Wireless World

SEPTEMBER 1969 Three Shillings

uropean television identification

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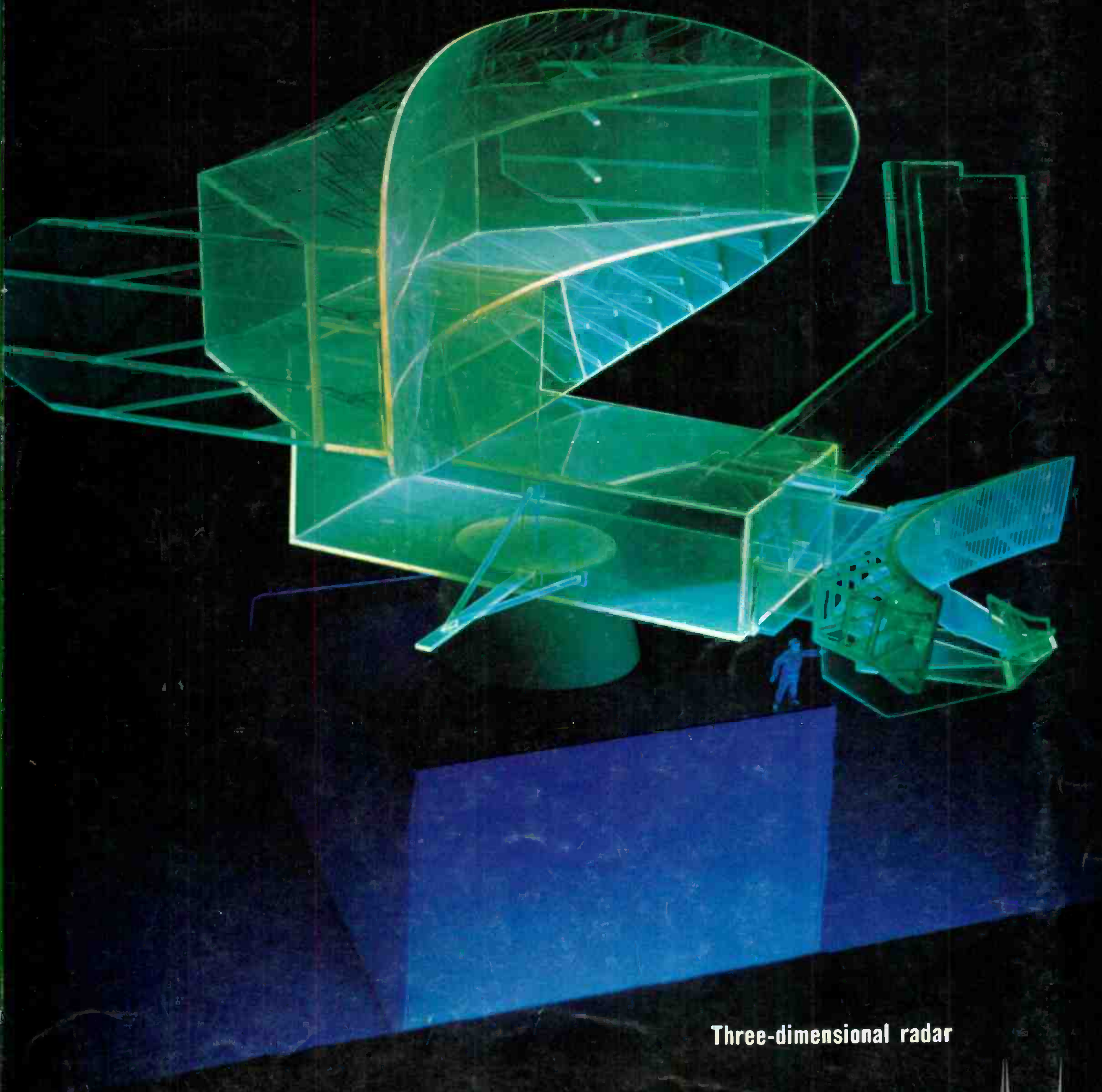
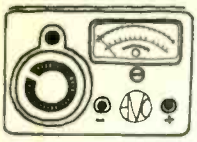
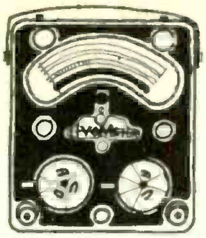


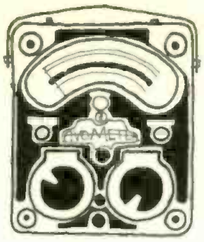
Three-dimensional radar



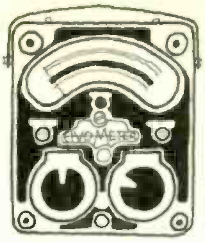
Multiminor – inexpensive, pocket-sized for the service engineer or hobbyist.



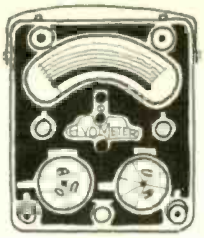
Model 7 – for the electrical engineer, general purpose use 50 ranges.



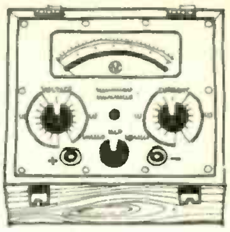
Model 8 – for the electronic, radio and TV engineer



Model 9 – similar to model 8 but controls marked with graphical symbols.



Model 40 – for the power engineer, extra robust 40 ranges.



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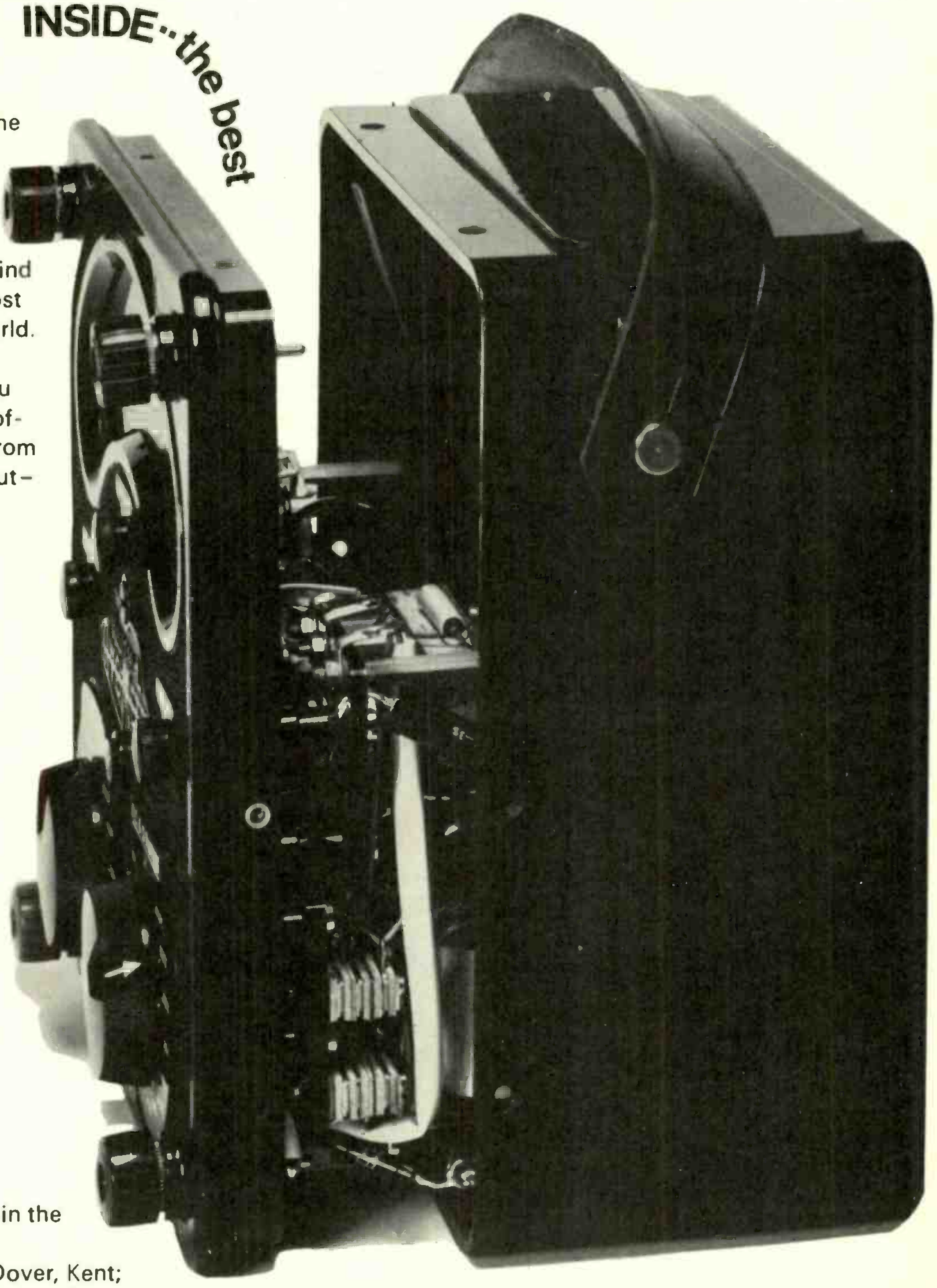

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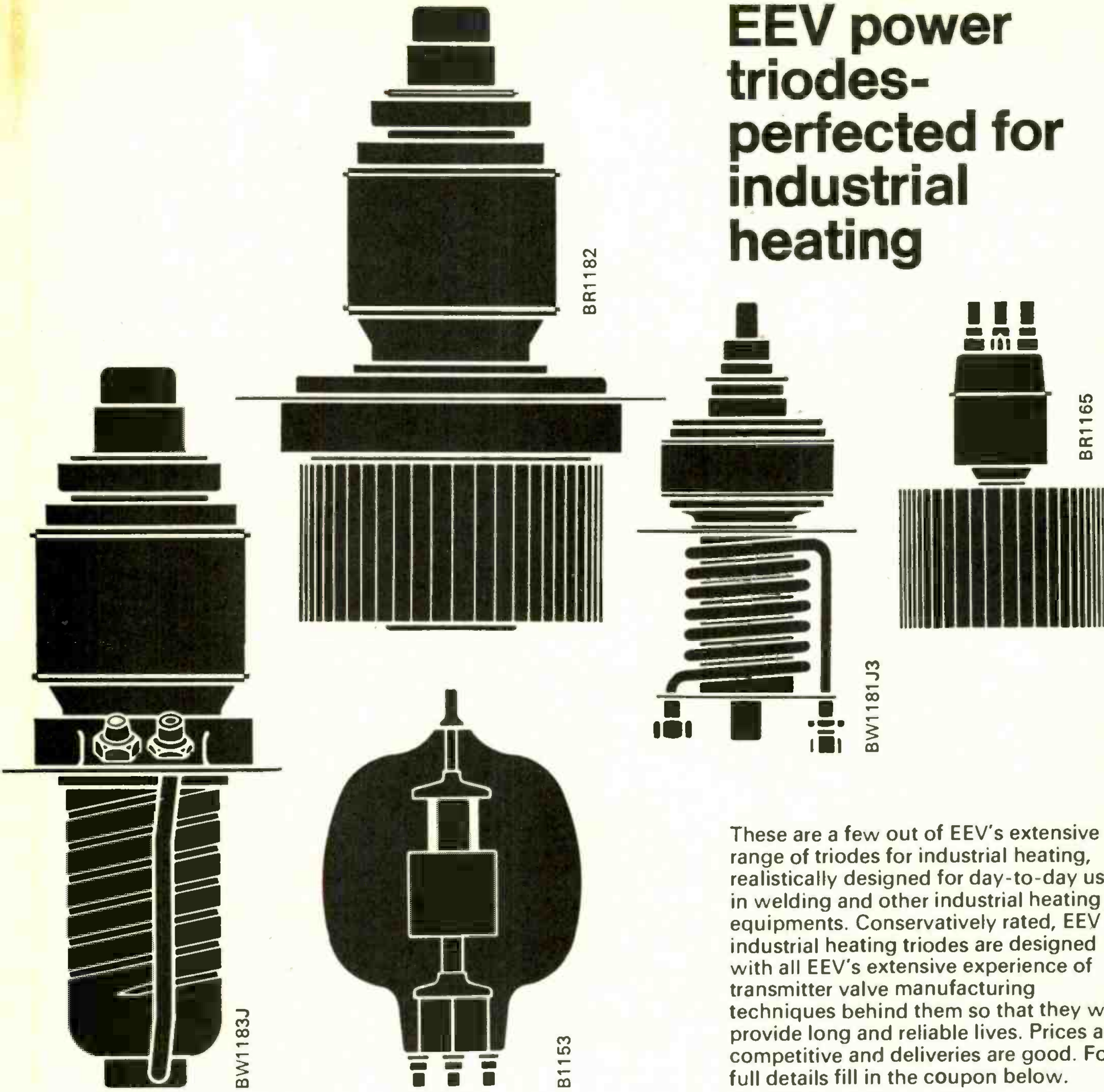

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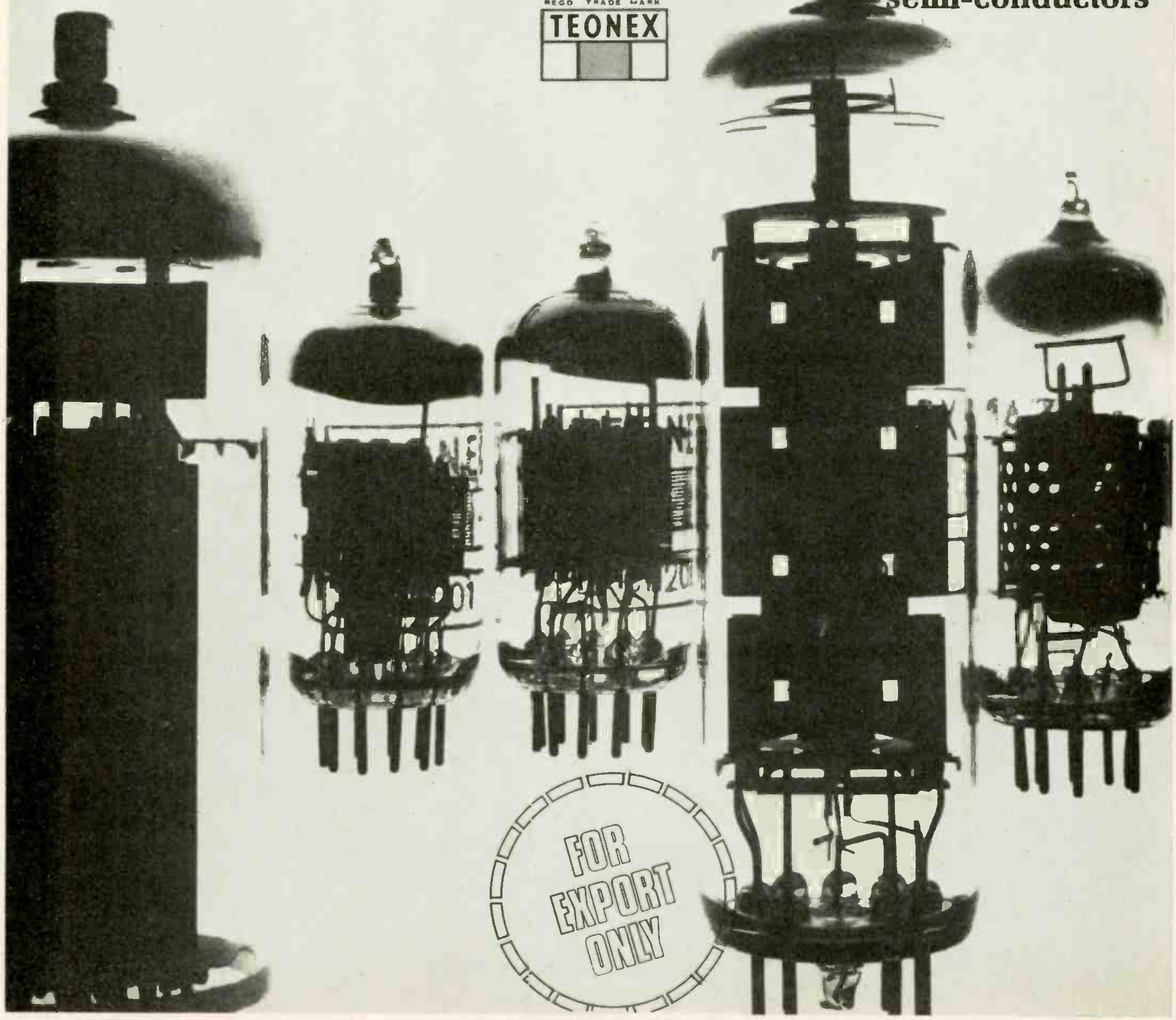

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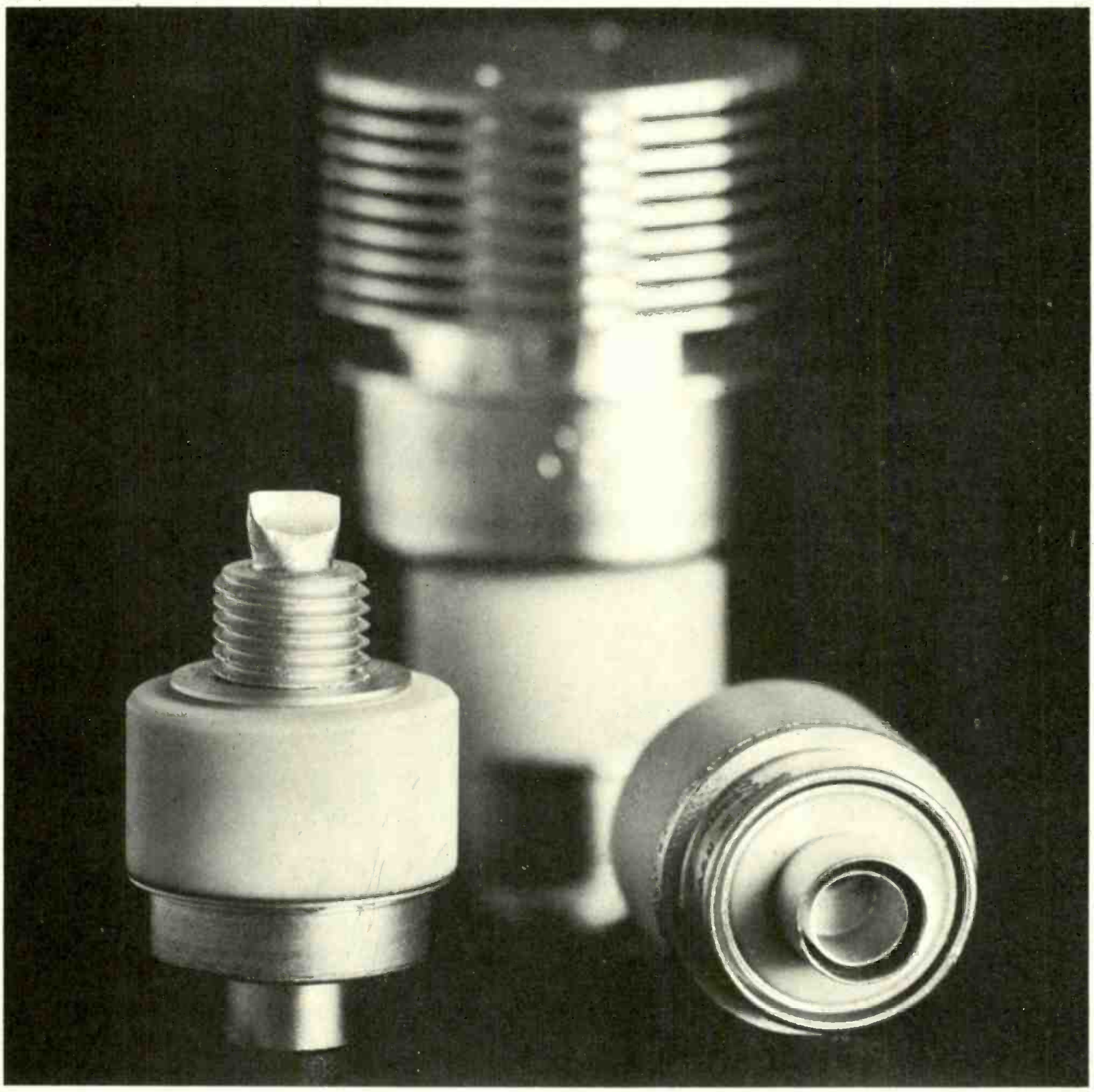

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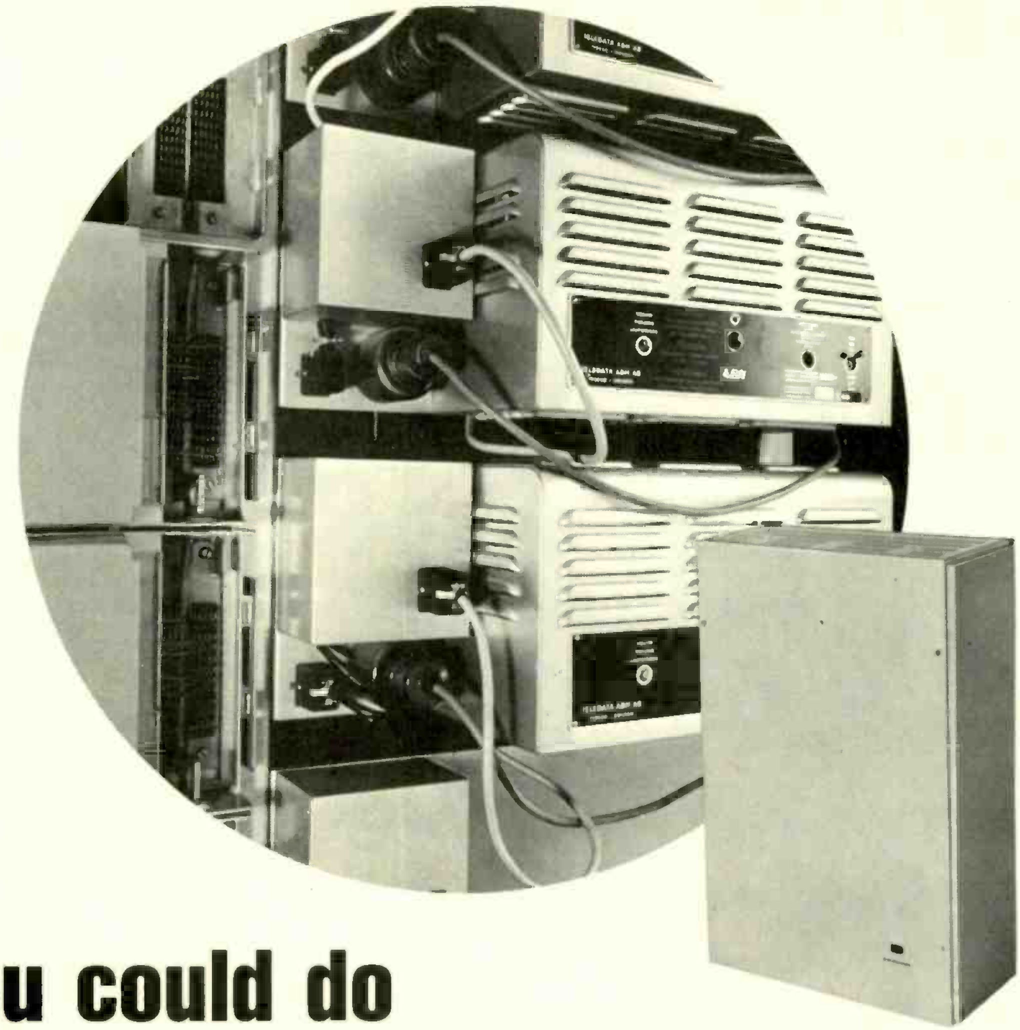

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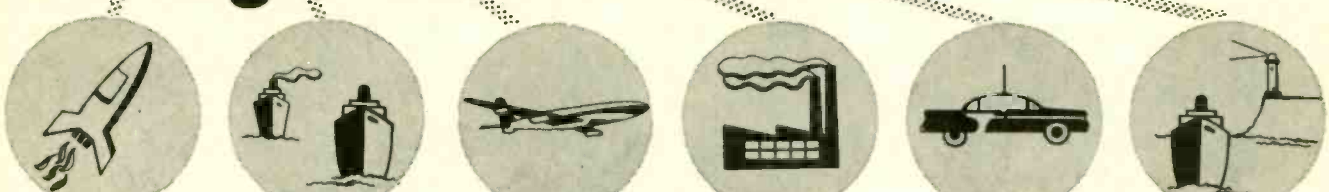

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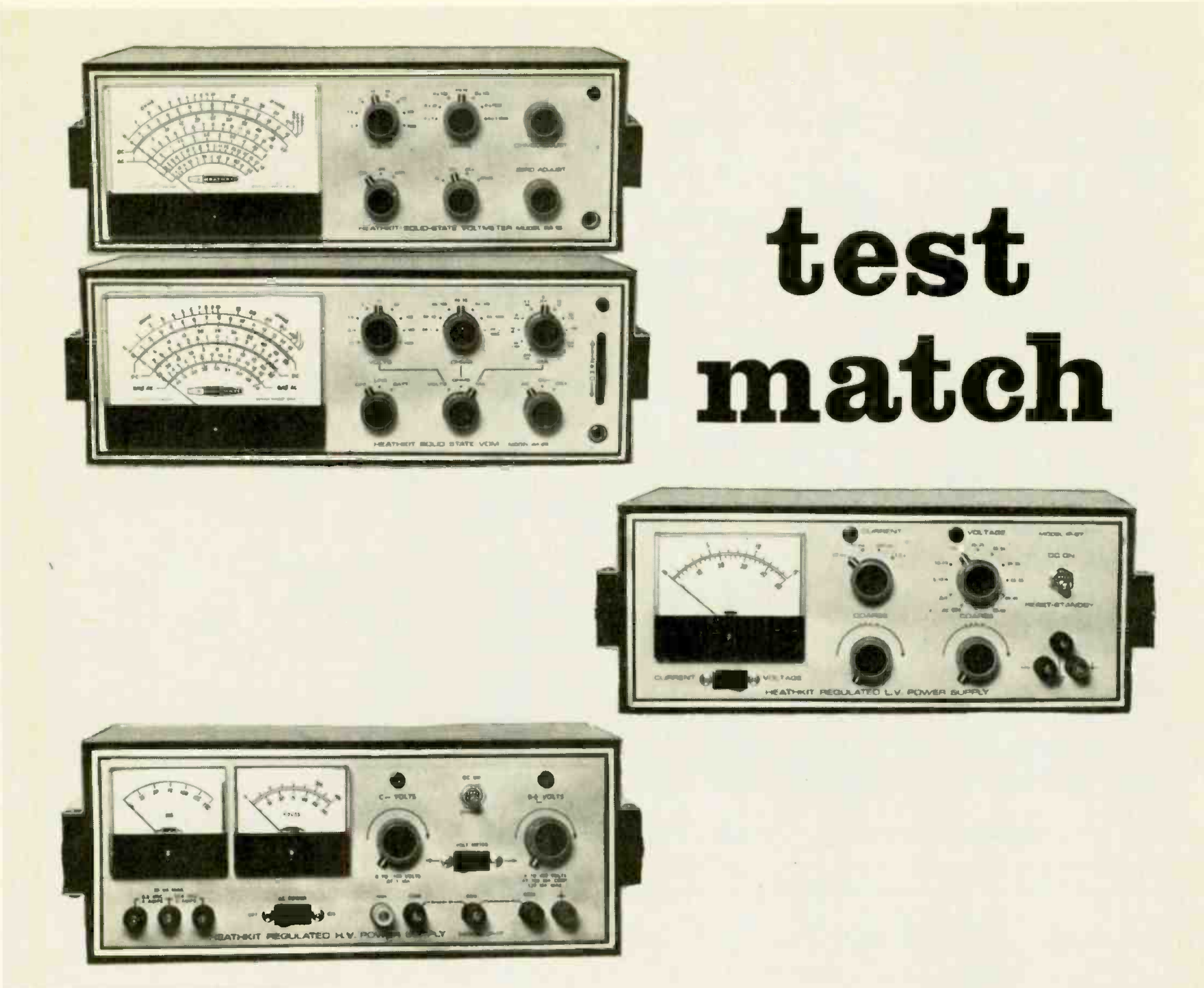

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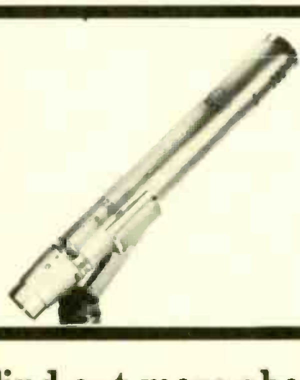

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Advanced studio microphone, employing two-way cardioid principle—the latest in microphone technology—in slim, elegant form. High-quality dynamic microphone ideal for all broadcasting and studio work. Incorporates bass attenuation switch and pivoted stand attachment.

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AKG microphones

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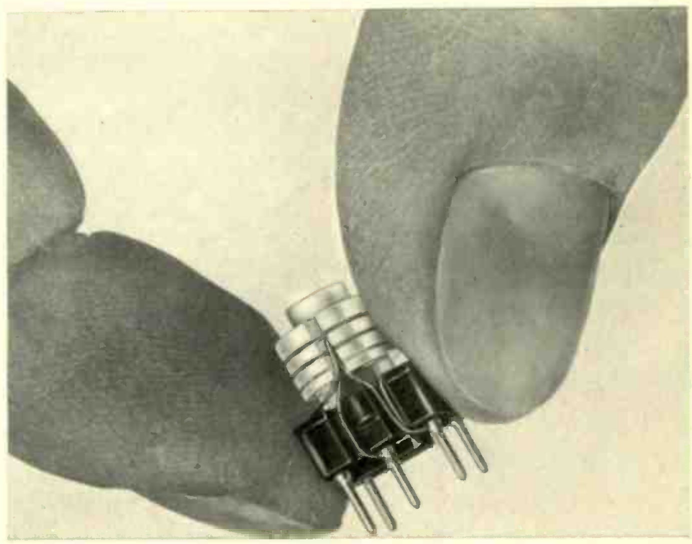
Impectron now offer IFT's with the unique bobbin construction



Available in 5, 7, and 10mm cans to meet AM and FM requirements, with frequency range from 100KHz to 100MHz. High packaging density, low cost with high reliability (reject rate 0·01). The unique construction of the bobbin enables close tolerance windings to within a quarter of a turn, and prevents shearing of wires on alignment.

