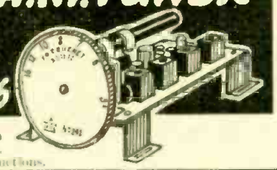
## TRANSISTOR A.M. TUNER

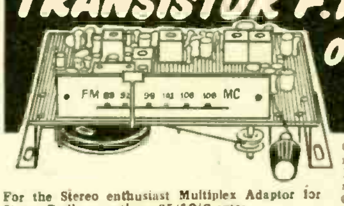
ONLY 69/6 P&P 2/6



3 Transistor AM Tuner covering full medium wave. Size 4¼in. x 2¾in. x 2⅞in. Ready built. 9 v. battery operation. Complete with instructions.

## TRANSISTOR F.M. TUNER

ONLY £6-7-6 P&P 4/-




For the Stereo enthusiast Multiplex Adaptor for Stereo Radio reception. £5/19/6 extra.

6 Transistor. FM tuner Frequency range 88-108 Mc/s. Size 6 x 4 x 2½in. Ready built for use with most amplifiers. 9 v. battery operation. Complete with instructions. ONLY FROM LIND-AIR!

## SPECIAL OFFER OF GARRARD DECKS

Modernise your old radiogram with one of these latest brand new Garrard units.

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| Model 3000 with Sonotone 9TAHC Stereo Cartridge | £8 19 6 |
| AT60 Mk. I less cartridge | £10 19 6 |
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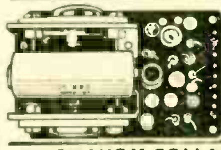
| SP25 Mk. II less cartridge | £10 19 6 |
| LAB80 Mk. II less cartridge | £24 19 6 |

Mono Cartridge 12/6 extra.
Stereo Cartridge 19/6 extra.

UP TO 25% OFF LIST PRICE

**TEAK FINISH PLINTHS** with perspex cover 6 gns. (For LAB80 8 gns.).. P. & P. 5/-. Agents for Thorens, Dual, Goldring. Prices on request.

## SINCLAIR PRODUCTS



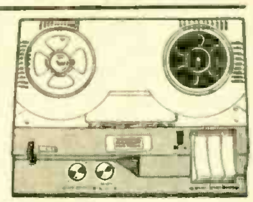
MICROMATIC RADIO. KIT ONLY 49/6. P. & P. 2/6.
MICROMATIC RADIO BUILT. ONLY 59/6. P. & P. 2/6.
MICRO FM. KIT—£5/19/6 complete. P. & &. 2/6.
Z.12 HI-FI AMP and PRE-AMP £4/9/6. P. & P. 2/6.
STEREO 25 Control Unit £9/19/6. P. & P. 2/6.
PZ3. Mains Power Supply Unit £3/19/6. P. & P. 2/6.

## MAGNAVOX-COLLARO 363 TAPE DECKS

The very latest 3-speed model—1⅞, 3¾, 7½ i.p.s. available with either 2 track or 4 track head. Features include: Pause control; digital counter; fast forward and rewind; new 4 pole fully screened induction motor; interlocking keys. Size of top plate 13½ x 11 x 5½in. deep below unit plate. For 200/250 v. A.C. mains 50 c.p.s. operation. New unused and fully guaranteed.

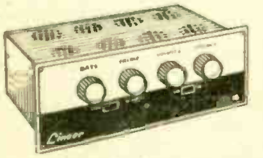
2 track model. £10/10/0 4 track model. £13/9/6

Carriage and Packing 7/6.



## LINEAR AMPLIFIERS

**Latest A.C. Mains Models offering highest quality at modest cost.**




**LT66.** All Transistor 12 watts Stereo. Inputs for Tuner, Gram., Mike. Separate Bass, Treble, Balance and Volume Controls, £15/15/-. Carr. 7/6. Teak case £3/10/- extra.

**PTA15.** All Transistor. 15 watts Mono. Inputs for Tuner, Gram., Mike, Guitar Bass, Treble and two volume controls, £15/15/-. Carr. 7/6. Teak case, £3/10/- extra.

**LT45. 2 VALVE** 5 watts Mono. Inputs for Tuner, Gram., Bass, Treble and Volume controls. £6/19/6. Carr. 5/6. Metal cover 15/- extra. Ful. details sent on request.

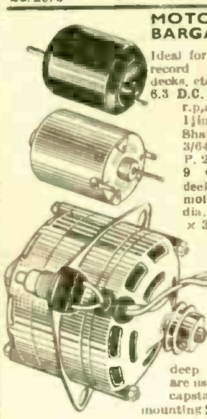
## MARTIN TAPE PREAMPLIFIERS

FOR USE WITH ABOVE TAPE DECKS.
2 track model £14/19/6; 4 track model, £15/19/6. Carriage and packing 7/6

## 2-3 WATT AMPLIFIER

An ideal basis for building your own portable record player. Just add speaker and turntable and you will have an above-average model for a mere fraction of the cost. 2-3 watt printed circuit, with control panel on flying lead. On. OFF, TONE CONTROL AND VOLUME, colourful escutcheon. Brimar valves: EZ80. ECL82 and composite installation booklet. Price £3/17/6 P. & P. 3/6.


## MOTOR BARGAINS



Ideal for model makers, record players, tape decks, etc.

6.3 D.C. Motor. 10.900 r.p.m. at 230 mA. 1⅜in. x 1in. dia. Shaft ⅛in. long x 3/64 dia., 9/6. P. & P. 2/6.

9 v. D.C. Gram. deck replacement motor. 2in. x 1⅜in. dia. Shaft ⅛in long x 3/32in., 17/6. P. & P. 2/-.

200/250 v. A.C. Tape Deck Motor. 50 c/s. 50 watts, single phase. Belt drive pulley. Take up and rewind. 3in. deep x 3in. dia. Two are used together with capstan motor. Easy mounting 27/6. P.& P. 5/6.

## EAGLE SUBSTITUTION BOXES

OM.B. 9 Capacitance ranges .0001. .0010. .0022. .0047. .01. .022. .047. .1. .22, mfd. With leads and clips. 21/-. P. & P. 2/-.

OM.G. Two Resistance ranges. Low: 15 ohm to 10 Kohm (1 watt resistors). High: 15 K ohm to 10 meg. ohm. (¼ watt resistors). Selects 24 separate resistances. With leads and clips, 29/6. P. & P. 2/-.

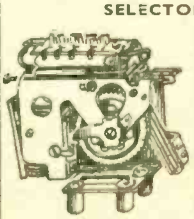
## AERIALS. TV/UHF/VHF/STEREO

**CRESTA** Room Aerial Band I/II/III. Cream or black. 25/-.
**VEEMASTER** Table Top VHF/UHF. Tunable Aerial. Chrome or grey. 70/-.
**YAGAI.** All Channel Table Top Aerial, BBC1/2/ITV/VHF. 65/-.
**HL535 LOFT AERIAL.** BILO V + 5 for vertical. Band I/III. With mounting arm and bracket. 49/-.
**NEW MAJOR.** 10-element BBC2 Aerial for loft or outdoor fixing. With roller bracket for up to 2in. dia. mast. 42/6.

## MULTIMETERS

TTC1001 (as illus.) 20.000 opv. £3/19/6.
C1000. 1,000 opv £2/2/-.
Caby NH 200 20,000 opv £6/10/-
Caby B40 4000 opv. £6/10/-.
TMK500 30.000 opv. £9/19/6.
TTC Model 1030 50.000 opv £9/19/6
TTC Model 1031 100.000 opv £12/19/6
Also stockists of Avo. Nombrex. Eagle etc. Test equipment. P.P. 3/6.

## SELECTOR DRIVE



12/6

Numerous applications. Electro magnet and brass tooth wheel. A switch wafer and contacts are coupled to this and arranged to be on for 10 pulses and off for 15. An auxiliary contact is normally on but off 1 in every 25. Complete with suppressor, resistors, plus series contact for continuous operation. Ideal window displays, switching lamps, models, etc. 12 v. or 24 v. D.C. Brand new and boxed, 12/6. P. & P. 2/6. Many more similar items available.

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| TRANSISTORS | | OCP71 | 10/6 | AF127 | 9/6 |
| | | ST721 | 15/- | AF139 | 10/- |
| OC3 | 6/- | ST723 | 10/- | AF186 | 17/6 |
| OC16 | 20/- | ST140 | 4/- | AFZ11 | 17/- |
| OC23 | 15/- | ST141 | 6/- | AFZ12 | 12/6 |
| OC28 | 12/6 | V62R | 6/- | ASY26 | 6/6 |
| OC22 | 10/- | V64R | 6/6 | MAT100 | 7/9 |
| OC24 | 17/6 | V68R | 7/- | MAT101 | 8/6 |
| OC25 | 9/6 | V1050A | 6/- | MAT120 | 7/9 |
| OC29 | 15/- | V1520P | 10/- | MAT121 | 8/6 |
| OC35 | 12/6 | V1530P | 10/- | Valves | |
| OC36 | 12/6 | V13020P | 8/- | EL84 | 6/6 |
| OC41 | 6/- | V60201P | 8/- | EF86 | 9/6 |
| OC42 | 5/- | V6030 | 10/- | EY86 | 9/6 |
| OC44 | 5/- | BFY50 | 8/6 | DY87 | 9/6 |
| OC45 | 2/6 | BFY51 | 7/- | ECC83 | 6/6 |
| OC66 | 19/6 | BFY52 | 6/- | ECC81 | 5/6 |
| OC70 | 4/- | BYZ12 | 10/- | EABC80 | 8/6 |
| OC71 | 4/- | BYZ13 | 10/- | UL84 | 8/6 |
| OC72 | 5/- | BCY33 | 7/6 | UF41 | 10/6 |
| OC73 | 6/6 | BCY34 | 8/6 | UY41 | 7/6 |
| OC75 | 6/- | BCY10 | 7/6 | EZ80 | 6/6 |
| OC76 | 5/- | BCY38 | 9/6 | EZ81 | 6/6 |
| OC77 | 7/- | BCY39 | 12/6 | PCC84 | 7/6 |
| OC78 | 5/- | BCY12 | 7/6 | PCL85 | 9/6 |
| OC78D | 5/- | AC107 | 14/6 | PCL82 | 8/6 |
| OC81 | 5/- | AC127 | 9/- | PCL86 | 9/6 |
| OC81D | 5/- | ACY17 | 8/6 | KT66 | 25/- |
| OC82 | 6/- | ACY19 | 6/6 | KT88 | 27/6 |
| OC123 | 11/6 | ACY20 | 5/6 | DY86 | 9/6 |
| OC139 | 8/- | ACY21 | 6/- | EBC33 | 8/6 |
| OC140 | 10/- | ACY22 | 4/6 | DK96 | 6/6 |
| OC170 | 6/- | AF102 | 18/- | DAF96 | 6/6 |
| OC171 | 7/- | AF114 | 7/- | DL96 | 7/6 |
| OC200 | 7/6 | AF115 | 6/6 | DF96 | 7/6 |
| OC201 | 12/6 | AF116 | 7/- | PY81 | 6/6 |
| OC202 | 13/6 | AF117 | 5/- | PL81 | 10/6 |
| OC203 | 10/6 | AF118 | 17/6 | PY33 | 13/6 |
| OC204 | 15/- | AF124 | 10/- | PL36 | 11/6 |
| OC205 | 15/- | AF125 | 10/- | Diodes | |
| OC206 | 19/6 | AF126 | 10/- | OA5 | 4/6 |

We have a complete range of new and old types of Valves, Transistors and Diodes. Lists available on application.

## PROFESSIONAL ELECTRIC INSTANT HEAT SOLDER GUN

Ideal for model makers, home repairs, electronics, radio, TV, etc. Unique features include interchangeable tips, extension barrels, comfortable grip with trigger control. "U" shaped 3¼in. bit to minimise wear. Light beam is automatically directed on to end of bit when ON/OFF trigger is in use. 85 watt element with special ventilation. Complete with 2-pin, 5 amp. plug 230-250 volts. Spares available. 49/6 plus 2/6 P.P.

## AUTO TRANSFORMERS

Input 0-200. 220. 240 v. Output 110 v.

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|---|---|---|---|
| 50w. | £1 7 6 | 600 w. | £6 9 6 |
| 75 w. | £1 17 0 | 1.000 w. | £9 9 0 |
| 100 w. | £2 5 0 | 1.500 w. | £15 15 0 |
| 150 w. | £2 15 0 | 2.000 w. | £18 10 0 |
| 200 w. | £3 5 0 | 3.000 w. | £25 10 0 |
| 300 w. | £4 5 0 | 4.000 w. | £34 18 0 |
| 400 w. | £4 19 6 | 0.30 v. 1 amp. | 30/- |
| 500 w. | £5 9 6 | 0.30 v. ½ amp | 17/9 |
| | | 0.30 v. 2 amp. | 30/- |
| | | 0.30 v. 3 amp. | 42/- |

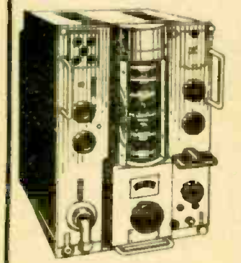
Post Extra

## MAINS TRANSFORMERS

Input 200-250 v. 50 c/s.

| | |
|---|---|
| 24 v. 3 amp. | £2 12 6 |
| 24 v. 5 amp. | £3 15 0 |
| 24 v. 8 amp. | £5 5 0 |
| 24 v. 12 amp. | £6 15 0 |

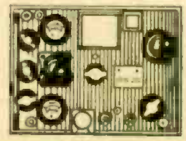
Post extra.
Mains and Output Transformer Lists available on request.



## ADMIRALTY B.40 RECEIVERS

Just released by the Ministry. High quality 10 valve receiver manufactured by Murphy. Coverage in 5 bands 650 Kc/s.-30 Mc/s. I/F. 500 Kc/s. Incorporates 2 R.F. and 3 I.F. stages, bandpass filter, noise limiter, crystal controlled B.F.O. calibrator, I.F. output, etc. Built-in speaker, output for phones. Operation 150/230 volt A.C. Size 19½in. × 13¼in. × 16in. Weight 114 lbs. Offered in good working condition. **£22/10/-**, carr. 30/-. With circuit diagrams. Also available B41 L.F. version of above. 15 Kc/s-700 Kc/s., **£17/10/-**, carr. 30/-.

## COLLINS TCS TRANSMITTERS



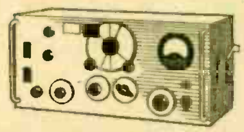
Frequency range 1.5-12 Mc/s. in 3 bands. Employ 7 valves. 2 or 1625 P.A. 1625 Buffer, 1625 Mod., 3 × 12 A6 Osc. R.T. or C.W. V.F.O. or provision for Xtals, incorporates plate and aerial-current metres. Require ext. P.S.U. Offered in excellent condition. **£8/19/6**. carr. 15/-.

# TWO-WAY RADIOS

### SUPERB QUALITY, BRAND NEW & GUARANTEED

3 TRANSISTORS **£6/15/-** PAIR.
4 TRANSISTORS **£6/19/6** PAIR.
5 TRANSISTORS **£7/10/-** PAIR.
6 TRANSISTOR **£8/12/6**
6 TRANSISTOR DE-LUXE LAFAYETTE **£12/10/-** PAIR.
10 TRANSISTOR **£22/10/-** PAIR.
13 TRANSISTOR 500 MW 2-channel **30 Gns.** PAIR.
18 TRANSISTOR 1 WATT 2-channel **£35** PAIR.
POST EXTRA.

## MARCONI TEST EQUIPMENT



EX-MILITARY RECONDITIONED
TF 144G STANDARD SIGNAL GENERATORS. 85 Kc/s.-25 Mc/s. **£25**. carr. 30/-.
TF.329G. "Q" METER. BRAND NEW, COMPLETE WITH ALL ACCESSORIES. **£75**. carr. 30/-.
T.F.195M. BEAT FREQUENCY OSCILLATOR. 0-40 kc/s. 200/250v. A.C. **£20**. Carr. 30/-.
All above offered in excellent condition fully tested and checked.

# POWER RHEOSTATS

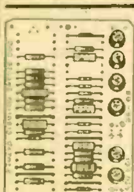
High quality ceramic construction. Windings embedded in vitreous enamel. Heavy duty brush wiper. Continuous rating. Wide range available ex-stock. Single hole fixing, ¼in. dia. shafts. Bulk quantities available.
**25 WATT.** 10/25/50/100/250/500/1000/1500/2500 or 5000 ohms, **14/6**. P. & P. 1/6.
**50 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.

## 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 10 μ/sec. to 10 m/secs. Calibrator. X amplifier D.C. to 2.5 Mc/s. Z Modulation. 110/200/250v. A.C. Supplied in good working order. **£65**. carriage £2, or available as received from Ministry unserviced **£50**. Carriage £2 (Handbook **£2** extra.)

## SOLARTRON MONITOR OSCILOSCOPE 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 200/250V. Supplied in excellent condition with cables, probe, etc., as received from Ministry **£8/19/6**. Carriage 30/-.



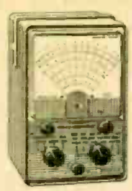
## PRINTED CIRCUITS

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

## MODEL ZQM TRANSISTOR CHECKER

It has the fullest capacity for checking on A B and Ico. Equally adjustable for checking diodes, etc.
Spec.: A: 0.7-099.67. B: 5-200.
Ico: 0-50 microamps. 0.5mA.
Resistance for diode 200 Ω—1 MEG. Supplied complete with instructions, battery and leads. **£5/19/6**. P. & P. 2/6.

## 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.
220/240 v. A.C. operation.
Complete with probe and instructions **£15**. P. & P 6/-.
Additional Probes available: R.F. **35/-**: H.V. **42/6**.

## T.E.40 HIGH SENSITIVITY A.C. VOLTMETER

10 meg. input 10 ranges: .01/.033/.1/.3/1/3/10/30/100/300 v. R.M.S. 4cps.-1.2 Mc/s. Decibels—40 to +50 dB. Supplied brand new complete with leads and intructions. Operation 230v. A.C. **£17/10/-**. Carr. 5/-.

## UNR-30 4 BAND COMMUNICATION RECEIVER

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

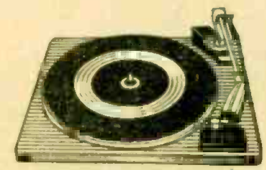
## LAFAYETTE LA-224T TRANSISTOR STEREO AMPLIFIER

19 transistors. 8 diodes. IHF music power 30 watts at 8 ohms. Response 30-20,000 ± 2. dB at 1 w. Distortion 1% or less. Inputs 3 mV and 250 mV. Output 3-16 ohms. Separate L. and R. volume controls. Treble and bass controls. Stereo phone jack. Brushed aluminium, gold anodized extruded front panel with complementary metal case. Size 10¼in. × 3⁵⁄₁₆in. × 7¹³⁄₁₆in. Operation 115/230 volt A.C. **£25**. Carr. 7/6.

## GARRARD DECKS

| | | | |
|---|---|---|---|
| SRP12 player, mono or stereo | £4 | 4 | 0 |
| 1000 changer, mono or stereo | £5 | 15 | 6 |
| 2000 changer, mono or stereo | £6 | 19 | 6 |
| A50 Mono or stereo | £7 | 17 | 6 |
| 3000 changer, mono or stereo | £7 | 19 | 6 |
| 3000 Sonotone stereo | £8 | 19 | 6 |
| AT6 Mk. II mono or stereo | £8 | 19 | 6 |
| A70 Mk. II less cartridge | £12 | 12 | 0 |
| A70 Mk. II Sonotone stereo | £14 | 14 | 0 |
| LAB80 II, changer, less cart. | £24 | 0 | 0 |
| 401 Transcription Deck | £27 | 0 | 0 |

All plus 5/- P. & P.