These IFT's are manufactured by the world's leading RF coil specialists, TOKO INC. and are imported into the UK by Impectron Limited

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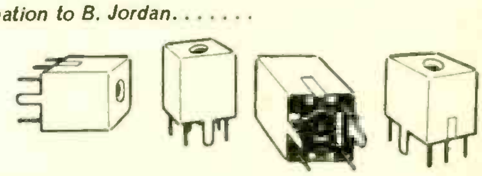

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- **Endless loop cassette facility.**
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- **4 digit, one-press re-set, gear-driven index counter.**
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- **Signal level meter for each channel operative on playback as well as record.**
- **Tape/original switching through to output stages.**
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- **Power output 10W per channel.**
- **Independent tone controls giving full lift and cut to both bass and treble each channel.**
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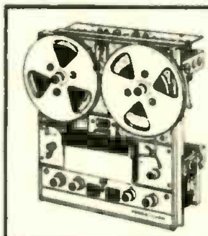
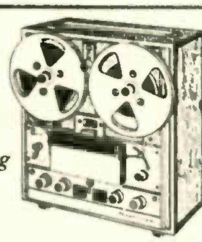


Ideal for rack mounting



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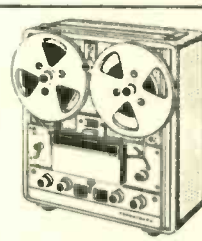

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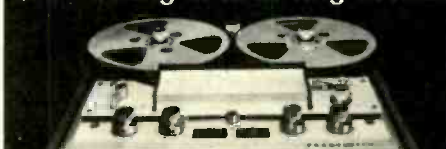

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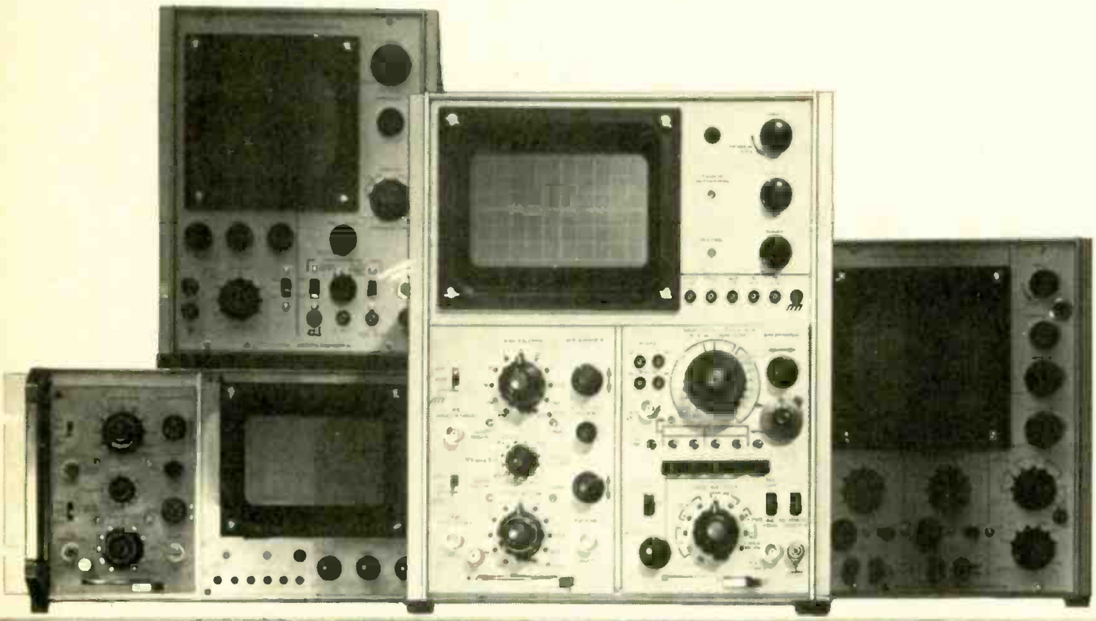

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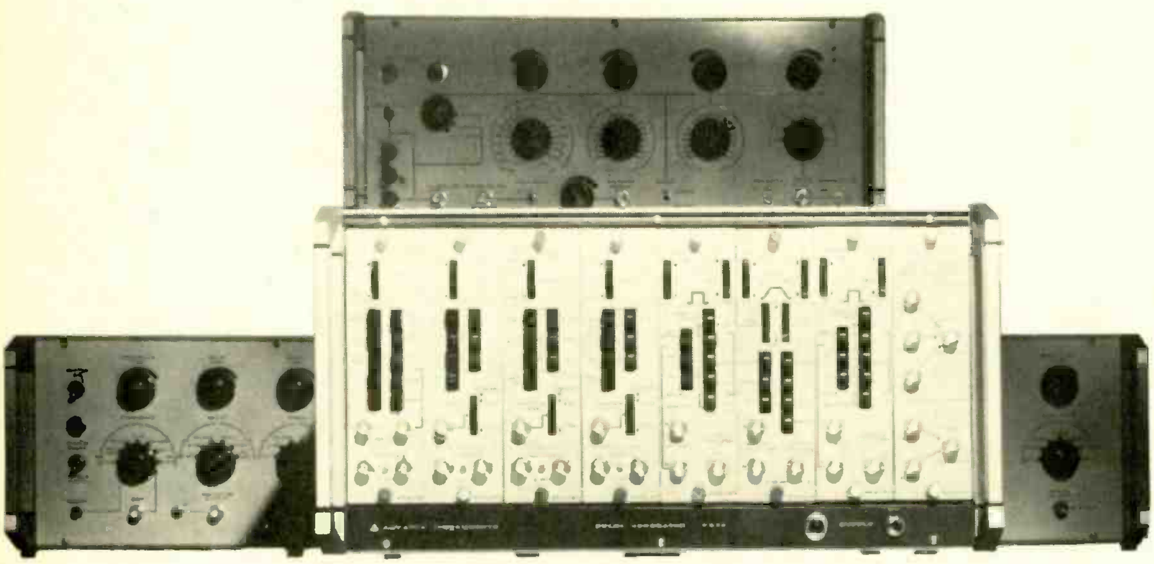

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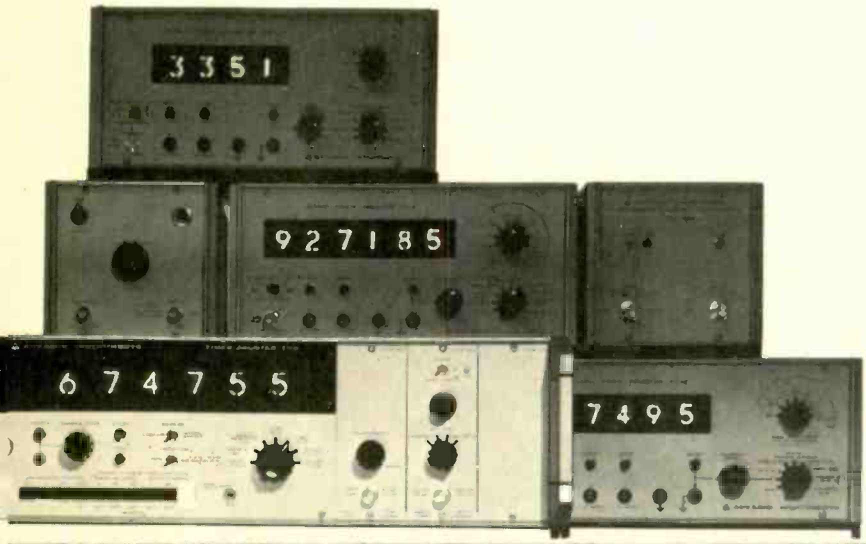

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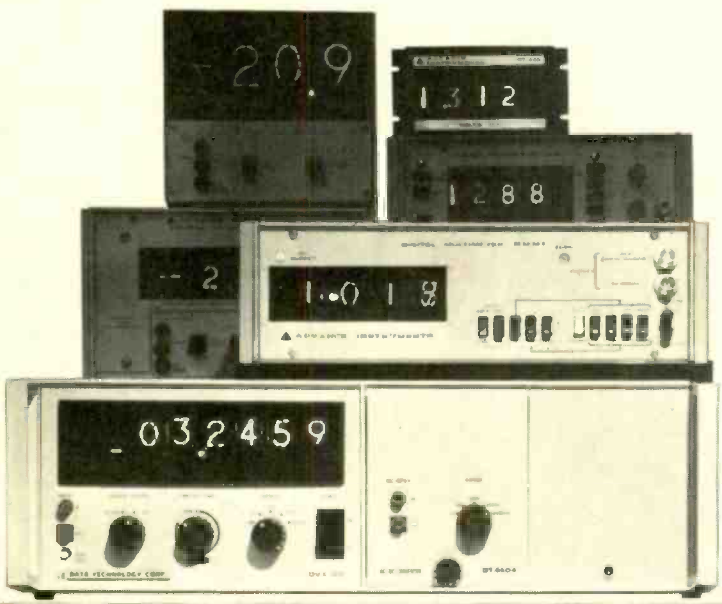

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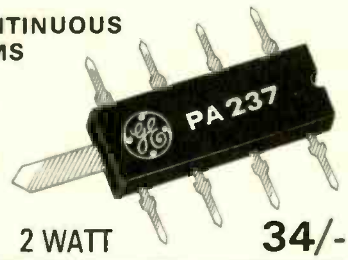

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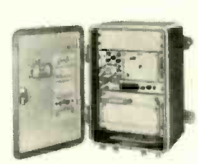

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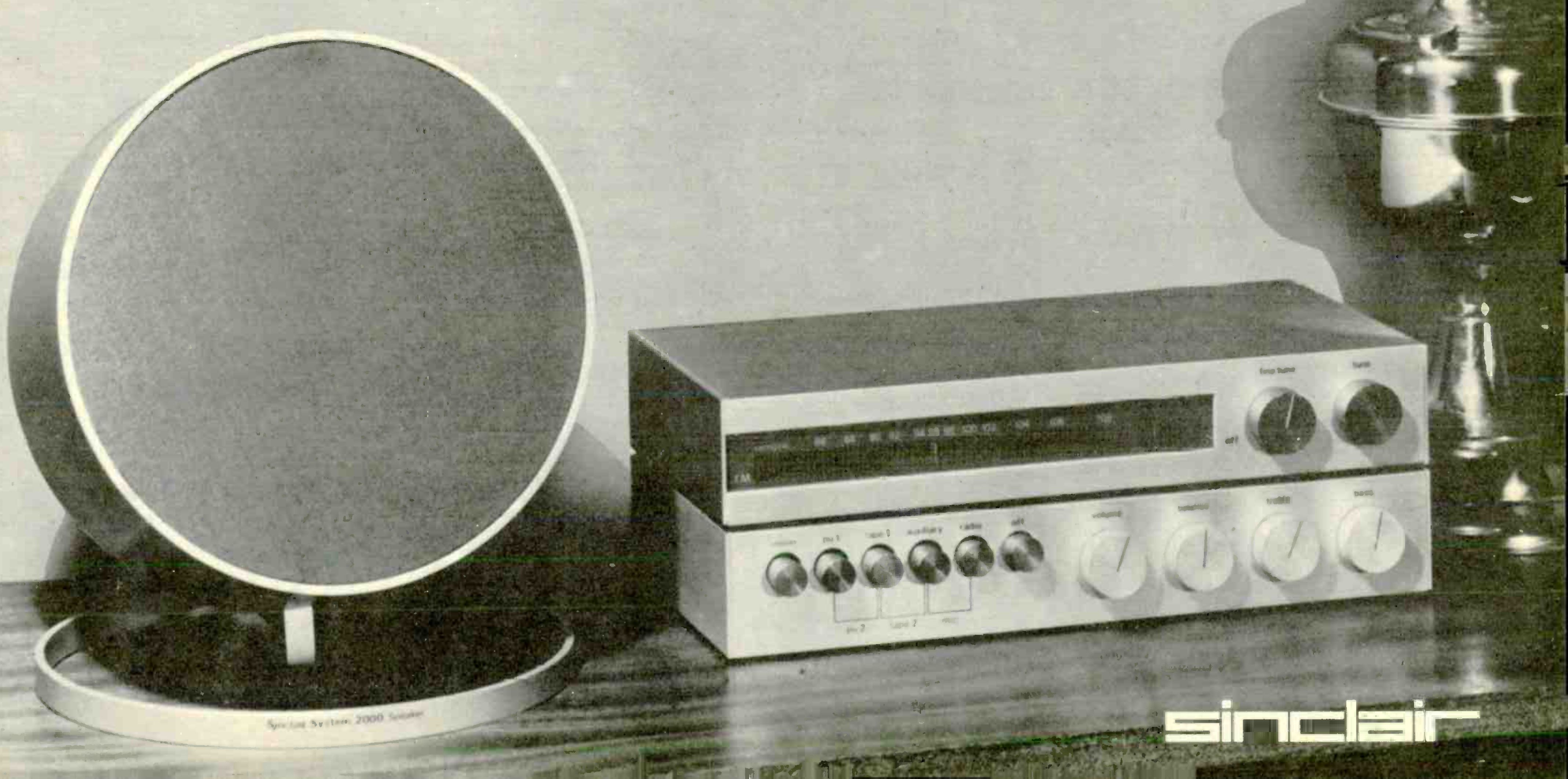

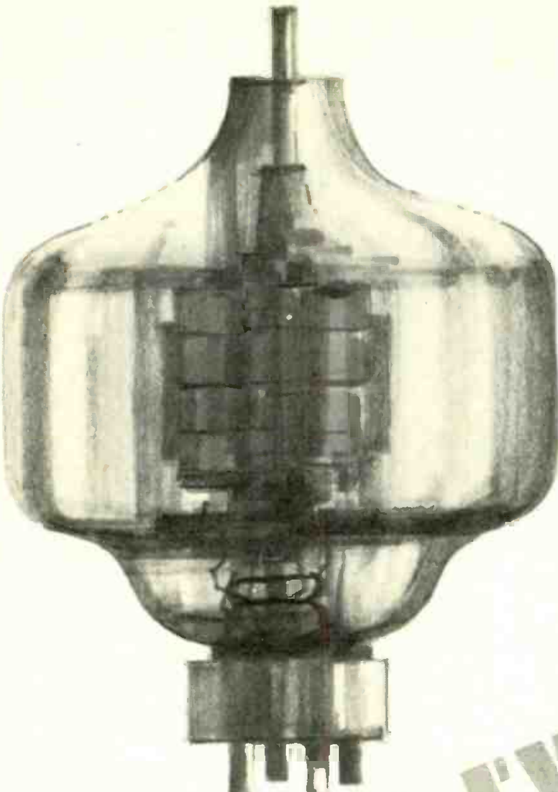

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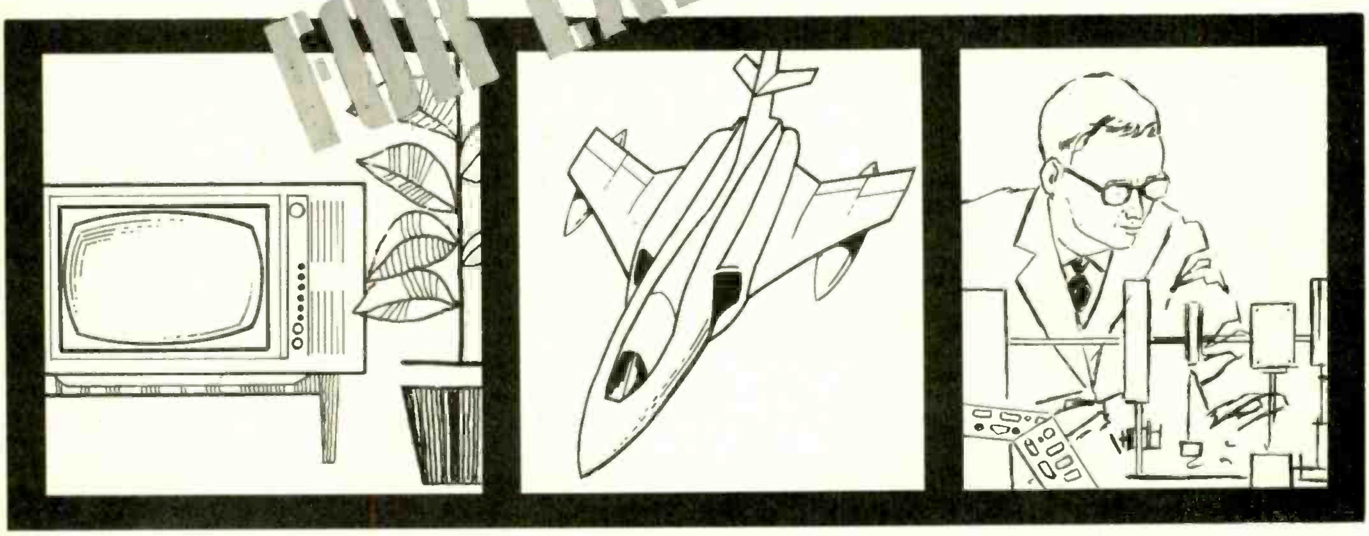

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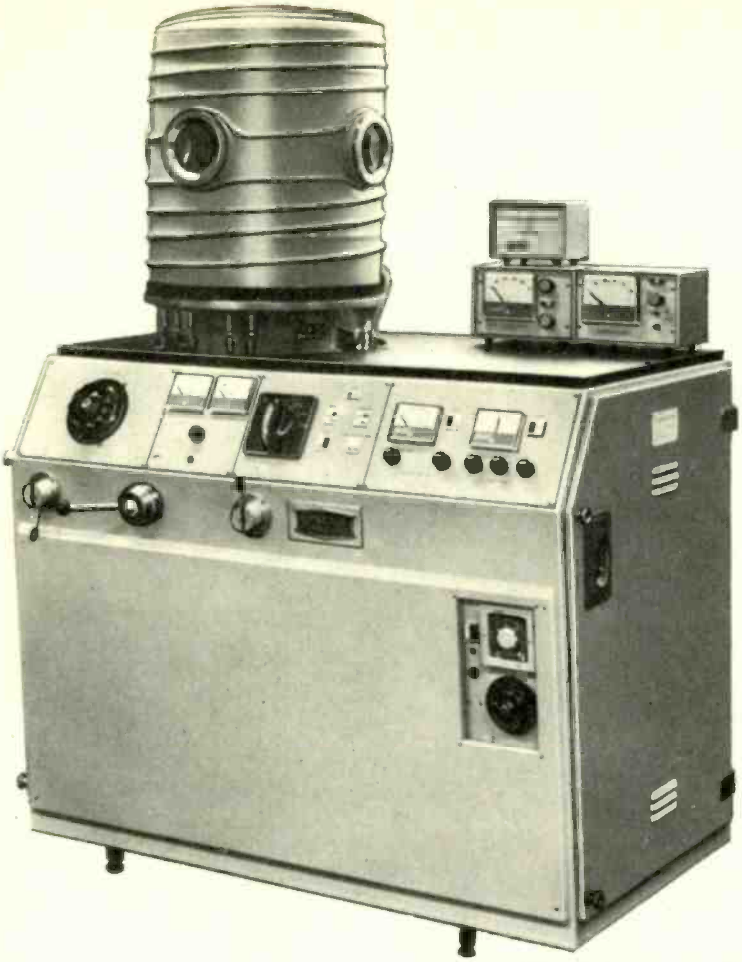

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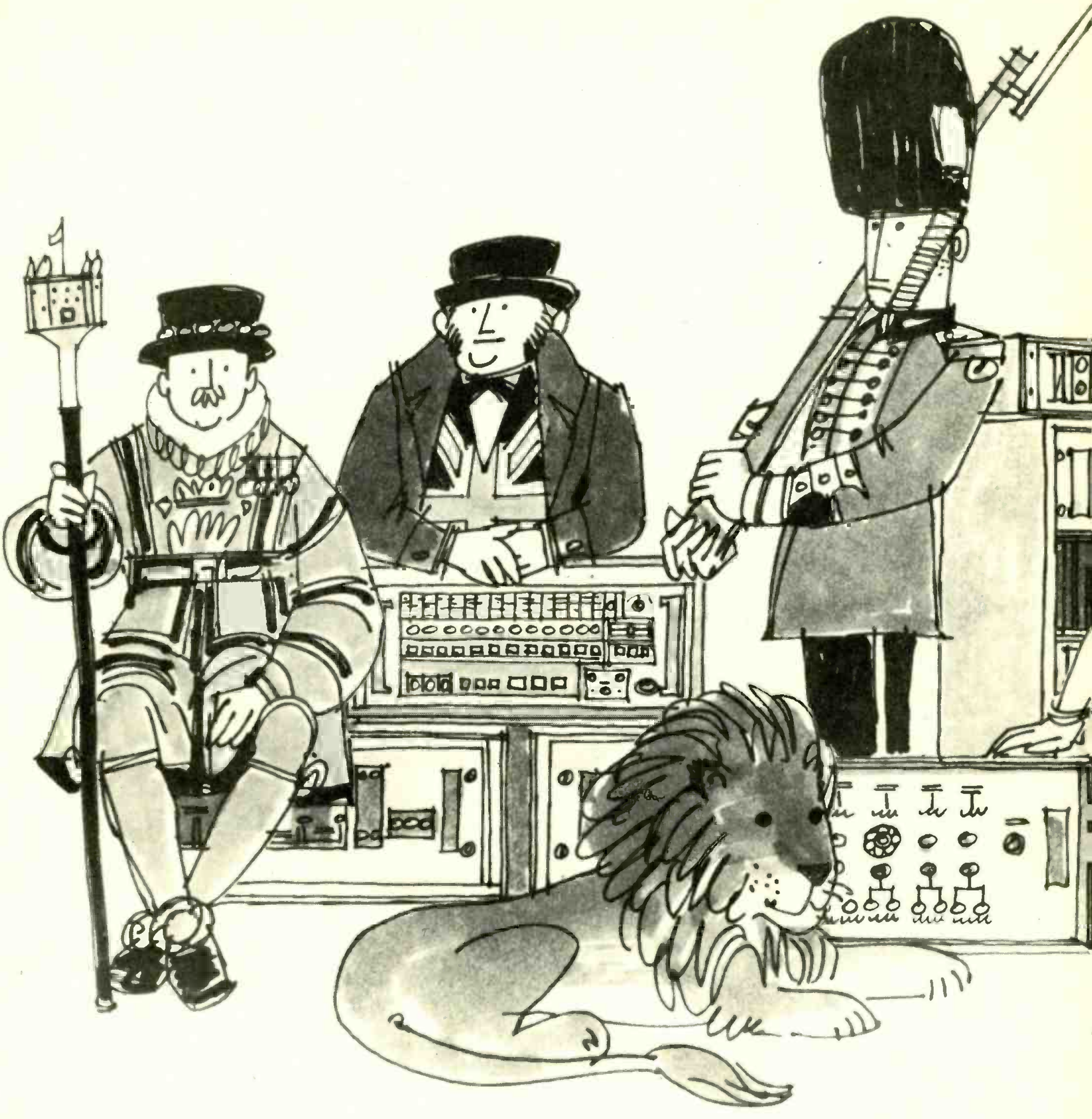

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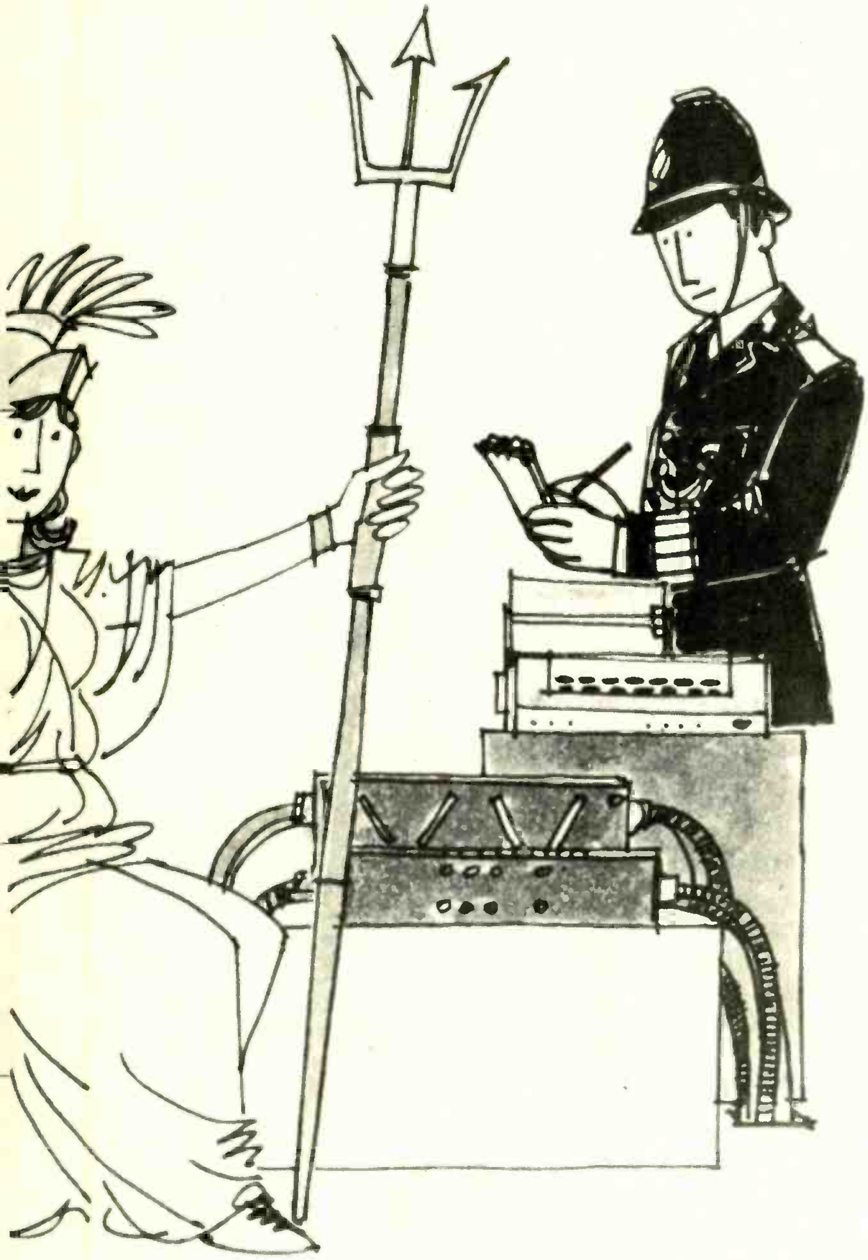

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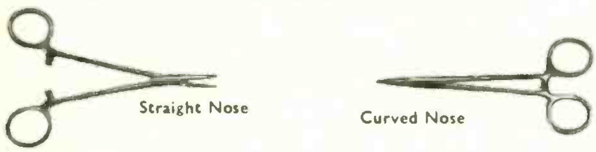

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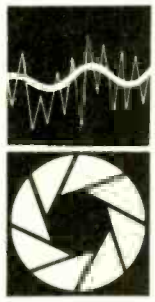

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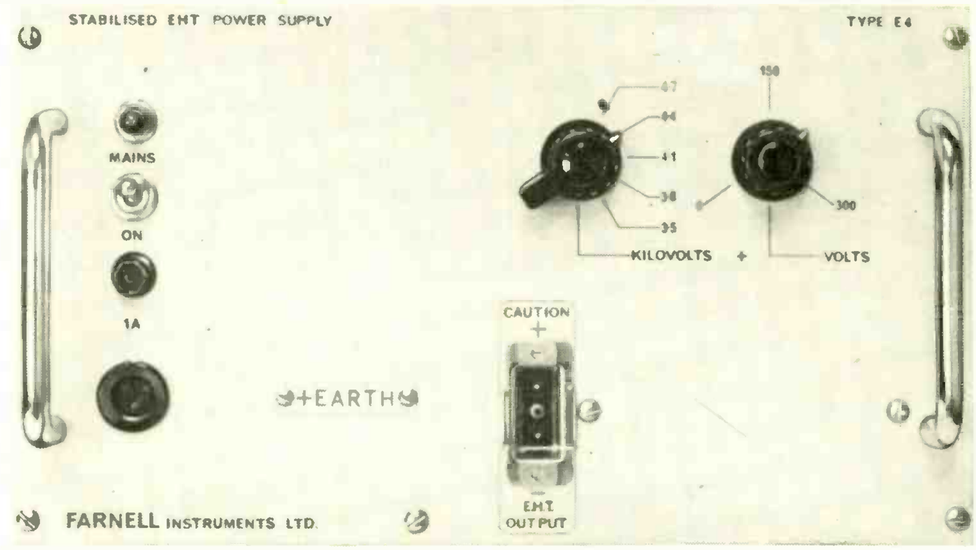

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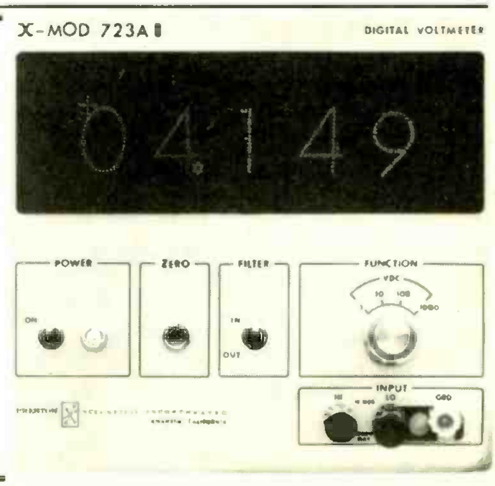

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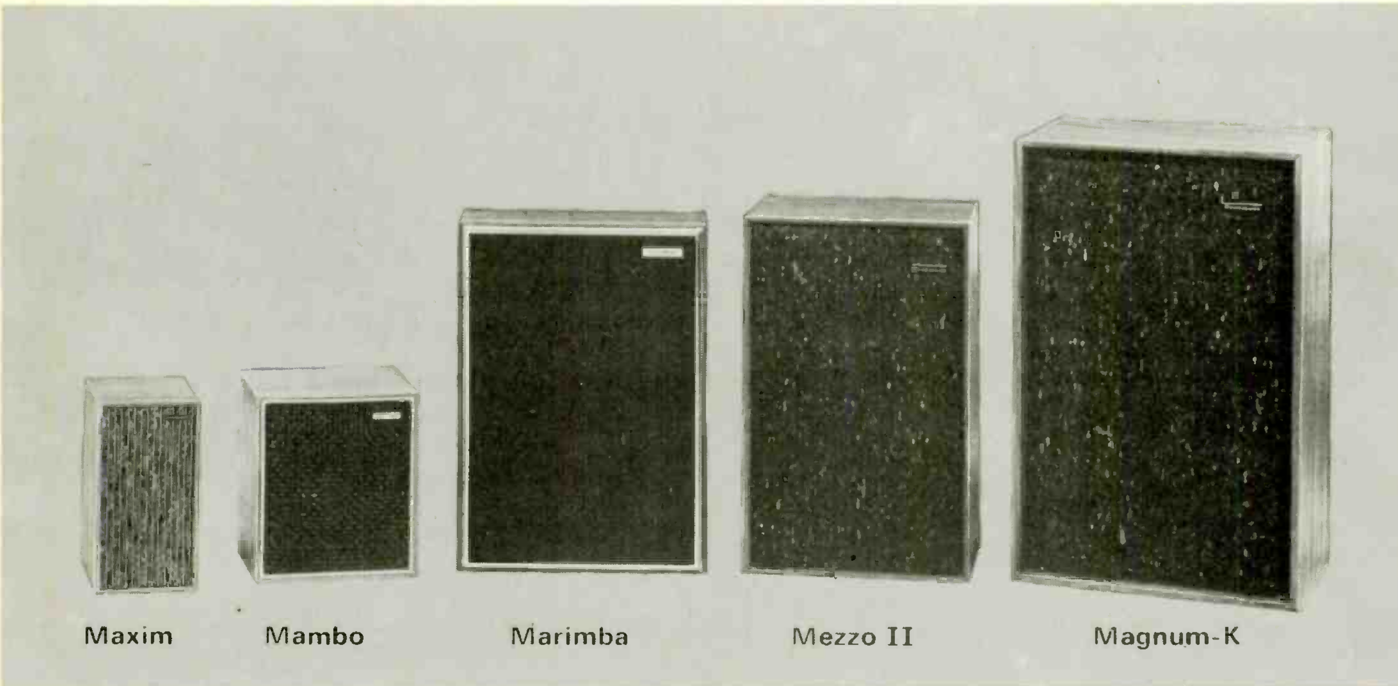

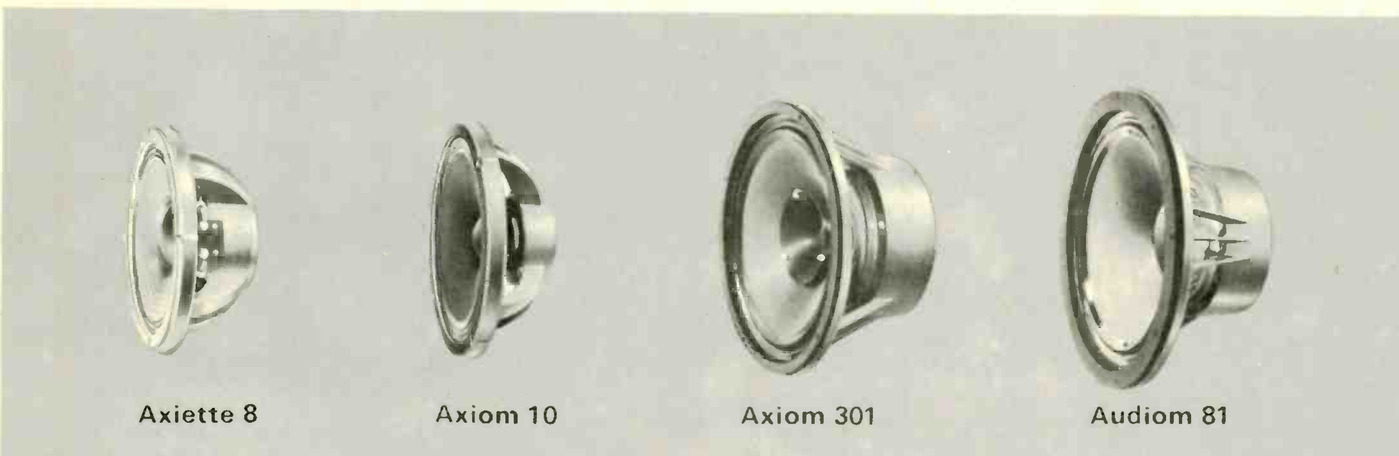

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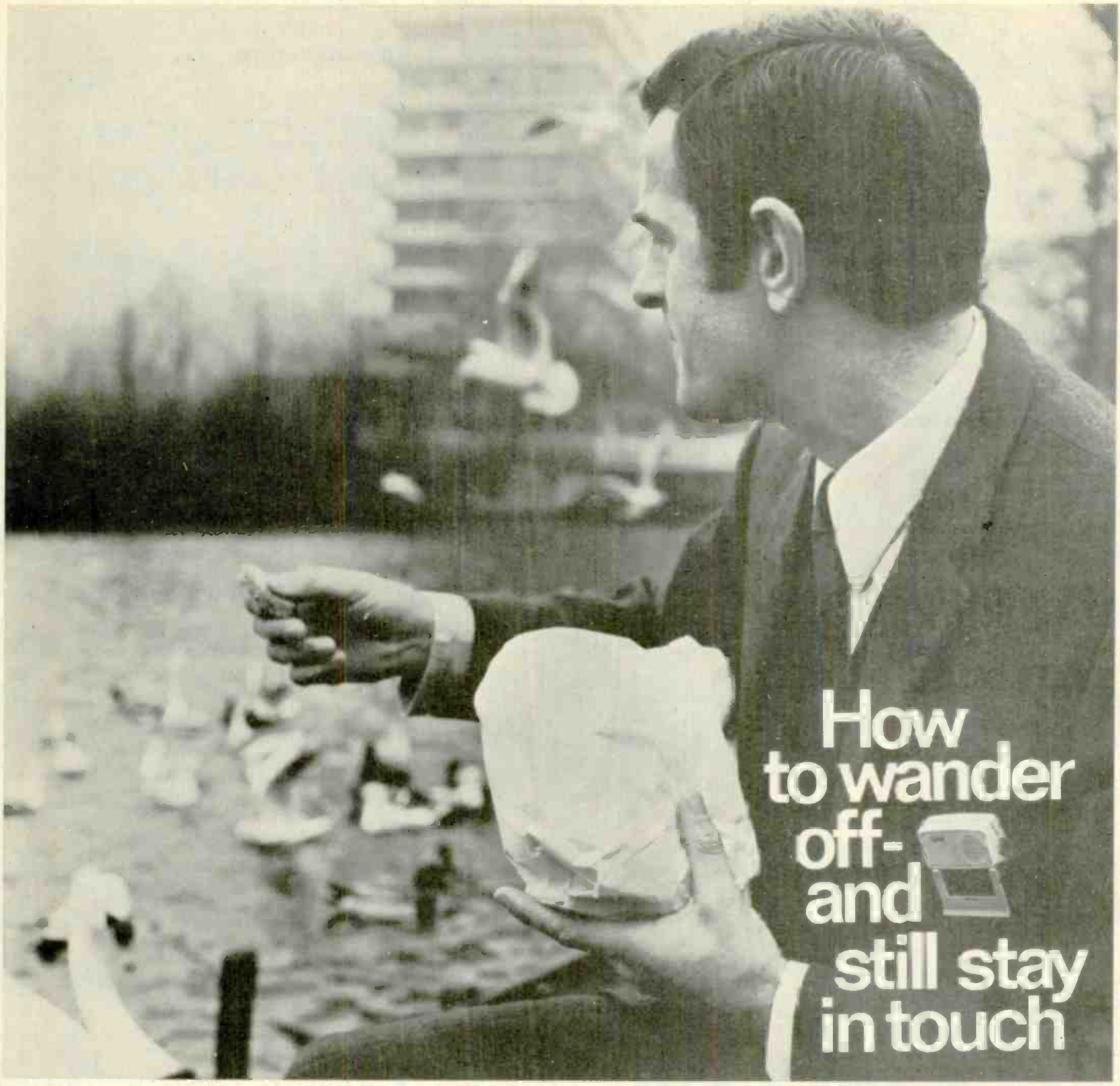

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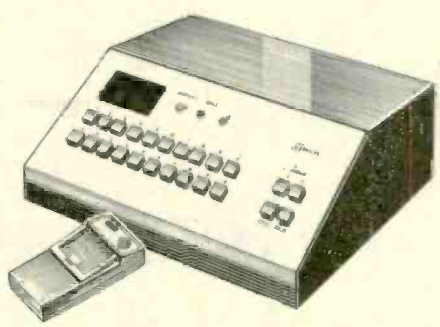

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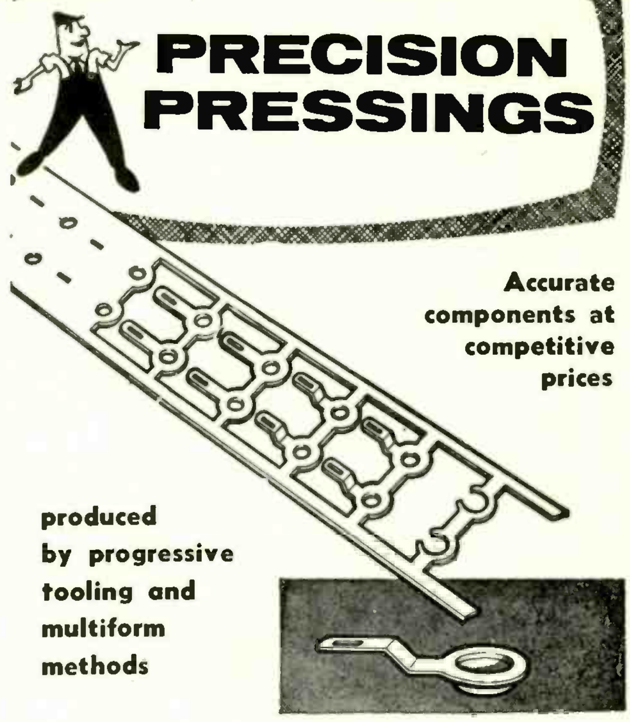

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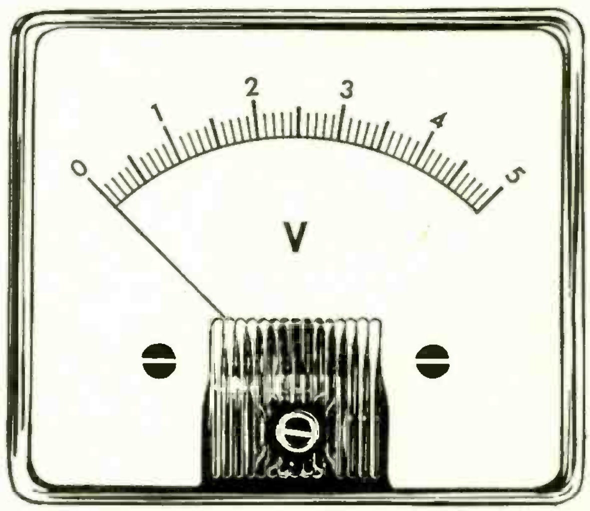

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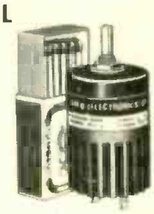

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Some notes on Bridge Measurement by WAYNE KERR

Number 2
Two, Three and Four Terminals

The first issue of these notes described the basic principle of the Transformer Ratio Arm Bridge, and it was shown that high impedance components such as small capacitors can be accurately measured at the end of very long lengths of screened cable with this type of bridge network, the balance point being unaffected by the capacitance of the connecting cables. Figure 1 illustrates this arrangement, which is often referred to as a 'three terminal' measurement having a third terminal used as a guard which can isolate the effect of electric fields and unwanted leakage currents between primary terminals. It is customary, when drawing the circuit configuration of a transformer, to label the common tapping point as 'neutral' and it should be remembered that for most practical purposes the terms 'neutral' and 'guard' are interchangeable for transformer ratio arm bridges.

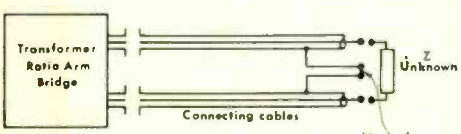

Figure 1

The bridge network can be arranged so that either of the measurement terminals or the neutral can be connected to earth. This gives a degree of flexibility which cannot be achieved with other types of A.C. bridge as these depend on a fixed earth point to reduce the effects of stray capacitances. Furthermore, it can be seen from Figure 1 that the bridge can measure balanced and unbalanced impedances with the neutral connection either earthed or floating.

A typical application of a three terminal measurement is illustrated in Figure 2. It is required to measure component A mounted on a circuit board without disturbing the connections to other components. The use of the neutral connection in this instance places the impedances represented by components B and C in shunt with the cable capacitances and, as we have already shown, these are incapable of affecting the point at which the bridge balances.

Component A can therefore be directly measured by this type of 'in situ' measurement, and an effective isolation occurs of this component from B and C.

A most interesting use of the transformer ratio arm bridge is the measurement of very low impedances, and in this case four terminals are used.

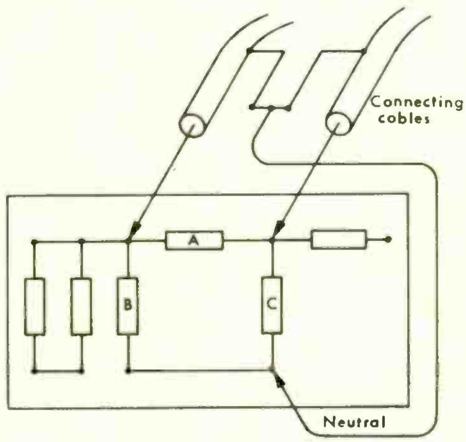

Figure 2

With conventional two-terminal bridges difficulties arise in the connection of the low impedance to the bridge. Variations occur due to terminals and clips introducing finite contact impedances in series with the component which cause substantial errors.

The general arrangement for a four terminal measurement, common to both AC and DC, is illustrated in Figure 3.

'A' represents a constant current with a series resistance so high that small variations caused by the terminals 1 and 2 are insignificant to (i) the current flowing through the unknown. The potential developed across the unknown is measured by 'V', a voltmeter having an internal impedance high enough to disregard the series contact resistance of terminals 3 and 4. If these conditions are met, the true value of the unknown is measured by V/i.

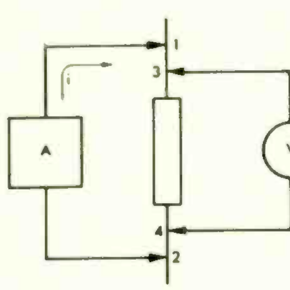

Figure 3

The transformer ratio arm bridge is readily adaptable to this arrangement in the case of AC measurement. Figure 4 shows the modification necessary to create a four-terminal facility suitable for measuring impedances below 10 ohms.

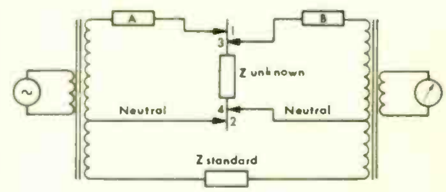

Figure 4

If a resistor A with a value of some thousands of ohms is inserted in series with the unknown impedance, which in this case returns to the neutral winding of the transformer, a current flows which is substantially independent of the contact resistances, which are small compared to the value of resistor A,

Resistor B similarly isolates the right hand pair of contact resistances from the second transformer network, and it can be shown that the standard impedance (Zs) will balance the T network which is formed on the unknown side of the bridge in the following manner:

$$Zu = \frac{R_A \ R_B}{Zs}$$

If the unknown impedance is a pure resistance and the bridge standard is calibrated in conductance, the bridge will now indicate the resistance directly if the values of R_A and R_B are multiplied by the conductance reading. In a similar fashion, a pure inductance will balance against a standard capacitance because of the reciprocal nature of the formula.

To summarise, the transformer ratio arm bridge enables three-terminal impedance measurements to be made, from a few ohms to many thousands of megohms. These measurements may be at any phase angle or in any quadrant of the complex plane and, if required may be carried out at the end of very long lengths of cable.

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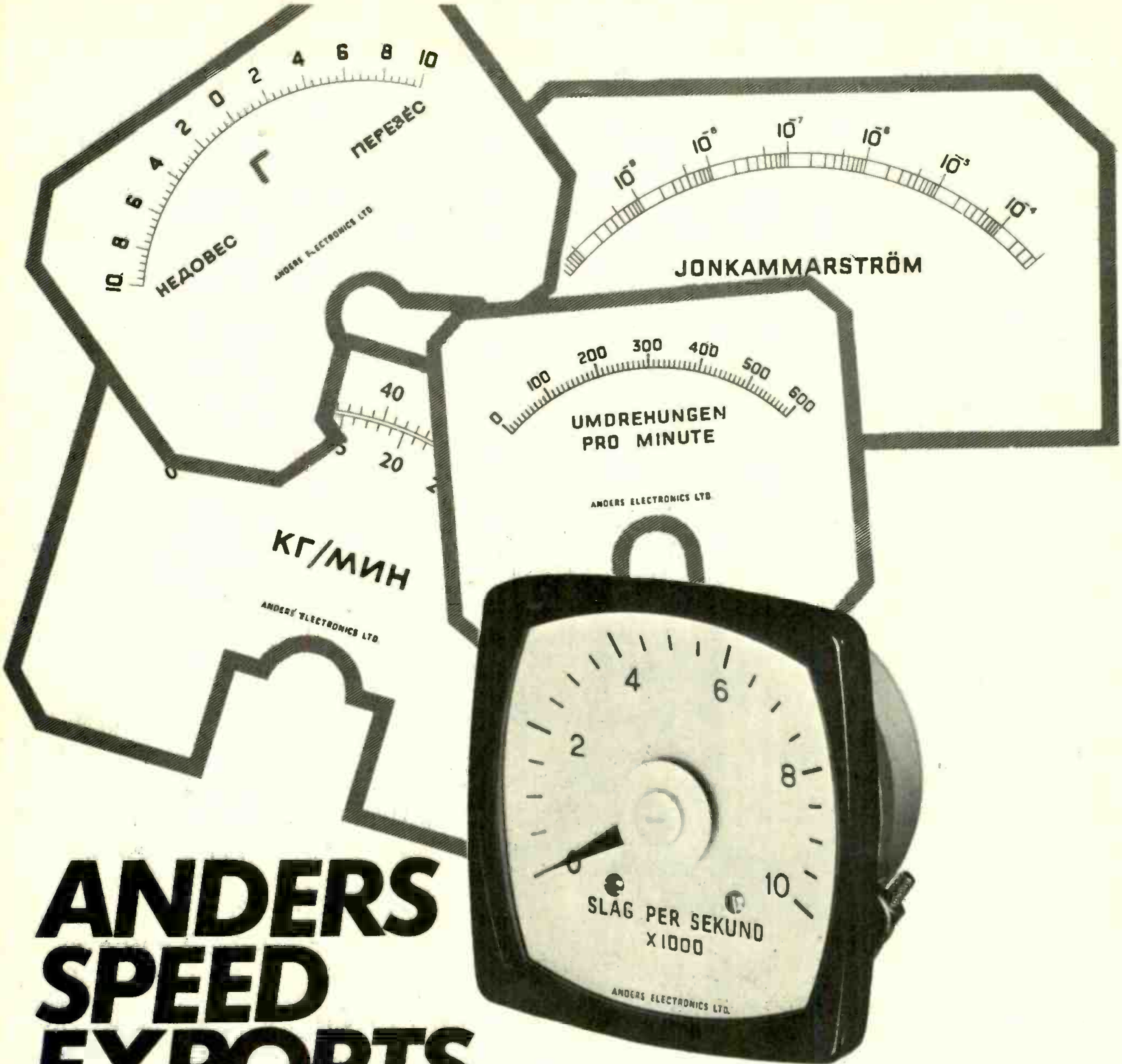

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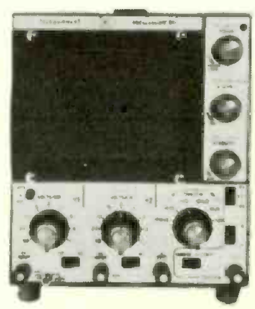

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Wireless World

Electronics, Television, Radio, Audio

Fifty-ninth year of publication **September 1969** **Volume 75 Number 1407**

This month's cover. A Perspex model of a three-dimensional radar scanner developed by R.R.E. (see p. 422) illuminated by ultra violet light.

Contents

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Labyrinths of Whitehall

Have we too many masters? This question must have come into the minds of those of our readers who have had occasion to consider to which Government Department some industrial-governmental question should be addressed.

The industry's "sponsoring department" is, of course, the Ministry of Technology but what does this term mean? One dictionary definition of sponsor is "one who binds himself to answer for another and is responsible for his default". The Minister may well answer for the industry in Government circles but one wonders what his Department's response would be if creditors of a defaulting company or group applied for restitution!

As the co-ordinating authority within the Government for our sector of industry the Minister seeks the advice of a large number of committees and advisory bodies, among them the National Electronics Council, set up in 1964 as the National Electronics Research Council, under the chairmanship of Lord Mountbatten. Its aims are briefly "For the sole purpose of benefiting the public, to enquire into and encourage the use of electronics calculated to lead to the improvement of national life in all its aspects; to provide assistance, advice and information to the Minister of Technology on the use of electronics; to consider the requirements and priorities of research; . . . and to advance education in the field of electronics". In the published reports of its quarterly meetings this 36-man Council of some of the top men in Government Departments, education, research and industry, "has before it" papers on a variety of subjects (from recruitment in industry to social implications of electronic equipment) but, like so many similar bodies, one sees little evidence of any specific action taken.

Then, of course, we have the Board of Trade, which although custodians of all the vital statistics for our economic survival—the Board's monthly import-export figures are a masterpiece of statistical jugglery—is not concerned specifically with economics. This is the province of the National Economic Development Office ("Neddy") one of whose offspring, the Economic Development Committee for the Electronics Industry (little "Neddy"), is concerned exclusively with our industry. Its reports, however, make sad reading for it would appear that its prime object is to collect, collate and issue facts on the industry's immediate past economic situation and to estimate its future prospects. But, can its prognostications make any difference to the final result which depends on the efforts of the companies within the industry and not the noddings of Neddy?

One of the labyrinths of Whitehall leads to a door marked P.M.G. (soon to be changed to Mintelecom?). As Minister of Posts and Telecommunications he will have even greater power over the telecoms industry. Under its new powers the Post Office will be able to manufacture its own equipment, and as the major purchaser of equipment can dictate its own terms.

If, of course, one's question is concerned with research then we might be redirected out of Whitehall to any one of several centres: Royal Radar Establishment, Malvern; Royal Aircraft Establishment, Farnborough (which has a large electronics and radio section); National Physical Laboratory, Teddington; Radio and Space Research Station, Slough; Signals Research & Development Establishment, Christchurch; etc, etc. The titles of these establishments are very different, but in many areas of research they are not.

What we need is a plain man's guide to the labyrinths of Whitehall—who is responsible for what. The rejoinder from Whitehall will doubtless be "physician heal thyself" for our own industry is bedevilled by committees, councils, consortia and conferences, but that is another story.

Moon Mission Radio-electronics

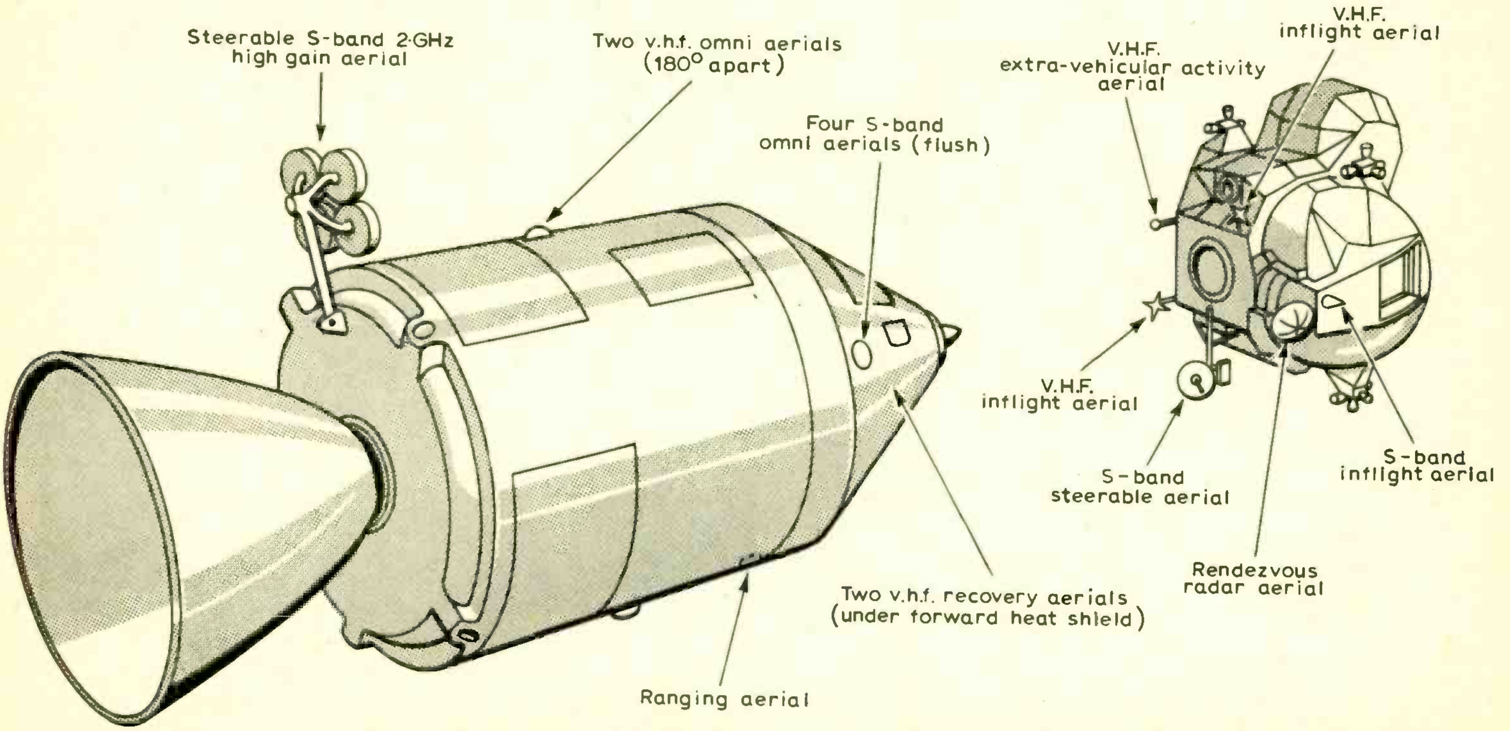
Tele-command, -metry, -vision and -communications

The Apollo 11 mission to the moon demanded the most extensive and complicated collection of radio and electronic systems ever applied to a single project. It certainly could not have taken place without the use of these techniques. Human pilots would have been quite unable to perform successfully all the critical manoeuvres, such as going into and out of orbit, and landing on and taking off from the moon, because they would not have received all the information necessary for navigation and flight control, and because human brains would have been quite incapable of processing and acting on this information with the necessary speed and accuracy. About nine-tenths of the radio-electronics was in fact concerned with automatic control of the mission—through telemetry, telecommand and high-speed computer processing of data—and the human communication via voice and television, though spectacular, was a relatively small part. The following can be no more than an outline of the systems that were operating in this immense feat of technology.

Ground network. Because of the rotation of the earth, it was necessary, in order to maintain contact with the spacecraft, to set up a circummondial network of radio transmitting and receiving stations, all linked to the Mission Control Centre at Houston, Texas. There were 17 ground stations, four ship stations and a number of aircraft stations. During the first phase of the flight, when the spacecraft was orbiting the earth, contact was maintained through a group of stations with 30ft dish aerials (Merritt Island, Grand Bahama Island, Bermuda, Canary Islands, Carnarvon [Australia], Hawaii, Guaymas [Mexico], Corpus Christi [Texas] and two tracking ships). When the spacecraft reached 10,000 miles from earth these stations were joined by three others, with 85ft, higher-gain aerials, situated about 120° apart at Madrid, Goldstone (California) and Canberra.

Spacecraft data received by these stations were relayed through the N.A.S.A. communications network of landline, submarine cables, communications satellites and conventional radio links to Mission Control at Houston. There the data were fed into computers to produce visual display information, such as spacecraft position on a map, and other information needed for transmitting flight control commands to the spacecraft. When the spacecraft separated into two parts—the command and service module and the lunar module—the network had to continue to provide telecommunication and telemetry between both of these craft and earth. For this purpose two aerials were

Aerials for various purposes on the command and service module (left) and the lunar module (right).



used at each of the 85ft-aerial stations, one for each module.

The N.A.S.A. communications network, with its main switching centre at Goddard Space Flight Centre, Greenbelt, Maryland, U.S.A., was similar to that shown in the map in our report on the Apollo-8 mission (February, 1969, issue, p.73).

Spacecraft flight control. During the early phases of the flight, that is until just after leaving earth orbit, all control was carried out by the instrument unit, which was a 3ft high, 22ft diameter cylinder mounted on top of Saturn-5's third stage. The instrument unit consisted of six main systems — structural, thermal control, guidance and control, measuring and telemetry, radio equipment, and power supply and control equipment.

A path-adaptive guidance system was employed. During the ascent through the atmosphere no automatic corrections were carried out for fear, in trying to compensate for high-altitude, high-velocity, air streams, that damage to the vehicle would result. After clearing the atmosphere the control of the vehicle's trajectory was handed over from the programmed control to the automatic inertial guidance systems.

Once out of earth orbit the Saturn rocket's third stage was jettisoned and control was passed to the command and service module. Again an inertial guidance system was employed coupled to a digital computer.

The lunar module itself was completely self-contained as far as navigation and guidance were concerned, having its own inertial navigation and computing facilities which were known as p.g.n.s. (primary guidance and navigation system) with a standby system, a.g.s. (abort guidance system), for use in emergency. Normally both systems are intended to run in parallel, with the a.g.s. operating in an "open ended" mode providing information for cross checking the p.g.n.s.

The p.g.n.s. was an optically assisted inertial navigator. In systems such as these the inertial navigator may give the present position as point X, while sightings made on stars, using a sextant coupled to the navigation computer, may give a position Y. The difference between X and Y is a direct measure of inaccuracies within the inertial system. The computer uses this difference to calculate angular correction signals in three dimensions which are used to correct the position of the inertial platform. In this way the inertial navigator becomes more and more accurate as time progresses.

We understand from TRW Incorporated that initially checking of the lunar module a.g.s. was done using a milk float as the test vehicle while driving round the streets of Houston!

Radar systems on the lunar module consisted of the rendezvous radar, which had a range of from 80ft to 400 nautical miles, and the landing radar, which was a doppler system, that fed the guidance computer with altitude and velocity information during the lunar landing.

Other systems that were used on the lunar module were the c.e.s. (control electronics section) which was responsible for controlling lunar module altitude by operating small thrusters through the p.g.n.s., and a system called Ordeal (orbital rate drive for Apollo and Lunar module) which displayed the local vertical on the flight director system during circular earth and lunar orbits.

Television. The television transmissions from the Apollo 11 mission originated from two cameras both made by Westinghouse (see photo)—a colour camera (left) aboard the command module, and a black-and-white camera (right) in the lunar module. The colour camera was a single-tube (secondary electron conduction), field sequential type using a 600 r.p.m. rotating colour filter wheel with six red, green and blue sections, and produced video signals on the American 525-line standard—though conversion was necessary on the ground to obtain the required 30 pictures/second. It had a zoom lens for wide-angle or close-up views, and a 3-inch c.r.t. monitor which could be mounted either on the camera or in the command module. The black-and-white camera, which, of course, was used on the moon's surface, was a slow-scan type with a scanning rate of 10 fields per second, 320 lines per picture (alternatively, $\frac{5}{8}$ fields/second, 1,280 lines/picture). Designed for a scene luminance range of 0.024 (near darkness) to 42,000 cd/m^2, it had a resolution of 500 television lines and a bandwidth of 2Hz to 500kHz. The pick-up tube was a secondary electron conduction type. The camera consumed 6.5 watts at 28 volts d.c. and weighed (on earth) 7.25lb. Two lenses were provided, a wide-angle type for close-ups and large areas and one designed for viewing moon surface features and activities in the near field of view with sunlight illumination. These could be changed by means of a bayonet lens mount on the camera body.

The two television cameras used on the mission: left, the colour camera carried in the command module to televise activities in flight; right, the black-and-white camera carried in the lunar module and used to televise scenes on the surface of the moon.

The lunar module had to be restricted to monochrome transmissions because there was insufficient electrical power available in the craft to meet the greater power requirements of colour television on top of the demands of the high-priority data transmissions. Signals were radiated by a 2-GHz (S-band) 20-watt transmitter and a helical aerial giving a 3-degree beam width.

On the ground the television transmissions, as well as all other signals, were picked up by 210-ft parabolic dish aerials at Goldstone, California, and Parkes, Australia, and by 85-ft dishes at Goldstone, Madrid and Canberra. The Parkes aerial is, in fact, a radio telescope operated by the Australian National Radio Astronomy Observatory, and it was this that was used to receive directly the lunar module television transmissions from the moon's surface. From Parkes the signals, after conversion to the U.S. television standard, were sent by microwave link to Sydney and thence via the Intelsat III communications satellite above the Pacific Ocean to the Mission Control Centre at Houston, Texas. From there they were distributed to world television networks.

Spacecraft Communications. The telecommunications system of Apollo 11 provided radio contact between the command module and lunar module when separated, between each of these modules and earth, between the spacecraft and the astronauts, and between the astronauts themselves. Types of information involved were: voice, television, p.c.m. telemetry, and command, tracking and ranging data. Voice communication between the spacecraft and ground was by S-band transmitter-receivers; between the command module and the lunar module it was by v.h.f./a.m. transmitter-receivers.

The various aerials used for all this are shown on the diagram. A particularly important one was a high-gain steerable S-band aerial on the command and service module for communication with the ground. It consisted of four 31-inch diameter parabolic dishes mounted on a folding boom at the aft end of the spacecraft. Until required for use the boom was nested along the length of the craft, then was swung out at right-angles to the longitudinal axis as shown. Signals from the ground could be tracked either manually or automatically by the aerial's steering system. On the lunar module there were one 26-inch, S-band, steerable dish aerial, two further S-band aerials and two v.h.f. aerials for voice communications. In addition the lunar module carried a rendezyous radar aerial, and its descent stage (not shown) had a landing radar aerial.

Telemetry system. The pulse code modulation telemetry system accounted for more than half of the electronic components required for the complete command module's communication and data network. The system was capable of receiving analogue and digital data from spacecraft sensors, sampling it at selected rates, and converting it to a serial p.c.m. form. It processed 365 high-level 0-5V analogue inputs at a rate of one to 200 samples per second and 304 parallel digital inputs plus one serial 40-bit word. The system was built to a reliability criterion which allowed the loss of not more than five analogue channels and eight digital bits. The equipment employed two types of internal redundancy. Four resistors — two in series and two in parallel — performed the function of one resistor. There was also a duplicate circuit arrangement known as "block redundancy" which included automatic switchover to a standby circuit in the event of primary circuit failure.

The lunar module p.c.m. telemetry and timing system accepted four types of data input signals: high-level and low-level analogue, and parallel and serial digital. Each parallel digital input contained a group of eight bits. The serial digital input was a return-to-zero signal, 40 bits per word in length, with a rate of 50 words per second. The high-level analogue signals were unipolar, 0-5V full scale, while the low-level analogue inputs were differential from zero to 40mV full scale.

The sampling rate of each channel was between one and 200 samples per second depending upon importance. An internal timing source with an accuracy of two parts per million for 136 hours served as a standby to the normal external timing source which was a caesium atomic clock. System bit-rate was 51.2kbs with an inherent capability of up to 64kbs and an accuracy of 1.5% peak.

The transducers on board the lunar module were interfaced to the telemetry equipment by a signal-conditioning electronics assembly, which contained a variety of precision signal-conditioning modules including buffer amplifiers, a.c./d.c. converters, low-level amplifiers, thermo-couple reference junctions and the like.

Many people consider that the huge amount of money spent so far on the American space programme could have been put to better use. This may be so, however before reaching any conclusion all the side benefits, or so called spin-off, should be taken into account. Apart from the obvious advances that have been made in the electronics industry as a result of the programme, and this means all those industries that employ electronics, considerable steps forward have been made in farming, meteorology, medicine and, believe it or not, fishing; as orbiting satellites can pinpoint the position of large shoals with ease.

Magnetic Holographic Store

An optical data store which can be erased and re-used repeatedly has been made possible by combining the new principle of holography with the old principle of magnetization. Normally, of course, information stored holographically on photographic film (see August issue, p.369), cannot be erased because the photosensitive material undergoes a permanent chemical change when exposed to light. The new type of store replaces the photographic film by a magnetic film. It was invented by RCA, who say that it could make possible an optical erasable memory capable of storing 100 million bits on a magnetic film one inch square. Writing time would be 10 nanoseconds and erasing time 20 microseconds.

The storage medium is an extremely thin film of manganese bismuth—a single-crystal layer 2 micro-inches thick—deposited on a base of mica. This film is subjected to a strong magnetic field that forces all its magnetic atoms to line up with their north poles in one direction and their south poles in the other. Light from a pulsed laser is split into two beams, one going directly to the film and the other going first to the information bit pattern to be recorded and then to the film. At those points where the two beams interfere additively the heat from the laser beams warms the magnetic material sufficiently (the Curie point) to allow its magnetic atoms to realign themselves so that the north poles of those in the heated portions now point in the same direction as the south poles in the unheated portions. Where the two beams interfere subtractively nothing happens at all.

Thus, a magnetic pattern is formed in the film corresponding to the interference pattern created by the converging laser beams—in fact a magnetic hologram is produced. This hologram can be read out in two ways: either by transmitting a laser beam through it and using the Faraday effect, or by reflecting the beam from it and using the Kerr effect. It can be erased by electrically pulsing a coil which subjects the film to a strong magnetic field and forces the magnetic atoms to line up, as at first, with all north poles in one direction and all south poles in the other direction.

RCA say that the speed and ease of making and erasing magnetic holograms, coupled with the fact that their resolution (2,000 lines per millimetre), far surpasses that of ordinary photographic materials, makes the process extremely attractive for achieving an optical computer memory. Also, there is no indication that the process causes any thermal decay or other type of fatigue in the material. Apparently, the write-erase cycle can be repeated indefinitely, and, because of the inherent redundancy of holographic storage, dust or minor imperfections in the magnetic film do not seriously affect the hologram readout.

The magnetic holograms were made using a Q-switched ruby laser with a 200-microjoule, 10-nanosecond pulse, and were read out with a continuous wave, helium neon laser. RCA say that they can also be made and read out with infra-red lasers.

Active Filters

2. Basic theory: 1st and 2nd order responses

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

Since any transfer function can be resolved into a product of 1st and 2nd-order factors, a knowledge of the characteristics of such factors is fundamental.

The basic 1st-order responses are the simple lag (low-pass), and the simple lead (high-pass). Responses of either type may be characterised by a single parameter, the time constant (or its reciprocal, the corner frequency ω_c).

The basic 2nd-order responses are the quadratic lag (low-pass), "tuned-circuit" response (band-pass), and the quadratic lead (high-pass). These are characterised by corner frequency, or undamped resonant frequency, and Q factor. 2nd-order notch response, a combination of low-pass and high-pass response, is also considered; and low-pass to band-pass transformation.

Throughout responses are presented first in transfer-function form, i.e. as a function of p, and are derived by analysis of passive CR, LR, and LCR networks.

For the three elements R, L, C, the relationships between instantaneous voltage and current may be expressed:—

$$v = iR \quad (1)$$

$$v = L\frac{di}{dt} \quad (2)$$

$$v = \frac{1}{C}\int i.\,dt, \text{ or } i = C\frac{dv}{dt} \quad (3)$$

From equn. (1) the ratio of voltage to current is obtained as $v/i = R$, Ohm's law. Similar expressions can be obtained from equns. (2) and (3) by substituting a more convenient symbol to represent the operation of differentiation with respect to time, d/dt. Our habit is to write p. So we write†

†We adhere to the convention of using capital V and I where functions of time rather than instantaneous values are meant.

$$V/I = pL \quad (4)$$

and

$$V/I = 1/pC \quad (5)$$

The operator p is analogous to the operator $j\omega$ used in steady-state (sine-wave) analysis; and pL and $1/pC$ are called the operational impedances of L and C, by analogy to $j\omega L$ and $1/j\omega C$, the steady-state impedances.

* Royal Radar Establishment.

1st-order filters, low-pass

The most elementary low-pass CR filter is the simple-lag network, Fig. 1. By inspection the voltage transfer ratio, V_{out}/V_{in}, may be written down in transfer-function form (i.e. as a function of p) as

$$F(p) = \frac{V_{out}}{V_{in}} = \frac{\dfrac{1}{pC}}{\dfrac{1}{pC} + R} = \frac{1}{1 + pCR} \quad (6)$$

For the corresponding circuit using inductance, Fig. 2,

$$F(p) = \frac{V_{out}}{V_{in}} = \frac{R}{R + pL} = \frac{1}{1 + pL/R} \quad (7)$$

Now both CR and L/R have the dimensions of time. It is reasonable, therefore, to write for both networks

$$F(p) = \frac{V_{out}}{V_{in}} = \frac{1}{1 + pT} \quad (8)$$

which shows that in considering the performance of the networks as filters our concern is with the time constant and not with whether it is realised by a CR product or by an L/R quotient.

The frequency-response function corresponding to equn. (8) is obtained by substituting $j\omega$ for p, i.e.

$$F(\omega) = \frac{V_{out}}{V_{in}} = \frac{1}{1 + j\omega T} \quad (9)$$

This gives both gain and phase information for sine-wave inputs. The gain or amplitude is the modulus, obtained by taking the square root of the sum of the squares of the real and imaginary parts,

$$\left|\frac{V_{out}}{V_{in}}\right| = \frac{1}{(1 + \omega^2T^2)^{\frac{1}{2}}} \quad (10)$$

The principal characteristics of this function are shown in Fig. 3.

At $\omega = 0$, $V_{out} = V_{in}$, i.e. the low-frequency asymptote is horizontal passing through the point (0, 1). At high frequencies where $\omega \gg 1/T$, the magnitude $\simeq 1/\omega T$, i.e. it approaches a high-frequency asymptote which falls at a rate of 6dB/octave. The two

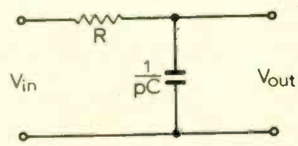


Fig. 1. 1st-order CR low-pass filter, or simple-lag network.

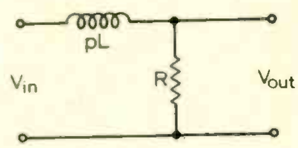


Fig. 2. 1st-order LR low-pass filter, or simple-lag network.

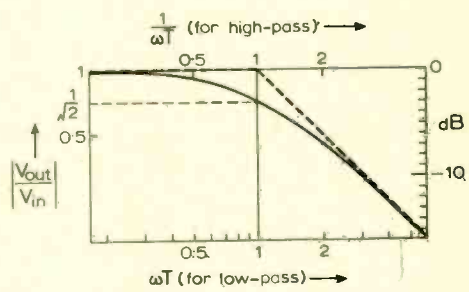


Fig. 3. Amplitude, or gain, characteristic of 1st-order l-p filter (lower scale), and 1st-order h-p filter (upper scale).

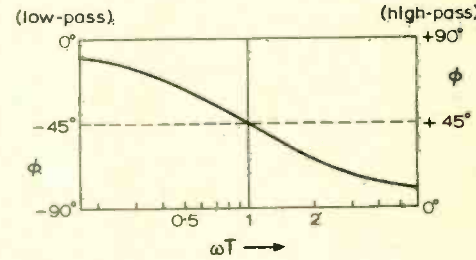


Fig. 4. Phase response of 1st-order filters: l-p (left-hand scale); h-p (right-hand scale).

asymptotes intersect at a frequency given by putting $\omega T = 1$, and the frequency so found $\omega_c (= 1/T)$ is usually the most convenient definition of the position of the curve on the frequency axis and is often referred to as the corner frequency.