## AVOMETER

Supplied in excellent condition, fully tested and checked. Complete with prods, leads and instructions.
Model 47A **£9/19/6**
Model 7 **£13/10/0**
Model 8 **£18/0/0**
Model 9 **£20/0/0**
P. & P. 7/6 each.

## SINCLAIR EQUIPMENT

Z12. 12 watt amplifier **89/6**
PZ4. Power Supply Unit .... **99/6**
STEREO 25. Pre-amplifier **£9/19/6**
Q.14 Speakers **£6/19/6**
Micromatic Radio Kit .... **49/6**
Built .. **59/6**
Micro FM Radio Kit .... **£5/19/6**
ALL POST PAID.

**SPECIAL OFFER**
2 Z12 amps. PZ4 Power Supply, Stereo 25. Preamplifier .......... **£22**

# *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.—**£4/10/-**: 2.5 amp.—**£5/17/6**: 5 amp.—**£9**: 8 amp.—**£13/10/-**
10 amp.—**£17**: 12 amp.—**£19/10/-**: 20 amp.—**£32/10/-**.

## SILICON RECTIFIERS

| | |
|---|---|
| 200 v. P.I.V. 200mA | 2/6 |
| 200 v. P.I.V. 6 amp. | 5/6 |
| 400 v. P.I.V. 3 amp. | 7/6 |
| 1,000 v. P.I.V. 5 amp. | 7/6 |
| 400 v. P.I.V. 6 amp. | 5/6 |
| 400 v. P.I.V. 8 amp. | 7/6 |
| 1,000 v. P.I.V. 650 mA. | 6/6 |
| 800 v. P.I.V. 500mA. | 5/6 |
| 800 v. P.I.V. 5 amp. | 7/6 |
| 400 v. P.I.V. 500mA. | 3/6 |
| 70 v. P.I.V. 1 amp. | 3/6 |
| 150 v. P.I.V. 165mA. | 1/- |
| 150 v. P.I.V. 25 amps. | 10/- |
| 700 v. P.I.V. 100 amp. | 35/- |

Discount for quantities. Post extra.

**THRYSISTORS**
**SILICON CONTROL RECTIFIERS**

| | |
|---|---|
| 400 P.I.V. 3 amp. | 7/6 |
| 100 P.I.V. 5 amp. | 13/6 |
| 200 P.I.V. 5 amp. | 15/6 |
| 400 P.I.V. 5 amp. | 17/6 |

## S.T.C. 1 WATT ZENER DIODES

**BRAND NEW. LIST 17/6 each.**

Available 2.4/2.7/3/3.9/4.3/13/16/18/20/30/33 v. **5/-** each type. P. & P. extra.

## AMERICAN RECORDING TAPES

First grade quality American tapes. Brand new and guaranteed. Discounts for quantities.

| | |
|---|---|
| 3in. 225ft. L.P. Acetate | 4/- |
| 3¼in. 600ft. T.P. Mylar | 10/- |
| 5in. 600ft. Std. plastic | 8/6 |
| 6in. 900ft. L.P. acetate | 10/- |
| 5in. 1,200ft. D.P. Mylar | 15/- |
| 5in. 1,800ft. T.P. Mylar | 35/- |
| 5¾in. 1,200ft. L.P. acetate | 12/6 |
| 5¾in. 1,800ft. D.P. Mylar | 22/6 |
| 5¾in. 2,400ft. T.P. Mylar | 45/- |
| 7in. 1,200ft. Std. acetate | 12/6 |
| 7in. 1,800ft. L.P. acetate | 15/- |
| 7in. 1,800ft. L.P. Mylar | 20/- |
| 7in. 2,400ft. D.P. Mylar | 25/- |
| 7in. 3,600ft. T.P. Mylar | 58/6 |

Postage 2/-. Over £3 post paid.

## RECORDING HEADS

Reuter ¼-track. As fitted to Collaro Mk. IV and Studio Decks. High imp. record play back, low imp. erase. Brand new. **19/6** pair. MINIFLUX ½-track set of 3, **29/6**. Post extra.

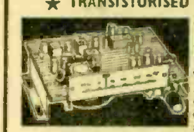
## MAGNAVOX 363 TAPE DECKS

3 speed. 1⅞-3¾-7½ ips. Carr. paid. 2-track **£10/10/-**: 4-track **£13/10/-**; 2-track Stereo **£13/10/-**.

## R.C.A. AR88 SPEAKERS

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

## ★ TRANSISTORISED FM TUNER ★



6 TRANSISTOR HIGH QUALITY TUNER SIZE ONLY 6in. × 4in. × 2½in. 3 I.F. stages. Double tuned discriminator, ample output to feed most amplifiers. Operates on 9 volt battery. Coverage 88-108 Mc/s. Ready built ready for use. Fantastic value for money. **£6/10/-**. P. & P. 2/6.

**STEREO MULTIPLEX ADAPTORS 5 Gns.**

## F.M. WIRELESS MICROPHONE

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

## TRANSISTORISED TWO-WAY TELEPHONE INTERCOM

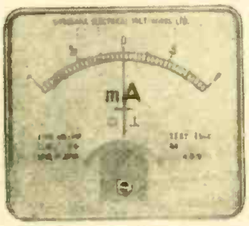
Operative over amazingly long distances. Separate call and press to talk buttons. 2-wire connection. 1000s of applications. Beautifully finished in ebony. Supplied complete with batteries and wall brackets. **£5/19/6** pair. P. & P. 3/6.

# G. W. SMITH
**& Co. (Radio) Ltd.**
**3-34, Lisle St., W.C.2.**
*ALSO SEE OPPOSITE PAGE*

# SEW PANEL METERS

Send S.A.E. for full lists. Other ranges available. Please include postage. Special quotations for quantities.

## CLEAR PLASTIC METERS



Type MR.38P. 1 21/32in. square fronts.

| | | | |
|---|---|---|---|
| 50µA | 32/6 | 6 amp | 22/6 |
| 50-0-50µA | 29/6 | 3V. D.C. | 22/6 |
| 100µA | 29/6 | 10V. D.C. | 22/6 |
| 100-0-100µA | 27/6 | 20V. D.C. | 22/6 |
| 200µA | 27/6 | 50V. D.C. | 22/6 |
| 500µA | 25/- | 150V. D.C. | 22/6 |
| 500-0-500µA | 22/6 | 300V. D.C. | 22/6 |
| 1mA | 22/6 | 150V. A.C. | 22/6 |
| 1.01mA | 22/6 | 40V. A.C. | 22/6 |
| 5mA | 22/6 | 150V. A.C. | 22/6 |
| 10mA | 22/6 | 300V. A.C. | 22/6 |
| 50mA | 22/6 | 500V. A.C. | 22/6 |
| 100mA | 22/6 | 8 meter 1 mA | 29/6 |
| 500mA | 22/6 | VU meter | 35/- |
| 1 amp | 22/6 | | |

Type MR.45P. 2in. square fronts.

| | | | |
|---|---|---|---|
| 50µA | 39/6 | 20V. D.C. | 25/- |
| 50-0-50µA | 35/- | 50V. D.C. | 25/- |
| 100µA | 35/- | 300V. D.C. | 25/- |
| 100-0-100µA | 32/6 | 15V. A.C. | 25/- |
| 500µA | 27/6 | 300V. A.C. | 25/- |
| 1mA | 25/- | 8 meter 1mA | 35/- |
| 5mA | 25/- | VU meter | 39/6 |
| 10mA | 25/- | 1 amp. A.C.* | 25/- |
| 50mA | 25/- | 5 amp. A.C.* | 25/- |
| 100mA | 25/- | 10 amp. A.C.* | 25/- |
| 1 amp | 25/- | 20 amp. A.C.* | 25/- |
| 5 amp | 25/- | 30 amp. A.C.* | 25/- |
| 10V. D.C. | 25/- | | |

Type MR.52P. 2½in. square fronts.

| | | | |
|---|---|---|---|
| 50µA | 57/6 | 10V. D.C. | 32/6 |
| 50-0-50µA | 57/6 | 20V. D.C. | 32/6 |
| 100µA | 47/6 | 50V. D.C. | 32/6 |
| 100-0-100µA | 47/6 | 300V. D.C. | 32/6 |
| 500µA | 37/6 | 15V. A.C. | 32/6 |
| 1 mA | 32/6 | 300V. A.C. | 32/6 |
| 5mA | 32/6 | S Meter 1mA | 39/6 |
| 10mA | 32/6 | VU Meter | 55/- |
| 50mA | 32/6 | 1 amp. A.C.* | 32/6 |
| 100mA | 32/6 | 5 amp. A.C.* | 32/6 |
| 500mA | 32/6 | 10 amp. A.C.* | 32/6 |
| 1 amp | 32/6 | 20 amp. A.C.* | 32/6 |
| 5 amp. | 32/6 | 30 amp. A.C.* | 32/6 |

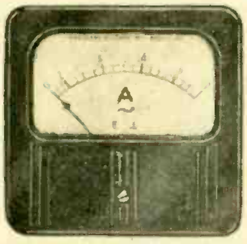
Type MR. 85P. 4¼in. × 4¼in. fronts.

| | | | |
|---|---|---|---|
| 50µA | 69/6 | 15 amp | 45/- |
| 50-0-50µA | 69/6 | 30 amp | 45/- |
| 100µA | 59/6 | 10V D.C. | 45/- |
| 100-0-100µA | 59/6 | 20V. D.C. | 45/- |
| 200µA | 55/- | 50V. D.C. | 45/- |
| 500µA | 49/6 | 150V. D.C. | 45/- |
| 500-0-500µA | 49/6 | 300V. D.C. | 45/- |
| 1mA | 45/- | 15V. A.C. | 45/- |
| 1.01 mA | 45/- | 300V. A.C. | 45/- |
| 5mA | 45/- | VU meter | 69/6 |
| 10mA | 45/- | 1 amp. A.C.* | 45/- |
| 50mA | 45/- | 5 amp. A.C.* | 45/- |
| 100mA | 45/- | 10 amp. A.C.* | 45/- |
| 500mA | 45/- | 20 amp. A.C.* | 45/- |
| 1 amp | 45/- | 30 amp. A.C.* | 45/- |
| 5 amp | 45/- | | |

Type MR.65P. 3½in. × 3½in. fronts.

| | | | |
|---|---|---|---|
| 50µA | 59/6 | 20V. D.C. | 35/- |
| 50-0-50µA | 59/6 | 50V. D.C. | 35/- |
| 100µA | 49/6 | 150V. D.C. | 35/- |
| 100-0-100µA | 49/6 | 300V. D.C. | 35/- |
| 500µA | 39/6 | 15V. A.C. | 35/- |
| 1mA | 35/- | 50V. A.C. | 35/- |
| 5mA | 35/- | 150V. A.C. | 35/- |
| 10mA | 35/- | 300V. A.C. | 35/- |
| 50mA | 35/- | 500V. A.C. | 35/- |
| 100mA | 35/- | VU meter | 59/6 |
| 500mA | 35/- | 1 amp. A.C.* | 35/- |
| 1 amp | 35/- | 5 amp. A.C.* | 35/- |
| 5 amp. | 35/- | 10 amp. A.C.* | 35/- |
| 15 amp. | 35/- | 20 amp. A.C.* | 35/- |
| 30 amp. | 35/- | 30 amp. A.C.* | 35/- |
| 10V. D.C. | 35/- | | |

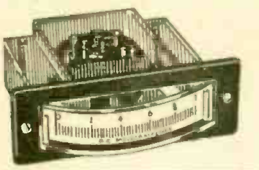
## BAKELITE PANEL METERS



Type MR.65. 3½in. square fronts.

| | | | |
|---|---|---|---|
| 25µA | 65/- | 50 amp. | 29/6 |
| 50µA | 42/6 | 5V. D.C. | 29/6 |
| 50-0-50µA | 42/6 | 10V. D.C. | 29/6 |
| 100µA | 39/6 | 20V. D.C. | 29/6 |
| 100-0-100µA | 39/6 | 50V. D.C. | 29/6 |
| 500µA | 35/- | 150V. D.C. | 29/6 |
| 500-0-500µA | 35/- | 300V. D.C. | 29/6 |
| 1mA | 29/6 | 30V. A.C.* | 29/6 |
| 1.0.1mA | 29/6 | 50V. A.C.* | 29/6 |
| 5mA | 29/6 | 150V. A.C.* | 29/6 |
| 10mA | 29/6 | 300V. A.C.* | 29/6 |
| 50mA | 29/6 | 1 amp. A.C.* | 29/6 |
| 100mA | 29/6 | 5 amp. A.C.* | 29/6 |
| 500mA | 29/6 | 10 amp. A.C.* | 29/6 |
| 1 amp. | 29/6 | 20 amp. A.C.* | 29/6 |
| 5 amp. | 29/6 | 30 amp. A.C.* | 29/6 |
| 15 amp. | 29/6 | 50 amp. A.C.* | 29/6 |
| 30 amp. | 29/6 | VU meter | 49/6 |

*Moving iron, all other moving coil.



### NEW RANGE OF "SEW" EDGEWISE METERS

MODEL PE 70. Dimensions 3 17/32in. × 1 11/32in. × 2¼in. deep overall. Available as follows:

| | | | |
|---|---|---|---|
| 50 microamp | 52/6 | 500 microamp | 42/6 |
| 50-0-50 microamp | 49/6 | 1 milliamp | 39/6 |
| 100 microamp | 49/6 | 300 volt A.C. | 39/6 |
| 100-0-100 microamp | 45/- | VU meter | 55/- |
| 200 microamp | 45/- | Post extra. | |

### LAFAYETTE HI-FI STEREO HEAD PHONES

★ Air Cushioned headband ★ Soft rubber ear pads ★ Frequency response. 25 to 15,000 cycles. ★ High sensitivity. Impedance 8 ohms per phone. Supplied complete with all cables, wires, overhead junction box and 3-connection plug. **79/6.** P. & P. 2/6.

### TE-20RF SIGNAL GENERATOR

Accurate wide range signal generator covering 120 kc/s-260 Mc/s. on 6 bands. Directly calibrated. Variable R.F. attenuator Operation 200/240 v. A.C. Brand new with instructions **£12/10/-** P. & P. 7/6. S.A.E. for details.

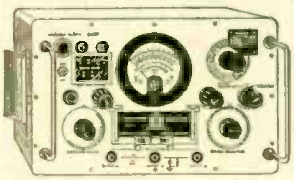

**Send today 5/- P&P 1/-**

# CATALOGUE

★ ELECTRONIC COMPONENTS
★ TEST EQUIPMENT
★ COMMUNICATION EQUIPMENT
★ HI-FI EQUIPMENT

We are proud to introduce our first comprehensive catalogue of Electronic Components and Equipment. Over 150 pages, fully illustrated, listing thousands of items, many at bargain prices. Free discount coupons with every catalogue. Everyone in electronics should have a copy.

### AVO CT.38 ELECTRONIC MULTIMETERS

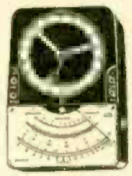


High quality 97 range instrument which measures A.C. and D.C. Voltage Current, Resistance and Power output. Ranges D.C. volts 250mV-10,000 v. (10 megΩ-110 megΩ input). D.C. current 10µA-25 amps. Ohms: 0-1,000 megΩ. A.C. volts 100 mV.-250 v. (with R.F. measuring head up to 250 Mc/s.). A.C. current 10µA-25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

**AVO CALIBRATION TEST UNIT TYPE CT.155.** For use with CT.38 Multimeter. Gives 7 standard voltages 250 mV./1 v/2.5 v./10/25/100 v. A.C. and 250 millivolts D.C. from internal standard cell. Operation 0/110/200/250 v. A.C. Brand new **£7/10/-.** P. & P. 10/6.

# MULTIMETERS for *EVERY* purpose!

**NEW MODEL 500.** 30,000 O.P.V. with overload protection, mirror scale. 0 / .5 / 2.5 / 10 / 25 / 100 / 250/500/1,000 v. D.C. 0/2.5/10 / 25 / 100 / 250 / 500 / 1,000 v. A.C. 0/50µA/5/50/500 mA. 12 amp. D.C. 0/60/K6. Meg./60. Meg.Ω **£8/17/6.** Post paid.



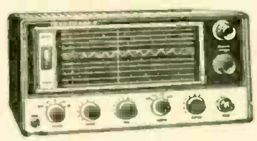
**MODEL TE.80.** 20,000 O.P.V. 0/10/50/100/500/1,000 v. A.C. 0/5/25/50/250/500/1,000 v. D.C. 0-50µA 5/50/500mA. 0/6/60K/600K/6 meg. **£4/17/6.** P.P. 3/-

**TE-900 20,000Ω/VOLT GIANT MULTIMETER** 6in. full view meter. 2 colour scale. 0/2.5/10/250/1,000/5,000 v. A.C. 0 / 2.5 / 12.5 / 10 / 50 250/1,000/5,000 v. D.C. 0/50µA / 1 / 10 / 100 / 00 mA / 10 amp. D.C. 02K/200K/20. MEG. OHM. **£12/19/6.** P. & P. 5/-.

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

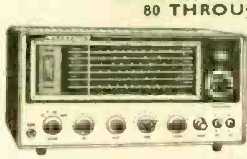
MANY OTHER MODELS AVAILABLE FROM AS LOW AS 39/6.

### NEW LAFAYETTE HA700 AM/CW/SSB AMATEUR COMMUNICATION RECEIVER



8 valves, 5 bands incorporating 2 MECHANICAL FILTERS for exceptional selectivity and sensitivity. Frequency coverage on 5 bands 150-400 Kc/s., 550-1,600 Kc/s. 1.6-4.0 Mc/s. 4.8-14.5 Mc/s., 10.5-30 Mc/s. Circuit incorporates R.F. stage, aerial trimmer, noise limiter, B.F.O. product detector, electrical bandspread, S meter, slide rule dial. Output for phones, low to 2K Ω or speaker 4 or 8 ohms. Operation 220/240 volt A.C. Size 7½in. × 15in. × 10in. Supplied brand new and guaranteed with handbook. **36 GNS.** Carr. 10/-. S.A.E. for leaflet.

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



New outstanding Ham Bands only receiver covering the 80/40/20/15/10/6 metre bands. Incorporates 10 valves, product detector, two mechanical filters, S Meter, dual conversion on all bands, crystal calibrator, B.F.O. noise limiter, aerial trimmer. I.F.s. 2.608 Mc/s. and 455 Kc/s. Output 8 ohms and 500 ohms. Operations 220/240 volt A.C. Supplied brand new and guaranteed with handbook **42 Gns.** Carr. 10/-. 100 Kc/s. crystal. **35/-.**

# G.W. SMITH & CO (RADIO) LIMITED

Phone: GERRARD 8204/9155
Cables: SMITHEX LESQUARE
3-34 LISLE STREET, LONDON, W.C.2

OPEN 9 a.m. to 6 p.m. every day Monday to Saturday. Trade supplied.

## TRANSISTOR STEREO 8 + 8

A really first-class Hi-Fi Stereo Amplifier Kit. Uses 14 transistors giving 8 watts push pull output per channel (16W. mono). Integrated pre-amp. with Bass, Treble and Volume controls. Suitable for use with Ceramic or Crystal cartridges. Output stage for any speakers from 3 to 15 ohms. Compact design, all parts supplied including drilled metal work. Cir-Kit board, attractive front panel, knobs, wire, solder, nuts, bolts—no extras to buy. Simple step by step instructions enable any constructor to build an amplifier to be proud of. Brief Specification: Freq. response ±3dB, 20-20,000 c/s. Bass boost approx. to +12dB. Treble cut approx. to −16dB. Negative feedback 18dB. over main amp. Power requirements at 25V. at .6 amp.

**PRICES:**

| | | |
|---|---|---|
| Amplifier Kit | £9/10/0. | P. & P. 4/6. |
| Power Pack Kit | £2/10/0. | P. & P. 4/-. |
| Cabinet (as illus.) | £2/10/0. | P. & P. 5/6. |

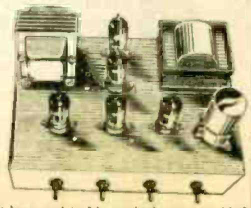
(Special Offer—£14/10/0, post free if all above ordered at same time).
Circuit diagram, construction details and parts list (free with kit) 1/6 (S.A.E.).

**HSL "FOUR" AMPLIFIER KIT**
3-VALVE 4 WATT USING ECC83, EL84, EZ80 VALVES for A.C. mains 200/240 v. ★ Heavy duty double-wound mains transformer with electrostatic screen. ★ Separate bass, treble and volume controls, giving fully variable boost and cut with minimum insertion loss. ★ Heavy negative feedback loop over 2 stages ensure high output at excellent quality with very low distortion factor. ★ Suitable for use with guitar, microphone or record player. ★ Provision for remote mounting of controls or direct on chassis. ★ All this builds on to a chassis size only 7½in. wide × 4in. deep. Overall height 4½in. ★ All components and valves are brand new. ★ Very clear and concise instructions enable even the inexperienced amateur to construct with 100% success. ★ Supplied complete with valves, output transformer (3 ohms only), screened lead, wire, nuts, bolts, solder, etc. (No extras to buy). PRICE 79/6. P. & P. 6/-. Comprehensive circuit diagram, practical layout and parts list 2/6 (free with kit).

**VIBRATORS.** Large selection of 2, 4, 6, 12, and 32 volt. Non sync. 8/6: Sync. 10/-. P. & P. 1/6 per vibrator. S.A.E. with all enquiries.

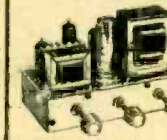
**S.T.C. SILICON AVALANCHE HALF-WAVE RECTIFIERS.** Type RAS, 508 AF, 6 amps. 960 P.I.V. 1in. long × ½in. dia. approx. List 50/-. OUR PRICE 8/6. Post free.

**10/14 WATT HI-FI AMPLIFIER KIT**



A stylishly finished monaural amplifier with an output of 14 watts from 2 EL84s in push-pull Super reproduction of both music and speech, with negligible hum. Separate inputs for mike and gram allow records and announcements to follow each other. Fully shrouded section wound output transformer to match 3-15Ω speaker and 2 independent volume controls, and separate bass and treble controls are provided giving good lift and cut. Valve line-up: 2 EL84s, ECC83, EF86, and EZ80 rectifier. Simple instruction booklet 1/6 (Free with parts). All parts sold separately. ONLY £7/9/6. P. & P. 8/6. Also available ready built and tested complete with standard input sockets. £9/5/-. P. & P. 8/6.

**3-VALVE AUDIO AMPLIFIER MODEL HA34**



Designed for Hi-Fi reproduction of records. A.C. mains operation. Ready built on plated heavy gauge metal chassis, size 7½in. w. × 4in. d. × 4½in. h. Incorporates ECC83, EL84, EZ80 valves. Heavy duty, double wound mains transformer and output transformer matched for 3 ohm speaker, separate bass, treble and volume controls. Negative feedback line. Output 4½ watts. Front panel can be detached and leads extended for remote mounting of controls. The HA34 has been specially designed for us and our quantity order enables us to offer them complete with knobs, valves, etc., wired and tested for only £4/5/-. P. & P. 6/-.

**BRAND NEW 3 OHM LOUDSPEAKERS**
5in. 12/6; 6½in. 15/-; 8in. 22/6; 10in. 27/6; 7×4in. 16/-; 10×6in. 27/6; E.M.I. 8×5in. with high flux magnet 21/-; E.M.I. 13½×8in. with high flux ceramic magnet 42/- (15 ohm 45/-). P. & P. 5in. 2/-; 6½ and 8in. 2/6; 10 and 12in. 3/6 per spkr.

**BRAND NEW.** 12in. 15w. H/D Speakers, 3 or 15 ohm. Current production by well-known British maker. Offered below list price at 89/6. P. & P. 5/-. Guitar models: 25w., £5/5/-; 35w. £8/8/-.
E.M.I. 3½in. HEAVY DUTY TWEETERS. Powerful ceramic magnet. Available in 3, 8 or 15 ohms. 15/-. P. & P. 2/6.

**HIGH GAIN 4-TRANSISTOR PRINTED CIRCUIT AMPLIFIER KIT Type TA1**
● Peak output in excess of 1½ watts. ● All standard British components. ● Built on printed circuit panel, size 6×3in. ● Generous size driver and output transformers. ● Output transformer tapped for 3 ohm and 15 ohm speakers. ● Transistors (GET 114 or 81 Mullard OC81D and matched pair of OC81, o/p). ● 9 volt operation. ● Everything supplied, wire, battery clips, solder, etc. ● Comprehensive easy to follow instructions and circuit diagram 2/6 (Free with Kit). All parts sold separately. SPECIAL PRICE 45/-. P. & P. 3/-. Also ready built and tested 52/6. P. & P. 3/-.

**FM/AM TUNER HEAD**
Beautifully designed and precision engineered by Dormer and Wadsworth Ltd. Supplied ready fitted with twin .0005 tuning condenser for AM connection. Prealigned FM section covers 86-102 Mc/s. I.F. output 10.7 Mc/s. Complete with ECC85 (6L12) valve and full circuit diagram of tuner head. Another special bulk purchase enables us to offer these at 27/6 each. P. & P. 3/-. Order quickly! Limited number also available with precision geared 3 : 1 reduction drive. 30/-. P. & P. 3/-.
**MATCHED PAIR AM/FM IF.s.** Comprising 1st I.F. and 2nd I.F. discriminator. (465 Kc/s/10.7 Mc/s.). Size 1in. × 1¼in. × 2¼in. H. Will match above tuner head. 11/- pair. P. & P. 2/-.

**4-SPEED PLAYER UNIT BARGAINS**
Mains Models. All brand new in maker's original packing.
**SINGLE PLAYERS.** Carr. 5/6 on each.
B.S.R. TU/12 £3/9/6. Garrard SP25 de luxe.. £10 19 6
B.S.R. GU7 with unit mounted pick-up arm.... £4 18 8
**AUTO CHANGERS.** Carr. 6/6 on each.
B.S.R. UA25 Super Slim £6/2/6. GARRARD 2000 £7 10 0
GARRARD 3000 £8/15/-. GARRARD 1000 with Hi-Fi cartridge £6/19/6. Latest GARRARD AT60 Mk. II £12 0 0
All the above units are complete with mono head with sapphire stylus or can be supplied with stereo head at 12/6 extra.

**QUALITY RECORD PLAYER AMPLIFIER MK. II**
A top-quality record player amplifier employing heavy duty double wound mains transformer. ECC83, EL84, EZ80 valves. Separate bass, treble and volume controls. Complete with output transformer matched for 3 ohm speaker. Size 7in. w. × 3in. d. × 6in. h. Ready built and tested. PRICE 69/6. P. & P. 6/-. ALSO AVAILABLE mounted on board with output transformer and speaker ready to fit into cabinet on right. PRICE 89/6. P. & P. 7/6.

**DE LUXE QUALITY PORTABLE R/P CABINET**
Uncut motor board size 14½ × 12in., clearance 2in. below, 5½in. above. Will take amplifier above and any B.S.R. or GARRARD Autochanger or single Player Unit (except AT60 or SP25). Size 18×15×8in. PRICE £3/9/6. Carr. 9/6.

**HARVERSON SURPLUS CO. LTD.**
**170 HIGH ST., MERTON, LONDON, S.W.19** *Tel: 01-540 3985*
*S.A.E. all enquiries. Open all day Saturday (Wednesday 1 p.m.)*

PLEASE NOTE: P. & P. CHARGES QUOTED APPLY TO U.K. ONLY. P. & P. ON OVERSEAS ORDERS CHARGED EXTRA.

# *Wilkinsons* FOR RELAYS

## P.O. TYPE 3000 AND 600

**BUILT TO YOUR REQUIREMENTS—QUICK DELIVERY**
**COMPETITIVE PRICES—VARIOUS CONTACTS**
**DUST COVERS—QUOTATION BY RETURN**

**LARGE STOCKS OF MINIATURE SEALED RELAYS, DETAILED LIST ON REQUEST**

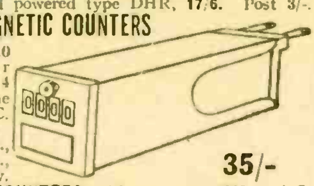
**PORTABLE VOLTMETERS** 0/160 Moving Iron AC/DC, 8in. mirror scale, in polished wood case, 99/6. Post 6/-. Resistor to double the range, 2/6.
**PORTABLE AMMETERS,** 0/3 AC/DC 3in., 35/-, p. 3/-.
**AVOMETERS.** Model 7. £13/10/-, post 7/-.
**FREQUENCY METERS.** 45/55 cycles per second. 230 volts; 6in. Flush Round. Brand new, £10/10/-.
**RESISTORS** wire wound or carbon, potentiometers, condensers, quantities ex-stock at low prices.
**GEARED MOTORS,** 3 R.P.M. or 1 R.P.M. 4 watts very powerful reversible, 24 v. A.C. 35/-, post 2/6, operated from 230 v. with our Transformer. 20/-.
**BLUE LINE** Heavy Duty Switches by Kraus & Naimer, Code AAL213 with extras, also C16 Switches available from stock at less than maker's price.

**KEY SWITCHES** (3 position)
4 C Non Lock/4 C Non Lock, 16/6.
4 C Non Lock/6 C Lock, 20/-.
2 C Lock/2 C Lock, 12/6.
4 C Lock/4 C Lock, 17/6.
Stop/4 C Lock, 12/6.
Many other types.
**Low Capacitance** 8 C Muirhead, 17/6.
Stop/2 C Lock, 7/6.
Stop/4 C Non Lock, 10/6.
2 C Lock/6 C Lock, 17/6.
All Post 1/6

**MAINS TRANSFORMERS.** Output 300-0-330 volts, 250 mA, 6.3 volts, 9 amp., 25/-. Post 6/-.
**AUTO TRANSFORMERS by S.T.C.** Totally enclosed C-core type. 110/250 volts. 8 tappings. 50 cycles. 1,000 watts. Size 6½×5¾×5½in., £4. P. 10/6.

**RATIO ARM UNITS.** Sullivan 600Ω+600Ω. 50/-.
**DOUBLE HEADPHONES.** High resistance, 4,000Ω, 14/6. Sound powered type DHR, 17/6. Post 3/-.

**SMALL MAGNETIC COUNTERS**



3½ × 1in., 10 counts per second with 4 figures. The following D.C. voltages are available, 6 v., 12 v., 24 v., 50 v. or 100 v.
35/-

**MAGNETIC COUNTERS,** with zero reset 230 v. A.C. or 110 v. Veeder Root 6 fig. 65/- ea. Counting Insts. flush type 48 v. D.C. 90/- ea., post 3/-.
**P.O. STANDARD RACKS** 6ft. U channel sides drilled for 19in. panels, heavy angle base 150/- cge. 20/-. LIGHT TYPE 5ft. high £5.
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**PLUG-IN RELAYS,** Londex 4 change-over HD contacts 28 v. D.C. or 240 v. A.C. with base and cover, 35/- ea.
**RELAYS.** 24 volt D.C., 4 Make, 4 Break, 10 amp. 5C/3944 with Dust Cover, 12/6 each.

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

**HAIR HYGROMETER.** 4in. round by Negretti & Zambra, scaled 0/100 reading relative percentage humidity, 65/-. Post 3/-.
**METERS GUARANTEEO.** Complete list available

| | |
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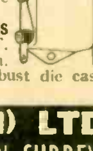
| Microamps 0/100 2½in. MC | 40/- |
| Microamps 0/500 2in. MC | 25/- |
| Microamps 0/500 2½in. MC | 37/6 |
| Milliamps 0/50 2½in. MC | 35/- |
| Milliamps 0/500 3½in. MC | 54/- |
| Amps 0 5 2in. MC ...... | 37/6 |
| Volts 5/0/5 2½in. MC.... | 25/- |
| Volts 0/20 2in. MC...... | 37/6 |
| Volts 0/5 A.C. 3½in. MI.. | 55/- |
| Volts 0/10 A.C. 3½in. MCR | 70/- |
| Microamps 0/50 scaled in Milli Rontgens 2½in. MC | 45/- |
| Millivolts 350/0/350 (3.5/0/3.5) MilliA 2½in. MC | 35/- |

**PORTABLE VOLTMETERS.** 0/250 Moving Iron AC/DC 6in. scale, in polished wood case, £7/10/-.
**MINIATURE BUZZERS** (as illus.), 12 volt with tone adjuster, 7/6.



**HIGH NOTE BUZZERS** 24 v. A.C./D.C. with tone adjuster, 2¾in. dia. Bakelite case, 10/6. Post 2/-.
**SUBMINIATURE MICRO SWITCHES HONEYWELL** 11SM1-TN13. S.P.D.T. Size; .781in. × .250in. × .356in., 6/6 each.
**MICRO SWITCH.** Burgess MK4BR, robust die cast casing 8/6 each. Post 9d.

**L. WILKINSON (CROYDON) LTD.**
LONGLEY HOUSE LONGLEY RD. CROYDON SURREY
Phone: THO 0236 Grams: WILCO CROYDON

# Lasky's Radio

## CONSTRUCTORS BARGAINS

### THE SKYROVER DE LUXE

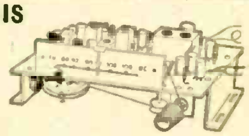
7 transistor plus 2 diode superhet, 6 waveband portable receiver covering the full Medium Waveband and Short Waveband 31-94M and also 4 separate switched band-spread ranges, 13M., 16M., 19M., and 25M., with Band Spread Tuning for accurate Station Selection. The coil pack and tuning heart is factory assembled, wired and tested. Superhet, 470 Kc/s. Mullard Transistors. Uses 4 U2 batteries. 5in. Ceramic Magnet P.M. Speaker, 500 MW Output. Telescopic Aerial and Ferrite Rod Aerial. Tone Circuit. In wood cabinet, size 11½ × 6½ × 3in., covered with washable material, plastic trim and handle. Car aerial socket fitted.

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

H.P. Terms: 60/- deposit and 11 monthly payments of 12/9 Total H.P.P. £10/0/3.

Data 2/6. Refunded if you purchase parcel. Four U2 batts. 3/4 extra. All components avail. sep. A simple additional circuit provides coverage of the 1100/1950M. Long Waveband. All necessary components with construction data. Only 10/- extra. Post Free. This conversion is suitable for receivers already constructed.

### TRANSISTOR FM TUNER CHASSIS



Fully tunable—range 88 to 108 Mc/s. Completely wired on printed circuit. 10.3 Mc/s. IF. 6 transistors and 3 diodes. Slow motion tuning drive. Size 6⅞ × 4 × 2¼in. Operates from any 9 v. D.C. source. Full data and circuit.

**LASKY'S PRICE £6.10.0** Post 5/- extra.

### MULTIPLEX ADAPTOR

Now you can enjoy stereo sound with the FM Tuner above. Brief spec.: MPX input sensitivity 100mV. Output 150 mV. Self powered by a 9 v. battery. 4 transistor and 6 diode circuit. Size 5¼in. × 2in. × ¾in. Also suitable for use with other FM tuners with MPX input.

**LASKY'S PRICE 99/6** Post 5/6.

PACKAGE PRICE IF BOUGHT TOGETHER £11.11.0. Post 5/-.

### LASKY'S PANEL METERS

Precision made in clear plastic HIOKI of Japan. Each meter boxed and fully guaranteed with all fixing nuts and washers. Sizes are of front panel. Spec. quotes for quantities. Add 1/6 post on each.

TYPE KR-5. 3 × 2¼in. (illus.)

| | |
|---|---|
| 1 mA. D.C. | 32/6 |
| 5 mA. D.C. | 32/6 |
| 300 V. D.C. | 32/6 |
| 100μA | 47/6 |
| 500μA | 37/6 |
| 1 mA S Meter | 39/9 |

TYPE MK-38A 1¾in. square

| | |
|---|---|
| 1 mA DC | 22/6 |
| 5 mA DC | 22/6 |
| 100 V. DC | 22/6 |
| 500μA | 29/6 |
| 100μA | 27/6 |
| 3 mA S Meter | 29/6 |

TYPE KR-65 3½ × 3in.

| | |
|---|---|
| 1 mA DC | 36/- |
| 5 mA DC | 35/- |
| 300 V DC | 35/- |
| 100μA | 49/6 |
| 500μA | 42/6 |
| 1 mA S Meter | 39/6 |

TYPE MK-45A 2in. square

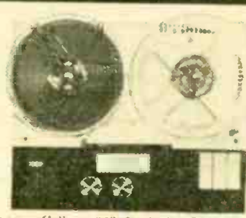
| | |
|---|---|
| 1 mA DC | 25/- |
| 5 mA DC | 25/- |
| 300 V DC | 25/- |
| 500μA | 25/- |
| 1 mA S Meter | 35/- |

TYPE MK-65A, 3in. square

| | |
|---|---|
| 1 mA DC | 36/- |
| 5 mA DC | 35/- |
| 300 V DC | 35/- |
| 500μA | 39/6 |
| 1 mA S Meter | 37/6 |

## STUDIO DECKS

### MAGNAVOX 363 TAPE DECKS



The very latest 3 speed model—1⅞, 3¾, 7½ i.p.s. available with either ½ track or ¼ track head. Features include: pause control; digital counter; fast forward and rewind; new 4 pole fully screened induction motor; interlocking keys. Size of top plate 13½ × 11 × 5¾in. deep below unit plate. For 200/250 v. A.C. mains. 50 c.p.s. operation. New unused and fully guaranteed.

**LASKY'S PRICE** ½ track model **£10.10.0**
**LASKY'S PRICE** ¼ track model **£13.9.6**
Carriage and Packing 7/6 extra

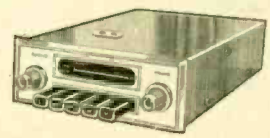
SPECIAL FOR OVERSEAS CUSTOMERS—the new Magnavox-Collaro 363 Deck for 110/125 v. 50 or 60 c.p.s. mains now available, prices as above. Post to any part of the world. 35/-.

### NEW MARTIN TAPE RECORD REPLAY AMPS.

Now available from stock—for use with the Magnavox 363 Tape Deck.
½ track model.......LASKY'S PRICE £14/19/6
¼ track model.......LASKY'S PRICE £15/19/6
Carriage & Packing 4/6 extra
Optional Extra: Control escutcheon to tape deck and amplifier controls.
LASKY'S PRICE 12/6. Post & Packing 2/6.

## SPECIAL INTEREST ITEMS!

### TWO BAND TRANSISTOR CAR RADIO BARGAIN! MODEL CR-62



A new high-quality imported all-transistor superhet car radio that really breaks the quality/price barrier. Unique features of this set are the four M/W band station pre-selection buttons which you yourself set to your own four favourite stations—this is in addition to full M/W band cover over 150-300 kc/s. (IF frequency 455 kc/s) Externally adjustable aerial trimmers ensure maximum output. Six transistor (including one drift type) and one diode circuit provides powerful 2 W. output. The set is adjustable for use on either pos. or neg. ground 12 v. systems (external line fuse fitted). Standard mounting size 6¾ × 5¾ × 2in.—front panel ¼in. larger all round—finished in anodised aluminium with black push buttons. Complete with mounting brackets, full installation instructions and 2 baffle boards (for round or elliptical speaker). Fully guaranteed.