The tangent of the phase angle ϕ is given by the ratio of the imaginary and real parts of equn. (9), i.e.

$$\phi = -\arctan(\omega T) \qquad (11)$$

the minus sign representing a lagging phase. The corresponding curve plotted in the conventional way with a linear phase-angle scale and a logarithmic frequency scale is shown in Fig. 4, and it can be seen that the curve has symmetry about the corner frequency, $\omega_c = 1/T$, already mentioned.

Low-pass to high-pass transformation

The transfer functions of the simple-lead networks shown in Fig. 5 can be set down by inspection as

$$\frac{R}{\frac{1}{pC} + R} = \frac{pCR}{1 + pCR}$$

and

$$\frac{pL}{R + pL} = \frac{\frac{pL}{R}}{1 + \frac{pL}{R}}$$

respectively. If T is then substituted for CR or L/R, as before, the result for both is

$$F(p) = \frac{V_{out}}{V_{in}} = \frac{pT}{1 + pT} \qquad (12)$$

This can be written

$$\frac{1}{1 + 1/pT}$$

in which form we have an example of a rule which applies generally—namely that a low-pass transfer function can be trans-

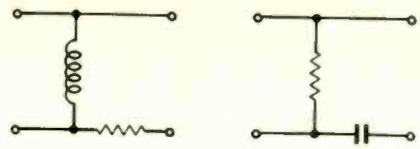


Fig. 5. 1st-order high-pass filters or simple-lead networks.

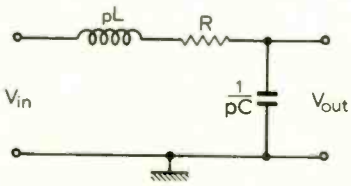


Fig. 6. 2nd-order LCR series network connected as l-p filter.

formed into the corresponding high-pass transfer function by substituting $1/pT$ for pT.

For the frequency-response functions the equivalent transformation is obtained by substituting $1/j\omega T$ for $j\omega T$, and this in turn means that in the amplitude or gain functions $(\omega T)^2$ is replaced by $1/(\omega T)^2$. Thus for the normalised l-p amplitude-response curve of Fig. 3, the corresponding h-p response is the mirror image of the l-p curve obtained by reflection in the vertical line passing through $\omega T = 1$; for on a logarithmic frequency scale a given increment represents multiplication by a certain factor if the movement is to the right and division by that factor if the movement is to the left. Alternatively the drawing of a new curve can be avoided altogether by relabelling the horizontal axis $1/\omega T$ instead of ωT.

The transfer function $pT/(1 + pT)$ is identical to a simple lag, $1/(1 + pT)$, multiplied by a differentiation, pT. The phase curve for a simple lead is, therefore, the same shape as the curve for a simple lag, but the phase angle is everywhere advanced by 90° with respect to that for the simple lag. This is shown in the double vertical scales applied to the sing "universal" phase curve of Fig. 4.

2nd-order LCR networks, series connection

1. Low-pass

The elements of the network shown Fig. 6 are, as before, labelled with the operational impedances. Since they a connected in series the same current flov through each, and the network behaves as potential divider.

Therefore

$$\frac{V_{out}}{V_{in}} = \frac{\frac{1}{pC}}{\frac{1}{pC} + R + pL}$$

$$= \frac{1}{1 + pCR + p^2LC} \qquad (1$$

This equation may be written in terms two time constants,

$$T_1 = CR \qquad (1$$

and $$T_2 = L/R, \qquad (1$$

as $$\frac{V_{out}}{V_{in}} = \frac{1}{1 + pT_1 + p^2T_1T_2}; \qquad (1$$

or alternatively as

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

where $$T = (T_1T_2)^{\frac{1}{2}} \qquad (1$$

and $$\frac{1}{q} = \left(\frac{T_1}{T_2}\right)^{\frac{1}{2}} \qquad (1$$

i.e. where $T/q = T_1$ and $Tq = T_2$.

If we look back to equns. (13) and (14) w see that $T = \sqrt{(LC)}$, i.e. $T = 1/\omega_c$ wher ω_c is the undamped resonant frequency c the circuit in radians/second; and tha

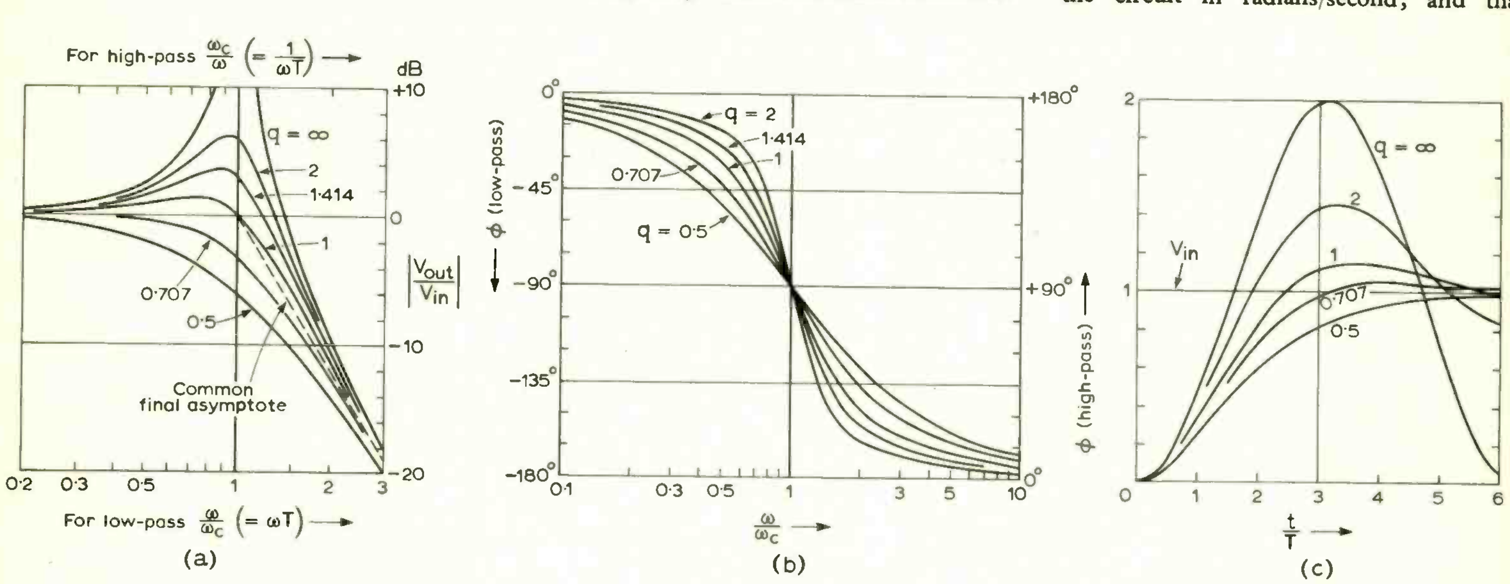


Fig. 7. Amplitude and phase curves, 2nd-order. (a) low-pass, lower frequency scale; high-pass, upper frequency scale. (b) low-pass, left-hand scale; high-pass, right-hand scale. The curves may also be used for 2nd-order band-pass, reading Ω for ω. (c) 2nd-order low-pass, response to step.

$q = \omega_c L/R$, i.e. q is equal to the conventional Q factor of the circuit. The present authors use a lower-case q in the transfer functions of low-pass (and high-pass) filters, as this leads to a convenient notation for a band-pass filter derived by transformation from a low-pass filter. The parameter q retains a meaning as a shape factor, although not a Q factor of the band-pass filter.

The frequency response is given by

$$F(\omega) = \frac{V_{out}}{V_{in}} = \frac{1}{1 + \frac{j\omega T}{q} - \omega^2 T^2} \quad (20)$$

from which we obtain expressions for amplitude and phase:

$$\frac{V_{out}}{V_{in}} = \frac{1}{\left\{1 + \left(\frac{1}{q^2} - 2\right)(\omega T)^2 + (\omega T)^4\right\}^{\frac{1}{2}}} \quad (21)$$

$$\tan\phi = -\frac{\omega T/q}{1 - \omega^2 T^2} \quad (22)$$

The nature of these expressions is shown by the families of normalised curves given in Figs. 7(a) and (b). In these curves we have in effect set $T = 1$, and are left with the single parameter q, which appears as the height of each curve of Fig. 7(a) at $\omega T = 1$. It will be noted that the point of maximum amplitude is always to the low-frequency side of $\omega T = 1$, and that the height of the maximum is greater than q. But as q increases the height at the maximum becomes more nearly equal to q, and the frequency of the maximum moves closer to $\omega T = 1$. Where accuracy on these points is required the expressions given in Fig. 8 may be of help.

All the curves of Fig. 7(a) approximate at high frequency to a common asymptote, $V_{out}/V_{in} = 1/\omega^2 T^2$ (12dB/octave slope), which cuts the unit-gain level (the low-frequency asymptote) at $\omega T = 1$. For any such family it is therefore reasonable, as for a simple lag (or 1st-order l-p network), to call $\omega_c (= 1/T)$ the corner frequency. This frequency may also be identified in Fig. 7(b) as the frequency at which all the curves show a phase angle of 90° lagging.

In most of the work that follows ω_c or T will be used as the definition of the position of a 2nd-order frequency-response curve on the frequency axis, and q will be used as the definition of the shape of the curve. This is generally more convenient and more immediately informative than the practice of quoting the positions on the complex-frequency plane of the "poles" of the response.‡ The greater the value of q the more peaky is the amplitude-response curve, and the steeper the fall of the phase curve in the vicinity of $\omega T = 1$. For both passive and active realisation the magnitude of q is a measure of the difficulty of obtaining a desired response.

‡Or writing out a transfer function in the form

$$\frac{B}{p^2 + Ap + B}$$

from which one has to calculate ω_c as $\sqrt{B}$ and q as

$$\frac{\sqrt{B}}{A}$$

The LCR series circuit may be used as a model for deriving other 2nd-order responses. If the circuit is redrawn as in Fig. 9 it is easily seen that the circuit may be thought of as having a single basic response, the current that flows in response to the exciting function V_{in}, and that the voltage responses that may be observed across the several possible pairs of output terminals may be considered as derivative and related to each other by the fact that the ratio of the voltage across any element to the voltage across any other element is equal to the ratio of the two impedances. Thus

$$\frac{V_R}{V_C} = pCR = pT_1 = \frac{pT}{q} \quad (23)$$

$$\frac{V_L}{V_R} = \frac{pL}{R} = pT_2 = qpT \quad (24)$$

and

$$\frac{V_L}{V_C} = p^2LC = p^2T_1T_2 = p^2T^2 \quad (25)$$

For frequency-response functions multiplication by pT becomes multiplication by $j\omega T$; so the process of differentiation causes the amplitude response to be multiplied by ωT, and the phase response to be advanced everywhere by 90°.

2. High-pass

For the network connected as shown in Fig. 10 we obtain, using either the results just noted or the rule for low-pass to high-pass transformation,

$$\frac{V_{out}}{V_{in}} = \frac{p^2T^2}{1 + \frac{1}{q}pT + p^2T^2} \quad (26)$$

The amplitude response, therefore, is as given by equn. (21) but multiplied by ω^2T^2, while the phase response is as given by equn. (22) but everywhere advanced by 180°. The result is a family of amplitude-response or gain curves which is the mirror image of the low-pass family as reflected in the vertical line $\omega T = 1$, and a family of phase-response curves exactly the same as in

(Continued on next page)

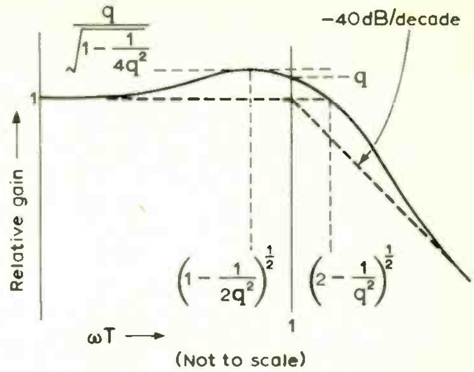


Fig. 8. Relative positions of some of the characteristic points on a 2nd-order low-pass amplitude/frequency response curve.

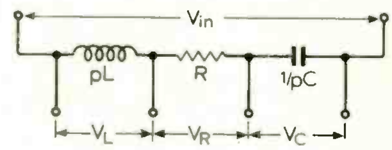


Fig. 9. Showing the voltages across each of the three elements.

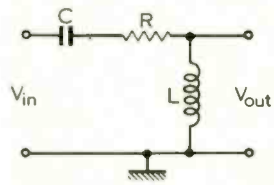


Fig. 10. 2nd-order LCR series network connected as h-p filter.

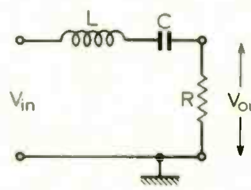


Fig. 11. 2nd-order LCR series network connected for "tuned-circuit", or 1st-order band-pass, response.

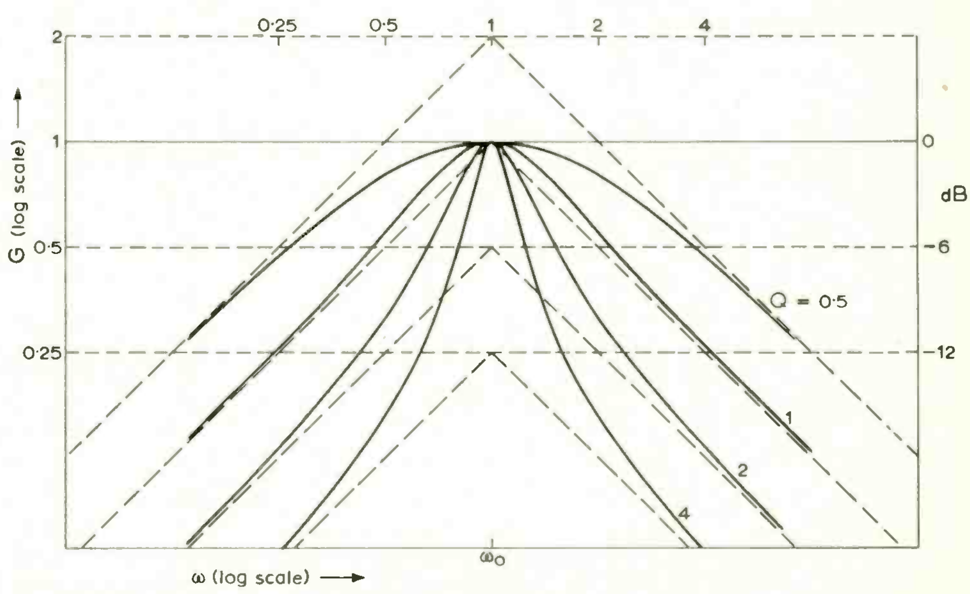


Fig. 12. Tuned-circuit response as defined by equns. (27) and (28).

Fig. 7(b) but all moved upwards by 180°. Alternatively we may for the amplitude curves relabel the frequency axis $1/\omega T$, and for the phase curves provide a new vertical axis with markings displaced 180° with respect to those for the low-pass case.

3. Tuned-circuit, or 1st-order band-pass

When the three elements are connected as shown in Fig. 11

$$\frac{V_{out}}{V_{in}} = \frac{\frac{1}{q}pT}{1 + \frac{1}{q}pT + p^2T^2} \quad (27)$$

This expression differs only in the numerator from those given by equns. (17) and (26), and by applying the rules already given a family of amplitude-response curves can be obtained from the low-pass family, Fig. 7(a), by multiplying by $\omega T/q$ (for from the high-pass family by multiplying by $1/q\omega T$). The nature of the family is shown in Fig. 12. For all values of q the curves reach the unity-gain level at the resonant frequency. This is consistent with the fact that at this frequency the series combination of L and C presents zero impedance and that consequently transmission is independent of the value of R. This result is, of course, somewhat abstract, as a real coil will have series resistance. We are, however, in this article considering ideal networks in order to get at the essential features of certain basic types of response.

The phase response is everywhere advanced on the low-pass response by 90°, being +90° at $\omega = 0$, 0° at $\omega = 1/T$, −90° at $\omega = \infty$.

The amplitude curves defined by equn. (27) and shown in Fig. 12 show maximum response at the undamped natural frequency and zero response at zero and at infinite frequency, the skirts or asymptotes of each curve falling at 6dB/octave. We shall usually give this type of response the name "tuned-circuit" response, because of the association with the response of the tuned circuits in a simple tuned amplifier. We shall, however, on occasion describe the response as "1st-order bandpass" because of an analogy with 1st-order lowpass response.

The amplitude-response curves shown in Fig. 12 are described by the equation

$$\frac{V_{out}}{V_{in}} = \frac{1}{\left\{1 + Q^2\left(\frac{\omega}{\omega_0} - \frac{\omega_0}{\omega}\right)^2\right\}^{\frac{1}{2}}} \quad (28)$$

where ω_0 is the resonant frequency in rad./second, a result easily obtained in the usual way by substituting $j\omega$ for p in equn. (27) and taking the modulus of the frequency-response function so found. ($\omega_0 = 1/T$).

Normalising by putting $x = \omega/\omega_0$ (i.e., in effect, by making the centre frequency = 1) we get

$$\frac{V_{out}}{V_{in}} = \frac{1}{\left\{1 + Q^2\left(x - \frac{1}{x}\right)^2\right\}^{\frac{1}{2}}} \quad (28a)$$

Now

$$\left(x - \frac{1}{x}\right)^2$$

has the same value for any pair of values of x which are reciprocals the one of the other. Hence any curve defined by equns. (28) and (28a) has the same value at any two frequencies (ω_1, ω_2) for which

$$\frac{\omega_1}{\omega_0} = \frac{\omega_0}{\omega_2}$$

i.e. the curve is symmetrical about the centre frequency (ω_0) when plotted to a logarithmic frequency scale, Fig. 13.

If we put

$$\Omega = \left(x - \frac{1}{x}\right)\omega_0$$

so that Ω is equal to the frequency difference ($\omega_1 - \omega_2$), equn. (28) may be written

$$\left|\frac{V_{out}}{V_{in}}\right| = \frac{1}{\left\{1 + \frac{Q^2\Omega^2}{\omega_0^2}\right\}^{\frac{1}{2}}} \quad (29)$$

If now this is compared with the equation for a 1st-order low-pass filter, equn. (10), which may be written

$$\frac{V_{out}}{V_{in}} = \frac{1}{\left\{1 + \left(\frac{\omega}{\omega_c}\right)^2\right\}^{\frac{1}{2}}} \quad (30)$$

we see that the frequency-difference parameter Ω in equn. (29) corresponds to ω in equn. (30), and that $\Omega = \omega$ if $Q = \omega_0/\omega_c$.

At the −3dB point for a 1st-order l-p filter $\omega = \omega_c$. Consequently for the corresponding two points on a tuned-circuit response curve,

$$\omega_1 - \omega_2 = \Omega = \omega_c = \frac{\omega_0}{Q} \quad (31)$$

This frequency difference between the two −3dB points is often called the bandwidth

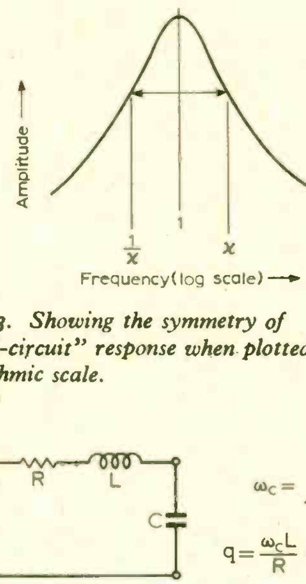


Fig. 13. Showing the symmetry of "tuned-circuit" response when plotted to a logarithmic scale.

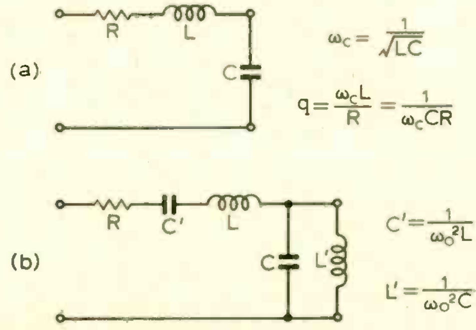


Fig. 14. Low-pass to band-pass transformation.

of the tuned circuit, and equn. (31) is an expression of the well known relationship, centre frequency/bandwidth = Q.

If we revert to relative or normalised frequencies as in Fig. 13, we have for the −3dB points

$$x - \frac{1}{x} = \frac{1}{Q} \quad (31a)$$

i.e.

$$x^2 - \frac{x}{Q} - 1 = 0.$$

Hence

$$x = \frac{1}{2}\left(\frac{1}{Q} \pm \sqrt{\frac{1}{Q^2} + 4}\right)$$

$$= \frac{1}{2Q} \pm \sqrt{1 + \frac{1}{4Q^2}}$$

and

$$\frac{1}{x} = x - \frac{1}{Q} = -\frac{1}{2Q} \pm \sqrt{1 + \frac{1}{4Q^2}}$$

We are not interested in negative values of $1/x$, so we discard the minus signs before the square roots and obtain

$$\left.\begin{aligned} x &= \sqrt{1 + \frac{1}{4Q^2}} + \frac{1}{2Q} \\ \frac{1}{x} &= \sqrt{1 + \frac{1}{4Q^2}} - \frac{1}{2Q} \end{aligned}\right\} \quad (32)$$

It may be noticed that the square root is the arithmetic mean of x and $1/x$.

Certain values of Q that crop up frequently are:— ¼ (balanced parallel-T network with conventional relative component values), ⅓ (lead-lag or Wien-bridge network with ditto), ½ (limit for CR network without feedback), 1 (bandwidth equals centre frequency); and the corresponding values of x and $1/x$ are given below.

Table 1 = Some relative values of −3dB frequencies

Q	x	$1/x$
¼	0·2361	4·2361
⅓	0·3028	3·3028
½	0·4142	2·4142
1	0·6180	1·6180

As Q increases to high values,

$$\sqrt{1 + \frac{1}{4Q^2}} \rightarrow 1,$$

and x and $1/x$ become equal to $1 \pm 1/2Q$ approx.

The idea of relating a network giving symmetrical band-pass response to an analogous low-pass network is useful not only in the case given above, tuned-circuit response/simple lag, but applies equally to networks of higher orders.

2nd-order band pass

Fig. 14(a) shows the second-order low-pass filter we have already discussed. For a low-pass filter we may, by analogy, call zero frequency the "centre" frequency. At this frequency L shows zero impedance and C

infinite impedance. For transformation into a band-pass filter this behaviour must be moved to the new centre frequency ω_0. To do this a suitable capacitance is placed in series with L and a suitable inductance in parallel with C as shown in Fig. 14(b). This is a fourth-order network. We shall now, however, show the close analogy between its performance and that of the low-pass filter from which it is derived, and so justify the title "2nd-order band-pass".

The impedance of the shunt arm,

$$X_1 = \frac{1}{\dfrac{\omega_0^2 C}{p} + pC} = \frac{p}{\omega_0^2 C + p^2 C}$$

and that of the series arm,

$$X_2 = \frac{\omega_0^2 L}{p} + R + pL$$
$$= \frac{\omega_0^2 L + pR + p^2 L}{p}$$

Hence

$$\frac{V_{out}}{V_{in}} = \frac{X_1}{X_1 + X_2}$$
$$= \frac{p^2}{\omega_0^2 C + p^2 C} \times$$
$$\times \frac{1}{\dfrac{p^2}{\omega_0^2 C + p^2 C} + \omega_0^2 L + pR + p^2 L}$$

which, by rearrangement, can be shown to be

$$= \frac{1}{1 + \omega_0 CR\left(\dfrac{p}{\omega_0} + \dfrac{\omega_0}{p}\right) \;\ldots\ldots\; + \omega_0^2 LC\left(\dfrac{p}{\omega_0} + \dfrac{\omega_0}{p}\right)^2}$$

Hence

$$G(j\omega) = \frac{1}{1 + j\omega_0 CR\left(\dfrac{\omega}{\omega_0} - \dfrac{\omega_0}{\omega}\right) \;\ldots\ldots\; - \omega_0^2 LC\left(\dfrac{\omega}{\omega_0} - \dfrac{\omega_0}{\omega}\right)^2}$$

$$= \frac{1}{1 + jCR\Omega - LC\Omega^2}$$

$$= \frac{1}{1 + j\dfrac{1}{q}\cdot\dfrac{\Omega}{\omega_c} - \left(\dfrac{\Omega}{\omega_c}\right)^2} \qquad (33)$$

where (as before) Ω is the frequency-difference variable, and q is the Q factor of the low-pass filter we started with. Comparison with the corresponding expression for the l-p filter,

$$G(j\omega) = \frac{1}{1 + j\dfrac{1}{p}\cdot\dfrac{\omega}{\omega_c} - \left(\dfrac{\omega}{\omega_c}\right)^2} \qquad (34)$$

shows that q determines the shape of the response curves for the band-pass filter just as for the low-pass, Fig. 15, and in particular determines the height of the familiar ears which appear towards the edges of the pass band as q rises above $1/\sqrt{2}$.

When plotting band-pass responses from an expression in the frequency difference Ω (or from the corresponding low-pass response) use may be made of the following relationships:

$$x = \frac{\omega_1}{\omega_0} = \sqrt{1 + \frac{1}{4}\left(\frac{\Omega}{\omega_0}\right)^2} + \frac{\Omega}{2\omega_0} \qquad (35)$$

$$\frac{1}{x} = \frac{\omega_2}{\omega_0} \quad \sqrt{1 + \frac{1}{4}\left(\frac{\Omega}{\omega_0}\right)^2} - \frac{\Omega}{2\omega_0}; \qquad (36)$$

or

$$x, \frac{1}{x} = \sec\left(\arc\tan\frac{\Omega}{2\omega_0}\right) \pm \frac{\Omega}{2\omega_0} \qquad (37)$$

Low-pass to band-pass transformation —general argument

An inductance presents zero impedance at zero frequency. To produce zero impedance at ω_0 a capacitance C' is placed in series with the inductance, with $C' = 1/\omega_0^2 L = T_0^2/L$ (where $T_0 = 1/\omega_0$). The impedance, which was pL, is now

$$pL + \frac{L}{pT_0^2} = \left(p + \frac{1}{pT_0^2}\right)L$$

Similarly a capacitance presents zero admittance at zero frequency, and to move the frequency of zero admittance to ω_0 the capacitance may be tuned with a parallel inductance of value $L' = 1/\omega_0^2 C = T_0^2/C$. So the admittance, which was pC, is now

$$pC + \frac{C}{pT_0^2} = \left(p + \frac{1}{pT_0^2}\right)C$$

In each case the operator p is replaced by

$$\left(p + \frac{1}{pT_0^2}\right)$$

which we may write P, a new operator (the replacement of p by P thus representing the operations just described).

To obtain a frequency-response function we write $j\omega$ for p, and the new operator becomes

$$j\left(\omega - \frac{\omega_0^2}{\omega}\right) = j\omega_0\left(\frac{\omega}{\omega_0} - \frac{\omega_0}{\omega}\right)$$

which as before may be written $j\Omega$. So a reactance $j\omega L$ in the low-pass filter has become $j\Omega L$, and a susceptance $j\omega C$ has become $j\Omega C$. Now, as we have seen, Ω has the same magnitude (but opposite signs) at any two frequencies symmetrically disposed about ω_0 on a logarithmic scale, and the difference between two such frequencies, $x\omega_0 - \omega_0/x$, is equal to Ω. Consequently the combination of L and C' in series has at the frequencies $x\omega_0$ and ω_0/x a reactance of the same magnitude as L had at the frequency ω, where $\omega = \Omega = x\omega_0 - \omega_0/x$. Similarly the susceptance of the parallel combination of C and L' at the frequencies $x\omega_0$ and ω_0/x has the same magnitude as the susceptance of C at the frequency ω. A little further thought shows that at the upper frequency the reactance and susceptance of the combinations have the same sign as the reactance and susceptance of L and C respectively, and at the lower frequency the opposite sign.

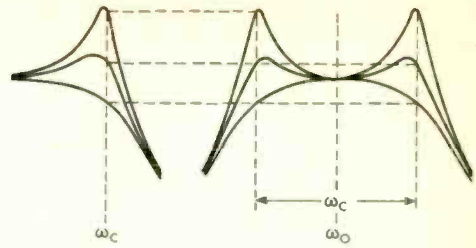


Fig. 15. Comparison of 2nd-order band-pass with corresponding 2nd-order low-pass responses.

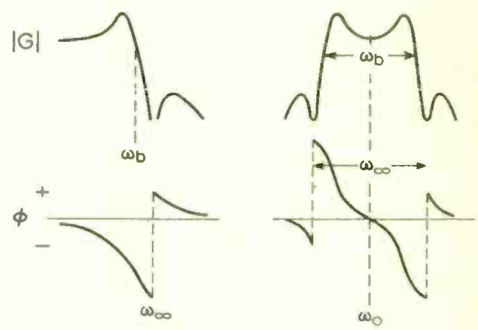


Fig. 16. Showing low-pass response transformed into band-pass response.

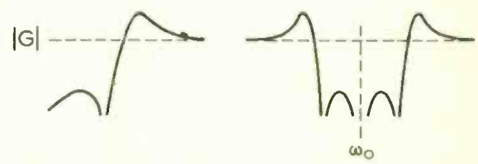


Fig. 17. High-pass response transformed into band-stop response.

Now in the frequency-response function for the original network every ω arises from a reactance of the type $j\omega L$ or a susceptance of the type $j\omega C$. Consequently the frequency-response function of the transformed network, $G(j\Omega)$, at the upper frequency as defined above is identical with that of the original network, $G(j\omega)$, at the frequency ω, which means that both the magnitudes and the phase angles are equal; whilst at the lower frequency as defined above (where $j\Omega = -j\omega$) the magnitudes are equal and the phase angles are numerically equal but of opposite sign. This conclusion is illustrated in Fig. 16. If the original network is a high-pass filter, the transformation produces a band-stop filter, Fig. 17. In all cases, of course, the resistances in the original network remain unaltered in the transformation.

Notch filters, 2nd order, series connection

1. Symmetrical response

If the inductance and capacitance of Fig. 9 are placed adjacent and an output taken across the pair, the voltage transfer ratio can be set down directly, either by reasoning that it is 1 minus the tuned-circuit voltage transfer ratio or that it is the sum of the low-pass and high-pass voltage transfer ratios:

$$\frac{V_{out}}{V_{in}} = \frac{1 + p^2T^2}{1 + \frac{1}{q}pT + p^2T^2} \quad (38)$$

The frequency response of the numerator is $(1 - \omega^2T^2)$, which gives a zero of transmission when $\omega T = 1$, i.e. at the frequency where the reactances of L and C have equal magnitude.

A convenient way of obtaining the complete amplitudes vs. frequency response is to use the relationships mentioned above,

$$\frac{V_{out}}{V_{in}} = 1 - \frac{\frac{1}{q}pT}{1 + \frac{1}{q}pT + p^2T^2} \quad (39)$$

the result being as shown in Fig. 18(a). While for the phase response we may use the second, remembering that since the phases of the low-pass and high-pass responses are everywhere 180° apart the phase of the vector sum is equal to that of the component with the greater amplitude, namely the l-p component for $\omega T < 1$ and the h-p component for $\omega T > 1$, Fig. 18(b). It also follows that the amplitude response of a notch is the arithmetic difference of a low-pass response and a high-pass response of equal q. As for tuned-circuit response, the width of a symmetrical notch between −3dB points is ω_0/q.

2. Asymmetrical notch response

If the inductance is split into two parts having impedances pL and $(1 - a)pL$, where $a < 1$ as shown in Fig. 19(a), the total inductive impedance being still pL, the voltage transfer ratio for the new pair of output terminals may be written down as the sum of the low-pass voltage transfer ratio (for the voltage across C) plus a fraction a of the high-pass voltage transfer ratio (for the voltage across aL), i.e.

$$\frac{V_{out}}{V_{in}} = \frac{1 + ap^2T^2}{1 + \frac{1}{q}pT + p^2T^2} \quad [a < 1] \quad (40)$$

The frequency response now has a transmission zero at a frequency given by

$$1 - a\omega^2T^2 = 0$$

i.e. at a frequency

$$\omega_\infty = \frac{1}{T\sqrt{a}} \quad (41)$$

Generally the amplitude vs. frequency response has the shape shown in Fig. 19(b). If a is nearly equal to 1 there is only a small peak even for fairly large values of q. As we have seen, when $a = 1$ (the symmetrical notch) there is no peak for any value of q.

At $\omega T = 0$, $V_{out}/V_{in} = 1$; while at $\omega T = \infty$, $V_{out}/V_{in} = a$ (and $a < 1$). The network is, therefore, a low-pass filter; although because the response is finite at infinite frequency a network giving a response of this type is more suitable for use as part of a l-p filter than as a complete l-p filter in itself.

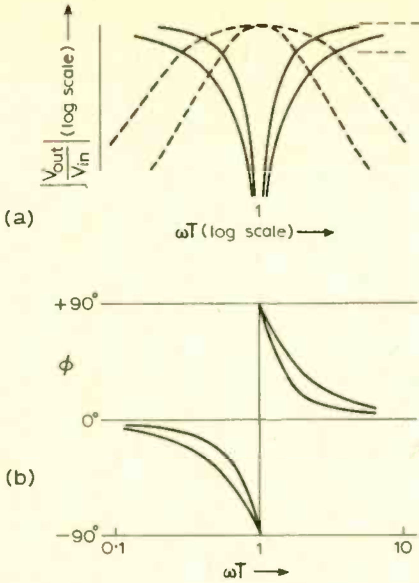


Fig. 18a. Symmetrical notches, normalised amplitude responses, together with tuned-circuit responses of equal Q factor.
Fig. 18b. Symmetrical notches, phase responses.

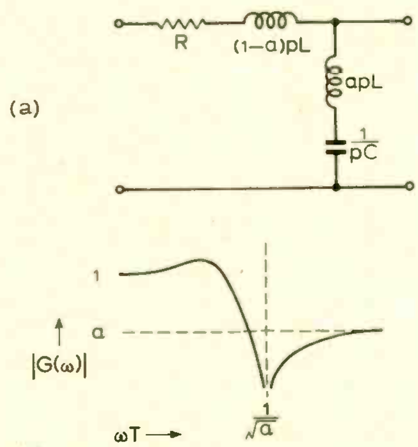


Fig. 19. 2nd-order filter giving unsymmetrical notch response (low-pass type),

$$\frac{V_{out}}{V_{in}} = \frac{1 + ap^2T^2}{1 + pT/q + p^2T^2}, \; a < 1:$$

(a) network, (b) amplitude response.