**LASKY'S PRICE £9.19.6** Post 5/-. 6 × 4in. elliptical 8Ω dynamic speaker. 17/6 extra—Post FREE.

#### SPECIAL OFFER—LOCKING CAR AERIAL

Model 83003 five section 40in. extension heavy chrome telescopic wing mounting type with unique locking device to protect the antenna when closed. Complete with mounting bracket, lead and plug and two "keys."

**LASKY'S SPECIAL PRICE 39/6** Post free with the Royal CR-62. Sep. Post 2/6.

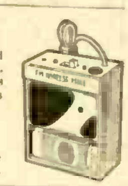
### NEW FOR THE RECORDING ENTHUSIAST VOICE ACTUATED MICROPHONE

MODEL B 5001

This new voice actuated microphone is designed for use with tape recorders with facilities for remote control. The microphone is fitted with a three position switch allowing normal hand remote control, voice sensitivity action and off. The degree of voice or sound level required to operate the recorder can be adjusted. The microphone is self powered by one 9V (PP3 type) battery giving 6 to 10 hrs. operating time. Super sensitive 6 transistor circuit. Strong black plastic case. Length 7¼ ins. Designed for hand-held use or lying flat. Fitted with 2.5 and 3.5 mm. plugs for fitting polarised sockets.

**LASKY'S PRICE £6.19.6** Post 3/6.

### EXPORT TTC B4002 FM WIRELESS MIC.

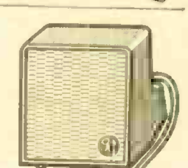


Highly sensitive—suitable for either static or mobile use. Signal can be picked up by any FM radio or tuner which receives frequencies between 96-104 Mc/s. over several hundred yards. Size only 3 × 2¼ × 1in. (in leather case). Operates on one PP3 type battery. Complete with neck cord, clip-on dynamic extension mike (¼ × ¾ × ⅝ in.) and battery.

**LASKY'S EXPORT PRICE £6.19.6** Post Free. Anywhere in the World.

TTC 13/500. More powerful version of above—size 7¼ × 1¾ × ¾in. Operates on the PP3 type battery. LASKY'S PRICE 12 Gns. Post Free. Anywhere in the World.

### MICROPHONE BARGAIN STC MODEL 414



A high quality omni-directional moving coil microphone—suitable for use with sound reinforcement and P.A. systems, tape recorders, transistor amplifiers, etc. Attractive grey moulded case for free standing or hand-held use—size 2¼ × 2¼ × 2¼in. Complete with 6ft. screened cable. New and unused in maker's cartons—fully guaranteed.

Type A. Low imp. 200Ω. LASKY'S PRICE £1/19/6
Type B. High imp. 50KΩ. LASKY'S PRICE £2/5/-. Post 2/-.

### MUSICASSETTES

There are now over 200 Musicasette titles available—Jazz—Pop—Shows—Classics—on Philips, Mercury, Fontana, C.B.S., Pye, Reprise, Chess, W.B., Kama Sutra, Page 1. *Send S.A.E. for full list of titles.*

### NEW INTERNATIONAL TAPE

FAMOUS AMERICAN MADE BRAND TAPE AT RECORD LOW PRICES

| | | | | | |
|---|---|---|---|---|---|
| 3in. | Message tape. 150ft. | 2/6 | 5¾in. | Long play. 1,200ft. Acetate | 12/6 |
| 3in. | Message tape. 225ft. | 3/9 | 5¾in. | Standard play. 850ft. P.V.C. | 11/6 |
| 3in. | Message tape. 300ft. | 7/6 | 5¾in. | Triple play. 2,400ft. Mylar | 45/- |
| 3¼in. | Triple play. 600ft. Mylar | 10/- | 5¾in. | Long play. 1,200ft. Mylar | 15/- |
| 4in. | Triple play. 900ft. Mylar | 17/6 | 7in. | Standard play. 1,200ft. Acetate | 12/6 |
| 5in. | Double play. 1,200ft. Mylar | 15/- | 7in. | Standard play. 1,200ft. Mylar | 12/6 |
| 5in. | Long play 900ft. Acetate | 10/- | 7in. | Long play. 1,800ft. Mylar | 19/6 |
| 5in. | Standard Play. 600ft. P.V.C. | 8/6 | 7in. | Double play. 2,400ft. Mylar | 25/- |
| 5in. | Triple play. 1,800ft. Mylar | 35/- | 7in. | Long play. 1,800ft. Acetate | 15/- |
| 5¾in. | Double play. 1,800ft. Mylar | 22/6 | 7in. | Triple play. 3,600ft. Mylar | 50/- |

1/- Post extra per reel; 4 reels and over Post Free.

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# Lasky's Radio

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**PLUS** many bargain offers and prices exclusive to Lasky's

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—just send your name, address and 6d stamp for postage only.

*A MUST FOR EVERY ELECTRONICS & HI-FI ENTHUSIAST!*

## RECORD PLAYERS

### B.S.R. AUTOCHANGERS NEW LOW PRICES

Fully guaranteed complete with cartridge and stylus

| | |
|---|---|
| UA16 ov. battery model | £5 19 6 |
| UA20 4-speed mains model | £5 19 6 |

**NEW—B.S.R. UA70** (Illustrated
4 speed mains autochanger superb modern styling at amazingly low price.

LASKY'S PRICE **£9/19/6** (ex cartridge)

### GARRARD AUTOCHANGERS

| | |
|---|---|
| AT60 Mk. I | £9 19 6 |
| AT60 Mk. II | £12 19 6 |
| 3000LM with stereo cartridge | £8 19 6 |
| A70 | £17 17 0 |
| Lab. A Mono/Stereo | £14 19 6 |
| Lab. A on plinth | £15 19 6 |
| A50 | £7 7 0 |
| A1000 | £6 6 0 |
| A2000 | £6 16 6 |

**GARRARD BASES**

WB1 ...... £3 16 3 WB2 £5 5 0

**CLEARVIEW PERSPEX COVERS**

WB1 ...... £3 17 0 WB2 £5 7 11

**TRANSCRIPTION MOTORS**

| | |
|---|---|
| GARRARD 401 | £27 19 0 |
| GARRARD Lab. 80, Mk. II | £25 0 0 |
| CONNOISSEUR | |
| Craftsman II | £17 2 11 |
| Craftsman III | £22 19 6 |
| Model B | £25 4 0 |
| LENCO GL58 | £17 1 9 |
| LENCO GL68 | £19 10 7 |
| LENCO G88 | £15 15 0 |
| LENCO GL70 | £29 18 8 |
| LENCO G99 | £21 19 5 |
| THORENS TD135 I | £26 5 0 |
| THORENS TD135 II | £40 5 8 |
| THORENS TD124 II | £40 5 8 |
| THORENS TD150 | £20 13 2 |

**SINGLE PLAYERS**

Auto. start and stop. Complete with pick-up and crystal cartridge.

| | |
|---|---|
| EMI with Stereo cartridge | £3 19 6 |
| COLLARO Junior 4-speed | £3 9 6 |
| GARRARD SRP12 | £4 7 6 |
| GARRARD SRP10 mains model | £4 19 6 |
| GARRARD SRP10 batt. model | £4 19 6 |
| GARRARD SP25 Light t/table | £9 19 6 |
| GARRARD SP25 Heavy t/table | £10 19 6 |
| *(Garrard SP25's are ex-cartridge)* | |
| PHILIPS AG/1016 | £12 12 0 |
| BRAUN PC4L Stereo | £8 19 6 |

**All other current models available. Postage on all above 5/- extra.**

## DEMONSTRATION STUDIOS

### *Lasky's High Fidelity Sound Centres*

**42 Tottenham Court Road, W.1** and **118 Edgware Road, W.2** are London's most comprehensive High Fidelity Sound Centres, designed to provide a real "Home-from-Home" for the discerning Hi-Fi Enthusiast. There you can see, hear and compare any combination of the finest quality equipment; our experienced staff are on hand to help you plan a complete system and to select the equipment most suitable to your requirements. In addition we are often able to offer considerable cash savings when you choose a complete system.

*If you cannot call at any of our branches please send details of your requirements to our head offices and we shall be pleased to quote without obligation. We operate the "Purchase Tax Free" scheme for overseas visitors. Full H.P. terms available.*

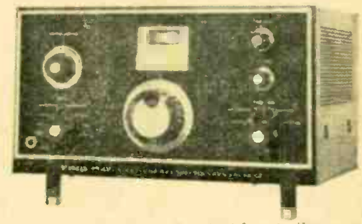
## PACKAGE DEALS

**A Lasky's "Package Deal"** allows you to purchase the complete Audio System of your choice at a worthwhile cash saving. We shall be pleased to quote our "Package Deal" price for any selection of equipment of your own choice. Send us details of your requirements. **H.P. and Easy Credit Terms can be arranged on "Package Deals."**

## COMMUNICATION RECEIVERS

*NOW AVAILABLE FOR THE FIRST TIME IN GREAT BRITAIN.* **TWO NEW TRIO RECEIVERS**

### MODEL JR-500SE



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

**LASKY'S PRICE £61.19.0** Carriage and Packing 12/6.

### MODEL 9R-59DE

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

**LASKY'S PRICE £36.15.0** Carriage and Packing 12/6.

## TAPE RECORDERS

### *JUST ARRIVED*—FANTAVOX TAPE CASSETTE PLAYER

This machine is the first of its type and is designed specifically to replay pre-recorded tape cassettes made for the PHILIPS and other cassette systems. The cassette is simply slipped into the machine and is immediately ready to play—each cassette gives over 40 minutes' play—(twin track), no loss of time in rewinding—simply turn cassette over. Constant tape speed 1⅞ i.p.s. Only two controls off/play and vol. Fully transistorised, powerful vol., built-in speaker, socket for personal earpiece. Operates on 6 pen-light batts. Very attractively styled shockproof plastic cabinet size 6¼ × 4¼ × 2ins. with wrist strap. Complete with earpiece and batteries. There are now over 200 musicassette titles available. JAZZ, POP, SHOWS and CLASSICS—this machine allows you to play the music of your choice anywhere—anytime.

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### *OUTSTANDING VALUE*—THE 'TELETON' 701

**7-TRANSISTOR TWO-SPEED CAPSTAN DRIVE MAINS/BATTERY RECORDER**

An outstandingly high quality machine that is unparalleled for value. Performance is equal on both mains and battery, excellent music and speech characteristics make this the ideal home or office recorder.

**Look at these outstanding features:**

● 7 transistor and 3 diode circuit—800mW output. ● Two speed, 1⅞ and 3¾ i.p.s. capstan drive system (wow and flutter better than 0.3% at 3¾ i.p.s.). ● Built-in 110/240 v. A.C. convertor for mains operation or uses 4 × 1.4 v. batteries. ● Takes 5in. spools giving 3 hrs. twin track recording at 1⅞ i.p.s. and 1½ hrs. at 3¾ i.p.s. ● Fast forward and rewind. ● Twin track A.C. bias recording system—frequency response 100 to 7,000 c/s. ● Record level meter (acts as battery check on replay). ● Piano key function controls, plus vol. and tone controls. ● Continental type 5 pin inputs for microphone, telephone adaptor pick-up and direct recording from radio or other recorder; switched input for earphone. ● 2¼ × 4¼ P.M. Dynamic speaker. ● Plastic cabinet in two-tone grey with chrome metal trim and carrying handle. ● **Accessories:** Dynamic stick microphone with clip-on stand, telephone pick-up, 5in. spool of tape and empty spool, earphone, direct recording lead mains lead with plug, batteries and instruction book with circuit comp. with all accessories. Fully guaranteed.

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(DEPT. W.W.)

8 Radnor House
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**W.W. DIGITAL COMPUTER TRANSISTORS and DIODES**

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|---|---|
| Trans. 2G-371/D1476 | 8d. each |
| Trans. Sil. 2S301C | 2/- each |
| Diodes Sil. 1S130 | 4d. each |

Prices for all qty's. All devices will meet W.W. specifications reqd. BRAND NEW.

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## NEW UNTESTED SUPER-PAKS
### Uncoded Devices

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| 40 | SIL. PLANAR TRANS NPN. Sim 2N706/8, BSY26/27, 2S103/4 | 10/- |
| 30 | MADT Metal Alloy Diffused Trans. Sim. MAT101/2, MA393, MA820, PNP. | 10/- |
| 50 | Sil. Planar Diodes 250mA. Sim. 1S121/130 OA200/202 | 10/- |
| 30 | AF Germ. Alloy Trans. PNP. Sim. 2G300 Series. OC71/75, AC125/8 | 10/- |
| 12 | Epoxy Case 500mA Sil. Rect. 100-600 p.i.v. Sim. BY101, BY130. | 10/- |
| 30 | Fast Switching Sil. Diodes. Sim. 1N914/916 TS12/16, Micro-Min | 10/- |
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## * VALUE PACKS for '68 NEW UNTESTED *

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| 120 Glass Sub-Min. | GERM. DIODES | 10/- |
| 50 Mixed Germ. | TRANSISTORS | 10/- |
| 20 Mixed Volts | ZENERS | 10/- |
| 30 NPN, PNP, MIXED | SIL. TRANS. | 10/- |
| 60 200mA Sub-Min. | SIL. DIODES | 10/- |
| 20 Germ. 1 Amp. | RECTIFIERS | 10/- |
| 40 Like OC81, AC128 | TRANSISTORS | 10/- |
| 10 2 Amp. Stud | SIL. RECT. | 10/- |
| 25 Sil. NPN, 200 Mc/s. | TRANSISTORS | 10/- |
| 16 Top-Hat 750mA | SIL. RECT. | 10/- |
| 75 GERM. DIODES | GOLD BONDED | 10/- |
| 20 Like BAY 50 charge storage | DIODES | 10/- |
| 10 50-400 PIV 1 Amp. | SCR's | 20/- |

## ★ QUALITY-TESTED VALUE PAKS ★ BARGAINS ★

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| 6 | Matched Trans. OC44/45/81/81D | 10/- |
| 16 | Red Spot AF Trans. PNP | 10/- |
| 16 | White Spot RF Trans. PNP | 10/- |
| 5 | Silicon Rects. 3 A 100-400 PIV | 10/- |
| 2 | 10 A Silicon Rects. 100 PIV | 10/- |
| 2 | OC1 140 Trans. NPN Switching | 10/- |
| 1 | 12 A SCR 100 PIV | 10/- |
| 3 | Sil. Trans. 2S303 PNP | 10/- |
| 4 | Zener Diodes 250 mW 3-12 V | 10/- |
| 3 | 200 Mc/s Sil. Trans. NPN BSY26/27 | 10/- |
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| 4 | High Current Trans. OC42 Eqvt. | 10/- |
| 2 | Power Transistors 1 OC26 1 OC35 | 10/- |
| 5 | Silicon Rects. 400 PIV 250 mA | 10/- |
| 4 | OC75 Transistors Mullard Type | 10/- |
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| 4 | Sil. Rects. 400 PIV 500 mA | 10/- |
| 5 | GET884 Trans. Eqvt. OC44 | 10/- |
| 5 | GET883 Trans. Eqvt. OC45 | 10/- |
| 3 | VHF Sil. Epoxy Trans. NPN 100 Mc/s | 10/- |
| 2 | 2N708 Sil. Trans. 300 Mc/s NPN | 10/- |
| 5 | GT41/45 Germ. Trans. PNP Eqvt. OC71 | 10/- |
| 3 | GT31 LF Low Noise Germ. Trans. PNP | 10/- |
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| 8 | OA95 Germ. Diodes Sub-min. 1N69 | 10/- |
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| 2 | OC22 Power Trans. Germ. | 10/- |
| 2 | OC25 Power Trans. Germ. | 10/- |
| 2 | OC73 Mullard Trans. | 10/- |
| 4 | AC128 Trans. PNP High Gain | 10/- |
| 2 | AC127/128 Comp. pair PNP/NPN | 10/- |
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| 12 | Assorted Germ. Diodes Marked | 10/- |
| 4 | AC126 Germ. PNP Trans. | 10/- |
| 5 | 1 Amp. Germ. Rect. 200 PIV | 10/- |
| 1 | ORP61 Photo-conductive cell | 10/- |
| 4 | Silicon Rects. 100 PIV 750 mA | 10/- |
| 3 | AF117 Trans. Mullard Type | 10/- |
| 7 | OC81 Type Trans. | 10/- |
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| 2 | Zeners Z2A150F. 15 V 1 watt | 10/- |
| 3 | 12 Volt Zeners 400 mW | 10/- |
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| 3 | BC108 Sil. NPN High Gain Trans. | 15/- |
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| 2 | Sil. Rects, 5 A 400 PIV Stud Type | 15/- |
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## UNIJUNCTION

UT46, Eqvt. 2N2646, Eqvt. TIS43 — 7/6

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| 50 | 2/- | 3/- | 4/6 | 9/6 |
| 100 | 2/3 | 3/6 | 6/- | 15/- |
| 200 | 2/6 | 4/6 | 6/6 | 20/- |
| 300 | 3/- | 4/9 | 8/- | 22/- |
| 400 | 3/6 | 6/- | 9/- | 25/- |
| 500 | 4/- | 6/6 | 9/6 | 30/- |
| 600 | 4/3 | 7/- | 10/- | 37/- |
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| 25 | — | 7/6 | — | 30/- |
| 50 | 7/6 | 8/6 | 10/6 | 35/- |
| 100 | 8/6 | 10/- | 15/- | 45/- |
| 200 | 12/6 | 15/- | 20/- | 55/- |
| 300 | 15/- | 20/- | 25/- | — |
| 400 | 17/6 | 25/- | 35/- | 80/- |
| 500 | 30/- | 40/- | 45/- | 95/- |
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Our vast stocks change daily with hundreds of Semi-conductor bargains becoming available. Just send 2/6 to cover 3 months mailing of our latest stock lists, eqvt. charts, circuits, etc.

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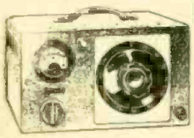
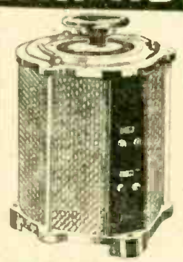


Input 230 v. A.C. Output variable 0-260 v. A.C. at 1.5 amp. Fitted in beautifully finished steel case. Complete with voltmeter, pilot lamp, fuse switch, carrying handle. **£8 10 -. P. & C. 10/-.** Also 2.5 amp. as above. £9/17/6. P. & C. 10/-.



50 AMPS

1 AMP.

INPUT 230 v. A.C. 50/60

BRAND NEW. Keenest prices in the country. All Types (and Spares) from ½ to 50 amp. available from stock.

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| 0–260 v. at 1 amp. | £4 | 10 | 0 |
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| 0–260 v. at 5 amps. | £9 | 0 | 0 |
| 0–260 v. at 8 amps. | £13 | 10 | 0 |
| 0–260 v. at 10 amps. | £17 | 0 | 0 |
| 0–260 v. at 12 amps. | £19 | 10 | 0 |
| 0–260 v. at 15 amps. | £22 | 0 | 0 |
| 0–260 v. at 20 amps. | £32 | 10 | 0 |
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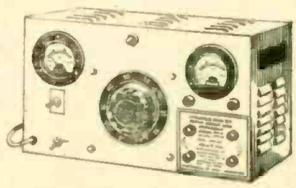
20 DIFFERENT TYPES AVAILABLE FOR IMMEDIATE DELIVERY. P. & C. EXTRA

### 5 Amp. AC/DC VARIABLE VOLTAGE OUTPUT UNIT



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Output variable. 0-260 v.

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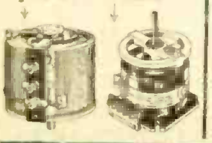
|---|---|---|---|
| ½ amp. | £3 | 3 | 0 |
| 1 amp. | £4 | 10 | 0 |
| 2½ amp. | £5 | 12 | 6 |

P. & P. 7/6

½ AMP. 1 AMP.



### CONSTANT VOLTAGE TRANS-FORMERS

Input 185-250 v. A.C. Output constant at 230 v. A.C. Capacity 250watt. Attractive metal case. Fitted red signal lamp. Rubber feet. Weight 17lbs. Price £11/10/-. P. & P. 10/-.

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**0-36 v. at 5 amp. £8.10.0—p. & p. 8/6**
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These fully shrouded Transformers, designed to our specifications, are ideally suited for Educational, Industrial and Laboratory use.

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Fully isolated. Fitted in robust metal case with Voltmeter Ammeter. Panel Indicator and chrome handles. Input and Output fully fused. Ideally suited for Lab. or Industrial use. £55 plus 40/- p. & c. Similar in appearance to above illustration.

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| Standard | | Long | |
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| 3in. 150ft. | 2/3 | 3in. 225ft. | 2/9 |
| 4in. 300ft. | 4/6 | 4in. 450ft. | 5/6 |
| 5in. 600ft. | 7/6 | 5in. 900ft. | 10/6 |
| 5¾in. 900ft. | 10/6 | 5¾in. 1,200ft. | 13/- |
| 7in. 1,200ft. | 12/6 | 7in. 1,800ft. | 18/6 |

| Double | | Triple | |
|---|---|---|---|
| 3in. 300ft. | 4/- | 4in. 900ft. | 13/- |
| 4in. 600ft. | 8/- | 5in. 1,800ft. | 25/- |
| 5in. 1,200ft. | 15/- | 5¾in. 2,400ft. | 34/- |
| 5¾in. 1,800ft. | 19/- | 7in. 3,600ft. | 44/- |
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| Quadruple | |
|---|---|
| 3in. 600ft. | 8/6 |

*Postage 1/- reel.*

Post Free less 5% on three reels.
Quality and Trade enquiries invited.
NOTE. *Large tape stocks at all branches.*

## UNREPEATABLE ★ SNIPS ★

GARRARD AT6 MK II — 9 Gns.
GARRARD SRP12 (110/230v.) — 59/-
COLLARO 9 VOLT 4 SPD. HEAVY T/T. LIGHT ARM (list £7) (p&p 5/-) — 49/-
*ABOVE LESS CARTRIDGES*
Mono. Cart. add 12/6
Stereo Ceramic Cart. add 19/-

**AUTOCHANGE PORTABLE CABINETS.** As used on 18 gns. record player. Due to fortunate purchase we offer complete with motor board and all fittings at only 49/-

**PLEASE NOTE.** *A wide range of cabinets to callers at all branches.*

**100 HI-STABS** 1% to 5% 100Ω to 5 mΩ. 9/6

**CO-AX** low loss, 8d. yd. 25 yds. 13/6. 50 yds. 25/-: BBC2 H/D fringe 1/6 yd. 25 yds. 30/-.

**100 RESISTORS** SIZES ¼-3 watt. 6/6

**MICROPHONE CABLE.** Highest quality, black, grey, white, 1/- YD.

**100 CONDENSERS** 9/6
Miniature Ceramic, Silver, Mica, etc. 3pF to 5μF. LIST VALUE OVER £4.

## SILICON H.T. RECTIFIERS

Guaranteed performance. Top makes. Tested 250 v. working.
120 mA (3 for 6/6) 2/9
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## LATEST GARRARD

*(POSTAGE 5/-)*

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| SRP12 | £4.7.0 |
| SP25 (De Luxe Die Cast) | £9.19.0 |
| AT.5 | £5.10.0 |
| Model 50 | £7.10.0 |
| Model 1,000 | £6.5.0 |
| Model 2,000 | £6.10.0 |
| Model 3,000 | £8.10.0 |
| AT60 Mk. II | £11.11.0 |
| A70 | £18.10.0 |
| LAB 80 Mk. II | £24.12.0 |
| 401 | £27.10.0 |
| ERG0 Stereo Ceramic Cartridge | 24/- |

## PLINTHS

Teak de luxe finish cut out for SP25. Model 50, 1,000, 2,000, 3,000 AT60 ... 59/-
Ditto, super Perspex clear cover, complete ... £5.15.0
Lab 80. 401. A70. Superb new hinged lid, teak and Perspex plinth (List £12.10.0) ... £9.19.0

## BARGAIN PARCELS

Including variable condensers, I.f. coils, loud-speaker plugs/sockets, knobs, pots, condensers, resistors, nuts, bolts, cabinet fittings, switches, transformer choke, rectifier, transistors at a small fraction of list value. Due to heavy demand we are now packing them in several sizes—TRY ONE.

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| 3 lbs. (post 3/-) | 9/- |
| 7 lbs. (post 5/-) | 17/6 |
| 14 lbs. (post 6/-) | 29/- |

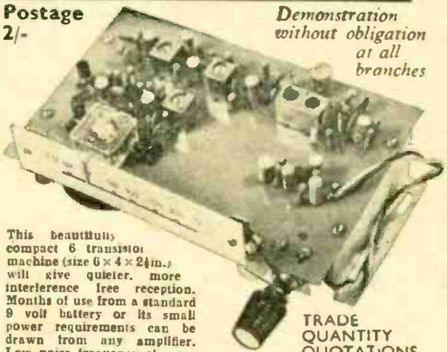
## HEAVY DUTY 14/20 watt AMPLIFIER KITS

Famous make consisting integrated controls, high/low gain preamp stages feeding EL34 Push Pull Output, C core transformers, complete with instructions down to the last bolt. Current model at fraction of list price. 8½Gns.

## Transistorised FM Tuner

Postage 2/-

*Demonstration without obligation at all branches*



This beautifully compact 6 transistor machine (size 6 × 4 × 2½in.) will give quieter, more interference free reception. Months of use from a standard 9 volt battery or its small power requirements can be drawn from any amplifier. Low noise frequency changer with smooth 2 gang tuning feeding no less than three I.F. stage, coupled to a double-tuned discriminator terminating in an L.P. stage giving ample output for all quality amplifiers.

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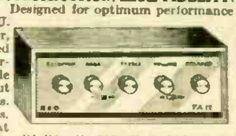
## R.S.C. TA12 13 WATT STEREO AMPLIFIER



FULLY TRANSISTORISED, SOLID STATE CONSTRUCTION. HIGH FIDELITY. OUTPUT OF 6.5 WATTS PER CHANNEL. Designed for optimum performance with any crystal or ceramic Gram P.U. cartridge, Radio, Tuner, Tape Recorder, "Mike," etc. ★ 3 separate switched input sockets on each channel. ★ Separate Bass and Treble controls. ★ Slide Switch for mono use. ★ Speaker Output 3-15 ohms. ★ For 200-250 v. A.C. mains. ★ Frequency Response 30-20,000 c.p.s. −2dB. ★ Harmonic Distortion 0.3% at 1,000 c.p.s. Hum and Noise −70dB. ★ Sensitivities (1) 300mV (2) 100mV (3) 100mV (4) 2mV. ★ Handsome brushed silver finish facia and knobs. Complete kit of parts with full wiring diagrams and instructions.

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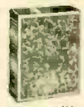

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**SE10.** For 10in. Hi-Fi Speaker. Size 24 x 15 x 10in. **6 Gns.**

**SE12.** For outstanding performance with any 12in. Hi-Fi speaker Cut for tweeter. Size 25 x 16 x 10½in. **7 Gns.**

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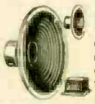

Consisting of matched 12in. 12,000 line, 15 ohm high quality speaker, cross-over unit and Tweeter. Smooth response and extended frequency range ensure surprising realistic reproduction. Standard 10 watts rating. Or Senior 15 watt inc. Audiotrine HF 126 speaker. 6 Gns. Carr. 6/6. **5 Gns.** Carr. 5/9

**FR3 3 SPEAKER SYSTEM** Inc. Audiotrine HF126, 12in. Bass unit, with .... 15,000 line magnet. 5in. 10 watt 11,000 line mid-range speaker HF 510M, High Flux 4in. Tweeter. Cross-over units for mid- and high-frequencies and circuit. Housed in suitable cabinet will provide quality comparable with very expensive units. Rating 15 watts. Impedance 15 ohms. **9 Gns.** Carr. 7/6

**AUDIOTRINE HIGH FIDELITY MODULES** Model MT 54

Consisting of HF 510M Mid-range speaker, Tweeter and Cross-overs used in FR3 3 Speaker system above mounted on baffle board 10½ x 5½in. wired and ready for connecting across a 12in. 15 ohms speaker. **£5.15.0** Carr. 6/6

**MODEL FR 12/54** This is the FR 3 3 speaker system fully wired and mounted on baffle board 12¼ x 17½in. **10 Gns.** Carr. 10/6.

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WITH MATCHING 5 WATT HIGH QUALITY A.C. MAINS RECORD/PLAYBACK AMPLIFIER for 3 ohm speaker. Switched equalisation for each speed. Magic Eye Recording level indicator.

2 TRACK **24 GNS.** 4 TRACK **27 GNS**

## LINEAR SOLID STATE HI-FI AMPLIFIERS IN STOCK

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Employing latest type Transistors. 200-250 v. A.C. mains operated. Frequency Response 30-20,000 c.p.s. −2dB Harmonic Distortion 0.3% at 1,000 c.p.s. Separate Bass and Treble "lift" and "cut" controls. 3 input sockets for Mike. Gram. Radio or Tape Input Selector Switch. Output 3-15 ohm speakers. Max. Sensitivity 5mV. Fully enclosed enamelled case, 9¼ x 2½ x 5½in. Attractive brushed silver finish facia plate 10¼ x 3¼in. and matching knobs. Complete kit of parts with full wiring diagrams and instructions. Or factory built with 12 mths. guarantee. Post paid 8 gns. Carr. 7/6 **6 Gns.**

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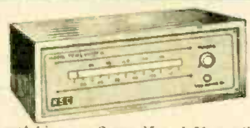
Total cost of parts with detailed wiring diagrams and instructions. Carr. 10/- **12½ Gns.** Or factory built 15½ Gns. Or in Teak finished cabinet as illustrated 19 GNS. Terms: Deposit £5 and 9 monthly payments 39/-. Total £22/11/-.



★ High Sensitivity. ★ 200-250 v. 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 reliability. The pre-wired tuning head facilitates speed and simplicity of construction. Printed circuitry. Only first grade components used. A quality product at half the cost of comparable units. Stereo version available. All parts 19½ Gns. Assembled 25½ Gns. In cabinet 29 Gns. Carr. 10/-

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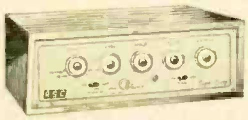
**SOLID STATE CIRCUITRY**

FULLY TRANSISTORISED 200/250 v. A.C. Mains. OUTPUT 10 WATTS R.M.S. cont. into 15 ohms. 15 WATTS R.M.S. cont. into 3-4 ohms. LATEST MULLARD TRANSISTORS. AD149. AD149. OC127Z. OC81Z. OC44. OC44. OC81Z. OC44, AC107. 5 POSITION INPUT SELECTOR SWITCH EQUALISATION to Standard R.I.A.A. and C.C.I.R. Characteristics for Gram and Tape Heads. FULL TAPE MONITORING FACILITIES SENSITIVITIES: Magnetic P.U. 4 mV. Crystal or Ceramic P.U. 400 mV. Microphone 4.5 mV. Tape Head 2.5mV. Radio/Aux. or Ceramic P.U. 110mV. FREQUENCY RESPONSE: ±2 dB 20-20,000 c.p.s. TREBLE CONTROL: +15dB to −14dB at 10 Kc/s. NEG. FEEDBACK: 52dB. BASS CONTROL: +12dB to −15dB at 50 c/s. HUM LEVEL: −75dB. HARMONIC DISTORTION at 10 Watts R.M.S. 1,000 c.p.s. 0.25%. Carr. 12/6. Complete Kit of parts with full constructional details and point to point wiring diagrams. Supplied factory built 15½ Gns. **11½ Gns.** Carr. 12/6. Terms: Deposit 4 Gns. and 9 monthly payments 31/1 (Total £18/3/9). Or fitted in beautiful walnut or Teak veneered cabinet as illustrated 4 Gns. extra.



THESE UNITS ARE EMINENTLY SUITABLE FOR USE WITH ANY MAKE OF PICK-UP OR MICROPHONE (Crystal, Ceramic, Magnetic, Dynamic or Ribbon) CURRENTLY AVAILABLE - SPECIFICATIONS COMPARABLE WITH UNITS AT ALMOST TWICE THE COST

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A DUAL CHANNEL VERSION OF THE SUPER 15. Employing Twin Printed Circuits. Close tolerance Ganged Pots. Matched Components. CROSS TALK: −52dB at 1,000 c.p.s. CONTROLS: 5 position Input Selector, Bass Control, Treble Control, Volume Control. Balance Control. Stereo/Mono Switch, Tape Monitor Switch. Mains Switch. INPUT SOCKETS (Matched Pairs). (1) Magnetic P.U. (2) Ceramic or Crystal P.U. (3) Radio/Aux. (4) Tape Head/Microphone. Operation of the Input Selector Switch assures appropriate equalisation. Rigid 18 s.w.g. Chassis. Size approx. 12in. x 3in. x 8in. Neon Panel Indicator. Attractive Facia Plate and Spun Silver Matching Knobs. Above facilities, except for Ganging and Balance Control, apply also to Super 15. SUPERB SOUND OUTPUT CAN BE OBTAINED BY USING THESE UNITS WITH FIRST RATE ANCILLARY EQUIPMENT. All required parts, point to point wiring diagrams and detailed instructions. *Send S.A.E. for leaflet.* Carr. 15/-. **19 Gns.** Unit factory built with 12 months full guarantee 26½ Gns. or deposit £6/2/- and 9 monthly payments 50/- (Total £30/17/-). Fitted cabinet as Super 15 30 Gns. Carr. 15/- or Deposit £6/2/6 and 9 monthly payments 64/- (Total £34/18/6).

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Attractive design with polished walnut finish. Model M for 10" speaker. Size 28x19x12in. **59/11** Model 8 for 12" speaker and tweeter. Size 31½x22¾x14in. **5 Gns.**

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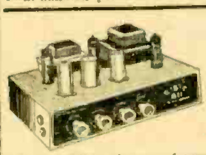

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| **FULLY SHROUDED UPRIGHT MOUNTING** | |
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| 80mA. 10H, 350 Ω | 7/9 |
| 60mA. 10H, 400 Ω | 4/11 |

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| Swan 230-XC Power supply (to suit 500 or 350) | 49 | 0 | 0 |
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| SX-122 Communications receiver | 148 | 5 | 0 |
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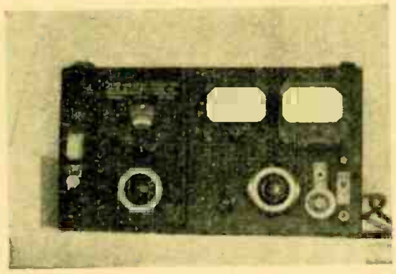

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CHANNEL 2 4MV. AT 470K. } microphone or guitars.
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WITH BASS AND TREBLE CONTROLS CENTRAL −3 db POINTS ARE 30 Hz/s. AND 20 KHz/s.

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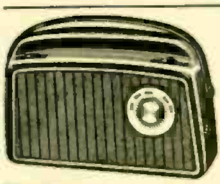

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### *with BABY ALARM Facilities*

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Circuit and parts list 2/6, free with parts.

600 milli-watt solid state 7 transistor plus diode and thermistor.
Completely modulised high quality portable radio featuring complementary N.P.N. and P.N.P. output stage.
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**BRESGES Geared Motor**
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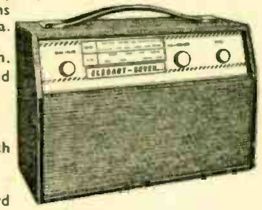
# 'ELEGANT SEVEN' MK IIIA

## SPECIAL OFFER

Power supply kit to purchasers of "Elegant Seven" parts, incorporating mains transformer, rectifier and smoothing condenser. A.C. mains 200/250 volts. Output 9 v. 100 mA. 9/6 extra.



★ De luxe wooden cabinet size 12¼ x 8¼ x 3¼in.
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| 3in. | L.P. | 240ft. | 4/– | 5in. | T.P. | 1,800ft. | 25/6 |
| 5¾in. | L.P. | 1,200ft. | 11/6 | 5¾in. | T.P. | 2,400ft. | 32/6 |
| 5¾in. | D.P. | 1,800ft. | 18/6 | 7in. | T.P. | 3,600ft. | 42/6 |
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A superb High Quality, yet inexpensive stereo amplifier. Due to great demand we are now able to offer this precision made instrument at a fantastically low price. Its quality, reliability and styling has in no way been marred by its low price.

**SPECIFICATIONS**
Elegant styled cabinet (sizes 16in. wide 5in. high, 8¼in. deep) in black rexine and woodgrained sides. Brushed aluminium front panel with contrasting black/silver knobs.

**CONTROLS**
Stereo/Mono switch. Gram/Aux. switch. Volume left. Volume right. Treble (cut and lift). Bass (cut and lift). Separate on/off switch. Neon pilot indicator.

**INPUTS AND OUTPUTS (per channel)**
Gram, Aux., Tape out and Speaker out. A switched mains socket is also provided at the rear of unit.
Employs Mullard valves throughout. ECC83 and 2 x ECL 86. With a metal bridge rectification.

**TECHNICAL SPECIFICATIONS**
Gram sensitivity 40 mv. at 1 KHz. Aux. sensitivity 50 mv. at 1 KHz. (sensitivities are given for rated output). 4 watts R.M.S. per channel (8 watts R.M.S. in monorall position). Output matches into standard 3 ohms speaker system. Suitable 10in. x 6in. speakers are available at 29/6 each + 5/- P. & P. Bass control at 100 Hz lift + 9dB, cut −10 dB.
Treble control at 10 KHz. Lift +8db, cut −13db.
Total harmonic distortion 0.35% at 3 watts and 2% for rated output at 1 KHz.
Negative feedback 13db at 1 KHz.
Mains supply 220-250 v. A.C. 50-60 Hz.
PRICE 13 gns. P. & P. 15/-.

**600 mW SOLID STATE**

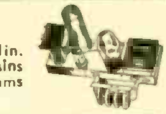
## 4-TRANSISTOR AMPLIFIER

Features NPN and PNP Complementary Symmetrical Output Stage. 2¼ x ¾ x ¾in. Speaker output impedance 12 ohms.
Frequency response −3dB points 90 c/s. and 12 kc/s. **Price 15/-** plus 1/- P. & P. 7 x 4 speaker to suit, 13/6, plus 2/- P. & P.

**BSR TAPE DECKS 200/250 v. A.C. mains**

**Type TD2.** Tape speed 3¾ twin track, £6/19/6.
**Type TD10,** 2-track, 3 speed, plus rev. counter, £7/19/6.
**Type TD10,** 4-track, 3 speed, plus rev. counter, £9/5/-. P. & P. on each 7/6.

## 3 TO 4 WATT AMPLIFIER



3-4 watt Amplifier, built and tested. Chassis size 7 x 3½ x 1in. Separate bass, treble and volume control. Double wound mains transformer, metal rectifier and output transformer for 3 ohms speaker. Valves ECC81 and 6V6, £2/5/- plus 5/6 P. & P.

## M.I.P. PYROMETER

*Temperature Range*
50°F—230°F and 10°C—110°C
Built in a robust case, (5¾in. x 4in. x 1⅞in.)
Complete with probe and batteries.
Only £5.0.0. Plus 5/- P. & P.