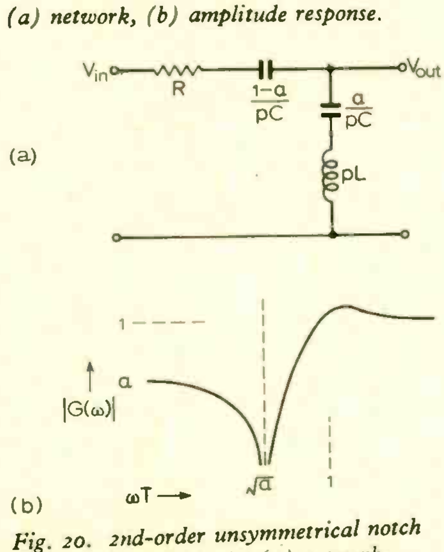


Fig. 20. 2nd-order unsymmetrical notch filter (high-pass type): (a) network, (b) amplitude response.

The corresponding high-pass asymmetrical notch response is given by

$$G(p) = \frac{V_{out}}{V_{in}} = \frac{a + p^2T^2}{1 + \frac{1}{q}pT + p^2T^2} \quad [a < 1] \quad (42)$$

i.e. the sum of the h-p response plus a fraction of the l-p response. It may be considered as being derived from the previous response, equn. (40), by the substitution of $1/p$ for p, or directly from the basic LCR network modified as shown in Fig. 20 with the capacitance split into two parts. The notch occurs when $(a - \omega^2T^2) = 1$, i.e. when

$$\omega T = \sqrt{a} \quad (43)$$

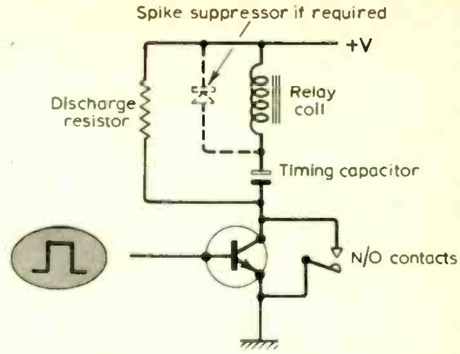
and so (for $a < 1$) at a frequency below the undamped natural frequency ($\omega T = 1$).

Books Received

Principles of Colour Television Systems, by C. R. G. Reed. This book deals with the basic principles involved in the coding of the colour information of a television signal and with the application of these principles to the N.T.S.C. SECAM and PAL systems of colour television. Its scope has been limited by the omission of many practical details of circuitry, display tubes and cameras, and by assuming that the reader is familiar with the principles of normal black-and-white television systems. Some of the technical terms peculiar to colour transmission are defined in the glossary at the end of the book. Several problems have been included in the text. They are mainly of a simple arithmetical type underlining the numerical relationships involved in the transmission systems or in the basic principle behind them, and the reader is advised to work through these problems in detail. Pp.196. Good index. Price 50s. Sir Isaac Pitman & Sons Ltd. Pitman House, Parker Street, Kingsway, London W.C.2.

Soldering Handbook, by B. M. Allen, is divided into three parts. For the operator, part 1 describes how to use the more common soldering methods and material available. It should prove useful to both the amateur and the industrial solderer. Part 2, for the designer and engineer, discusses how to choose the right methods and materials to solve particular soldering problems. To help in making this choice, part 3 gives several tables of material properties and specifications. The emphasis throughout is on practical knowledge rather than theoretical understanding. No previous knowledge of soldering is assumed. (The author is senior works chemist with Multicore Solders Ltd. Pp.128. Price 45s hard, 21s limp. Iliffe Books Ltd. 42 Russell Square, London W.C.1.

Circuit Ideas

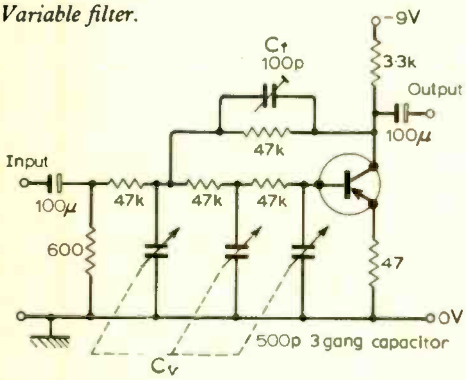


Monostable relay.

Variable frequency low-pass filter

The circuit operates over the frequency range 10kHz to 200kHz. C_f is included to reduce the 'hump' at cutoff typical of

Variable filter.



this type of circuit. The range may be altered by fixed capacitors across C_v although this practice will reduce the range.

R. CARTWRIGHT,
Muxton,
Shropshire.

Stereo Decoder Adaptor

The stereo decoder described in the January 1967 issue of *Wireless World* had a small disadvantage in that the voltage gains for mono and stereo were about 0.5 and 0.25 respectively. By adding the circuit below to the decoder, unity gain for both mono and stereo is obtained.

For a stereo signal Tr_7 and Tr_8 are on, hence Tr_9 is off and Tr_{10} on. The stereo signal is amplified 4.5 times by Tr_{10}, giving an overall decoder gain of about 1.1. With a mono signal Tr_9 is on and Tr_{10} off. The signal is halved by the attenuator formed by the 56kΩ, 68kΩ and 390kΩ resistors before being amplified by Tr_9.

The maximum output is greater than 1V r.m.s. and distortion less than 0.1% at 1V output. The input impedance is 50kΩ and the output should look into not less than 50kΩ. For positive earth decoders the transistor type BC154 is suitable.

B. W. GROSSMITH,
SGS (United Kingdom) Ltd.,
Aylesbury.

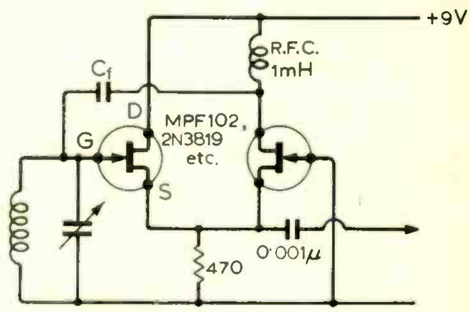
Monostable relay

A positive pulse at the base of the transistor causes the voltage at the collector to fall and the relay to pull in. The normally open relay contacts close, shorting out the transistor and holding the relay in until the timing capacitor has charged fully. The relay then drops out. If the voltage to the transistor base is a d.c. condition the relay will drop out just the same. The circuit must not be retriggered until the timing capacitor has been allowed to discharge through the bypass resistor or the subsequent pull in time will be shortened.

P. J. BURRIDGE,
Abingdon,
Berks.

F.E.T. 'two terminal' oscillator

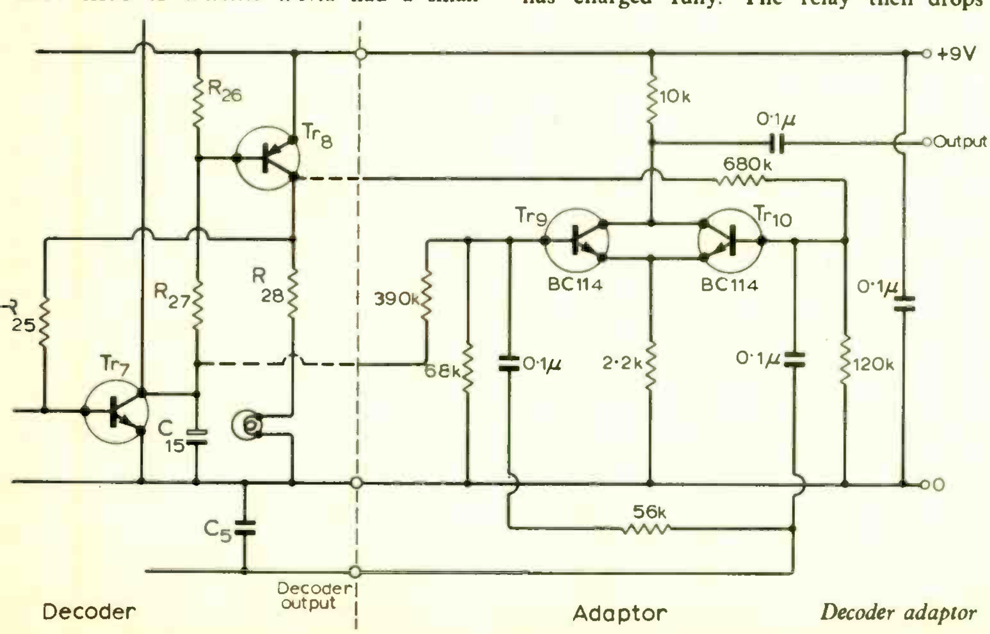
The circuit is basically equivalent to a twin triode cathode-coupled oscillator. By merely changing the tank circuit constants, output over a very wide frequency



F.E.T. oscillator.

range can be obtained — from less than 1MHz up into the v.h.f. region. 30 pF is a good compromise for the feedback capacitor C_f.

L. F. HELLER,
London W.4.



Decoder adaptor

OUR NEXT ISSUE

Since the days of the annual London Radio Show it has become almost a tradition for the October issue of *Wireless World* to include a survey of domestic radio and television receivers. This year will be no exception and in addition to surveying the trends in the receivers shown at the individual trade shows being held in London this month by manufacturers and agents we plan to review some of the latest sound reproducing equipment to be seen at the Audio Fair (Olympia, October 16th-22nd).

We also hope to include a review of the German National Radio & Television Show opening in Stuttgart on August 29th.

For the audio enthusiast there will be constructional details of a 15-watt amplifier, the main feature of which is its low cost—£5 per channel.

Long-distance Television Reception

Some European test and identification cards

The abnormal propagation conditions during the past few months have increased the interference from, and therefore the reception of, Continental television stations in the U.K. These conditions have stimulated interest in long-distance television reception and several readers have written on the subject. One letter was published last month.

There are now nearly 5,000 television transmitting stations in Europe of which about 1,000 (mainly low-power relay stations) are in Italy. The problem of identifying the actual station being received, even if the country of origin is known, is made more difficult by the fact that frequently the sound is not heard because the vision-sound carrier separation may be different from that employed in this country.

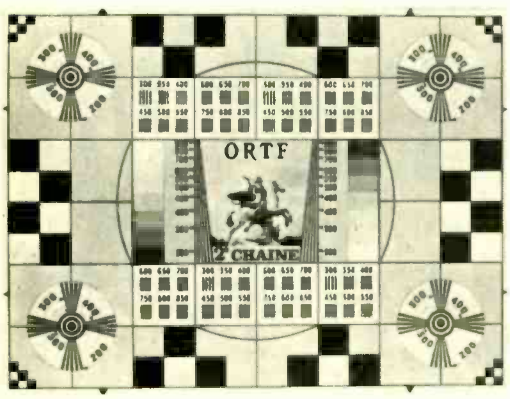
However, to facilitate the visual identification of stations we reproduce on these pages a selection of test and identification cards supplied by M. Dolci, a correspondent in Italy.

In the table below are the basic parameters of the various television systems employed throughout the world. The code letters, which are those used by the C.C.I.R., are given in parentheses beside the headings to the illustrations.

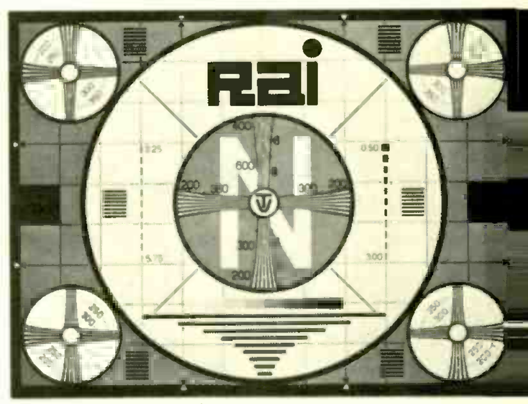
Readers interested in modifying equipment to receive Continental stations are referred to the complete list of channels, with sound and vision carrier frequencies for the various TV systems, given in the current edition of "Guide to Broadcasting Stations" available from this office price 6s.

Code	No. of Lines	Channel width MHz	Vision band-width MHz	Sound separation (from vision)	Vision mod. sense	Sound mod.
A	405	5	3	− 3.5	+	a.m.
B	625	7	5	+ 5.5	−	f.m.
C	625	7	5	+ 5.5	+	a.m.
D	625	8	6	+ 6.5	−	f.m.
E	819	14	10	±11.15	+	a.m.
F	819	7	5	+ 5.5	+	a.m.
G	625	8	5	+ 5.5	−	f.m.
H	625	8	5	+ 5.5	−	f.m.
I	625	8	5.5	+ 6	−	f.m.
K	625	8	6	+ 6.5	−	f.m.
L	625	8	6	+ 6.5	+	a.m.
M	525	6	4.2	+ 4.5	−	f.m.
N	625	6	4.2	+ 4.5	−	—

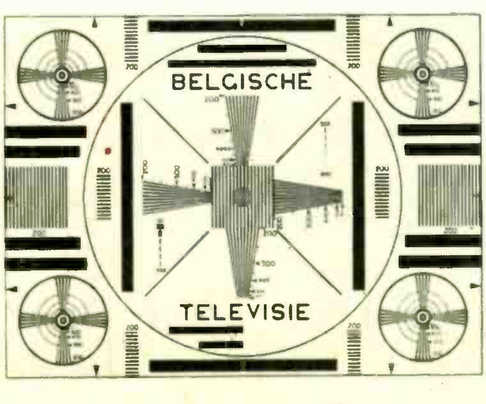
The field frequency for all systems is 50 per second except system "M" in the U.S.A. and some other countries where 60 per second is used



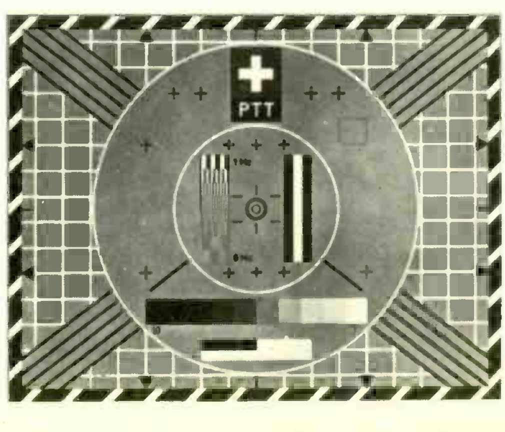
FRANCE (E & L)
This test card suitably marked is used for both the first and second programmes of the O.R.T.F.



ITALY (B & G)
A similar test card with the figure 2 in the centre is used for the second programme (system G).



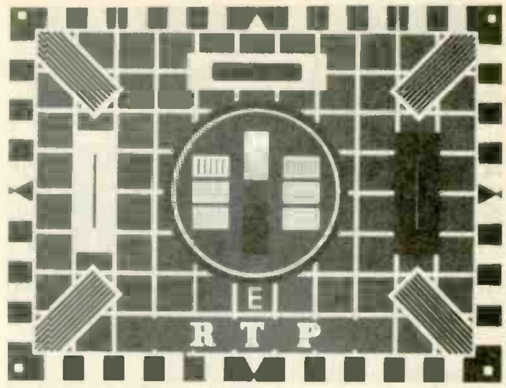
BELGIUM (C)
The Flemish title is changed to Television Belge for the French transmissions.



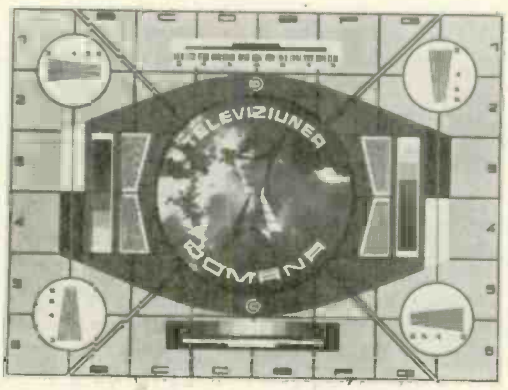
SWITZERLAND (B)
The test card used by the country's tri-lingual television service.

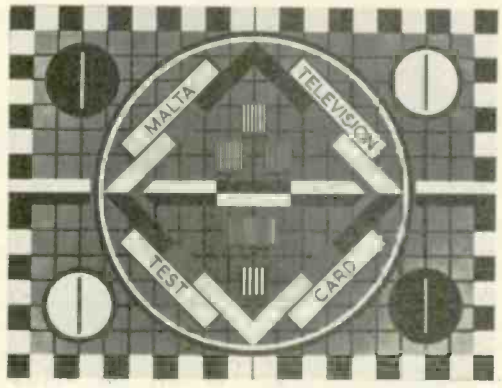
NETHERLANDS (B & G)
An identification card used by the stations of the Nederlandse Televisie Stichting broadcasting the first programme.

PORTUGAL (B)
Radiotelevisao Portuguesa's twenty or more stations use this test card.

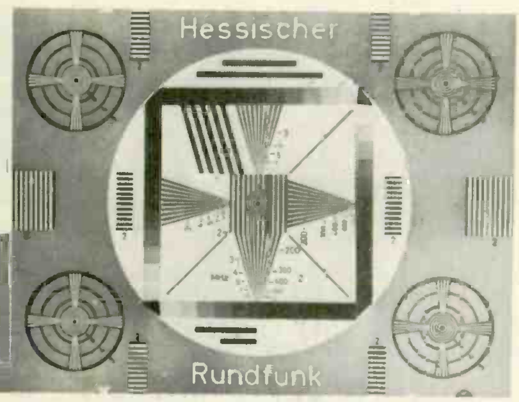


ROUMANIA (D)
Roumania has two high-power transmitters and ten low-power all of which use this test card.



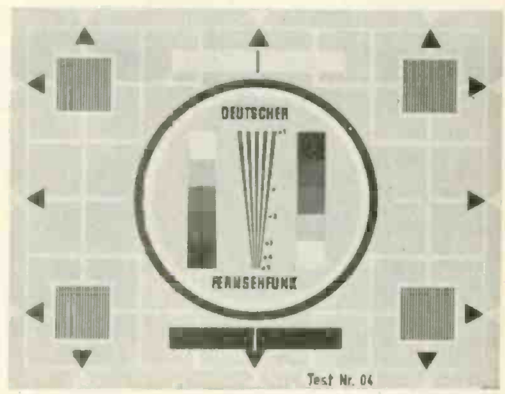


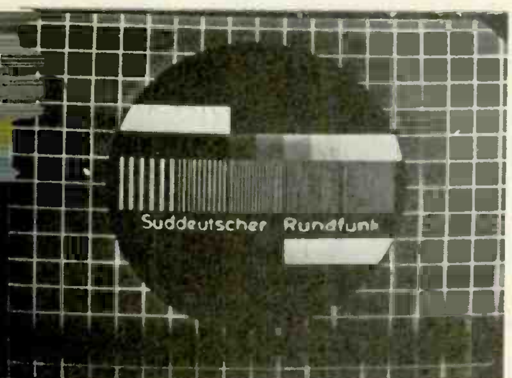
MALTA (B)
The island has one main (5-kW) transmitter.



W. GERMANY (B & G)
This test card with the appropriate name is used by each of the broadcasting authorities.

E. GERMANY (B)
The basic test card of the Deutscher Fernsehfunk.



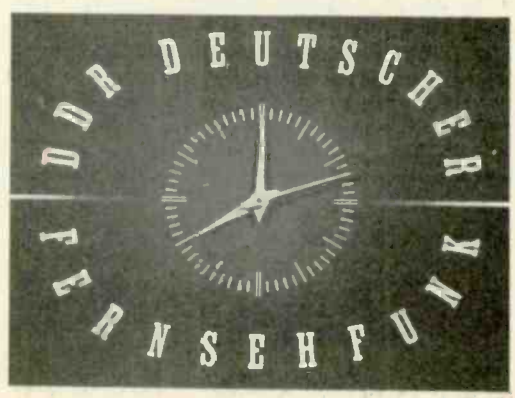


Identification card used by Süddeutscher Rundfunk and some other organizations.

An alternative test card with the station name superimposed.

Stations of Norddeutscher Rundfunk use this card.

An alternative identification card used by stations of the D.F.F.



News of the Month

Earth station at Goonhilly

On 6th August the Postmaster General, the Rt. Hon. John Stonehouse, M.P., inaugurated the expanded Post Office satellite-communications earth station at Goonhilly in Cornwall, and also the service via the Intelsat III satellite over the Indian Ocean. This service makes it possible to exchange direct live colour television pictures with Japan.

It is, of course, seven years since the first Goonhilly station was completed in readiness for the first experimental satellites. Later experiments with synchronous satellites culminated in Intelsat I (Early Bird) in April 1965. Since then the original aerial and equipment have been improved and a new station built, which is the one which has just become operational.

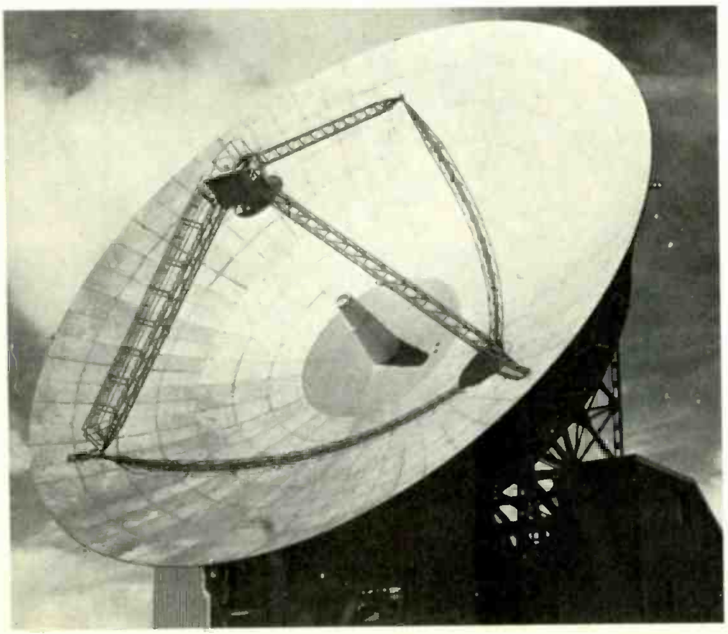
Integral with the supporting structure for the dish are cabins containing the s.h.f. transmitting and receiving equipment and the frequency changers. The whole structure of aerial and cabins is pivoted at the centre of a circular rail and carried by two bogies on the rail. The dish itself can be tilted in the vertical plane and the two movements are controlled automatically by servo systems. Tracking errors can be measured with an accuracy within 1 minute of arc.

The dish is a true paraboloid made up of rings of "petals" of stainless steel surrounding a central mild steel dish of 24ft diameter. The petals are adjustable by struts, and their profiles by screwed studs behind the reflector.

The transmitter is capable of a maximum output of 12kW but is normally operated at 1-2kW. The receiver has input parametric amplifiers which are helium cooled to operate at 18 °K and produce about 40 dB gain. They are duplicated with automatic changeover. The output is passed by waveguide to the cabin where a down-converter changes the frequency to 70MHz, and after amplification the signals are passed by cable to the main building. The input power to the first amplifier from the aerial is about 0.1 $\mu\mu$W.

Although only just officially inaugurated the equipment has actually been in use for some time and handled the television signals from the Investiture of the Prince of Wales as well as the recent pictures from the moon.

In the supply of the equipment, Marconi, GEC/AEI, Mullard and Husband have all played an important part, for the Post Office has now gone over to a system of ordering earth stations which places the full responsibility for design upon industry.



The Cassegrain aerial system of the new Goonhilly satellite communications station is a 90-ft dish some 350ft above sea level, and has the advantage that when a satellite is on a nearly stationary orbit tracking can be effected by movement of the sub-reflector and without having to move the main dish.

. . . and at Bahrain

A space communications station, built in Bahrain by the Marconi Company, was formally opened on July 14th by the ruler of Bahrain. To inaugurate the station, the ruler made a 3,000-mile telephone call, via the Intelsat III satellite over the Indian Ocean and the Goonhilly I station in Cornwall, to the Duke of Edinburgh in Windsor Castle.

Cable and Wireless Ltd, for whom Marcon built the terminal, will operate as part of the global scheme which will provide telephone and data links, using principally Intelsat II and Intelsat III satellites.

The aerial employs a 90-ft diameter computer-profiled quasi-parabolic dish incorporating a Cassegrain sub-reflector which is made of aluminium panels attached to a steel backing structure.

Two high-power amplifiers are installed, one operational and one standby. These use a travelling-wave tube which has a peak saturated r.f. power output of 12kW and a bandwidth of 500MHz. They can therefore cover the entire civil satellite communicatior transmission band of 5925MHz tc 6425MHz.

The communications traffic is frequency modulated on a 70MHz intermediate frequency carrier by equipment installed in the main building. This i.f. signal, at a level of about 0.5V r.m.s., is fed to the transmitte drive equipment housed in the aerial building. The signal is fed to a varactor diod frequency converter which changes th 70MHz signal to the r.f. transmission frequency in the 6GHz band. It is then fed t the main power amplifier at a level c approximately 10mW. Provision for com bining additional outgoing telephony an television carriers is made at this point i the transmitter system.

Signals received at the earth station ar within the civil satellite communication band extending from 3700MHz to 4200MHz Received signals are fed to a parametri amplifier which has a bandwidth of 500MHz the amplifier being mounted in close proxim ity to the feed.

The parametric amplifier consists of thre identical gallium arsenide varactor diode stages, connected in cascade. These thre stages are mounted together with their asso ciated circuitry, inside a low-temperatur enclosure.

Each of the three stages is fed from klystron pump source through a 3-way pa sive splitter. These klystrons and the lov noise t.w.t. following the parametric amplifi are the only parts of the receiving syste which do not use completely solid-state com ponents. They provide 30mW of pum power at a frequency of about 34GHz.

After amplification, using a low-noi t.w.t. at the receive frequency, the signal passed via a waveguide connection to the main building and into a passive splittir network with 16 outlets, thereby separatir the individual r.f. carriers. The outlets a connected to separate frequency down co verters using a balanced diode mixer with crystal-controlled local oscillator, followed b i.f. amplification, channel capacity bandpa filtering and group delay equalization.

For telephony traffic, threshold extensi demodulators are used with a capacity of 132, four-kHz wide, channels.

Three microwave radio links worth abo £250,000 supplied and installed by GE AEI Telecommunications Ltd, conne the telephone network of the States of the Arabian Gulf with the earth station. One 2GHz link carries all the telephone traffic from the earth station to the international switching centre at Salmania, the other two 7GHz links form part of the radio system that connects the Bahrain switching centre with Dubai and, through the existing network, to the other Gulf States.

International apprentice competition results

The U.K. was thoroughly trounced by Japan in the eighteenth International apprentice competition held in Brussels recently. The U.K. failed to obtain any gold medals at all, against Japan's nine, Switzerland's six, Germany's four, Spain's three and Korea's two. We did a little better on silver medals sharing the highest number, five, with Korea.

In the overall result we shared fourth place with Holland; the Japanese winning the competition. The most alarming fact to come to light in studying the detailed results is that the U.K. received no awards at all in the basic engineering trades, and with the exception of jewellery, all our awards were in the construction trades.

In the three categories associated with electronics the results were as follows: Industrial Electronics: gold—Japan, silver—Switzerland, bronze—Spain, honourable mentions—Germany and U.K. Radio and TV repair: gold—Japan, silver—Italy, bronze—Korea, honourable mentions—Germany, Portugal and U.K. Instrument Making: gold—Japan, silver—Holland, bronze—Germany.

Two more scientific satellites for ESRO

At a meeting in July, the council of the European Space Research Organization approved the adoption in the E.S.R.O. programme of two new scientific satellites. The first will be a cosmic ray satellite (expected to be launched in mid-1974) and the second a geostationary magnetospheric satellite (mid-1975).

The cosmic ray satellite will contain a single, rather large and sophisticated experiment designed to investigate the gamma flux from the universe and will be built by an international team of European laboratories.

The geostationary satellite will contain about ten experiments provided by European laboratories. Its main purpose will be to investigate particle fluxes, electric and magnetic fields as well as electromagnetic waves in the outer magnetosphere at about 38,000 km.

In the meantime E.S.R.O. has four satellite launches on its books from now until 1972.

New British Semiconductor Group

GEC-English Electric have announced the formation of GEC Semiconductors Ltd which brings together under a single management company, the semiconductor interests of Marconi-Elliott Microelectronics Ltd and AEI Semiconductors Ltd. Dr J. Shields, managing director of AEI Semiconductors Ltd, will be the managing director of the new company. The two companies within the new group will continue to trade separately and will retain their existing facilities.

Design '69

Everything from television sets to food warmers and a desk computer to a sheepskin teddy bear will be exhibited at the Design Centre (Haymarket, London S.W.1) in a five-week international exhibition, Design '69, which starts on September 10th.

In all, 22 countries will be participating in the event and items in the electronics field to be shown are: television sets from Argentina, France, and Japan; a table top computer from Japan; and panel instruments from West Germany.

University electronics advisory unit

The department of electronics in the University of Southampton has recently received a grant from the Wolfson Foundation for the establishment of an Industrial Advisory Service.

The grant will allow the department to increase the services which it currently offers to industry. The department will undertake advisory or design work on a normal consultancy basis and will be especially concerned with the role of electronic techniques in increasing productivity by undertaking the design and building of prototype integrated circuits and other projects in the fields of lasers, opto-electronics and control.

A comprehensive integrated circuit manufacturing facility is available and this, coupled to the materials advisory and diagnostic service which the University also offers, will enable a wide variety of problems to be handled.

In particular the needs of smaller firms who may not retain a regular staff of electronic engineers, but who nevertheless are becoming increasingly dependent on electronic techniques will be catered for.

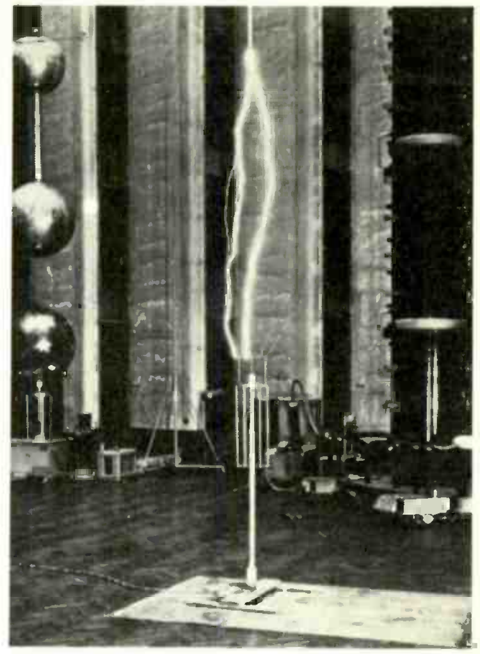
Automatic bearings on distress calls

A new, simple, and inexpensive method of taking automatic d.f. bearings on the positions of ships in distress has been developed by the Marconi International Marine Company Limited.

The system, based on the Marconi "Lodestar" automatic direction-finders, couples the automatic direction-finder to a ship's existing auto-alarm receiver when the radio officer goes off watch. If an alarm signal is received the "Lodestar" pointer swings to the bearing of the vessel in distress and locks there so that when the radio officer returns to the radio room the bearing of the distress incident can be read off immediately relative, of course, to ship's head at the time of receipt.

The coupling between the "Lodestar" and the auto-alarm receiver is achieved by a small unit, incorporating a switch, a solid-state timer, and a relay, which can be supplied for less than £20. When the radio officer goes off watch, in addition to switching on his auto-alarm receiver in the normal way, he switches on the "Lodestar" and tunes it to 500kHz and also sets the coupling unit switch to "Watchkeeping". In this mode the coupling unit relay cuts the supply to the servo motor of the "Lodestar" bearing pointer, holding it disabled unless an automatic alarm signal is received.

This signal, which activates the alarm bells in the wheelhouse and the radio officer's living quarters, is also employed to actuate the relay which restores the power to the "Lodestar" servo motor, which then drives the bearing pointer to the correct bearing of the distress signal. At the same time the solid-state timer is set in operation and this, after a lapse of two seconds, causes the relay to interrupt the power to the servo motor and thus "freeze" the bearing pointer. Even if no further signal is heard from the vessel in distress an unambiguous bearing will have been obtained. This bearing would be relative to ship's head at the time of observation. A further optional refinement can be made to interrupt the "Lodestar's" gyro repeater circuit when the system operates in



Semiconductor portion of an active aerial defies a lightning strike. Designed for air traffic control by Rhode & Schwarz, the aerial operates between 100 and 186 MHz. The transistor amplifier is housed in a metal cylinder which is connected to a 300mm diameter top plate via a series resonant circuit with a very low series capacitance. The top plates are supported by two metal rods which are also connected to a basket-shaped counter weight and are at earth potential. If lightning strikes the aerial, current flows via the two outer metal rods. The space around the transistor amplifier remains free from magnetic fields. If lightning strikes nearby the electronics still remain free from induced currents because the transistor circuit is really in the null arm of a balanced bridge.

order to preserve ship's head true, and consequently a true d.f. bearing. Bearings are held fixed until the coupling unit is switched from "Watchkeeping" to "Normal", or until the auto-alarm receiver is reset.

Irish standards converter

A television standards converter was designed and built in only five weeks by Radio Telefís Éireann, and flown to the Space Communication Centre at Buenos Aires in the Argentine. It was used to convert American 525-line transmissions of the Apollo-11 moon flight to the local 625- and 405-line picture standards. The converter was commissioned by Research and Production Ltd, for Western Union International.

Laser colour television

The Central Research Laboratory of Hitachi Ltd in Japan have succeeded in using three lasers, one for each colour, to project a colour television picture onto a 4 × 3 m screen. Each of the lasers has an output of 8W.

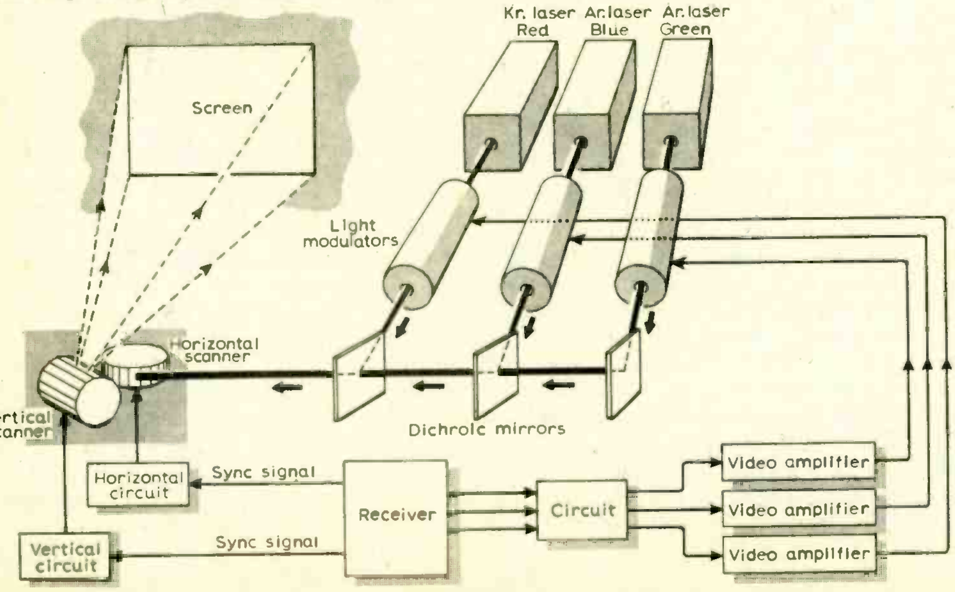
Signals from a standard television set, or a television camera, are fed through a specially developed video amplifier which increases the signal swing to 1kV. The amplified television signals are then impressed on the three coloured laser beams by three crystal light modulators. The modulated beams are then focused on a set of dichroic mirrors which combines them into a single beam which is relayed to a second mirror system.