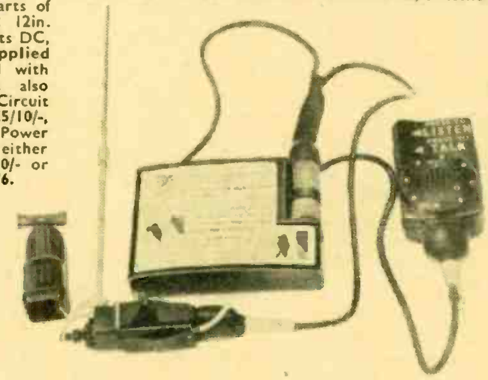
A very useful instrument, directly calibrated in centigrade and Fahrenheit on an easy to read moving coil meter.
Particularly suitable where heat-rise plays an important part in the functions of:— Instruments, Cars, Cooling or Heating Systems, etc.

# RADIO AND T.V. COMPONENTS (ACTON) LTD

21A HIGH STREET, ACTON, LONDON W.3.
SHOP HOURS 9 a.m. to 6 p.m. EARLY CLOSING WEDNESDAY.
*Terms C.W.O. Goods not despatched outside U.K. All enquiries stamped add. envelope.*
**323 EDGWARE ROAD, LONDON, W.2.** Early closing Thursday.
*PERSONAL SHOPPERS ONLY. All orders by post must be sent to our Acton address.*

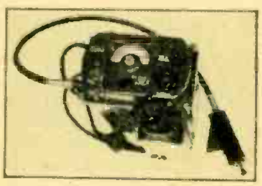
## TRANS/RECEIVER TWO-TWO

This is one of the Latest Releases by the Govt. of an extremely recent R/T set covering 2-8 Mc/s. In two switched Bands, containing 13 Valves (3 EL32s in TX Output) which can be used for Morse CW or R/T. Also has Netting Trimmer, BFO, RF & EF Controls, Switched Meter for checking all parts of set, Size 17in. × 8in. × 12in. Power required LT 12 volts DC, HT 325 Volts D.C. **Supplied Brand New** and Boxed with **Headphones & Mike,** also **Two Spare Valves** and Circuit of set. **Few only at £5/10/-,** Carr. 50/-. New Plug in Power Supply made by us for either 12 volts D.C. Input **£5/10/-** or 200/250 Volts A.C. **£3/17/6.**



## LARGE QUANTITY OF SARAH V.H.F. TRANS/RECEIVERS AVAILABLE FOR IMMEDIATE EXPORT.

General Information. This set is normally carried in the life jacket of Airmen, it is a complete miniature lightweight radio Trans/Receiver, which is used to give a Beacon plus two way speech communication in the event of finding themselves in the sea. It comprises a Transmitter-Receiver, a speech unit, a coding unit and a power supply either Battery OR Transistor. These three items are permanently interconnected and all units are completely sealed and watertight using a combined speaker/Mike, Press to talk or listen buttons, Fold up Aerial, a total of three Valves are used, power required 6.3 Volts LT 90 Volts and 435 Volts DC RT. Frequency 243Mc/s. Transmitter output pulse power—Beacon 15 Watts, Talk 3 Watts. **Supplied in maker's boxes** in Grade 1 condition singly at 45/-, post 5/- with circuit. New batteries If available 7/6 each.



## FEW ONLY LEFT! WALKIE-TALKIE MK111 AND CRYSTAL CALIBRATOR NO.9

We have a few of these V.H.F. 12 Valve Transreceivers operating on 3 switched channels between 60 Mc/s-95 Mc/s, complete with all 6 Crystals, Headphones, Mike, Mobile Aerial and Dipole Aerial, all Connectors plus Alloy Tripod for mounting the set on. Power Input 12 volts D.C., TX output 3 Watts, Internal Speaker (All Valves BG7). All **Air Tested O.K.,** Supplied in good Grade 2 Condition at **£10/-/-** each, Carr. 30/-. Also available in Matched Pairs **£25** per pair, Carr. 30/- Tested.

## JOHN'S RADIO

OLD CO-OP, WHITEHALL ROAD, DRIGHLINGTON, BRADFORD.
TEL.: DRIGHLINGTON 732

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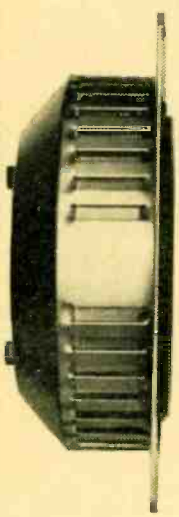


## TITANIUM CONE LOUDSPEAKERS

**TITANIUM CONE**—provides the highest standard of definition ever achieved.

**BERYLLIUM COPPER SUSPENSION**—provides powerful low-distortion bass.

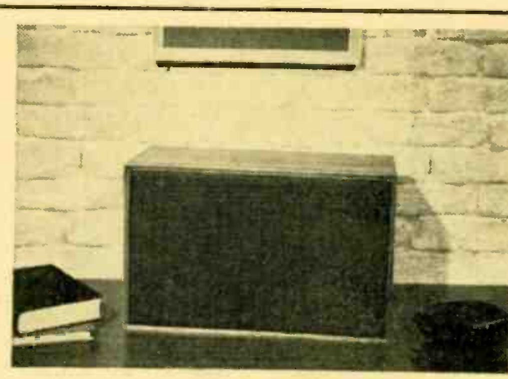
**MASSIVE CERAMIC MAGNET**—for large and easy power handling.

**HIGH "PERFORMANCE TO SIZE" RATIO**—securing deep fundamental from small systems.

**MODULAR APPROACH**—allows flexibility of system design.

**VERSATILE**—the ideal driver for the home constructor.

**HIGH DEFINITION PRODUCT**



The "Titan-Mini" is a no compromise bookshelf system employing a Titanium Cone Loudspeaker module. The remarkable characteristic of the hyperbolic titanium cone lies in its ability to reproduce detail in complex sound with hitherto unheard of accuracy. Due to the beryllium copper suspension stabilising the free air resonance the cabinet is designed as a low friction phase inverter and provides the perfect load to the driver.

For further details on this unique product please request from:

## AUDIO & DESIGN LIMITED

40, QUEEN STREET MAIDENHEAD BERKS. TEL. 25204

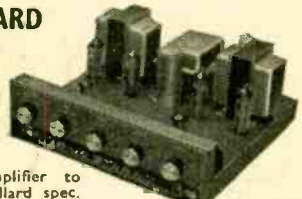
WW—146 FOR FURTHER DETAILS

# BARGAIN OPPORTUNITIES FROM TRS

## Amplifiers

### IN KIT FORM AND COMPLETE

**MULLARD 10-10 STEREO**



Valve amplifier to exact Mullard spec. With pre-amp, tapped o/p transformer 3 and and 15Ω all controls, H.T. and L.T. outlet, mono, stereo and speaker phase switching. Complete with escutcheon, knobs, plugs, etc. Ready built (p. & p. 12/6) **£20 . 0 . 0**

In kit form with chassis, knobs, plugs, etc. (p. & p. 12/6) **£17 . 10 . 0**

**MULLARD 5-10 MONO**

5 valve 10 watt basic amplifier, complete with valves and instructions. (p. & p. 7/6) **£9.19.6**

With passive network and control panel (p. & p. 7/6) **£11.19.6**

2 valve pre-amp and control assembly, complete kit with valves and instructions. (p. & p. 6/-) **£6.12.6**

**SPECIAL MULLARD 2+2 PRE-AMP**

Stereo pre-amp and control unit. Complete kit with valves and instructions. S.A.E. brings details. BUILT—13 gns. Kit, complete 10 gns. (P. & P. either 7/6).

**PEAK SOUND SA 8-8**

14 Transistor Kit builds into superb hi-fi amp. 8W per channel (16W mono) with integrated pre-amp to take high quality ceramic p.u. Unusually easy to build by following the instructions (1/6 purchased separately and refunded when kit is bought). This makes one of the best and most economical stereo transistor amps., we have ever offered. All purchases backed by TRS service facilities. When built and fitted in its special cabinet the SA 8-8 equals the best in modern styling.

**AMPLIFIER KIT** (p. & p. 4/-) **£9.10.0**
**POWER PACK KIT** (p. & p. 4/-) **£2.10.0**
**MODERN SLIMLINE WOOD CABINET** (p. & p. 5/-) **£2.10.0**
**COMPLETE ASSEMBLY** post free if ordered at same time. **£14.10.0**

**7 VALVE AM/FM RG CHASSIS**

A superbly powerful high performance instrument for the keenest enthusiasts. Provides tuning on long, medium and F.M. wavebands. Excellent sensitivity. Permeability tuning on F.M. Large clear dial, A.V.C. good neg. feedback. Magic eye 3W output. A.C. 220/250V. Circuit diagrams available. Aligned, tested and ready for use (Carr. and ins. 7/6). S.A.E. brings full details. **£13.19.6**

**SINCLAIR Z.12 AMPLIFIER**

This famous amplifier operates from 6 to 20V D.C. and is adaptable to a wide range of applications because of its very small size. Supplied ready built with comprehensive instructions manual. *Post free.* **89/6**

**SINCLAIR STEREO 25**

De luxe pre-amp control unit for use with two Z.12s. Smart front panel and knobs. Ready built. *Post free.* **£9.19.6**

SINCLAIR PZ.3 Power supply unit for two Z12s and stereo 25. *Post free* **79/6**

JUST INSTALLED—A new arrangement enabling you to hear in our shop any combination of our advertised amplifiers, speakers, tuners, etc. Personal shoppers are particularly invited to come along and hear this for themselves.

**SHOPPING BY POST**

Please send cash with Order or pay C.O.D. Please mention "Wireless World".

**POSTAGE.** Unless stated add 1/- on ½lb. orders, 1/9 on 1lb., 3/6 on 2lb., 5/- on 6lb., 6/6 on 10lb., 8/- on 14lb. Over, 10/6.

## GARRARD UNITS AND PLINTHS

### FOR IMMEDIATE DELIVERY

**LM3000** Record Player with 9T.A. Stereo Cartridge. Brand new as from factory. **£8.15.0**

**AT.60 Mk. II De-luxe** Auto-changer, diecast turntable. Less cartridge **£11.19.6**

**SP.25 De luxe** single record player, diecast turntable Less cartridge. **9½ gns.**

Packing and carriage on any one of above 7/6 extra.

**Garrard Plinth.** Ideal mounting for the Garrard Units offered here. Will readily suit any hi-fi set-up. In fine Teak Complete with useful soft plastic dust cover. Carriage and pack 5/- **75/-**

Garrard clear-view rigid perspex cover (carriage 3/6) **57/6**

**CARTRIDGE OFFER**

*The following are offered to all purchasers of GARRARD UNITS AND PLINTHS:*

**MONO**
5NBD Turnover crystal 17/6
TC8/M crystal 25/-
Acos GP 91-1 19/6

**STEREO**
Ronette 105S. 32/6
Sonotone 9TA/HC. 37/6
Ditto with diamond 47/-

**DECCA DERAM** — diamond stylus. List 94/6. our price 79/6.

**6 VALVE AM/FM TUNER**

Med. and V.H.F.—6 valves metal rectifier. Self-contained power unit. Magic-eye, 3 push-button controls. Diode and high output sockets. Illuminated 2-colour dial. chassis 11¾in. × 4in. × 5¾in. A.C. 200/250 v. **Unbeatable value.** Complete kit, inc. Power Pack as illustrated, **11 gns.** Carr. 7/6. Ditto less Power Pack, **10 gns.** Carr. 7/6. Circuit and Const. details 4/6. Free with kit.

**SINCLAIR MICROMATIC**
AT NEW REDUCED PRICES

The world's smallest radio now includes hi-fi magnetic earpiece, yet costs even less.

Complete kit formerly 59/6, now **49/6**

Ready built and tested formerly 79/6, now **59/6**

**SINCLAIR MICRO FM**

Complete kit for building 7-transistor cigarette packet size tuner/receiver unit. For use with amplifier, etc. or pocket receiver. With earpiece and telescopic aerial. **£5.19.6**

**TRS FM DECODER**

Based on Mullard design and produced by T.R.S. Built-in indicator. 6-transistor model, readily adaptable for use with valve tuners as well. For 9-15 v. operation. Complete kit with Mullard Specified inductors already aligned. **£5.5.0** (p. & p. 2/6).

## SAVE ON SPEAKERS

**TRS TEAK ENCLOSURES,** size 21in. × 15in. wide × 7½in. Cut to take tweeter and 8in. or 10in. unit to order. Acoustically loaded for finest quality **FANTASTIC VALUE at** **£4.15.6**

*(Add 7/6 for part cost of packing and forwarding)*

**15 OHM UNITS**

8in., 15,000 lines, ceramic magnet 10 watts. Foam suspended cone **£5.19.6**
10in. Goodman Axiom Type 10 **£7.5.0**
8in. FR8 **£5.15.0**
W B 8in. HF12 **£4.10.0**
Goodman's 8in. Axiette **£6.0.0**

*The above units are particularly recommended for use with the TRS Teak Acoustic Enclosure and wherever high-fidelity standards are required at modest outlay.*

**EMI.** 3-ohm Elliptical speaker 13¼ × 8in. heavy duty unit **55/-**

**SINCLAIR Q.14**

A remarkable new reproducer from a famous house, 9¾in. sq. 15 ohms. Truly superb quality obtainable in stereo, each **£6.19.6**

## EXCLUSIVE TRS TAPE WALLET OFFER

With each reel of this fine tape by an internationally famous manufacturer we give you a beautifully made wallet strongly made in simulated leather with space for a reel of tape each side. This is professional quality full frequency tape with metallised leader/stop foils. These library wallets solve once and for all the problems of storing tapes efficiently and tidily.

5¾in. reel, 1200ft., with wallet. **17/6**
5in. reel, 900ft. with wallet. **12/6**
7in. reel 1800ft., with wallet. **22/6**

p. & p. 1/6 per reel

TAPE REELS—7in., 2/3; 5¾in.—2/-; 5in.—2/-; 3in.—1/3 (p. & p. 6d.).

**FOR ONLY 6d.** You can start to enjoy not only the bargains to be found in TRS latest 8-page printed list, but the personal service TRS give with every transaction however large or small. SEND 6d. FOR LATEST TRS LIST TODAY.

**NEW IMPROVED "CIR-KIT"**

Now incorporates 0.1in. matrix board in convenient sizes, together with improved "Cir-Kit" material. Easier than ever to use. No drilling necessary. See HI-FI NEWS, Nov. issue.
5ft. spool of "Cir-Kit" 2/-, "Cir-Kit" Matrix Board, 5in. × 3¾in., 4/-; 3¾ × 2¾in., 2/6; 3¾in. × 2in., 1/9.

**LARGE STOCKS OF TRANSISTORS, TRANSISTOR COMPONENTS, COILS, SWITCHES, VALVES, SPEAKERS, ETC., ALWAYS AVAILABLE AT KEENEST PRICES.**

**VEROBOARD**—All standard sizes, including 2½in. × 5in., 3/8; 2½in. × 3¾in., 3/-; 3¾in. × 5in., 5/2; 3¾in. × 3¾in., 3/9; 2½in. × 17in., 12/6. All accessories and tools in stock.

**STEREO BALANCE CONTROLS.** Log/Anti-Log 5K, ½, 1 or 2 Meg., 9/- ea.

**RESISTORS**—Modern ratings, full range 10 ohms to 10 megohms. 10% ⅛-½W., 4d. each; 20% 1W, 6d each; 2W 9d each; 5% Hi-stab ½W, 5d. each, ¼W, 6d each; 1.2-10 meg. 10% ¼W. 4d each; ½W, 5d 5d each. 1% Hi-stab, ½W, 1/6 each (below 100Ω, 2/- each).

**WIREWOUND RESISTORS**—25Ω to 10kΩ 5W, 1/6 each; 10W, 1/9 each. 15W, 2/3 each.

**CONDENSERS**—Silver Mica. All values 2pF to 1,000pF, 6d each. Ditto ceramics. 9d. Tub. 450V T.C.C., etc. 0.001-0.01 mFd, 10d each.; 0.1-350V, 10d each; 0.02-0.1mF. 500V, 1/- each. TCC 350V 0.25, 1/9 each; 0.5, 2/- each.

**CLOSE TOL.S/MICAS**—10% 5-500pF. 9d; 600-5,000pF, 1/-. 1%, 2-100pF, 11d 100-250pF, 1/2; 270-800pF, 1/-; 800-5,000pF, 2/-.

**ALUMIN. CHASSIS**—18g. Plain undrilled, folded four sides, 2in. deep. 6in. × 4in., 4/6; 8in. × 6in., 5/9; 10in. × 7in., 6/9; 12in. × 6in., 7/6; 12in. × 8in., 8/- etc.

**TYGAN FRET** or Vynair speaker fabric, 12in. × 12in., 2/-; 12in. × 18in., 3/-; 12in. × 24in., 4/-, max. width 48in.

**BONDACOUST** Speaker Cabinet Acoustic Wadding, approx. 1in. thick 18in. wide, any length cut, 2/3 ft., 6/- yd.

**SILICON RECTIFIERS**—Miniature—Wire ended. ¼in. × ¼in. MULLARD Type BY100 800 v. 500mA, 8/6. BY236 250 v. 500mA, 5/-, BY114 450 v. 500mA 8/-, BY237 500 v. 500mA, 6/6.

**NEON MAINS INDICATOR LAMP.** Wire ends. 3/6.

**ENAMELLED COPPER WIRE.** 2 oz. reels—14g-20g, 3/-; 22-28g., 3/6; 30-34g 4/3; 36-38g., 4/9; 38-40g, 5/-.

**TINNED COPPER WIRE.** 16g-22g., 2 oz. 4/-.

**B.B.C. 2—U.H.F. Low Loss Cable,** per yard 1/3.

**80 OHM CO-AX CABLE**—Famous make—1st Grade Quality. Semi-air-spaced, low-loss, high quality 80 ohm Aeraxial Cable. Stranded Conductor, standard ¼in. dia. approx. 6d per yard. Special Discount for Quantity Lengths. 20 yds., 9/-, carr. 2/-. 40 yds., 17/6, carr. 3/-. 60 yds., 25/-, carr. 3/6.

Super Aeraxial (Fringe quality), 1/044. 1/3 per yard.

**COAX CABLE ACCESSORIES**

| | |
|---|---|
| Coax Plug (Aerialite) etc., each | 1/3 |
| Car Radio Type, EKCO, etc. | 1/6 |
| Coax Sockets, Chassis Mounting Belling Lee, etc., each | 1/- |
| Coax Sockets (cable end type) each | 1/9 |
| Cable Couplers—back-to-back sockets | 1/6 |
| Outlet Boxes—1 in 1—out, each | 4/- |
| Ditto 1 in—2 out compensated, each | 10/- |
| Attenuators Plug in type Aerialite Adjustable 6dB-36dB, each | 7/6 |
| Band 1-Band 2- Band 3 Cross over Unit (Splitter Box) | 13/6 |
| Band 1, Band 3 | 10/6 |

**TRS SPECIAL SERVICE IN TRANSFORMERS**

All types, and chokes available in singles or small production runs to specification at competitive prices. Enquiries invited. Private enquiries, please send S.A.E.

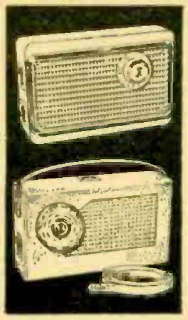
# TRS RADIO COMPONENT SPECIALISTS

**70 BRIGSTOCK RD., THORNTON HEATH, SURREY.**

Established 1946

Telephone: THO 2188 | Hours 9 a.m.-6 p.m. (1 p.m. Wednesday) | Few doors from Thornton Heath Stn. (Southern, Victoria Section)

# BUILD YOURSELF A QUALITY TRANSISTOR RADIO!



**TRANSONA FIVE MED. LONG & TRAWLER BAND.** 5 transistors and 2 diodes, ferrite rod aerial, tuning condenser, volume control. 2¾in. speaker. 6¼ × 4¼ × 1¾in. Total Building Costs 42/6. P. & P. 3/6. Plans and Parts list 1/6 (free with parts).