The second optical section consists of a horizontal scanner with 16 mirror faces, which rotates at a constant speed of 60,000 r.p.m., and a vertical scanner with 24 mirror faces rotating at 150 r.p.m. The vertical scan mirror is tilted rapidly back and forth by a special motor, while a small synchronous motor spins the horizontal scanner.

Finally, the laser-projected video signals impinge on the screen and form an image which is larger and brighter than anything which could be achieved with a cathode-ray tube.

Dr. Yamada, the man who developed the system, says, "The lasers have a very narrow spectral range and that means that with this system we have very pure red, green, and blue colour. The fluorescent materials used in ordinary television sets have a broad spectrum band and, therefore, cannot produce pure colour."

Showing the operating principles of the laser colour television system. At present the light modulators employ a dipotassium phosphate crystal, it is hoped to use gallium molybdenate when large enough crystals become available.



New structure for GEC-Marconi

A new management structure has been announced by the GEC-Marconi group of companies. The various companies within the group have been split into four main companies as follows: Marconi Communications Ltd under the managing directorship of T. Mayer, consisting of Marconi's Broadcasting, Radio Communications, Space Communications, Line Communications, Mercantile Marine, and Mobile Communications Divisions; GEC-AEI (Electronics) Ltd.; Eddystone Radio Ltd; and Marconi Specialized Components Division. The second main company, Marconi Radar Systems Ltd, under the managing directorship of J. W. Sutherland, consists of Marconi Radar Division, Elliott Airspace Control Division and GEC-AEI (Electronics) Ltd. Dr. B. J. O'Kane will be the managing director of the third main company, Marconi-Elliott Avionic Systems Ltd, which consists of Marconi Aeronautical and Electro-optical Systems Divisions, Elliott Flight Automation and Elliott-Automation Radar Systems. The fourth main company, GEC-Elliott Space and Weapons Systems Ltd, has A. S. Walsh and D. W. Malim as joint managing directors and consists of GEC-AEI (Electronics) Ltd and Elliott Space and Weapon Automation Ltd.

Credit for the constructor

In order that home constructors can benefit from the advantage of running an account Home Radio (Components) Ltd have introduced a scheme which will allow orders to be accepted over the telephone from private individuals. Basically the constructor who joins the scheme places a deposit, equal to half of the maximum credit he requires, with Home Radio. Goods may then be ordered valued up to 75% of the maximum credit allowed for the first month. After this period, goods to the full credit amount can be ordered. Invoices are enclosed with each order and a statement is posted monthly. The cost of goods ordered is not deductible from the deposit which is held until the agreement is terminated. Orders can be placed over the telephone answering system at any time. We congratulate Home Radio on an excellent idea.

British participation at Hannover?

The first meeting of the exhibitors on the British Electronic Centre stand at the 1970 Hannover Trade Fair took place recently.

Proposals and draft plans were discussed for the stand in the new hall which is under construction by the fair authorities. The Centre has a large island site in the middle of this new hall which will be devoted entirely to electronic components.

The plans have yet to be settled in final detail and there is a limited amount of space still available for British component manufacturers on a first come, first served basis. It is significant that all the other stand spaces in the new hall have already been taken and the Centre stand offers the only opportunity for British manufacturers in this field. British electronic component firms wishing to take advantage of this opportunity should contact:– The Secretary, Mr. R. W. Hardisty, 31, Morden Road, Blackheath, London, S.E.3. Telephone 01-852 3467.

Microwave link to Scilly Isles

The Post Office is to establish a microwave link between the Scilly Isles and the mainland which will operate in the 6 to 7GHz region. A new solid-state equipment, type 14000/300, manufactured by the Communications and Control Group of Ferranti, is to be used for the project.

Because of the long oversea path space diversity techniques will be used for reception and a measure of frequency diversion will be employed for the protection channels. The equipment will be fully automatic with control, monitoring and fault reporting facilities.

Edwin Spreadbury Premium

The Council of the Society of Electronic and Radio Technicians has established the Edwin Spreadbury Premium which has an annual value of £15. This premium is a tribute to the work of E. A. W. Spreadbury, the first chairman of the Society, in the establishment and development of S.E.R.T. The premium is being sponsored by I.P.C. Business Press, publishers of *Electrical and Electronic Trader*, of which Mr. Spreadbury was editor.

WW—084 FOR FURTHER DETAILS

Letters to the Editor

The Editor does not necessarily endorse opinions expressed by his correspondents

Minimum standing current in class A

read the article by Mr. J. L. Linsley Hood, n the April issue of *W.W.* with great nterest, and the results he has achieved are ertainly excellent for so simple a design. However I think he has done the cause of class A amplifiers a slight disservice, by the figures for minimum standing current Table 1, p. 150) which are considerably above the true minimum figures, a fact which I have checked in practice.

The value of standing current required to ust enable the output to swing to the oints where one or other of the output ransistors is bottomed depends on the esired output power and load impedance. These factors also dictate the minimum upply voltage. These values of voltage are $V_{supply} = 2\sqrt{2\ P_{out}\cdot R_{load}} + 2\ V_{ce\cdot sat}$. rom $P_{out} = V^2/R$ where V is the r.m.s. utput). Likewise the peak current may be

etermined $I_{pk} = \sqrt{\dfrac{2P_{out}\cdot R_{load}}{R_{load}}}$

hich equals $\sqrt{\dfrac{2\,P_{out}}{R_{load}}}$

ow the standing current need be only half his value, since the change in load current is ue to the upper transistor cutting off and e lower transistor doubling its current r vice-versa), a total change of current which must flow through the load of twice at originally flowing in the transistors, i.e. e standing current. Evaluating these for o watts and 8-ohm load we get (ignoring $V_{ce\cdot sat}$) figures of 25·3 volts and 790mA ving a total dissipation of exactly 20 watts, hich is in agreement with the theory for ich a "perfect" stage (i.e. 50% efficiency). n practice we must add the figure of $V_{ce\cdot sat}$ as stated by Mr. Linsley Hood. e thus get figures of 26·5V and 790mA. The corresponding figures for a 10-watt itput are 16·7V at 1·29A (3 ohm), and ·oV at 580mA (15 ohm). In practice we ust also add an allowance to the current to ovide for the variation which will take ace due to temperature etc. This excess urrent is especially necessary in the design scribed, where the only thing having any ppreciable control of the standing current the current gain of the output pair. I feel that this point was not sufficiently emphasized, or for that matter, the fact that to use any given pair of output transistors, and obtain the correct standing current needs quite a range of the total value of $R_1 + R_2$, from the values quoted of 100 + 560 ohms (for the 8-ohm case) for a high gain pair down to say 68 + 150 ohms for $H_{fe} = 40$. These lower values mean a considerable drop in loop gain, which probably accounts for much of the increased distortion, with lower gain transistors. These lower value resistors would in fact reduce the feedback by about 10dB. If the circuit of Fig. 10 is used it will also be necessary to use lower values for R_1 and R_2 to allow for an excess current which may then be controlled, I therefore question the contention of page 152 that the circuit allows for "precise control of the series current without affecting . . the distortion characteristics". Any reduction of loop gain must increase the distortion.

I have just measured a very similar stage to that described and find that for an 8-ohm load and 10-watt output, a supply of around the 27 volts quoted and a standing current of 850 to 900mA is ideal.

L. Nelson-Jones,
Bournemouth,
Hants.

The author replies:

I thank Mr. Nelson-Jones for his comments. Taking his second point first, it is evident that the current gains of the output transistors (particularly Tr_2) influence the standing current through the output chain. However, due to the flattening effect of operation at high junction currents and temperatures, the current variation from transistor to transistor with a given value of $R_1 + R_2$ is much less than the manufacturer's quote range of H_{FE} (30–200) would suggest. The tests which I made last year with limit-value devices gave a spread of ±150mA, when the current gains of the devices were badly matched, and rather less than this with limit-value matched pairs.

It had been in my mind at the time of writing the article that the constructor of the circuit should make adjustments to the value of R_2 (not R_1, which is part of the bootstrap circuit) to obtain the correct standing current, and made the comment (p. 149) that "the resistor R_2 .... can be used to set the static current of the output stages". The use of a variable resistor, in series with some suitable fixed value, would have facilitated the setting of this, and I had from time to time wished in retrospect that I had suggested this, as an alternative. Where this arrangement is adopted, however, care must be exercised in the layout of the leads to the potentiometer to avoid undesirable output-input feedback capacitances. The potentiometer should also be at the end of R_2 nearest to R_1.

With regard to Mr. Nelson-Jones first point (about the correct standing current for a class A stage of this type) the calculations he shows are correct, and are substantially identical to those which I made myself in the initial stages of the design of this amplifier. However, in the particular case of a class A design of this type which cannot provide a load current which increases with demand, three further points must be considered.

1. The simple calculation of the ratio of peak-to-mean currents, as in the equations above, gives an answer which is valid only for symmetrical waveforms. Most of the waveforms in speech and music, for which such an amplifier will be used, are unsymmetrical and some allowance must be made for this.
2. The calculations assume that the load is resistive. In practise, loudspeakers present reactive loads, also their impedance may fall to lower than the nominal value.
3. The optimum performance of the output stage is given when the current swing does not take either transistor into current cut-off.

Because of these considerations, which were confirmed experimentally, I suggested a value of *quiescent* current which was in excess of the bare minimum "sine wave into resistive load" value, even though this involves an increase in the thermal dissipation of the system. Safety factors can always be cut down—provided that one knows the circumstances.

J. L. Linsley Hood

Class A/B amplifier

I have been most pleased to see the increased emphasis on articles of practical value in *W.W.* In particular many readers like myself will be delighted by the useful and straightforward articles by Mr. Linsley Hood. My own findings have been that the circuits are easy to build, economical in components, easy to adapt and give outstandingly good results.

I noticed that in a letter published in your July issue Mr. Linsley Hood suggests that an amplifier operating in class A on low power but class B on higher power would be a good answer to problems of distortion in circuits which are economical in power consumption. On the face of it this idea seems to offer many advantages, I wonder, could Mr. Linsley Hood offer a practical circuit for a class A/B amplifier as effective as his previous designs?*

Norman W. Vale,
Mickleover,
Derby.

* Mr. Linsley Hood has designed and is testing a class A/B amplifier preparatory to describing it in the journal. Ed.

Symmetry in a class B

I read I. M. Shaw's article (June issue, p. 265) with great interest, his modification being an alternative to that which I briefly described in a recent London lecture to the B.K.S.T.S. and which is shown in Fig. 1.

There are many possible variations that can be played on the basic quasi-complementary output-stage theme as first conceived by Lin, and in order to be able to assess the relative virtues of these, and perhaps suggest improvements, it is necessary to acquire a detailed and vivid understanding of just what goes on in these rather subtle circuits. I have found the following approach to be particularly effective.

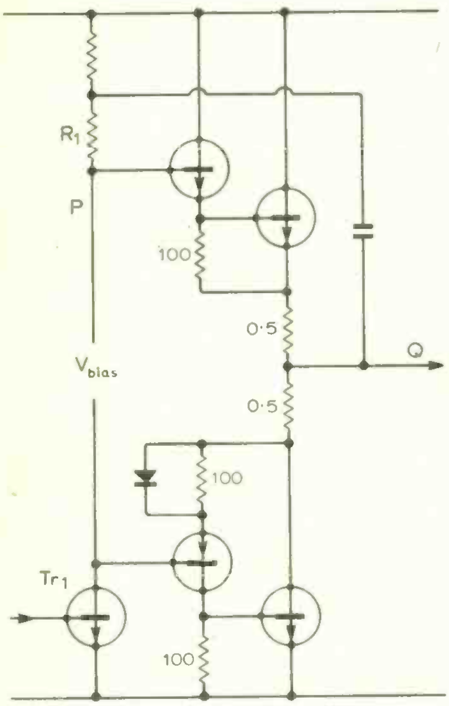


Fig. 1. An effective modification for reducing crossover distortion.

Referring to Fig. 1, the transistor Tr_1 is initially regarded as an ideal infinite-output-impedance source feeding its current into R_1, which is effectively connected between the points P and Q. It is thus as if a floating signal-voltage source, of internal resistance R_1, were connected between P and Q. Now it is of no fundamental importance which point in a circuit is taken as earth, and it is rather convenient, both for promoting an easier understanding and also for performing some initial practical experiments, to earth point Q. Indeed, a few hours spent experimenting with a set-up such as that shown in Fig. 2 will be found very instructive. The effect of finite output impedance in Tr_1 (Fig. 1) may be visualized in terms of a resistance shunted across the ideal transistor. This resistance then appears in the position shown in broken line in Fig. 2, and will be seen to apply shunt negative feedback. Since the effective resistance value varies with the instantaneous signal level, the negative feedback introduced is of a nasty non-linear type, and it is better to choose Tr_1 for the highest possible output impedance, or even to replace Tr_1 by a suitable high-output-impedance transistor pair. The less the local feedback of the above kind, the more will be the overall feedback round the complete amplifier, and this latter type of feedback is the best for reducing distortion. The first requirement, however, is to understand the behaviour of the Fig. 2 circuit without either of these types of feedback.

In reasoning about and experimenting with circuits such as these, I would strongly advocate that *voltage drive* should be regarded as the initial ideal concept, the effects of finite input impedance being allowed for later. (For many years I have felt that the almost universal tendency to regard transistors as "basically current-operated devices" has exerted a major retarding influence on progress in good transistor circuit design. Mutual conductance should, I believe, receive much greater emphasis[1,2,3].)

Fig. 3 shows mutual characteristics, plotted with the aid of a Tektronix curve tracer, for the top (Darlington) pair of Fig. 2 on its own. As the point B_1 swings up positive from below cut-off, the driver transistor has developed sufficient mutual conductance, by the time the output transistor comes on, to operate as an emitter follower with approaching unity gain. The initial curvature of the transfer characteristic for the complete pair is thus determined almost entirely by the output transistor and its 0·5-ohm resistor alone. When the output transistor current has risen to about 50mA, the reciprocal of its mutual conductance is about 0·5 ohm and the slope of the pair then reaches about half its final value of 2 A/V. Two pairs of this type (requiring complementary power transistors) would thus have an optimum quiescent current, for minimum crossover distortion, of about 50mA in each power transistor.

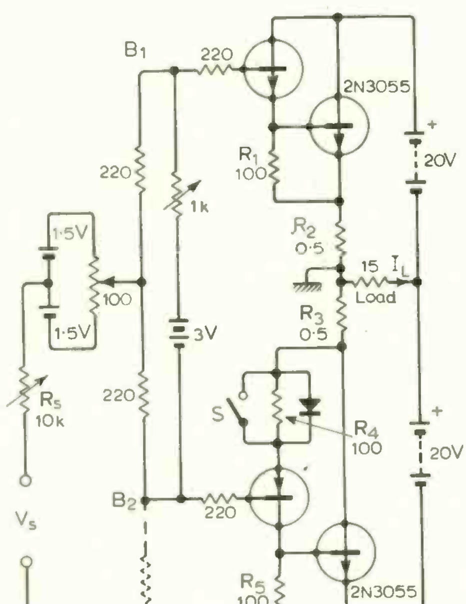


Fig. 2. Experimental circuit with shifted earth point. The broken-line resistor represents the effect of finite output resistance in Tr_1 of Fig. 1. The 220-ohm base resistors are to prevent parasitics; the writer's rather straggly version also required a series combination of 33 ohms and 100pF between base and collector of the top driver transistor only.

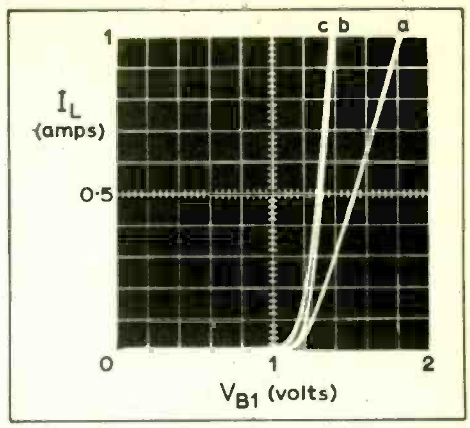


Fig. 3. Characteristics for upper (Darlington) pair of Fig. 2. Curve (a) circuit as shown; (b) R_2 short-circuited; and (c) R_1 omitted, R_2 short-circuited.

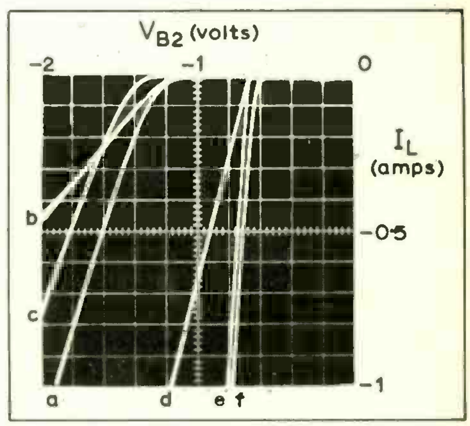


Fig. 4. Characteristics for lower (conjugate) pair of Fig. 2. Curve (a) circuit as shown; (b) diode removed; (c) S closed, power diode inserted in series with R_3 (Mr. Shaw's scheme); (d) S closed, otherwise as shown; (e) S closed, no diode, R_3 short circuited; and (f) as for (e) but with R_5 removed.

Fig. 4 shows characteristics for the lowe pair, or "conjugate" pair as it is sometime called. The sharp turn-on corner, when n diodes are used, arises because the firs transistor of the conjugate pair, as its bas swings negative from cut-off, develops a considerable voltage gain by the time th necessary half volt or so has been built up across its 100-ohm collector resistor to brin the output transistor on. Thus the initia exponential part of the latter's mutua characteristic, when referred to the input o the pair, is diminished in voltage magnitud by the gain of the first stage, which is in th region of 20. Once the second-stage mutua conductance becomes high enough t establish a sufficient amount of negativ feedback via the 0·5-ohm resistor to th first stage emitter, a splendidly linea characteristic, with a slope of very nearl 2A/V, is obtained. Unity gain round thi loop requires only about 2·5mA in th output transistor, so the overall charac teristic looks very linear down to, say

10mA. If a push-pull amplifier were made with two such conjugate pairs, the correct quiescent current, giving half the full slope from each pair, would be about 2·5 mA in each power transistor.

Between B_1 and earth we have (a) the driver emitter-base voltage, (b) the voltage across a 100-ohm resistor shunted by a "diode" (the input of the power transistor) and (c) the voltage across the 0·5-ohm resistor. By adding a 100-ohm resistor shunted by a silicon junction diode in the emitter lead of the conjugate-pair driver transistor, we introduce into the path between B_2 and earth a voltage component similar to that existing between base and emitter of the output transistor, and thus make the overall behaviour of the lower pair simulate closely that of the upper pair. An alternative solution, i.e. that due to Mr. Shaw, is to insert a power diode in series with the 0·5-ohm resistor of the lower pair—the resistor value may, with advantage, be slightly reduced to allow for the spreading resistance of the diode.

So far we have considered the behaviour of the circuit with low-impedance voltage drive. In practice, however, R_1 in Fig. 1 is not usually low enough, in relation to the driver-stage input impedance, to justify this assumption fully; though the high-current-gain transistors now becoming common make the approximation to voltage drive tend to be better than in the past. To allow for the effect of a finite source resistance, R_s, we need to know how the driver base current varies with the base voltage in Fig. 2. In the top pair, before the output

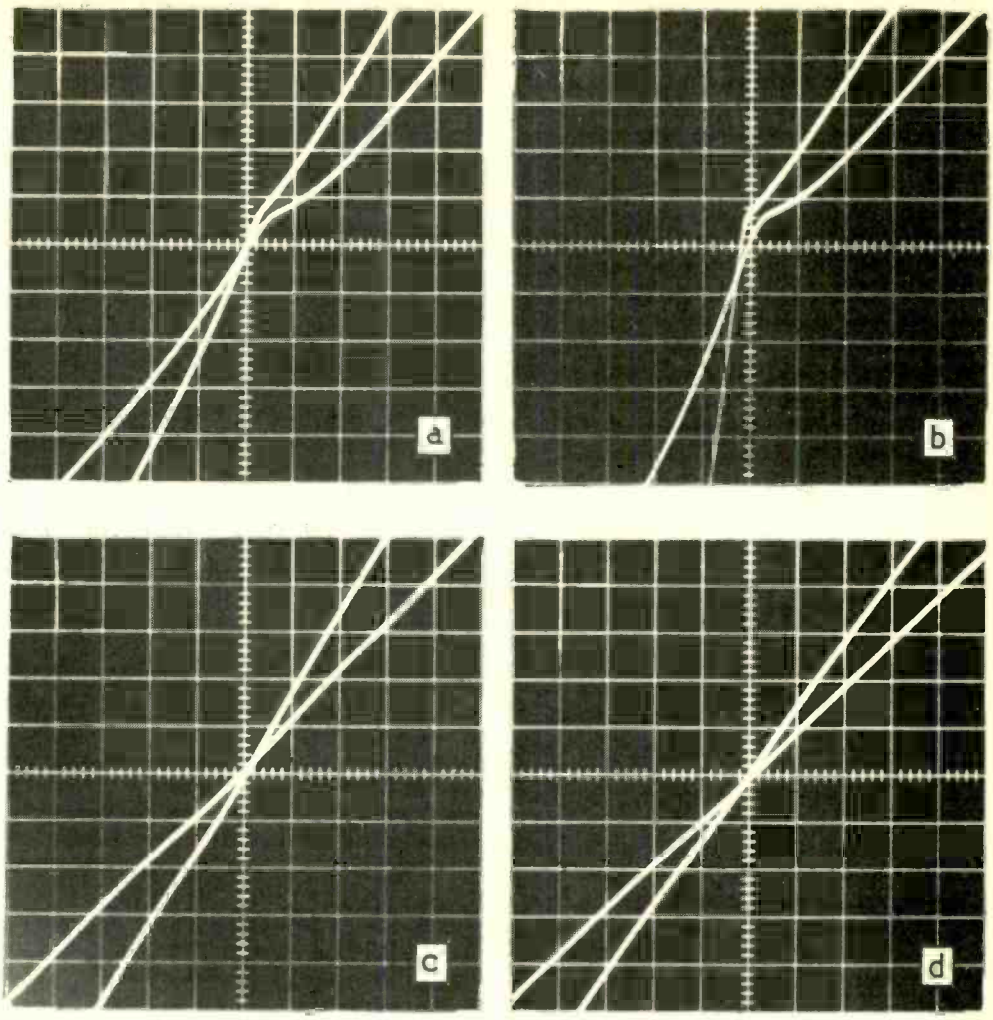


Fig. 6. Plots of I_L (vertically, 100 mA/ large division) against V_S (horizontally, 0·1 V/large division). The steeper curve in each case is for $R_S = 0$, and the less steep curve is for $R_S = 5\,k\Omega$. Zero I_L and V_S at centre of plots. Quiescent current approx. 60 mA in all cases. (a) Fig. 2 circuit with S closed; (b) As for (a) plus R_3 short-circuited (Mr. Shaw's Fig. 1); (c) S closed, power diode in series with R_3 which was reduced to about 0·35 ohm to compensate for diode spreading resistance. (Mr. Shaw's Fig. 2 scheme); and (d) Circuit as shown in Fig. 2, with slight extra improvement due to inserting 10 ohms in series with top driver emitter to compensate for diode spreading resistance.

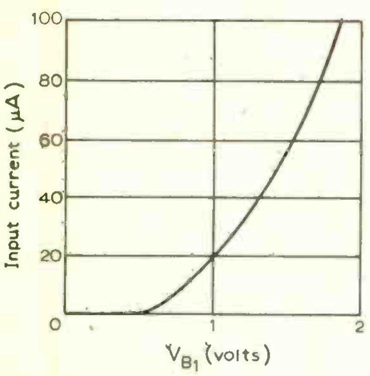


Fig. 5(a). Input characteristic for upper (Darlington) pair of Fig. 2.

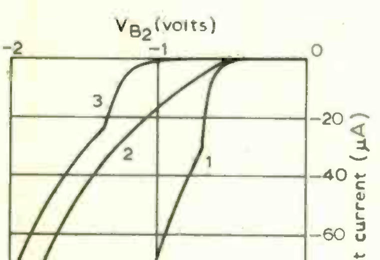


Fig. 5(b). Input characteristics for lower (conjugate) pair of Fig. 2. Curve 1, S closed; 2, circuit as shown; and 3, S closed, power diode in series with R_3 (Mr. Shaw's scheme).

transistor comes on, the driver transistor has 100 ohms in its emitter and therefore has a high input impedance (not less than 20kΩ if $\beta = 200$). In the lower pair, when no diode is used, the driver transistor, before the output transistor comes on, has only 0·5 ohm in its emitter, which is negligible. Consequently, as its base swings negative, the input current rises in a rapidly-increasing exponential manner until the output transistor comes on and feedback to the driver emitter is established, after which it rises much more gradually. With the diode and resistor inserted in the driver emitter lead, however, the input current is caused to vary in substantially the same manner as in the Darlington pair. These effects are illustrated by the measured input-current characteristics of Fig. 5, from which it will be seen that a diode and resistor in the driver emitter lead give an input-current characteristic much more like that of the Darlington pair than does a diode in series with the output transistor.

In Fig. 6 are shown transfer characteristics for the complete push-pull circuit of Fig. 2, under a variety of conditions.

In conclusion, I would like to express my opinion that even without these recent diode refinements—or earlier rather less satisfactory distortion-reducing dodges—the better versions of 6-transistor quasi-complementary class B amplifiers already have a distortion level which is subjectively quite negligible, but the use of diodes should enable similar results to be obtained with a smaller input signal level, less feedback then being required. It is perhaps worth mentioning that I have seen commercial versions of this type of circuit with overall voltage gains varying from 4 to 200.

P. J. BAXANDALL,
Malvern,
Worcs.

1. "Transistor Mutual Conductance", Editorial in *Electronic Technology*, Vol. 38, No. 3 (March 1961).
2. "Low-Distortion Amplifiers", P. J. Baxandall, *J. Brit. Sound Recording Assn.*, Vol. 6, No. 11, pp. 246-256. (Nov. 1961).
3. "The Bipolar Transistor as a Voltage-operated Device", E. A. Faulkner, *J.I.E.R.E.*(Brit.), Vol. 37, No. 5, pp. 303-305 (May 1969).

Letter from America

The Consumers' Electronic (Trade) Show in New York attracted an attendance of nearly 30,000, beating last year's figure by about 5000. The exhibits were even more elaborate and eye-catching—in spite of the absence of some of the larger manufacturers.

Interest was pretty well divided between TV, compact stereo systems and Hi-Fi equipment. A good deal of interest was also shown in video recorders and cameras—a field in which Japanese products were well in evidence. Colour television did not make the impact it did at the last two or three shows, which is understandable when one realizes that now more than 36% of all American homes have colour sets. This does not mean that colour TV development is at a standstill—far from it. For instance, the new Magnavox sets have a unique colour control circuit called TAC (Total Automatic Control) which eliminates the need for frequent colour control adjustments after the set is tuned to a station. (No more green or purple faces!) A logic circuit is used to control both gain and phase of the colour burst signal*. The need for adjustments almost every time one switched channels has been more or less accepted as one of those things—like static and man-made interference in the old days of radio. Causes are transmission phase errors, video tape differences, camera divergencies and so on. A top level committee, representing the National Association of Broadcasters, the Electronic Industries Association and others concerned, was formed some time ago to look into the problem and their report is due very soon. However, in view of the Magnavox development, the committee might well shrug its collective shoulders and pass the problem right back to the manufacturers. As a matter of fact, automatic colour control was also featured by several other manufacturers but no information was available. Most sets had some form of automatic tuning (a.f.c.) although a few still used manual fine tuning with some kind of visual indication such as vertical bars on the screen. Both RCA and Zenith announced brighter colour tubes (and both claimed 100% brighter!) to be released later this year. Neither of these firms were at the main show but had their own exhibitions nearby.

Electrohome of Canada were demonstrating a luxury large screen TV with a novel type of electronic (varactor) tuning—the viewer changes channels by merely sliding his hand along a bar. Push-button station selection with a varactor "front end" was also used on several Panasonic models and there is no doubt that many other firms will follow suit later this year. Sylvania had a very interesting signal-seeking u.h.f. tuner employing a logic circuit and an optional r.f.-operated remote control unit. The band is swept in 25 seconds, reverses at the high end and then stops at the low. Black-and-white sets are still quite popular—especially inexpensive portables. Both Sony and Panasonic had new models with built-in digital clocks (seen on many radio sets).

One of the most unusual portables is a Philco model using a new 13in. tube which has the neck at an oblique angle to the screen†, thus reducing the depth. The entire set is only 5½in. deep and Philco (I ought to say Philco-Ford) are working on a colour version. Compact stereo record player systems were more prolific than ever and they ranged from inexpensive imports (3 to 5 watts per channel, ceramic pickup, two cheap 5in. or 6in. speakers in small boxes) selling for less than $60 complete, right up to elaborate systems by Scott, Fisher, Harmon-Kardon, Benjamin (who use EMI speakers), Sherwood and many others. The Japanese were very prominent in this field as indeed they are in the whole area of Hi-Fi and some well-designed, superbly styled amplifier-receivers were shown by Panasonic, Toshiba, Yamaha, Pioneer, JVC, Kenwood etc. American manufacturers have apparently come to the conclusion that it is impossible to compete with Japanese imports, especially in the lower price range, and so are acting on the policy of "if you can't beat 'em, join 'em." Thus firms like EV, Harmon-Kardon, Sherwood and Marantz are either using Japanese components or complete units. Many Japanese speaker systems were to be seen and heard. As far as Hi-Fi is concerned, the only area in which the Japanese appear to be lagging behind is in the production of top-quality stereo pick-ups—but I imagine it will not be for long.

In brief: Panasonic had a stereo f.m. radio built in a pair of earphones, Sonora were showing a floating radio for swimming pools—but for the ultimate in gracious living the prize must go to Nordmende for a four-screen television receiver—one colour plus three black-and-white tubes to see what's happening on the other channels! Finally, how about the Japanese extension speaker complete with 14 small metal tubes called "The worlds most beautiful-sounding speaker, frequency resonant to sweeten the highs, lower the lows, truly a pipe dream". What could I add to that?

More news about neural hearing: it is now well over a year since I reported this development (March 1968) pioneered by a small firm called Intelectron and since then much progress has been made. Neural hearing is a method of using a modulated r.f. signal to activate the nerves direct, by-passing the ears entirely. A generator is coupled to the head by electrodes, so the head becomes in effect the dielectric of a capacitor. The signal is detected by the nerves themselves and by the cochlea in a complex manner involving the modulation of a d.c. barrier potential induced in the tissues. The system can be used for hearing aids or it can actually improve hearing by a process of "electrostimulation". Here is how it works: the carrier signal (40 to 100kHz) is brought to resonance and is modulated by an audio signal that sweeps from 100Hz to 20kHz and back with a four-minute cycling rate and each discrete audio frequency is cycled from 0 to 100% modulation at a one-second rate. These signals are recorded on tape and applied to the patient by the transdermal electrodes which can be bare metal or metal covered with insulation material. Patients (up to 100 a week at present), read or carry on other activities during treatment—usually for an hour a day. Power used is around 3 to 5mW at 2 volts or less.

Progress has been made with hearing aids too and several models will be marketed next year. One of these is a microminiature device built in a pair of spectacles with the transdermal contacts in the spectacle arms. Yet another version (shades of James Bond), is built in a tooth!

It is obvious that there will be many other uses for neural hearing systems, communication under high ambient noise levels, paging, and possibly for Hi-Fi listening. Distortion should be very low (no cones or diaphragms to contend with!) but there is a snag. The human head has an essentially non-linear impedance so receivers would have to be individually matched for optimum results. Frequency response is claimed to be from below 30 Hz to over 20kHz. The only demonstration I have heard up to now has been with speech, which was very good. I hope to have an opportunity of hearing music later this year—but *not* with the tooth receiver!

G. W. TILLETT

* Of course, America uses N.T.S.C. and not PAL.—ED.

† In 1953 Philips produced, experimentally, a bent-neck tube. (*W.W.*, Jan. 1954, p. 12).—ED.

Wireless World Logic Display Aid

5: Completing the basic instrument

*designed by B. S. Crank**

Last month the Boolean expressions for forming the output variables were derived and the appropriate circuits were given. The time has now come to describe the testing of these circuits.

Testing the output variable circuits

Plug all the boards which have just been constructed into their sockets in the main logic unit. Switch on. Connect the amplifier probe to P18/B6; the circle representing Venn A should appear on the screen in the position shown in Fig. 58. Connect the probe to P18/B7; the circle representing Venn B should appear as per Fig. 59. To complete the Venn tests connect the probe to P18/B8; the circle representing Venn C should appear as per Fig. 60.

To check the Truth table variables proceed as follows: connect the probe to P13/B4 and the dots within the shaded area labelled A in Fig. 14 should appear on the screen. Connect the probe to P14/B4 and the dots within the shaded area labelled B in Fig. 14 should appear on the screen. Next connect the probe to P12/B4 and the dots which should show this time are in the area labelled C or $\bar{C}$ in Fig. 14.

If at any time during the above tests the desired result is not obtained trace back through the circuit with the probe in the manner previously described in order to trace the fault.

Combining the output variables

All the output variables have to be routed to the output variable terminals on the front panel under the control of the signals V, K and T so that the video circuits and the variable circuits are operating in the same mode.

The circuits for achieving this are shown in Figs 66 and 65. It can be seen that the control signals are AND gated with the output variables and that each output variable and its complement are available for feeding to the front panel.

The wiring of this circuit is straightforward except for the input to P19/B2 which is from a second pole on

*Assistant editor Wireless World.

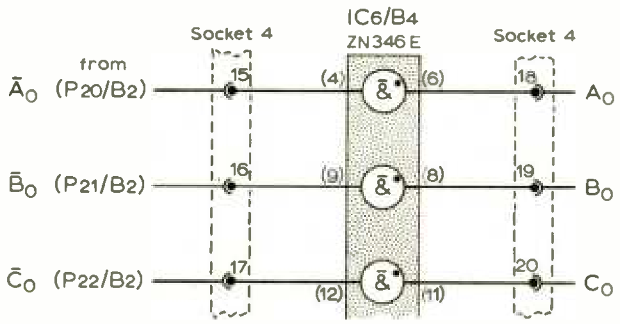


Fig. 65. Circuit employed with Fig. 66.