**MELODY SIX. MED & LONG WAVES.** 6 transistors and 2 diodes. Push-pull output, tuning condenser, ferrite rod aerial. 3in. speaker, etc., 6¾ × 3¼ × 1¾in. Total Building Costs 59/6. P. & P. 3/6. Plans and parts list 2/- (free with parts).

**POCKET FIVE. MED. & LONG WAVES & EXTENDED MED. WAVE BAND.** 5 transistors and 2 diodes, ferrite rod aerial, tuning condenser, 2¾in. speaker, etc. 5¼ × 1¼ × 3¼in. Total Building Costs 39/6. P. & P. 3/6. Plans and parts list 1/6 (free with parts). Also available POCKET FIVE MEDIUM AND LONG WAVE VERSION with miniature speaker 29/6. P. & P. 3/6.

**SUPER SEVEN. MED. LONG & TRAWLER BAND** 7 transistors and 2 diodes. 3in. speaker, 2 R.F. stages, push-pull output, etc. 7¼ × 5¼ × 1¼in. Total Building Costs 69/6. P. & P. 3/6. Plans and parts list 2/- (free with parts).

**ROAMER SEVEN Mk. 4.** 7 wavebands—MW1, MW2, LW, SW1, SW2, SW3 and Trawler Band. 7 transistors and 2 diodes. Ferrite rod aerial and telescopic aerial. Socket for car aerial. 7 × 4in. speaker. Airspaced ganged tuning condenser, etc. Size 9 × 7 × 4in. Total Building Costs £5/19/6. P. & P. 6/6. Plans & parts list 3/-, (free with parts).

**ROAMER SIX.** 6 wavebands—MW1, MW2, SW1, SW2, LW and Trawler Band. 6 transistors and 2 diodes. Ferrite rod and telescopic aerials. 3in. speaker. Top grade components. Size 7¼ × 5¼ × 1¼in. Total Building Costs 79/6. P. & P. 3/6. Plans and parts list 2/- (free with parts).

**RADIO EXCHANGE. 61 High Street, Bedford. 'Phone: 52367**

Callers side entrance Barratts Shoe Shop. Open 9—5 p.m. (Sat. 9—12.30 p.m.)

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## MARCONI AUDIO TESTER, TYPE TF89

This directly calibrated AF oscillator from 50c/s to 12kc/s has a maximum output of 300mW into 600 ohm and is fitted with an output level meter and 600 ohm ladder attenuator of 0-50dB. An alternative 5,000 ohm outlet is provided and the level in each case is continuously variable. AF measurements; the voltmeter may be used for AF inputs (external) over the ranges of 0 to 80V in 4 ranges, providing a very useful facility. Supplied in excellent condition and working order for only £18.10.0. Power supply 240V a.c. (internal).

## COSSOR DOUBLE BEAM OSCILLOSCOPES TYPE 1035

An attractive end of contract run enables us to offer these fine professional scopes in perfect working order at only £25 each plus 25/- P. & P. Brief technical spec.: 4in. flat face C.R.T.; bandwidth 20c/s to 10Mc/s; timebase repetitive, triggered or single stroke 15μsec to 150msec; size 16in. × 11in. × 19in. Also Cossor 1049 DC Coupled DB Scope same size and appearance as 1035. Price £30 plus 25/- P. & P.

## DIGITAL VOLTMETER

For the first time ever, we proudly present a three digit a.c./d.c. voltmeter for less than £100!

Manufactured by the world-famous Hawker Siddeley Group at its Gloucester Works, the Digimeter Type B.I.E. 2123 is a fully transistorised multi-range instrument possessing the following distinctive features:

**Electrical Characteristics:** D.C. ranges: 10mV to 400V in four ranges (1,000V for positive voltages).
Accuracy: the greater of ±0.1% of ±1 digit.
A.C. ranges: 100mV to 250V r.m.s. in three ranges.
Accuracy: the greater of ±0.5% or ±1 digit over the frequency range 30c/s to 10kc/s.
Range change is manual.
Input impedance: D.C.-15MΩ on two lower ranges, 1MΩ on two higher ranges.
A.c.-a.c. coupled, approximately equivalent to a shunt impedance of 8KΩ in series with the parallel impedances 180KΩ and 550pF.
Input characteristics: Single ended, floating. The potential between terminal connected to OV and earth should not exceed 400V d.c. or 250V a.c.
Input filter: 55dB attenuation at 50c/s.
Conversion time: 300msec.
Sampling rate: 1 reading per 2sec. or manually controlled.
Power Supply: 100/120V; 200/250V 50 c/s.
**Mechanical Characteristics:**
Dimensions: 10¾in. high × 7in. wide × 13in. deep.
Weight: 15lbs.
Display details: Three digit with decimal point indication. Character height 1in.

*At the price we can offer these instruments no laboratory can afford to be without one! They are ideally suited to production and inspection application.*

Brand new in manufacturer's packing. With Handbook. **£92.10.0** *Carriage extra at cost*

IMMEDIATE DELIVERY!

## SOLARTRON LABORATORY OSCILLOSCOPE TYPE 711/S2

This magnificent scope will take pride of place in any service dept., college or university, offered at one-fifth of manufacturer's price, in perfect working order and excellent condition, £80 plus carriage. Brief specification: bandwidth DC-7Mc/s; sensitivity 3mV/cm to 100V/cm; sweep velocity 0·33cm/sec to 3·3cm/μsec; X expansion variable up to X 10; size 16in. × 13in. × 27in. deep.

## MARCONI AF ABSORPTION WATTMETER TYPE TF938/CT44

Designed to measure the power output of all audio equipment in the range of 10 micro watts to 6 watts in 3 ranges. Impedance 2·5 to 20Ω switched in 11 ranges. Indication to large 5in. meter, a small portable modern instrument. Price £25 plus P. & P. 12/6.

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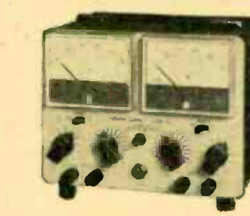

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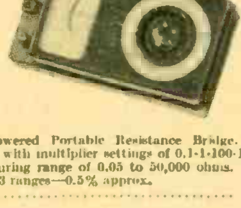

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PRICE .......... 110/-

3BP1—3in. screen Green Trace Medium Persistence Oscilloscope Tube. EHT required 1500 to 2000v. Sensitivity approx. 100-150v. DC/in. at 1500v. and 150-200v. D.C./in at 2000v. 6.3v. heaters. B14A base. Overall length 10¾in.
PRICE .......... 55/-

4BP31—4in. screen Flat Face Green Trace Medium Persistence TWIN GUN Oscilloscope Tube. EHT required 1000 to 1800v. Sensitivity Y = 26v. DC/in; X = 40v. DC/in. 6.3v. heaters. B12F Base. Overall length 12in.
PRICE .......... 200/-

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

Current Production — Zaerix — First Quality

# VALVES FOR EXPORT

Here are a few examples from our stock of over 2,500 items.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| OA2 | 3/- | 2D21 | 3/11 | 6B4G | 12/6 | 6SN7GT | 3/2 |
| OA3 | 5/9 | 2E26 | 18/4 | 6CY5 | 13/11 | 6V6GT | 3/2 |
| OB2 | 3/6 | 3C45 | 46/- | 6CW4 | 9/9 | 310A | 20/8 |
| OC2 | 14/4 | 3V4 | 3/2 | 6D84 | 9/2 | 311A | 28/9 |
| OC3 | 4/7 | 5U4GB | 3/11 | 6J4 | 6/1 | 328A | 23/- |
| OD3 | 4/4 | 5Y3GT | 3/6 | 6J5GT | 3/6 | 329A | 23/- |
| 1B3GT | 3/6 | 5Z4GT | 4/4 | 6J7 | 5/2 | 807 | 6/4 |
| 1U4 | 2/6 | 6AK5 | 3/6 | 6L6GC | 4/11 | 811A | 34/6 |
| 1V2 | 3/9 | 6AL5 | 1/9 | 6N7GT | 4/4 | 813A | 70/- |
| 1Z2 | 20/2 | 6AQ5 | 2/8 | 6SL7GT | 3/9 | 829B | 52/- |

THE ABOVE PRICES ARE FOR DIRECT EXPORT, I.E. FOR DELIVERY TO OVERSEAS ADDRESS, OR TO THE SUPPLIERS, FOR VALVES TYPE MARKED AND BULK PACKED, IN LOTS OF 100 PER TYPE.

**FULL EXPORT PRICE LIST AVAILABLE ON REQUEST**

OUR NEW 1967/68 VALVE CATALOGUE AND PRICE LIST IS NOW READY. IT CONTAINS FULL REFERENCE DATA ON SEMI-CONDUCTORS, CATHODE RAY TUBES, ETC. Please send s.a.e. (quarto.).

WW—147 FOR FURTHER DETAILS

WW—148 FOR FURTHER DETAILS

# CLASSIFIED ADVERTISEMENTS

**DISPLAYED SITUATIONS VACANT AND WANTED:** £6 per single col. inch.
**LINE** advertisements (run-on): 7/- per line (approx. 7 words), minimum two lines.
Where an advertisement includes a box number (count as 2 words) there is an additional charge of 1/-.
**SERIES DISCOUNT:** 15% is allowed on orders for twelve monthly insertions provided a contract is placed in advance.
**BOX NUMBERS:** Replies should be addressed to the Box number in the advertisement, c/o Wireless World, Dorset House, Stamford Street, London, S.E.1.
No responsibility accepted for errors.

Advertisements accepted up to FEBRUARY 6 for the MARCH issue, subject to space being available.

## SITUATIONS VACANT

AN OVERSEAS CAREER with International Aeradio Limited.
TO meet the requirements of constant growth and expansion, we invite applications from technicians and engineers for an overseas career in North, West and East Africa, the Mediterranean area and the Arabian Gulf. If you have recently completed service in a trade such as Ground Wireless Fitter in the R.A.F., Radio Electrical Artificers in the Royal Navy or R.E.M.E., Army, or have other experience in the maintenance of H.F. and V.H.F. communications, R.T.T. and navigation aids, we should be interested to hear from you. Successful candidates would normally spend six weeks at our Radio Engineering School, Southall, Middlesex, before proceeding overseas, but in some cases staff with suitable qualifications and experience may be offered immediate posting. Overseas staff receive a tax-free salary with married and child allowances if appropriate and accommodation, bachelor or married is provided free; other benefits include generous U.K. leave and membership of an excellent pension and life assurance schemes.
WRITTEN applications please, to Personnel Manager, International Aeradio Limited, Aeradio House, Hayes Rd., Southall, Middlesex. [19

TRAINED engineers required for interesting work on radio/radar equipments at a flying unit in North Wales.—Apply: Short Bros. & Harland, Ltd., R.A.E. Llanbedr, Merioneth, N. Wales. [22

RADIO Engineer/Mechanic, first-class communications work, required by large company engineers, 12 ms. service overseas, excellent opportunity.—Write age, experience, Box W.W. 1909, "Wireless World."

EXPERIENCED enthusiasts required, London, W.1 for tape editing, disc cutting, mobile work, evenings, weekends, state experience and salary expected.—Box W.W. 1951, "Wireless World."

SENIOR EXECUTIVE ENGINEERS, POST OFFICE. Four posts in London for men and women normally aged 35 or over (well-qualified younger candidates considered). The successful candidates will be concerned with: (a) Leadership of a team engaged on the design and development of large vehicular and non-vehicular equipment for the mechanisation of the installation of external engineering plant required for the provision of telecommunications services; (b) Leadership of a team engaged on the design and development of specialised mail handling machinery and equipment for the full scale mechanisation of the postal services; (c) Leadership of a small group of engineers making theoretical studies of transmission techniques to be used for the provision of radio and other services by communications satellites; (d) The mechanical and electrical development, and standardisation of, relays and telephone exchange switching mechanisms. Qualifications: Posts (a) and (b); degree in mechanical engineering, or corporate membership of the Institution of Mechanical Engineers or an equivalent or higher qualification. For post (a) knowledge of the design and operation of mechanical aids together with experience of hydraulic and/or pneumatic equipment and a knowledge of modern manufacturing techniques desirable. For post (b) experience in the design of manipulative machinery or mechanised handling plant essential; a flair for invention in this field and the ability to design experimental rigs desirable. Posts (c) and (d); degree in engineering, or an equivalent or higher qualification. For post (c) basic knowledge of the technical methods used in modern commercial communications essential; general knowledge of satellite technology and related principles desirable. For post (d) experience in the development and large scale production of light electromechanical apparatus, preferably in the telecommunications field essential; appreciation of cost and value engineering desirable; general knowledge of telephone exchange switching and signalling an advantage. Salary (Inner London): £2,050 to £2,609. Starting salary may be above the minimum. Non-contributory pension. Promotion prospects.—Write to Civil Service Commission, Savile Row, London, W.1, for application form, quoting S/6847/68. Closing date 15th February, 1968. [1949

**FOR SALE AND WANTED ADVERTISEMENT FORM TURN TO PAGE No. 139**

**ELECTRONIC DESIGN & DEVELOPMENT ENGINEERS (ALL GRADES) SALARIES UP TO £2,800 P.A.**
**ELECTRONIC TEST & SERVICE ENGINEERS (ALL GRADES) SALARIES UP TO £1,600 p.a.**
**TECHNICAL SALES ENGINEERS (EXPERIENCED) SALARIES UP TO £2,500 p.a.**
**TECHNICAL AUTHORS (ALL GRADES) SALARIES UP TO £1,800 p.a.**
**ALSO**
**DRAUGHTSMEN, PRODUCTION ENGINEERS**

We have over 500 registered vacancies for above types of engineers in the Home Counties and South England areas. If you have had at least 2 years' experience in British Industry and require a job which offers first class prospects, top salaries and interesting work.

*Phone (any time day or night) or write to:—*

**ELECTRONICS APPOINTMENTS LTD.,**
**Norman House,**
**105-109, Strand, W.C.2**
*TEMple Bar 5557-8.*

# *if* ELECTRONIC TEST TECHNICIANS

**this big 'if' is worth up to £1,500 a year to you**

We need really experienced Electronic Test Technicians who can tackle fault-finding, test and calibration problems in complex electronic equipment with confidence and flair.

If you think you can meet our spec. there are vacancies waiting at our new plant in the Herts/Beds area offering the following benefits—and more:

- **Up to £1,500 basic salary.**
- **Up to £200 re-location expenses (plus help with house purchase).**
- **Full staff conditions, plus superannuation, plus free life assurance.**
- **Stable, permanent employment, plus the chance to advance in a vigorous, expanding company.**
- **5-day week, plus generous, progressive holiday scheme.**

*Please quote reference No. WW 164*

TAYLOR RECRUITMENT
85 GLOUCESTER PLACE, LONDON W.1

*Strict confidence will be observed. Just state separately the companies to whom you do not wish your application forwarded*

City and County of Bristol

**BRISTOL TECHNICAL COLLEGE**
**DEPARTMENT OF NAVIGATION, MARINE RADIO AND RADAR**

Applications invited for post of
ASSISTANT LECTURER GRADE B IN RADIO AND RADAR Ref. No. T67/74/1

Duties to commence 1st May, 1968.
Applicants should hold a First Class P.M.G. Certificate in Radio Telegraphy. Additional qualification such as B.O.T. Radar Maintenance Certificate, H.N.C. in Electronics or Electrical Engineering, Aircraft Radio Maintenance Engineer's Licence (Categories A & B) or similar an advantage.

Salary Scale: £955-£1,625 with additions for approved qualifications. Starting salary dependent upon approved experience and qualifications.

Further particulars and application forms (returnable by 29th January), from Registrar, Bristol Technical College, Ashley Down, Bristol, 7. Quoting ref.

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**UNIVERSITY OF NOTTINGHAM**

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

## EXPERIMENTAL OFFICER

Applications are invited for the above appointment to commence as soon as possible. Candidates should have a good knowledge and practical experience of basic electronic circuit techniques using both vacuum-tube and solid-state devices; they will normally be expected to have H.N.C. or equivalent qualification. Salary will be within the range of £915 to £1,525 per annum. Forms of application and further particulars, returnable not later than 29th January, 1968, from the Registrar.

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## Television

We are expanding our activities in the field of television-by-wire, and need an experienced development engineer who can undertake important work on both immediate and long-term projects, involving both transmitting and receiving systems and equipment.

Good Laboratory experience and proven ability are the main requirements for the appointment, which offers very good security and opportunities for promotion to an engineer of the right calibre. All enquiries will be treated in strict confidence, and should be addressed to

**The General Manager, British Relay (Electronics) Ltd.,**
**1-7 Croft Street, Deptford, London, S.E.8.**

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# ELECTRONIC MAINTENANCE ENGINEERS

There are excellent opportunities in the Installation and Maintenance Division of E.M.I. Electronics Ltd., for engineers to carry out maintenance work on a wide variety of electronic equipment, including laboratory test gear, tape recorders, broadcast and studio T.V. equipment, and electronic automation equipment.

Candidates should be between 21 and 45, have had at least three years' experience of this type of work, and be willing to travel.

Good commencing salaries will be paid, and staff conditions include a contributory pension scheme and free life assurance. Grants towards re-location expenses will be made in suitable cases.

**EMI CAREERS**

**EMI**

Applications, giving concise personal/career details to:
P. JONES · GROUP PERSONNEL DEPARTMENT · E.M.I. LTD
BLYTH RD · HAYES · MIDDLESEX · TEL: 01-573-3888 · EXT: 411

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# TECHNICAL/COMMERCIAL ASSISTANTS

## RADIOS AND TAPE RECORDERS

A vacancy exists in the technical-commercial department of both the Radio and Tape Recorder Divisions of Philips Electrical Limited, for an assistant to the Manager.

Applicants for both these positions should be between 25 and 35 years of age and be qualified to H.N.C. or City and Guilds final standard. Membership of an appropriate professional institution would be an added advantage.

The job is basically one of liaison and communication between the commercial, financial, production and design functions. A knowledge of the Radio and Tape Recorder market, with regard to appearance, price and performance is desirable. Experience in methods of measuring expressing performance and field test reporting is essential. If you would like to know more about these positions, please write to:

**E. G. Johnson,**
**PHILIPS ELECTRICAL LTD.,**
**Century House, Shaftesbury Avenue,**
**London, W.C.2**

**ELECTRONIC ORGANBUILDERS REQUIRE**

TEST & INSPECTION ENGINEERS; men with sound Electro-mechanical background, valve and transistor amplifier experience, some musical knowledge an advantage.

DRAUGHTSMEN with at least 5 years' Electro-mechanical and Electronic experience, minimum qualification ONC or equivalent.

These positions carry good salaries and prospects.

Applications, giving age & career details to Mr. J. Meredith, COMPTON ORGANS LIMITED, CHASE ROAD, London, N.W.10.

## RADIO TECHNICIANS

A number of suitably qualified candidates are required for unestablished posts, leading to permanent and pensionable employment (in Cheltenham and other parts of the U.K. including London). There are also opportunities for service abroad.

Applicants must be 19 or over and be familiar with the use of Test Gear, and have had practical Radio/Electronic workshop experience. Preference will be given to candidates who can offer "O" level and GCE passes in English language, Maths and/or Physics, or hold the City and Guilds Telecommunications Technical Intermediate Certificate or equivalent technical qualifications.

Pay according to age, e.g. at 19—£812 at 25—£1046 (highest age pay on entry) rising on 1.1.68 to at 19—£828, at 25—£1,070.