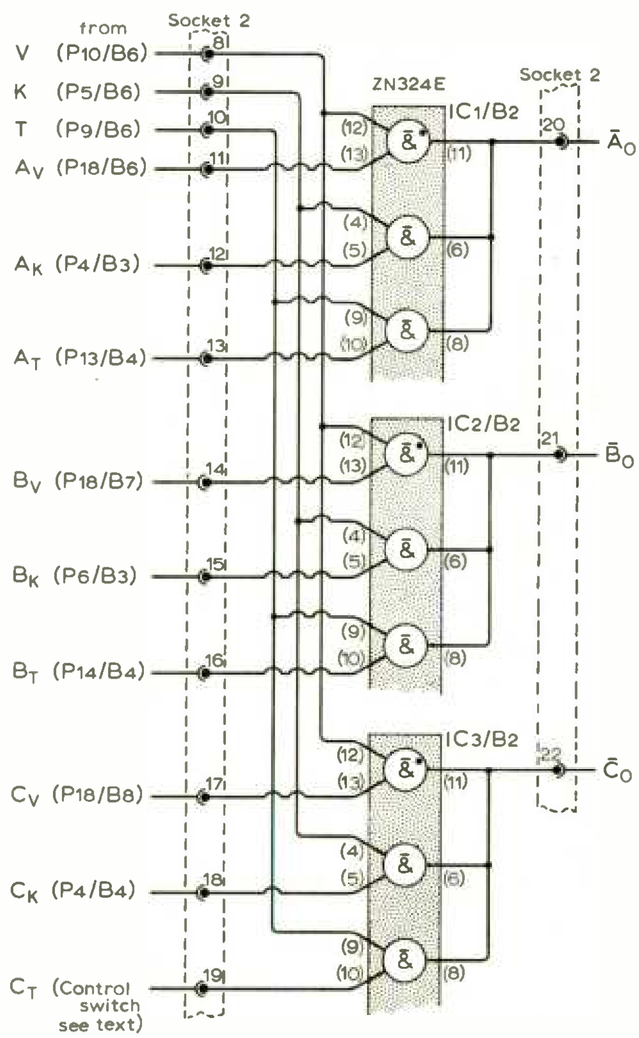


Fig. 66. Circuit which allows the control signals to select the correct output variables

the switch used to select C or $\overline{C}$ in the truth table mode. Connection details are given in Fig. 67.

These circuits can now be built and the appropriate inter-board connections made. Temporarily mount 9 terminals on a piece of board and label them A, B, C, D, $\overline{A}$, $\overline{B}$, $\overline{C}$, $\overline{D}$ and Z and connect them to the points indicated below:

A. P18/B4	$\overline{A}$. P20/B2
B. P19/B4	$\overline{B}$. P21/B2
C. P20/B4	$\overline{C}$. P22/B2
D. P6/B4	$\overline{D}$. P5/B4
Z. P4/B8	

Finally connect the amplifier probe to P23/B5.

Testing the complete main logic assembly

These tests are similar to the ones just carried out except that now the variable producing circuits and the character generation circuits are tested together. Once the unit has passed these tests the reader can rest assured that all the circuits built so far are functioning correctly.

All the interconnections referred to in the tests are carried out on the board containing the nine terminals.

Connect A to Z: select Venn—the circle for Venn A should appear on the screen; select Karnaugh—1s should appear in the map in the area representing A, the rest of the map should contain 0s; select Truth table—the area representing A in the result column should contain 1s, the result column should contain 0s.

Connect $\overline{A}$ to Z, go through the series of tests mentioned above; this time the areas representing $\overline{A}$ will either be visible or will contain 1s as appropriate. Repeat for B and $\overline{B}$, and C and $\overline{C}$. In the Truth table tests for C or $\overline{C}$ do not forget to take into account the position of the C/$\overline{C}$ switch. For D and $\overline{D}$ it is only necessary to carry out the tests in the Karnaugh mode.

Video amplifier and flyback suppression

With the circuits as they stand readers will have noticed, with some oscilloscopes, that some of the dots on the screen are distorted and that flyback lines appear. These faults are cleared, as are problems of uneven brightness mentioned earlier, by using a simple gated video amplifier which is built alongside the buffer amplifiers on board one.

The flyback lines are caused by the response time of the dians and by the propagation delay across the bistables in the counter and across the various gating networks. All the various signal paths are of different lengths and contain different combinations of elements so that the signals arrive at their destinations at different times. In order to allow time for this settling down the

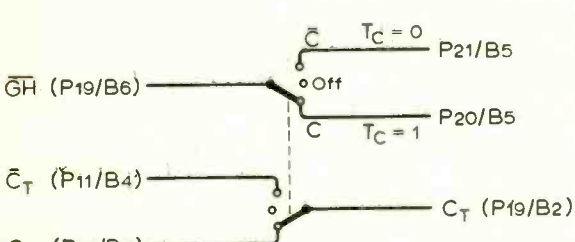


Fig. 67. Wiring of the Truth table column C control switch

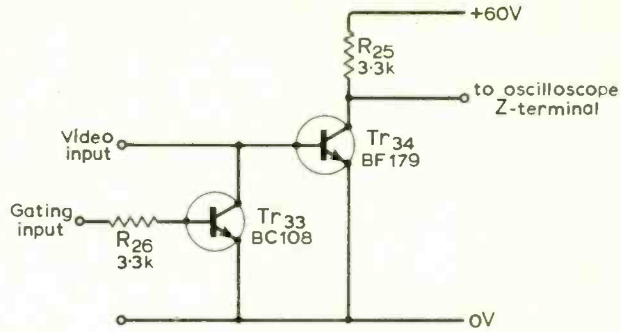


Fig. 68. The video amplifier

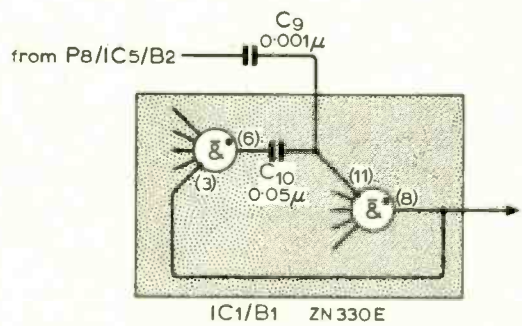


Fig. 69. The monostable which provides the gating pulses for the video amplifier

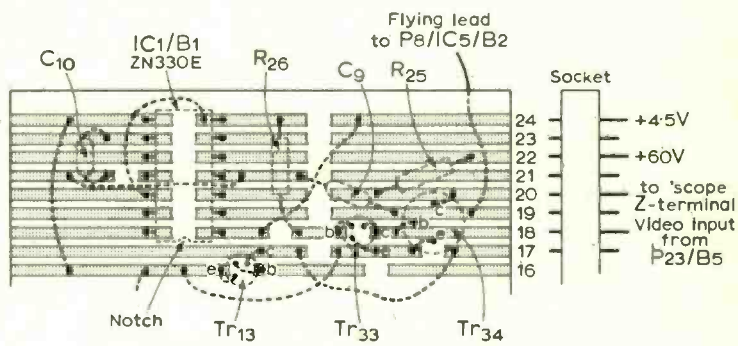


Fig. 70. Practical details of the video amplifier and monostable circuits

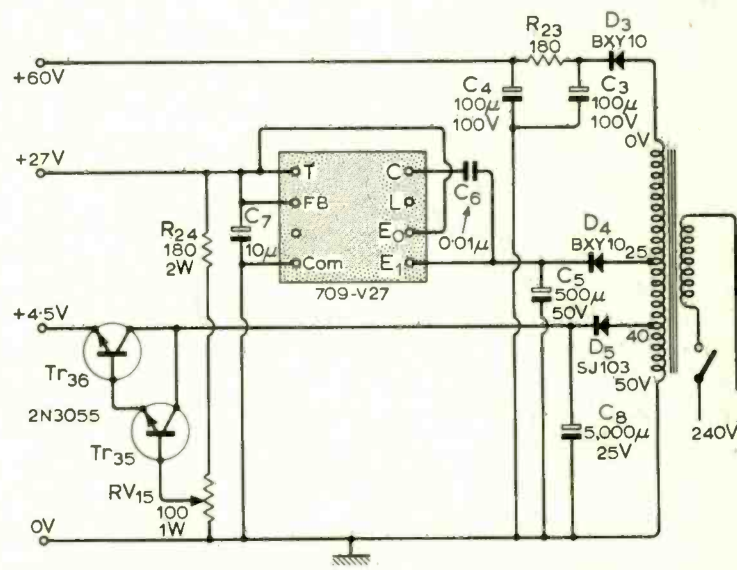
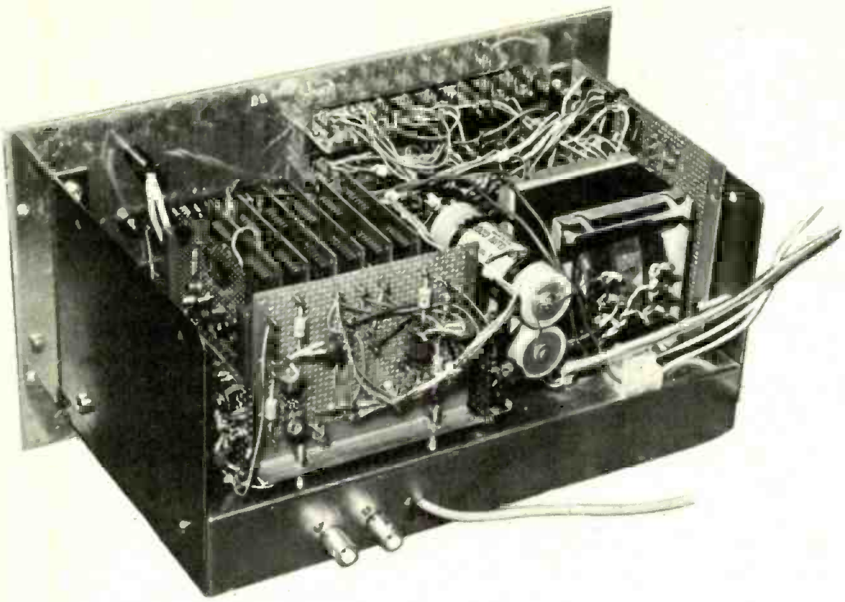
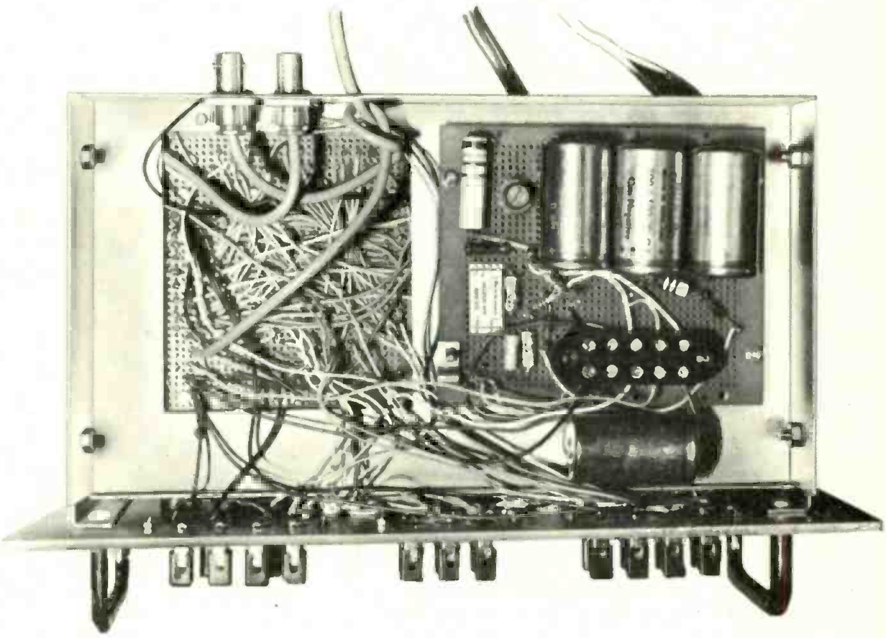


Fig. 71. The power supply



(below) Fig. 72. *Under chassis view of the complete instrument. On the left, through the cutout in the chassis, the underside of the main logic assembly can be seen. On the right is a board containing the small components of the power supply.*



(above) Fig. 73. *Rear chassis view of the prototype. The extra board mounted on the rear of the main logic unit contains the parts for one of the modifications to be described later in the series. The board on the right, behind the mains transformer, is also associated with a modification.*

video amplifier is switched on and off by pulses from a monostable multivibrator which is in turn triggered by the clock multivibrator. The timing and connections are such that the video amplifier is switched off during the time that the circuits are in a state of transition.

The video amplifier circuit is shown in Fig. 68 and the monostable multivibrator in Fig. 69. It is regretted, but the two resistors and two capacitors used in this circuit were omitted from the components list. The circuit can now be built on board 1 as shown in Fig. 70. The connection from the output of the monostable to the gating input of the video amplifier is taken by a flying lead over the top of the boards as there is not a spare pin on board 2. When this work is complete recheck the functioning of the instrument. A "cleaner" display should have been achieved.

Power supplies

The power supplies circuit (Fig. 71) is fairly conventional. The requirements are 60V at a few mA, 27V at 30mA and 4.5V at 1A, all positive with respect to the OV line.

The 60V is derived from a simple half-wave rectifier and an *RC* smoothing circuit.

The 28V supply also employs half-wave rectification and is stabilized using the Beckman Instruments' thick-film voltage regulator.

A potential divider between the 28V line and earth provides a reference voltage for the simple series regulator used to obtain the 4.5 supply. The main current carrying transistor, Tr_{36}, is mounted on the heat sink specified in the components list.

In order to obtain the correct voltages the tappings on the mains transformer are used "back-to-front" as indicated on the circuit diagram, i.e. the 50V tapping is connected to the 0V line.

In the prototype the capacitor C_8 was made up from two smaller capacitors to fit the available space and the heat sink with Tr_{36} was mounted on the rear outside wall of the cabinet.

It is not proposed to give a wire by wire connection diagram of the power supply as this is fairly straight forward. The majority of the components are mounted on a piece of Lektrokit board fitted below the chassis on the left-hand side of Fig. 72. The large components, the transformer and C_8, are mounted above chassis and can be clearly seen in Fig. 73.

Before connecting the power supply to the logic unit perform the following checks. Connect dummy load resistors between the supply lines on 0V. For the 60V line the resistor should be about 3.3k, for the 27V about 1k and for the 4.5V line about 10Ω at 3W.

Switch on the power supply and check that the 27V line is 27V. Adjust RV_{15} to give exactly 4.5V and check that the 60V line is roughly right.

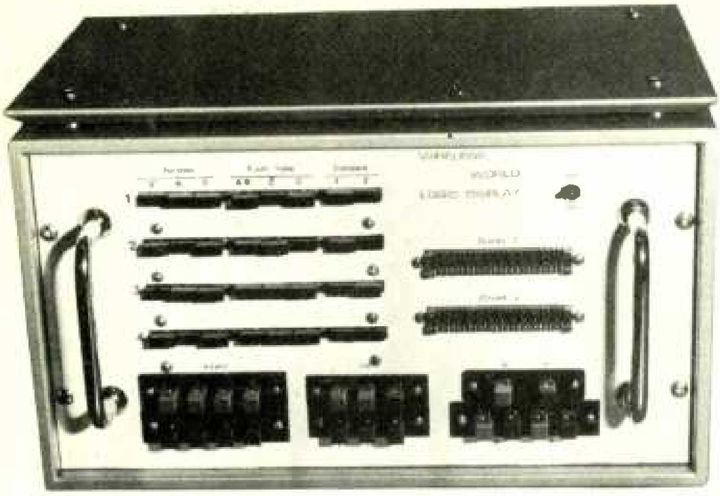


Fig. 74. Front view of the completed prototype, presented as a guide only

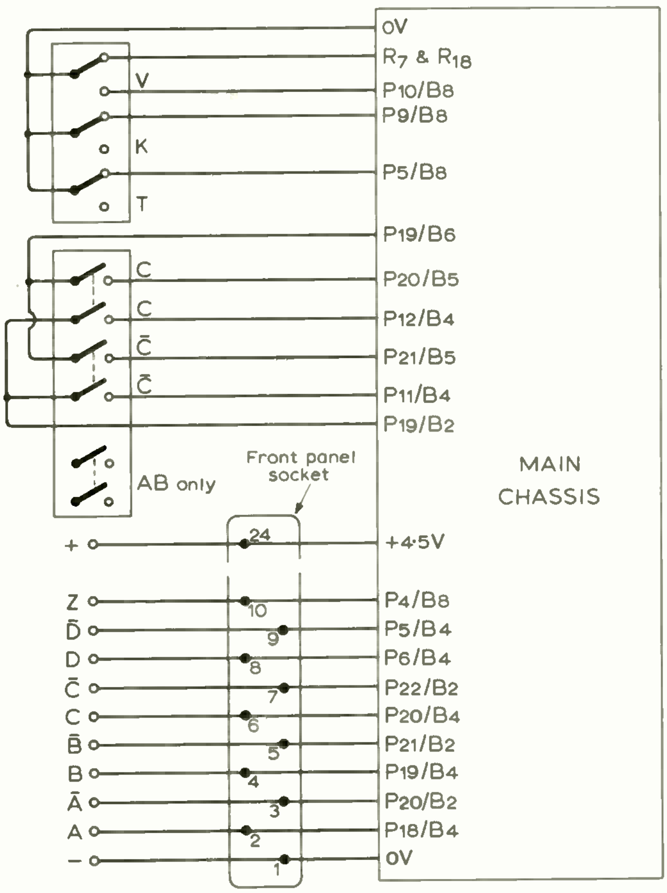


Fig. 75. Front panel components to main chassis connection diagram

The power supply may now be connected to the logic unit and the whole assembly checked for correct operation.

Tidying things up

The logic unit and the power supply can now be mounted on the chassis in the positions shown in Fig. 72 and 73. The board attached to the main logic unit facing you and the board mounted on the far side of the mains transformer in Fig. 73 are only required if the more advanced versions of the instrument are to be built. These extra circuits will be described later. The X, Y and Z outputs can be connected to coaxial sockets mounted on the rear of the chassis.

All that now remains to be done is to mount and connect the front panel switches. However, this must be delayed until it is decided which version of the instrument is to be built.

Finishing the basic instrument

It is stressed that these instructions are to be followed only by the readers who do not wish to build one of the more advanced versions. Next month's article will be devoted to describing the various modifications that can be carried out.

The photograph of Fig. 74 will give readers some idea as far as front panel layout is concerned. In the basic version being described only one row of push-buttons, one card socket and ten push-terminal units will need to be mounted on the front panel. Care must of course be taken to ensure that components projecting behind the front do not foul anything that is mounted to the chassis.

Fig. 75 gives details of how the front panel components are wired. It may be found helpful to swop the red and black covers of the terminal units so that red represents the true variable and black the complement.

Next month: the various modifications that will extend the usefulness of the instrument will be discussed and a complete system diagram of the basic instrument will be given.

Three dimensional radar

The front cover picture shows a perspex scale model, illuminated by ultra-violet light, of the aerial system associated with a three-dimensional radar which is now in service with the Royal Air Force. The radar was developed by A.E.I. Ltd. (now GEC/AEI Electronics Ltd), in collaboration with the Royal Radar Establishment, Malvern, as a sensor for use in air-surveillance and air traffic control. The term "three-dimensional" implies that the information output includes the height as well as the plan-position of radar targets within the coverage. The version represented in the model was based upon an experimental radar which is still in use at R.R.E. for study and development of radar techniques. Both the model and the experimental radar were on view at the R.R.E. Open Days in June.

The radar operates in the S-band (approx. 3GHz) and employs the stacked-beam principle; that is, the angular coverage in the elevation plane is built up from a series of individual overlapping beams rather than from a single shaped beam. The resulting angular resolution provides some degree of discrimination against interfering signals, such as echoes from ground features and from rain, and permits a rough division of the coverage into different levels of air space by means of the height-layering facility. Continuous height-finding on all targets within the coverage is another feature which follows from the stacked-beam form.

During the design phase there was an extensive study, by means of scale models mounted in a wind tunnel, of the wind forces which would be exerted upon the overall system. One outcome was the addition of wings to the structure backing the paraboloidal reflector, in order to give a more uniform angular variation of the torque required to turn the aerial at the nominal rate of 4 r.p.m.

Towards True Stereophony

A practical headphone system

by "Toneburst"

When a stereophonic programme is heard over loudspeakers the listener may experience a strange detachment which does not trouble him in monophonic reproduction. It seems very likely that this detachment is due to a contradiction in perception between certain unambiguous spatial clues given to the imagination and the poorly defined overall ambience recreated. (By ambience is meant here a complex of relatively low level sounds, largely reverberant, which are precisely located in three dimensions and which give 'life' to a concert hall performance.)

In a 'normal' living room sound reflection often becomes troublesome at a dynamic level lower than that required to develop a good spatial image. At low levels the ambient sounds are below the threshold of hearing or are absorbed by soft furnishings. Under these conditions complex choral and orchestral passages can become very cloudy at whatever dynamic level they are reproduced.

Two-and-a-half-dimensional sound

There is a notion abroad that good stereophony is something to do with the horizontal distribution of sounds. The image is described in terms of 'width', with 'depth' rather as an afterthought. There is no aesthetic merit in being able to point to the position of orchestral soloists—more often than not this is impossible in the concert hall if you close your eyes.

The difference between this so-called stereo, which we are encouraged to accept as a standard of fidelity, and true stereo is, to use a visual analogy, the difference between the Cinerama picture screen and the live theatre as appreciated from a seat in the stalls.

Simply feeding 'stereophonic' signals from radio or records to ordinary two-channel (binaural) headphones will not provide stereophonic sound. What you get by doing this can readily be simulated in everyday life by sticking a short length of pipe into each ear.

Is there any real hope then for those of us who delight in a sense of occasion? How can we get a true stereophonic image?

The problem posed can be rationalized as follows:

Instead of attempting to recreate the whole sound scene in space and then allowing the hearing mechanism to make the best of it, we must somehow produce two signals which, when fed separately, one to each ear, are understood by the brain as a three-dimensional sound scene external to the listener.

Towards a solution

Fig. 1 is a graph first published by Weiner[1]. The curves show the differences in dynamic level between signals reaching the left and right ears from a sound source positioned at an angle of 45° to the left of the listener.

It will be noticed that though the sound intensity is the same (0dB) for both ears at 200Hz, at 3kHz the level is up by 5dB for the left ear and down by 10dB for the right ear. Assuming that both ears are the same (!) an identical graph will be

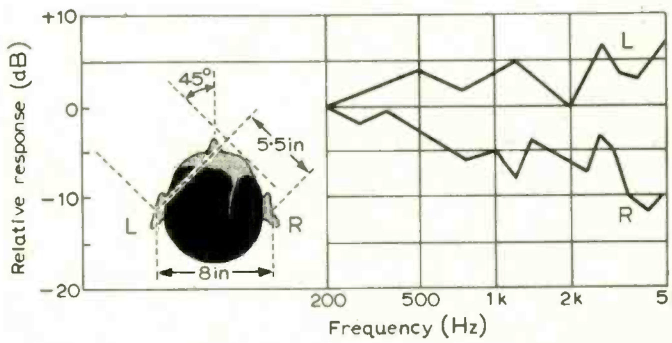


Fig.1. Graph of level differences for a sound source located at 45° to the left of the listener.

obtained, *matatis mutandis*, for a speaker placed at 45° to the right of the listener.

These data were obtained by averaging a range of subjective responses—often widely different. Therefore as an average statement they are weakened insofar as error in subjective judgment is compounded with differences in human hearing. However, assuming that the human head has an average ear-to-ear width of 8 inches, thus giving an extra path length of 5½ inches to the ear farthest from the speaker, a calculated time delay of 0.4ms is arrived at. Using these data and the fact that stereophony does not appear to depend upon time delays for frequencies above 1kHz, but rather on relative intensities, Bauer[2] used the C.B.S. Laboratories analogue computer to develop an electrical circuit for use with headphones, which simulates the cross-feed and delays ideally produced by stereophonic speaker systems. The form of the circuit which we can usefully discuss is shown in Fig. 2.

The same left and right signals which would normally be fed to two loudspeakers placed ideally at 45° to left and right of the listener are fed into the inputs of the circuit. After considerable attenuation the two signals meet each other in a π-network. The chokes cross feed the signals between the two channels and introduce delays for frequencies up to about 1kHz. The capacitor-bypassed 50-Ω resistors in series with the phones result in attenuation that decreases with increasing frequencies. The circuit response follows Weiner's graph quite closely.

However, considering the points made earlier about the nature of Weiner's data before he averaged his results, it might be thought possible to bring some of the component values of Bauer's circuit more in line with what the shops sell. The simplicity of the circuit encourages experimenting—tampering if you like—and Fig. 3 shows the writer's set-up.

Notes on the practical system

The use of 120-Ω series resistors before the cross-feed network

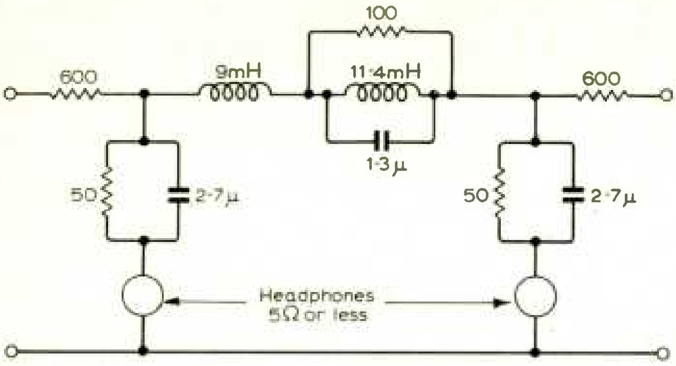


Fig.2. Bauer's original network.

results in some loss of cross-feed below 200Hz, but this is inaudible. On some occasions it might be desirable to control the image position, so a balance-control has been included across the outputs. The volume controls across the inputs can be replaced by fixed resistors if the amplifier controls are to be used. (It might be more convenient to leave the main amplifier

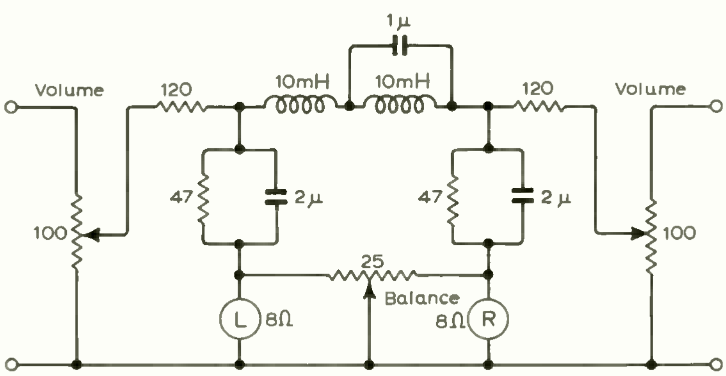


Fig.3. Experimental network.

controls alone, if they are normally set up for loudspeaker reproduction.) Needless to say, the amplifier is not required to supply much power but its stability must be good to tolerate the light loading.

Although the image with the experimental set-up is dramatically real—almost to the point of being a waking dream—some listeners have noticed a wide and near image slip from the front to the back, as though by some acoustic mirror trick. This is an aural illusion which compares with certain geometrical optical illusions. Simply reminding oneself where the image should be cures the complaint.

Dynamic levels far higher than tolerable for mono listening are gratefully accepted as stereophonic fuel.

The best effect will of course be obtained with earphones with a flat frequency response. The comfortable phones selling at moderate prices in many shops are not too good in this respect—rapid tremolo effects may be experienced at high dynamic levels. Best of all would be phones with the sound duct coaxial with the meatus of the outer ear.

The layout of the system is uncritical and may be set up inside or outside the main amplifier as deemed convenient.

REFERENCES

1. Francis M. Weiner, "On the Diffraction of a Progressive Sound Wave by the Human Head", *J. Acoust. Soc. Am.*, Vol. 19, pp. 143-146 (1947).

2. B. B. Bauer, "Stereophonic Earphones and Binaural Loudspeakers", *J. Audio Eng. Soc.*, Vol. 9, No. 2, April 1961.

Wireless World Reprints

When we recently announced that reprints of several of the more popular constructional articles were to be issued, the booklet (No.1) containing the 20-watt and 30-watt amplifiers designed by Dr. A. R. Bailey was not then available. This has now been prepared and will be on sale within the next month.

For the sake of new readers or those who missed the original announcement we reproduce the full list of *Wireless World* reprints obtainable from the Trade Counter, Dorset House, Stamford Street, London S.E.1. Prices include postage and packing.

The next reprint in the series will, it is hoped, be that covering the *Wireless World* Colour Television Receiver, but a further announcement will be made when this is ready.

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

No. 2. **Stereo Decoder and Simulator** by D. E. O'N. Waddington, (Jan. and Oct. 1967). Describes the construction of a stereo decoder for positive or negative power supplies and contains details of an instrument for producing a stereo multiplex signal. Price 3s.

No. 3. **Portable 1-MHz Frequency Standard** by L. Nelson-Jones (Feb. 1968). Presents a design for a frequency standard which is phase locked to the 200kHz Light Programme transmissions. Price 3s.

No. 4. **Wide-range General Purpose Signal Generator** by L. Nelson-Jones (April 1968). Range 150kHz to 120MHz in five bands; output attenuator range 100dB in 20dB steps (±0.5dB); modulation depth 0 to 50% (can be set to within ±5% of meter indication); max. output 100mV (from 75Ω). Price 3s.

No. 5. **Low-cost High-quality Loudspeaker** by P. J. Baxandall (Aug. and Sept., 1968). Can be built for a few pounds! Excellent performance above 100Hz but is improved if used with a woofer for the low frequencies. Price 5s.

No. 6. **Wireless World Crosshatch and Dot Generator** (Sept. 1968). A pocket sized instrument using digital integrated circuits. Price 3s.

In addition, the following reprints from earlier issues are still available:

Wireless World Oscilloscope: Main frame, X amplifier, E.H.T. unit (March, June, July and August 1963), price 5s; No. 1 (audio) Y amplifier (April 1963), price 2s 6d; No. 1 (audio) Timebase Unit (May 1963), price 2s 6d; Calibration—Alternative E.H.T. Unit (Feb. and Oct. 1964), price 2s 6d; and Wide-band Amplifier (March and April 1964), price 2s 6d.

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

Wireless World Crystal-controlled F.M. Tuner (July 1964). Pulse counting type not suitable for stereo. Price 3s.

Transistor High-quality Audio Amplifier by J. Dinsdale, (Jan and Feb. 1965 Very popular 10W design. Price 5s.

Wireless World Computer (Aug. to Dec. 1967). Eight-bit digital machine for instructional purposes. Price 10s.

Techniques of Acoustical Holography

An outline of the principles and possible applications

by D. Holt* and J. R. Coldrick*

The problem of seeing clearly in an optically opaque medium is currently being tackled by such methods as X-rays and underwater sonar. However, these methods are not entirely satisfactory because turbulence and turbidity in the medium can cause image degradation, and small density variations may not be detected. There are reasons to believe that the answer to this problem may be provided by a new technique, known as acoustical holography, first reported about two years ago[1].

Sound waves have been used for imaging for many years. Pulse-echo (sonar) systems have been employed at sea to detect underwater objects, although their reliability for identification is generally recognized to be limited.

Direct image-forming systems have also been used. In these methods an acoustical lens or mirror forms an acoustical image which may be transformed into a visual image. However, both the depth of field and the angular field of view are limited and the resolution is limited by geometrical aberrations as well as by the turbulence and turbidity of the medium.

All of the above limitations may be overcome by acoustical holography which, in addition, possesses the advantages that optical holography has over conventional optical imaging systems, such as the possibility of forming three-dimensional images.

There has been considerable investigation in several laboratories during the past two years, but there still remains a number of basic problems to be solved before the technique of acoustical holography can find very extensive applications. If these problems can be overcome, applications can be expected in medical diagnosis (e.g. visualisation of tumours), underwater exploration and mapping, engineering inspection, and ultrasonic microscopy.

Principles of holography

One of the oldest principles in optics is the use of a lens to form an image of an object. However, in 1948 Gabor [2] announced a process for producing images without the use of lenses. This new process exploits *all* the optical information given by an object, in a three-dimensional way, and has been given the name holography, from the Greek *holos*, meaning 'the whole'. The idea was originally conceived by Gabor as a means of improving electron microscope pictures, and although he was able to demonstrate the principle, it was the availability of the coherent laser source of light about twelve years later that first enabled the technique to be put into practice. Holography is a two-stage process involving the production of an intermediate record of the object—the hologram—from which an image can be reconstructed.

The optical holographic process is illustrated in Fig. 1. At the construction stage, shown in Fig. 1(a), a parallel beam of coherent laser light partially illuminates the mirror M and the object O. The object scatters diffusely and some of the scattered light reaches the photographic plate P where it interferes with the reference beam reflected from M. The photographic record of the interference pattern constitutes the hologram. If now, a transparency made from this photographic record is illuminated by the coherent reference beam, the image of the original object is reconstructed as shown in Fig. 1(b). The reconstructed image is three dimensional and exhibits parallax and perspective effects, etc.

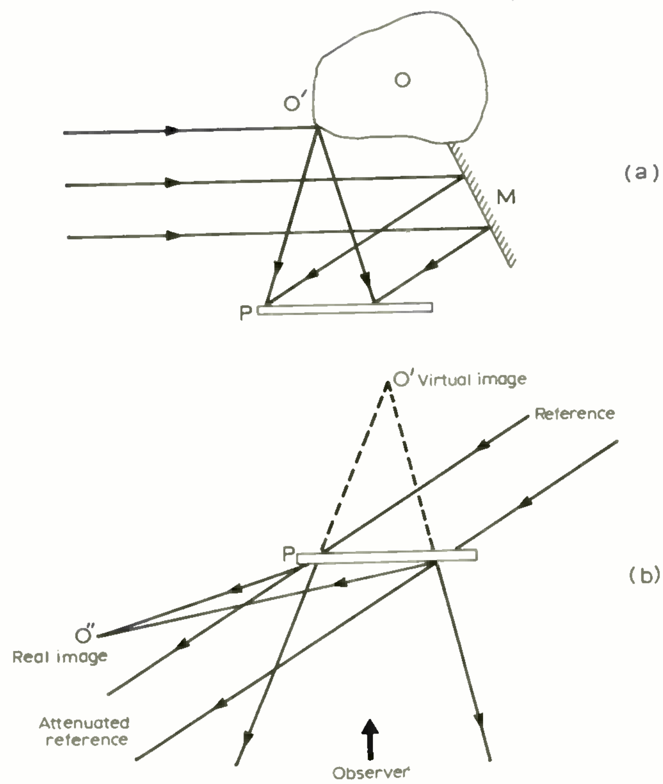


Fig. 1. The holographic process: (a) making the hologram; (b) reconstructing the three-dimensional image.