Prospects of promotion to grades in salary range £1,159-£1,941. There are a few posts carrying higher salaries.

Annual leave allowance of 3 weeks 3 days rising to 4 weeks 2 days. Normal Civil Service sick leave regulations apply.

Application forms available from:—

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

## TECHNICAL ASSISTANT

Applications are invited from young electrical or electronic engineers with a live mind to work in the Group patents department of Pye of Cambridge Ltd.

The successful applicant will have a flair for describing technical equipment and be required to liaise between patent agents, inventors and legal advisers.

An attractive salary taking into account age and experience will be offered.

Please apply, giving full details of age, qualifications and experience to: The Personnel Manager, Pye of Cambridge Ltd., St. Andrew's Road, Cambridge.

**ENTHUSIASTS** Have you considered a career in Technical Authorship? If you have sound experience in electronics or communications and ability to write clear concise English we would train applicants as Technical Authors. The commencing salaries range from £1,300 to £1,700 depending on experience with the prospects of high future rewards and earnings.

**Box No. 5039, c/o Wireless World**

## THE UNIVERSITY OF LEEDS

Applications are invited for the position of Electronics Technician in the department of Biochemistry. Duties will include the maintenance of electrical and electronic equipment used in all types of chemical analysis.

Qualifications: O.N.C. or H.N.C. with Electronics endorsements, City and Guilds Finals, Radar Fitter with appropriate industrial experience.

Salary within the Senior Technician range (£912 - 1,150) plus a qualification allowance where applicable. Apply to: Dr. T. A. Scott, Department of Biochemistry, 9 Hyde Terrace, Leeds, 2.

## TELECOMMUNICATIONS TECHNICAL OFFICERS

## DIPLOMATIC WIRELESS SERVICE

### Hanslope Park, Bucks. and Crowborough, Sussex

Several posts for men, normally aged 23 or over but well qualified younger candidates considered, for installation, modification, maintenance and operation of (a) radio transmitters and receivers, remotely tuned aerial systems, teleprinters and voice frequency telegraph equipment over a worldwide network, *OR* (b) very high power transmitters, receiving equipment, tape recorders, generating plant, etc., at several high power broadcasting stations.

QUALIFICATIONS: O.N.C. in Electrical Engineering, or City and Guilds Intermediate Certificate in Telecommunications (old syllabus, i.e., subject No. 50) plus Radio II, or Intermediate Telecommunications Certificate (new syllabus, i.e., subject No. 49) plus Certificate in Mathematics B, Telecommunications Principles B, and Radio and Line Transmission B, or equivalent standard of technical education, and at least 5 years' appropriate training and experience.

SALARY (national): £983 (at 21) to £1,066 (at 23) to £1,283 (at 28 or over). Scale maximum £1,449. Prospects of promotion. Non-contributory pension.

WRITE to Civil Service Commission, Savile Row, London, W.1, for application form, quoting S/6670/67. Closing date 7th February 1968. Candidates who have already applied should not do so again.

**University of Salford**

## SENIOR TECHNICIAN

THERE is a vacancy in the rapidly expanding Department of Electrical Engineering for a **SENIOR TECHNICIAN.**

The successful applicant may work in a research group and be concerned with building, maintaining and operating research equipment; or in an electronic workshop, where equipment for teaching and research is manufactured and maintained.

The post will particularly appeal to those who have practical experience of a variety of electro-mechanical and electronic equipment and who prefer to work on their own initiative in a wide variety of fields.

The salary scale is £1,040 to £1,385 per annum for which the desirable minimum educational qualification is H.N.C. The starting point on the scale will depend on age, experience and qualifications. The post is superannuable.

Applications, giving details of age, education and experience, should be sent to the Registrar, University of Salford, Salford 5, Lancs., by 29th January, 1968, quoting reference E/99/IE.

**FIELD SERVICE ENGINEER FOR PUBLIC ADDRESS EQUIPMENT AND AUDIO AMPLIFICATION EQUIPMENT**

Covering London and Southern Counties. Experience Essential. Good Salary. Expense Allowance. Company Vehicle or Vehicle Allowance provided.

Write:

SERVICE MANAGER, MAGNETA (B.V.C.) LTD., Parsons Green Lane, London, S.W.6.

WORKS Manager required for progressive company engaged in transformer winding and light electronic assembly in the South Midlands. The position should appeal to a man with some technical knowledge and the ability to obtain increased production.—Write Box W.W. 1950, "Wireless World."

RECORD COMPANY requires a qualified Sound Engineer to operate and maintain studio and disc cutting equipment. Previous experience in the use of modern professional sound equipment and a genuine interest in music essential. Attractive salary offered commensurate with the responsibilities of this important position.—Replies to Box W.W. 1962, "Wireless World."

RADIO ENGINEERS required by the National Guard of Saudi Arabia. Initial contracts for one year, including six weeks' paid leave in United Kingdom. Unmarried men preferred. Salary and allowances approximately £3,300 per annum net. Candidates should have good knowledge of modern HF SSB communications equipment and VHF techniques. Previous experience of petrol engines and teleprinters an advantage. Duties involve repair and maintenance of static, mobile and portable radio equipment throughout Saudia Arabia, and training of local personnel as radio mechanics and operators. Frequent air and road travel is involved. Initial applications, giving brief details of qualifications, experience and past employment, should be made to Brigadier H. E. R. Watson, c/o H.Q., National Guard, P.O. Box 182, Riyadh, Saudi Arabia, by civil air mail at full postage rates. [1961

**University of Wales**
**INSTITUTE OF SCIENCE AND TECHNOLOGY**
**CARDIFF**
**DEPARTMENT OF APPLIED PHYSICS**
**M.Sc./DIPLOMA COURSE in ELECTRONICS**

Applications are invited for places in the full-time one-year M.Sc./Diploma course in Electronics, commencing 30th September, 1968.

Further details can be obtained from the Registrar and Secretary, University of Wales Institute of Science and Technology, King Edward VII Avenue, Cathays Park, Cardiff, CF1 3NU. Application forms should be completed and returned to the Institute as soon as possible.

# Computer Engineers

Due to continued expansion NCR require additional **ELECTRONIC** and **ELECTRO-MECHANICAL ENGINEERS** for Computer Maintenance. Posts are available for men wishing to become Site Engineers.
Training Courses are arranged for suitably qualified men. H.N.C. Electronics, City & Guilds Final or equivalent standard required. Men from Forces with radar experience welcome.
Knowledge of electronic or electro-mechanical equipment necessary. Good Pension and Bonus Plan in operation.
Please write for Application Form to The Personnel Officer.
NCR, 1000 North Circular Road, London, NW2, quoting Publication and month of issue.

Plan your future with NCR

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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

WEST London Aero Club invite "A" and "B" licensed engineers with capital and/or necessary equipment to commence Radio Workshop. Alternative propositions may be considered. Write full details to—White, Waltham Airfield, near Maidenhead, Berks. [68

ASSISTANT Editor required to work on technical books, mainly concerning radio, electronics and electrical engineering; experience of handling book or periodical, also technical MSS. and illustrations desirable, a knowledge of electrical/electronics technology. Progressive post in a rapidly expanding organisation in modern offices in Feltham, Middx.—Please write to: The Managing Editor, Practical and Home Division, The Hamlyn Group, Hamlyn House, 42, The Centre, Feltham, Middlesex. [1956

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# INSTALLATION ENGINEERS

The Installation and Maintenance Division of E.M.I. Electronics Ltd., requires Installation Engineers. New contracts for 1968 include the complete installation of equipment for T.V. studios, and of Robotug transport systems. Successful applicants will be responsible for the planning and on-site supervision of installation, for a wide range of commercial electronic equipment including closed-circuit T.V. systems and automated systems, in addition to those already mentioned.
Applicants should have a good knowledge of electronic equipment, and preferably some experience of installation work. A sound knowledge of basic electrical and electronic theory is necessary.
Commencing salaries and staff benefits are good, and relocation grants may be made in suitable cases.

**EMI CAREERS**

*Applications, giving concise career and personal details to:-*

P. JONES · GROUP PERSONNEL DEPARTMENT
E.M.I. LIMITED · BLYTH ROAD · HAYES · MIDDX

EMI

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ROLLS-ROYCE

Aero Engine Division

# Laboratory Assistant

We have a vacancy in the experimental services section of our Advanced Research Laboratory for an assistant to help in the construction, wiring and testing of prototype electronic and electrical apparatus and in the checking and calibration of laboratory electronics. The section provides instrumentation support to the scientific staff of the laboratory.
Applicants should have experience in electronic laboratory practice and in the wiring and testing of transistor circuits and preference will be given to candidates who have an O.N.C. in electrical engineering or equivalent qualification.
Please write for application form giving brief details of career to date, to:

**Laboratory Manager,**
**ROLLS-ROYCE LIMITED,**
**Old Hall, Burton Road,**
**Littleover, Derby, DE3 6FJ.**

ROLLS RR ROYCE

ST. LAURENCE'S HOSPITAL, DUBLIN 7
(Richmond, Whitworth & Hardwicke Hospitals)

## ELECTRONICS MAINTENANCE TECHNICIAN

Salary: £800 × £50—£1,200 per annum.

Applications are invited for the above position from persons holding the following qualifications:

(a) City & Guilds Telecommunications Technicians Certificate B Level Examination, and

(b) City & Guilds Electronic Servicing Certificate Final, or equivalent qualifications.

Particulars and application forms available from the Secretary to whom completed applications must be returned so as to reach him not later than 12 noon on 23rd February, 1968.

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## ROYAL HOLLOWAY COLLEGE
**(University of London)**
**Englefield Green, Surrey**

SENIOR ELECTRONICS TECHNICIAN required to assist with design and construction of equipment used in advanced teaching and research. This appointment offers the opportunity for a wide range of interesting and non-repetitive work. Salary on the scale £912—£1150 plus qualification allowance and London Weighting. 37½ hour week. 4 weeks holiday. Applications should be made to the Secretary.

---

### 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

### TAPE RECORDING ETC.

SAVE on cost of Hi-Fi. See Audio Supply notice (advert No. 1954, Services Offered column). [1955

TAPE to disc transfer, using latest feedback disc cutters; EPs from 21/-; s.a.e. leaflet.—Deroy, High Bank, Hawk St., Carnforth, Lancs. [70

TAPE/Disc/Tape transfer editing, duplicating, if quality and durability matter (especially with LPs from your previous tapes), consult Britain's oldest transfer service. Fund raising records published for schools musical societies (tax free).—Sound News Productions, 10, Clifford St., London, W.1. Reg. 2745. [1952

### SERVICE & REPAIRS

REPAIRS.—Our modern service department equipped with the latest test equipment including a wow and flutter meter and multiplex setereo signal generator is able to repair Hi Fi and tape recording equipment to manufacturers' standard.—Telesonic, Ltd., 92, Tottenham Court Rd., London, W.1. 01-636 8177. [21

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## FIELD AIRCRAFT SERVICES
**Radio/Radar Centre, London Airport**
require three additional
**RADIO MECHANICS**

for bench and light aircraft work. Aircraft experience not essential and suitable applicants will be considered for relevant training.

Apply by letter or telephone to:
Mr. D. W. Griffiths,
Heathrow Airport-London,
Hounslow, Middlesex.
Tel.: SKY 2141.

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**Eastern GAS**

COMMUNICATIONS DEPARTMENT

## COMMUNICATIONS TECHNICIAN

Eastern Gas is in the process of modifying an extensive mobile radio network covering a large geographical area. Due to this, it is necessary to strengthen the Communications Department by the appointment of a suitably qualified person to assist in all planning and operational aspects of V.H.F. and U.H.F. mobile radio networks.

The successful applicant will be based at the Board's Headquarters at Watford, Herts.

The salary for this position will be within the range £1,170-£1,400 per annum, with initial placing according to qualifications and experience.

Apply in writing, giving full personal particulars, and quoting reference number 4069 to Area Personnel Manager, Eastern Gas, 49 Clarendon Road, Watford, Herts., within 10 days from the appearance of this advertisement.

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# Research in Opto-Electronics

We are still building our team for work in Modern Optics, and need an experienced

## Electronics Engineer

with enthusiasm for new fields of engineering. His chief duty will be to study applications of the basic research now in hand on pattern recognition and other optical information processing.

Please write to:—

**The Personnel Manager (Ref. 46),**
**Hawker Siddeley Dynamics Ltd.,**
**HATFIELD,**
**Herts.**

HAWKER SIDDELEY dynamics

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## TELEPRINTER MECHANIC

Responsibility will initially be for the development and maintenance of logic controlled systems at locations within a 20 mile radius of Southall.
This position will appeal to a man with a sound knowledge of Telegraphic or logic switching who seeks the opportunity to commence a career with a fast expanding Company.
Driving licence desirable.
Our business is telecommunications.
A good salary will be offered commensurate with experience. The Company has an excellent pension and life assurance scheme. Substantially reduced holiday air fares are available to most parts of the world.
Please apply in writing stating details of age and experience to:
General Manager, Personnel,
INTERNATIONAL AERADIO LIMITED
Aeradio House, Hayes Road,
Southall, Middlesex.

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### V.H.F. WIDE-BAND AMPLIFIERS

*Specification:*
Bandwidth, 40-230MHz; Gain, 20DB ± 1.5DB Max. Output (1 carrier) 3 volts; Input/Output Impedance 75 ohms; 19in. Rack Mounting. Two-stage Distributed Circuit. Power Requirement, 100-250 volts 50 watts
Built to Professional Standards. Brand New and Fully Guaranteed.
For Sale at the Reduced Price of £30.0.0.
Further details Box No. 5040, c/o "Wireless World."

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## ELECTRONIC SUBCONTRACTORS

A subsidiary of a large American Company manufacturing high quality Electronic products has capacity available for assembly wiring or manufacture of electronic equipment.
We should be pleased to quote promptly for your requirements however large or small.

Write or telephone Mr. Brandon or Mr. Mills.

Baldwin Burns Ltd.,
Chesham Close,
Romford,
Essex.
Romford 46465

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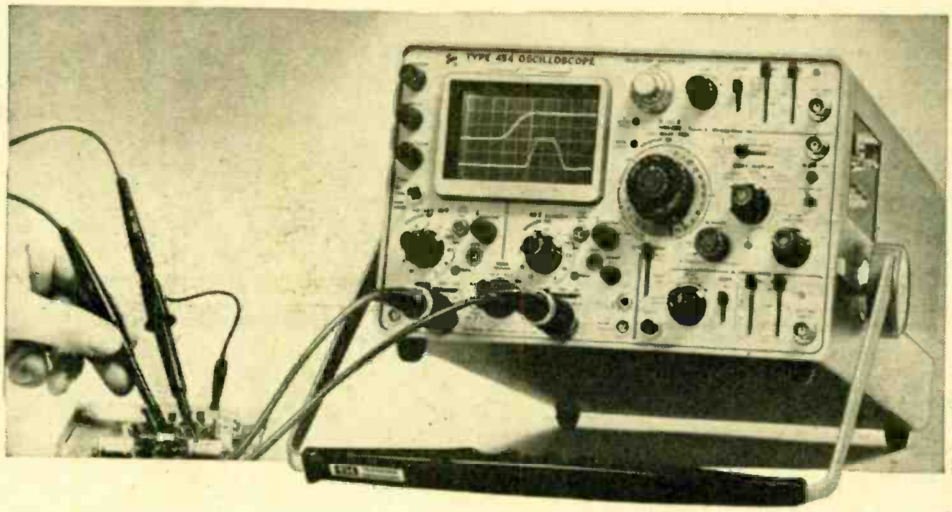
## TELEVISION ENGINEERS
### with Management in mind

Rapidly expanding Company in CCTV requires seven senior engineers to control its Sales/Servicing operations in the London, Midlands—Birmingham, North West—Manchester, East Anglia—Cambridge, Southern—Southampton, West—Bristol, and Yorkshire — Leeds areas. Ability to maintain one inch helical scan video VR 7003 recording machines, T/V monitors and vidicon cameras essential.

In addition to servicing CCTV installations, they will be required to promote new business in their areas. Estate car will be provided and there is a pension scheme. Salary to be negotiated and promotion for the right men guaranteed. Write giving full details to:—
Technical Director, Television Applications Ltd., 9/11 Windmill St., London, W1

**THIS IS ONE OF THE WORLD'S MOST ADVANCED OSCILLOSCOPES.**

**WHY NOT HELP US MARKET OR MAINTAIN IT?**



We are looking for Marketing and Maintenance Engineers who would take pride in being part of a team providing Tektronix Products and services in a diverse and expanding field.

If you have a sound basic knowledge of Oscilloscope applications or circuitry with a pleasant telephone manner and the ability to write good letters, or a flair for repair and calibration, we would like to hear from you.

We offer pleasant working conditions, progressive salary opportunities, profit sharing and non-contributory life assurance and pension scheme.

To be considered for one of these outstanding opportunities, write to

**Mr. R. M. Garrett, Field Engineering Manager,**
**Tektronix U.K. Ltd., Beaverton House,**
**Station Approach, Harpenden, Herts.**

**MINIATURE KEY SWITCHES.** (P.O. Lever Type 1000), centre off. 2 c/o each way. 7/6 ea.
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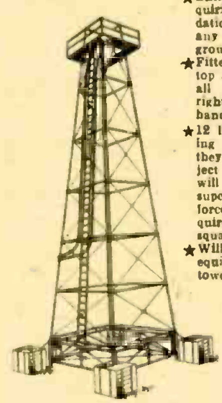

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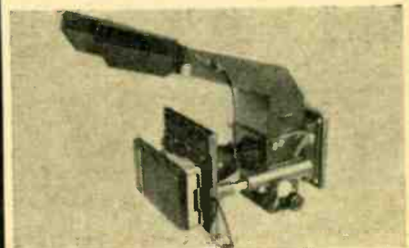

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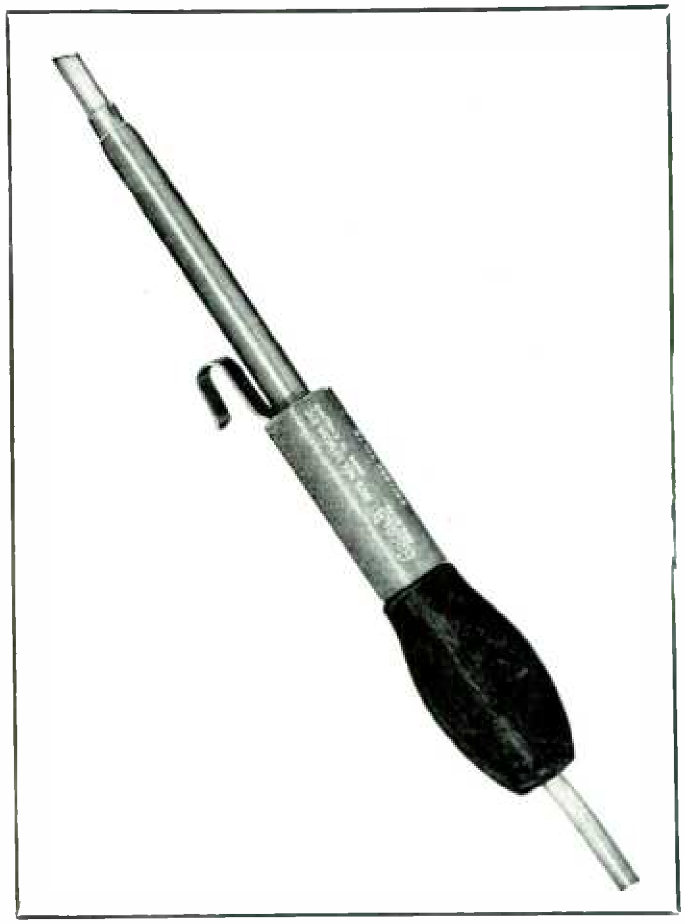

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