If two acoustic wavefronts are caused to interfere and the resultant sound field pattern is recorded, the recording is an acoustical hologram. If this acoustic interference pattern is converted into an optical one and then placed in a laser beam, a reconstruction can be obtained. Thus an optical image of an object can be obtained from a recording of how the object diffracts sound waves. Due to the fact that the wavelength of the laser light is much less than the wavelength of the sound, the reconstructed optical image will be very small. In order to view the image full size, the acoustical hologram would have to be first demagnified in the ratio of optical wavelength to acoustic wavelength before the hologram is placed in the laser

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beam. However, since in practice this would result in a reduced hologram of about 0.1mm square, the reconstructed image would be extremely faint. For this reason, a compromise is usually made and the hologram is reduced to about 5mm square; the reconstruction can then be viewed through either a low power microscope or an eyepiece.

Although acoustical holography is analogous to optical holography, it poses quite different problems during investigation. Progress in optical holography was hampered for years because, before the laser, coherent light sources were not available. Recording the holograms was simply a matter of using a high resolution photographic plate. In acoustical holography however, most sound sources are coherent, but the difficulty has been in recording the interference pattern since there is no acoustical equivalent of the photographic plate.

Recording acoustical holograms

The most commonly used method of recording acoustical holograms is by X-Y scanning a single receiver or pick-up over the hologram plane, converting the received signal into a lamp brightness modulation, and recording the brightness variations on film by means of a camera and time exposure. A typical holographic recording process is illustrated in Fig. 2. It will be

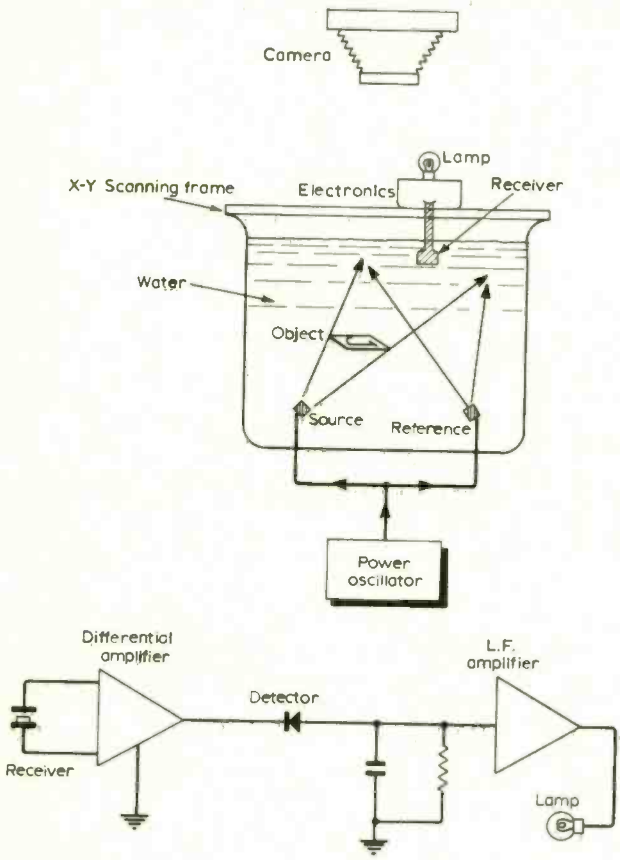

Fig. 2. Typical acoustical holograph recording process.

noted that in this case two sound sources are used, rather than a single source as in the optical case of Fig. 1(a). The reference beam in optical holography may be generated by reflecting light from a plane mirror, but in acoustical holography a separate source may be used because two sources driven from the same electrical source must be coherent.

The sound wave from the reference and the sound diffracted by the object form an interference pattern at the water surface. The interference pattern or hologram is recorded by a piezoelectric crystal which converts the sound intensity into an electrical signal which is then amplified, detected and used to modulate the brightness of a lamp. As the pick-up scans the water surface in a raster, the lamp brightness modulations are recorded on film. The electronic system is very simple in principle, but there are troubles. The first difficulty is to distinguish between the true acoustic signal and the unwanted electrical pick-up in the receiver leads. Careful screening of leads, of course, is essential, but a differential amplifier with a high common-mode rejection ratio was used to reduce unwanted signal to a minimum. A linear integrated circuit used in a differential amplifier configuration with a differential gain of about 100 has been used successfully as a first signal amplifier. This is followed by a simple diode detector and an *RC* smoothing network which produces a low frequency signal which after further amplification modulates a lamp. Two types of lamp have been used; a small tungsten filament lamp, and later a Ferranti gallium-phosphide junction diode (type XP50) which emits green light. It soon became evident that the tungsten lamp was introducing temporal delays which were shown up in the holograms as small displacements of the fringes. The response of this type of lamp is insufficiently fast even at the slowest scanning speeds. A current drive rather than a voltage drive is required for a gallium-phosphide lamp, and with this provision satisfactory holograms were produced. The intensity of a GaP diode is much lower than a tungsten lamp, and hence a faster photographic film for recording was necessary. The hologram of Fig. 3 was recorded on type 57 Polaroid

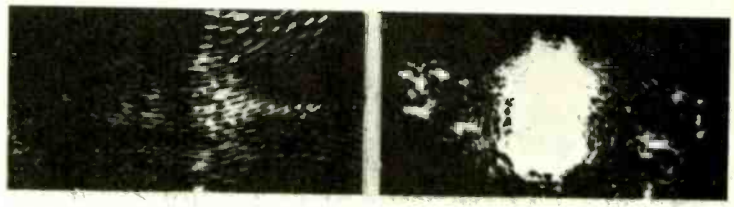

Fig. 3. Hologram (left) and reconstructed image of a letter J.

Land film, the time taken to complete the raster scan being 30m. The object in this case was a letter J, cut out of thin aluminium sheet. The stroke width of the J was 20mm, which corresponds to only 13 wavelengths at the frequency of 1 MHz used throughout these experiments. The hologram was reduced in size to about 5mm square, and placed in the optical system shown in Fig. 4. The reconstructed letter J may be seen to the left of the bright area. The pattern to the right of the bright area is the out-of-focus conjugate image.

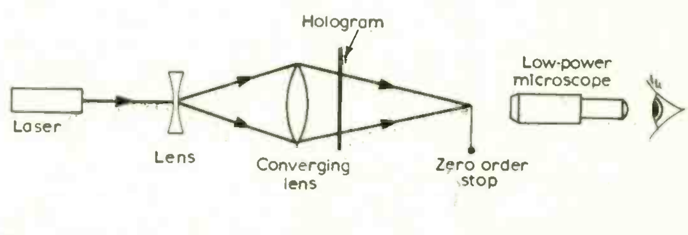

Fig. 4. Optical system for reconstructing a three-dimensional image.

Acoustical holograms have been produced by techniques other than mechanical scanning, for example Mueller and Sheridan[1] used intense sound sources which caused rippling of the water surface. The water surface was then photographed, the photograph was reduced in size, and a transparency made from the reduced photograph was placed in a laser beam for viewing the reconstruction. A different method, demonstrated by Marom *et al.*[3], used an ultrasound camera as a sound field detector. This device is similar in principle to a vidicon except that the photoconductor is replaced by a piezoelectric material.

The mechanical scanning frame

The mechanical scanning frame used to produce the holograms is shown in Fig. 5. The carriage is moved in the X direction by means of a pulley and belt system, and in the Y direction by

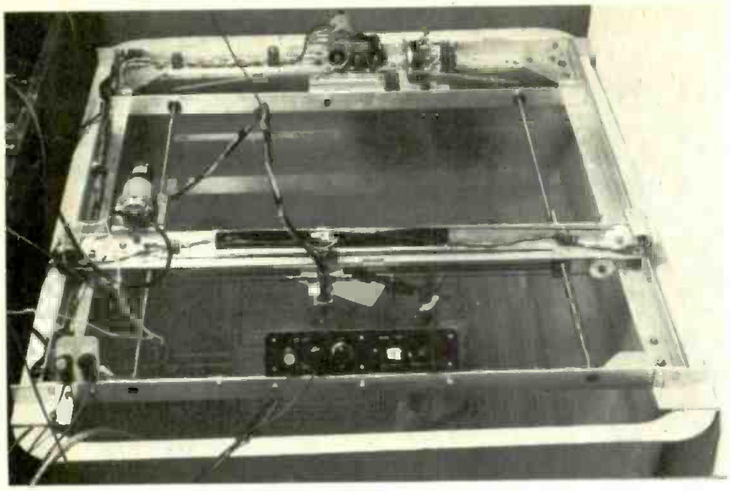

Fig. 5. Mechanical scanning frame used to produce holograms.

means of screw threads. The speed in the X direction is variable from 10mm/s to 100mm/s, and in the Y direction, a full traverse takes between 15m and 30m. Great care must be taken to minimize all vibrations. The hologram plane should be flat to within $\lambda/8$ (0.2mm at 1MHz in water), and vibration amplitudes should be less than $\lambda/8$. Fig. 5 also shows the water tank and sound absorbing material at the base of the tank. The GaP diode may be seen just above the transducer mounted on the slide. An alternative method of recording the hologram is to brightness modulate a c.r.o. and slowly build up a raster. The difficulty here is that the spot on the c.r.t. must be accurately slaved to the position of the transducer within the frame. This method has been used by Metherell *et al.*[4]

Electronic reference techniques

A unique feature of acoustical holography results from the fact that linear acoustic detectors are available. All light detectors are of the square-law type. Indeed it is the main contribution of holography that it makes possible the recording of phase information of an optical field. Linear acoustic detectors, on the other hand, allow independent manipulation of the amplitude and phase information of the acoustic field, and hence, the feasibility of recording each type of information separately if so desired, or the use of an electronic reference beam. The best acoustical holograms produced so far have all been made with a reference beam, the system being illustrated in Fig. 6. The sound is detected as before and amplified, but in this case is summed with a signal direct from the oscillator. Since the sound is coherent with the electrical signal producing it, the signal direct from the oscillator acts as a plane wavefront and a hologram is produced. The signal from the summer is rectified and displayed in the normal way.

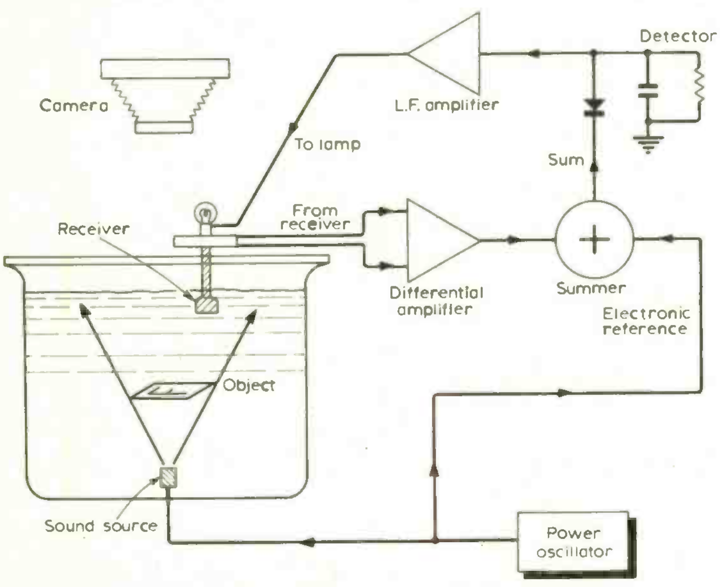

Fig. 6. System using a reference beam from an oscillator.

The use of a plane reference wave enables some of the classic interference experiments to be carried out. A typical example is the Newton's rings pattern of Fig. 7. Here interference of the spherical wavefront from the acoustic source and the electrical reference signal was recorded by the scanning frame as the characteristic pattern. Placing an object between the sound

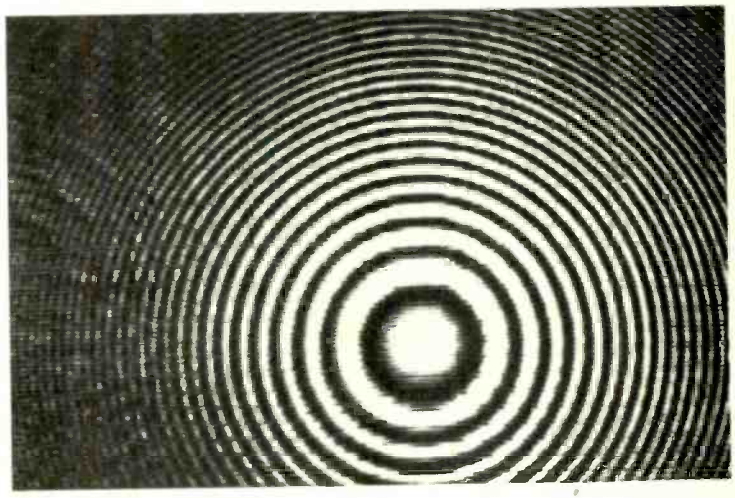

Fig. 7. Newton's rings.

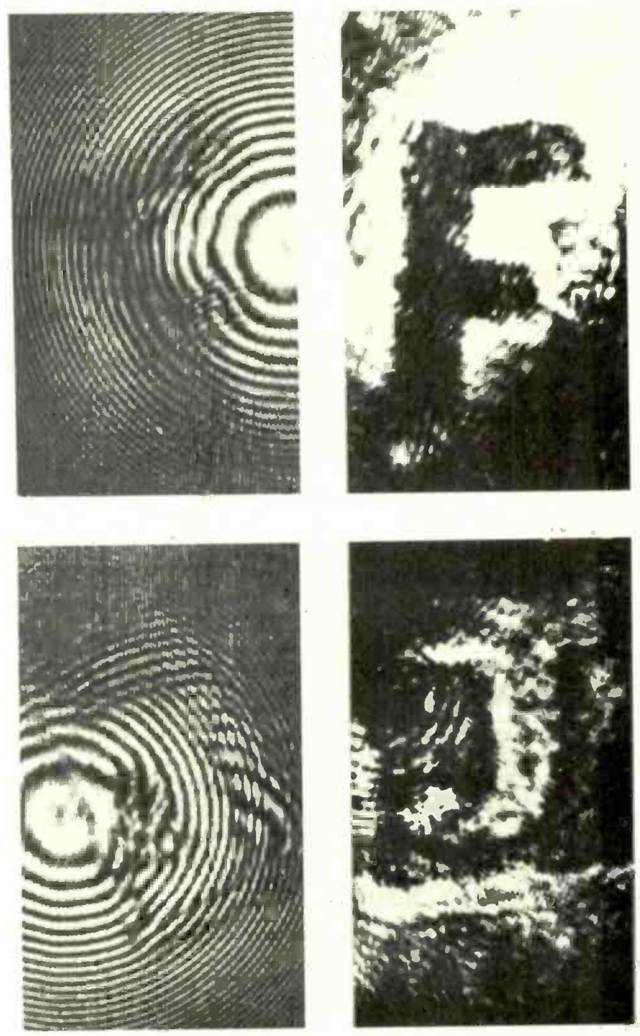

Fig. 8. Holograms and reconstructed images of hardboard F and aluminium J.

source and the water surface produces modulation of the Newton's rings as illustrated in Fig. 8.

If these holograms are placed in a laser beam for viewing (after first being reduced in size), the reconstructions shown may be found. The edge of the letter J may also be seen in the reconstruction. The letter F was made from hardboard. Note that the cutout appears bright, whilst the object appears dark, and that there is more optical noise in the J image, since the aluminium is a better sound reflector than hardboard and therefore introduces noise into the hologram. Another feature is that irregularities in the cutouts are recognizable in the reconstruction, for example the top edge of the F is not straight. The depth of the irregularity is about 1mm, therefore the resolution of the reconstruction is about one wavelength. This, then, is a fundamental limitation of an acoustical holographic viewing system, that the resolution is limited to an acoustic wavelength, which may be several millimetres.

Problems remaining

One of the basic problems is that most objects have surfaces which appear smooth to acoustic waves, and are therefore perfect reflectors. If the surface irregularities are smaller than an acoustic wavelength, a spherical object appears as a point 'highlight' whilst a cylindrical object appears as a line 'highlight'. Acoustical images may appear to be quite different from optical images and require interpretation. A further problem which is hindering the progress of research is that efficient acoustical to optical image converters are not available.

If these problems and others, including the achievement of a real-time or near real-time reconstruction, can be overcome, acoustical holography may establish itself, not only as another technique of visualization, but as the *only* technique that will provide a solution to certain problems in medical diagnosis, geology, oceanography, and engineering inspection.

Acknowledgement

The authors acknowledge useful discussions with Dr. B. M. Watrasiewicz.

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Announcements

Seventeen organizations, including the I.E.E., I.E.R.E., I.E.E.E., I.E.E.T.E. and S.E.R.T., are sponsoring a symposium on **management and economics in the electronics industry** to be held from the 17th to 20th March next year. One of the sessions will deal with personnel and training and include subjects such as "educating the electronics engineer", and "the role of the electronics technician engineer and technician". The secretariat is at the I.E.E., Savoy Place, London, W.C.2.

Datafair 71 will be the fourth conference on computers and computing of the series initiated and organized by the British Computer Society. It is to be held at Nottingham University from 29th March to 2nd April 1971.

A one-day **symposium on multilayers** has been organized jointly by the U.K. Branch of the International Society for Hybrid Microelectronics and the Ministry of Technology. It will be held on September 17th at the I.E.E., Savoy Place, London W.C.2. Registration forms (fee £4) and further information can be obtained from D. I. Gaffee (U.K. secretary), 36 Essendene Road, Caterham, Surrey.

The 3rd conference on **Magnetic Recording** organized by the Hungarian Optical, Acoustical and Filmtechnical Society will be held from August 11th to 15th, 1970, in Budapest.

European Microwave Conference. The first of what is planned to be a series of biennial conferences on microwave technology (alternating with the well-established MOGA conference on microwave and optical generation and amplification) is being held at the I.E.E. from September 8th to 12th. It is co-sponsored by the I.E.E., I.E.R.E. and I.E.E.E.

The next **International Broadcasting Convention,** sponsored by the Electronic Engineering Association and several professional institutions, will be held at Grosvenor House, London, from 7th to 11th September, 1970.

The conference on **trunk telecommunication by guided waves** which was to be held at the I.E.E. from 15th to 17th September 1969 has been postponed until late September or early October 1970.

We have been notified by the following establishments that they are holding **Radio Amateurs' Examination Courses** during the coming session: Wembley Evening Institute, Copland School, High Road, Wembley, Middx; Gascoigne Recreation Centre, Gascoigne School, Morley Road, Barking, Essex; Mexborough Schofield Technical College, Park Road, Mexborough, Yorks; Brentford Centre for Adult Education, Brentford Secondary Girls' School, Clifden Road, Brentford, Middx; Adult Education Institute, Hereford Centre, Ely Road, Grimsby, Lincs; and Ainsty Institute for Further Education, Knaresborough Centre, Stockwell Road, Knaresborough, Yorks. Some of these will also be holding Morse classes.

A radio and television evening course covering theory and some practical work, will be held at Stonebridge Evening Institute, Brentfield Road, London N.W.10, beginning in September.

The headquarters of the **Association of Supervisory and Executive Engineers** has transferred from 26 Bloomsbury Square, London W.C.1, to Wix Hill House, West Horsley, near Guildford, Surrey (Tel: Clandon 383/6).

General Microwave Corporation, Long Island, New York, have appointed MI-Sanders as sole U.K. and Eire distributors for their range of products which include thin film power meters, microwave power monitors, an automatic solid-state noise figure meter and noise generators.

Athena Semiconductor Marketing Co. Ltd., 140 High Street, Egham, Surrey, have been appointed representatives of **National Semiconductor Corporation,** of Santa Clara, California, U.S.A.

Cosmocord Ltd, Eleanor Cross Road, Waltham Cross, Herts, have been appointed sole **U.K. agents** for a range of magnetic pickup cartridges manufactured by the Empire Scientific Corporation of New York.

Rediffusion Industrial Services Ltd., Astronaut House, Hounslow Road, Feltham, Middlesex, have been appointed agents in the U.K. and Ireland for the **International Video Corporation,** manufacturers of colour television and colour television cameras.

All relay design, manufacturing and sales activities of Clare Elliott Ltd., Elliott Brothers (London) Ltd and Elliott Automation (Relay Division) now operate under the name of **Associated Automation Ltd,** a member of the GEC group of companies.

Thermionic Products (Electronics) Ltd, now a member of the Racal Group, have changed the name of the company to Racal-Thermionic Ltd, Hythe, Nr. Southampton, Hants.

Elstone Electronics Ltd have changed the name of the company to Farnell-Tandberg Ltd, Hereford House, Vicar Lane, Leeds 2.

A new company, Integrated Photomatrix Ltd, of The Grove Trading Estate, Dorchester, has been set up to provide a service in the area of opto-electronic components and instrumentation.

H H Electronic of 147 High Street, Harston, Cambridge, have moved to Industrial Site, Cambridge Road, Milton, Cambridge CB4 4AZ (Tel: Cambridge 63070).

Fairchild Semiconductor Ltd have opened European headquarters at 62 Wiesbaden, Aarstrasse 1, Postfach 2740, West Germany. Marketing Offices are now established in England, France, Germany and Italy.

Muirhead are to supply sixteen facsimile communications units for weather picture recording in the Soviet Union. The contract is worth over £55,000.

A £1M order for the extension of **South Korea's broadcasting service** has been received by Pye TVT Ltd. Under the contracts the company will provide studios, transmitters, and ancillary equipment for three new television companies.

Plessey Electronics Group has received an order from the British Aircraft Corporation for lightweight **i.f.f. transponder equipments** to be installed in BAC 167 aircraft for the Singapore Government.

Operational Amplifiers

8. Selection of a practical amplifier

*by G. B. Clayton,** B.Sc., A.Inst.P.

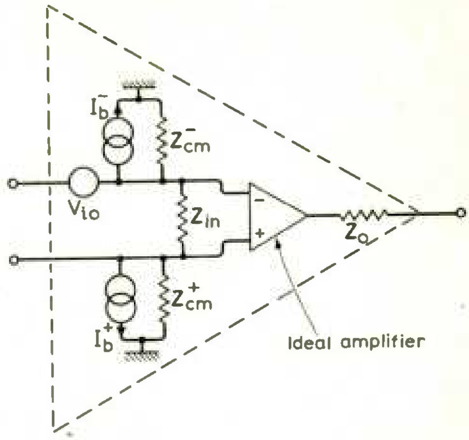


Fig. 1. Simplified equivalent circuit for real amplifier.

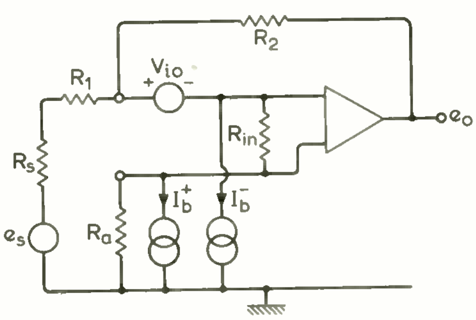
In previous articles the principles underlying some of the many possible applications of op. amps have been dealt with. In order to implement a particular application, further consideration must be given to the performance of real amplifiers, as distinct from that of ideal amplifiers. The meanings of the principal parameters used to specify an amplifier's performance have already been discussed. From a knowledge of these parameters the designer must select the most suitable amplifier for an intended application. Selection of an amplifier to fulfil operational requirements is straightforward for some aspects of a design, but in other aspects the relationship between the published characteristic and the performance of the amplifier to be expected in a specific circuit is less obvious. In what follows we will consider some of the factors which must be borne in mind when selecting an amplifier to perform a specific task.

Output voltage and current capability. This must be adequate for the proposed application. It must be remembered that the amplifier output current is supplied to both the external load and to any feedback path that might be connected to the amplifier output. Remember also that it is always possible to increase the output current capability of an amplifier by the addition of a booster amplifier.

Open-loop voltage gain, A_{VOL}. The exact value of the open-loop gain of an amplifier will normally not be of great significance since when used with negative feedback the operating gain is the closed-loop gain, and this is determined by the feedback components. In such cases the value of A_{VOL} will control the value of the loop gain (βA_{VOL}) and hence the gain error and other aspects of closed loop performance which are dependent on loop gain (see first article February). Manufacturers normally specify a guaranteed minimum value of A_{VOL} for an amplifier of a particular type, and an amplifier should be chosen so that this minimum value is sufficient to ensure adequate loop gain in the particular application. A greater loop gain resulting from the use of an amplifier with A_{VOL} in excess of the minimum will do no harm.

Drift performance. Several factors contribute to the drift of practical amplifiers Drift may be caused by changes in supply voltages. Amplifiers also show a long term drift with time due to component ageing, but drift with temperature is normally the dominant drift source and in many applications represents the largest single source of error. The drift performance of amplifiers is normally specified in terms of the temperature coefficients of bias current and input offset voltage and current. These parameters must be related to the drift errors to which they will give rise in a particular circuit configuration if one is to assess the suitability for use of a particular amplifier type.

The significance of input voltage offset (V_{io}), input bias current (I_b) and input offset current (I_{io}) was considered briefly in



It is assumed that $R_s \ll R_1$. If this is not the case then R_1 should be replaced by $(R_1 + R_s)$ in the equations

$$e_o = -\frac{R_2}{R_1}\left[e_s - V_{io}\frac{R_2 + R_1}{R_2} - I_b^- R_1 + I_b^+ R_a\left(\frac{R_1 + R_2}{R_2}\right)\right]\left(\frac{1}{1 + \frac{1}{\beta' A_{VOL}}}\right)$$

closed loop gain — signal — input error — error factor

The feedback fraction

$$\beta' = \frac{\frac{R_1(R_{in} + R_a)}{R_1 + R_{in} + R_a}}{R_2 + \frac{R_1(R_{in} + R_a)}{R_1 + R_{in} + R_a}} \cdot \frac{R_{in}}{R_{in} + R_a}$$

With equal impedances connected to input terminals,

$$R_a = \frac{R_1 R_2}{R_1 + R_2}$$

the input error becomes

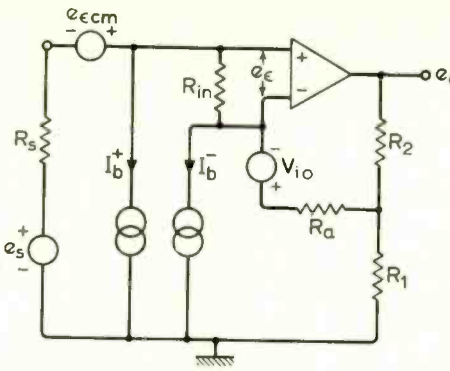
$$V_{io}\frac{R_2 + R_1}{R_2} + I_{io}R_1 \quad (I_{io} = I_b^- - I_b^+)$$

With the non-inverting input terminal earthed, $R_a = 0$,

the input error term becomes $V_{io}\frac{R_2 + R_1}{R_2} + I_b^- R_1$

Fig. 2. Errors for inverting configuration.

* Liverpool College of Technology



It is assumed that $R_s \ll R_{cm}$. Common mode error voltage

$$e_{\epsilon cm} = \frac{e^+}{\text{c.m.r.r.}}$$

$$e_o = \underbrace{\left(1 + \frac{R_2}{R_1}\right)}_{\text{closed loop gain}}\Big[\underbrace{e_s}_{\text{signal}} + \underbrace{e_{\epsilon cm} + V_{io} - I_b^+ R_s + I_b^-\left(R_a + \frac{R_1 R_2}{R_1 + R_2}\right)}_{\text{input error}}\Big]\underbrace{\left\{\frac{1}{1 + \frac{1}{\beta' A_{VOL}}}\right\}}_{\text{error factor}}$$

The feedback fraction

$$\beta' = \frac{\dfrac{R_1(R_a + R_{in} + R_s)}{R_1 + R_a + R_{in} + R_s}}{R_2 + \dfrac{R_1(R_a + R_{in} + R_s)}{R_1 + R_a + R_{in} + R_s}} \cdot \frac{R_{in}}{(R_a + R_{in} + R_s)}$$

With equal impedances connected to the two input terminals, i.e. with

$$R_a = R_s - \frac{R_1 R_2}{R_1 + R_2}$$

the input error term becomes $e_{\epsilon cm} + V_{io} + I_{io}R_s$.

Fig. 3. Errors for non-inverting configuration.

the first article of this series. We must now consider the way in which these parameters affect the performance of a practical amplifier used in a particular feedback configuration. An ideal amplifier with its differential input terminals both connected to earth would give zero output voltage; the real amplifier under these conditions gives some non-zero output voltage or offset. It is convenient to refer this offset voltage to the amplifier input and to consider the output offset voltage of a real amplifier in terms of an ideal amplifier with a voltage generator of magnitude equal to the input offset voltage of the real amplifier connected to its input terminals. In a similar manner the effects of input bias currents may be represented in terms of current generators and an equivalent circuit representing the electrical behaviour of the real amplifier may be set up.

A simplified equivalent circuit for a real amplifier is shown in Fig. 1. The circuit introduces further departures of the real from the ideal (Z_{in}, Z_{cm}, Z_o) which are normally specified for an amplifier and have not previously been mentioned in these articles. Z_{in} represents the differential input impedance defined as the impedance between the two input terminals. In addition to this impedance between the amplifier input terminals there is also an effective impedance from each input to earth or power supply common which is called common-mode input impedance. The parallel sum of the impedances from each input to earth is sometimes specified as the common-mode input impedance

$$Z_{cm} = \frac{Z_{cm}^+ Z_{cm}^-}{Z_{cm}^+ + Z_{cm}^-},$$

in other cases Z_{cm}^+ and Z_{cm}^- are specified separately. Z_{cm} is normally some ten to a hundred times greater than Z_{in}. The impedances are largely resistive. Reactive components may normally be represented by shunt capacitance of a few picofarads. In most applications, as we shall see, the impedances do not have a dominant roll in determining closed loop performance. Z_o is the open-loop output impedance. This can vary from a few ohms to as much as several thousand ohms with the majority of solid state amplifiers having an output impedance in the range 100 to 500 ohms. The effect of the open-loop output impedance is to form a voltage divider with the effective amplifier load (external load plus feedback components) thus attenuating the open loop gain. Manufacturers normally specify open loop gain at a rated load, thus effectively allowing for the existence of Z_o. Open loop gain will, however, vary slightly with change in amplifier load because of non-zero output impedance.

The equivalent circuit may be used to compute errors in a particular application, and this has been carried out for the inverting amplifier configuration in Fig. 2 and for the non-inverting configuration in Fig. 3. Results only are quoted, but the details of the derivations are included in the appendices.

The equations of Figs 2 and 3 illustrate the effects of departures from the ideal on the closed-loop performance of an amplifier. We may use them to compute the temperature drift to be expected with a particular amplifier type. They also provide help in deciding which circuit configuration is most advantageous for a particular application.

Before one can decide whether or not the drift performance of an amplifier is adequate for a particular application one needs to know a value for the allowable drift error. This is related to the magnitude of the input signal and the accuracy with which it is desired to manipulate this signal. For example if it is required to amplify a d.c. signal of 0·1 V with an accuracy of 0·1% then the allowable drift in the input error is 100 microvolts. This assumes that other sources of error such as gain error factor and loading error have already been allowed for. An amplifier should be chosen so that the drift in the input error over the expected range in operating temperature is less than the allowable drift error. The input offset error can, of course, be reduced to zero at a particular temperature by the application of an offset signal using an offset balance control (see later) and the temperature drift to be expected can be obtained by substitution of the specified temperature coefficients of the offsets in the input error term. Thus in the case of the inverting configuration with the non-inverting input terminal earthed the drift in the input error for a temperature ΔT is

$$\Delta T\left(\frac{dV_{io}}{dT}\cdot\frac{R_2 + R_1}{R_2} + \frac{dI_b^-}{dT}R_1\right).$$

If the amplifier is used with equal impedances connected to its two input terminals the drift term becomes

$$\Delta T\left(\frac{dV_{io}}{dT}\cdot\frac{R_2 + R_1}{R_2} + \frac{dI_{io}}{dT}R_1\right),$$

which illustrates the value of this technique in reducing drift due to the temperature dependence of bias currents. The temperature drift for the non-inverting configuration is obtained in the same way by substituting the appropriate offset temperature coefficients in the input error term. Common-mode input error $e_{\epsilon cm}$ is proportional to the input signal and can be allowed for by adjustment of closed-loop gain (see first article).

The equations enable a choice of the most suitable configuration in terms of allowable drift and closed-loop input impedance. The closed-loop input impedance of the inverter is R_1 but amplifier bias current flowing through R_1 adds to the input error. There is thus a conflict between the requirement for a high input impedance and a low offset error. The non-inverting configuration, where other factors allow its use, generally makes a better choice for high input-impedance, wide-bandwidth circuits. The high closed-loop input impedance possible with this configuration arises from the way in which the feedback is applied. The input signal is opposed by the signal feedback, and the open-loop input impedance of the amplifier Z_{in} is effectively multiplied by the loop gain. With large loop gains the upper limit of closed-loop input impedance is effectively the common-mode input impedance Z_{cm}. The input drift error is always less with the non-inverting configuration; this follows obviously from the fact that the bias current I_b flows through the series combination $R_s + R_1$ in the case of the inverter but only through R_s in the case of the non-inverter. The high input impedance of the non-inverter is obtained without the use of large values for R_1 and R_2. Relatively low values for these components reduce the effects of stray capacitance and allow a wider bandwidth with this configuration. However, as we have seen in previous articles, it is not possible to use the non-inverting configuration for functions such as integration and summation. There are also problems associated with common-mode limitations and errors.

Amplifier open-loop input impedance (Z_{in}). The equations of Figs 2 and 3 show that the value of the feedback fraction is dependent on the value of the amplifier open-loop input impedance. If $R_{in} > R_1$ the finite value of R_{in} has a negligible effect and

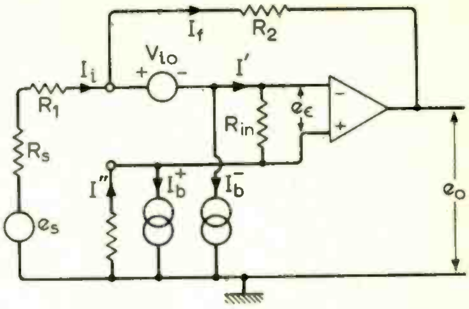
$$\beta' \simeq \beta = \frac{R_1}{R_1 + R_2}.$$

For values of R_1 comparable to R_{in}, β' and the loop gain ($\beta' A$) are reduced. This does not have a direct effect on closed-loop gain except in so far as it results in a larger error factor. It does, however, cause a degradation in closed-loop performance through its effect on the closed-loop properties such as output impedance, distortion and bandwidth, which are dependent on the magnitude of the loop gain. This means that as a general rule R_1 should be given some value less than the open-loop input impedance of the amplifier in use.

Frequency response characteristics are a further consideration in the selection of an amplifier for a particular application. Many applications are concerned mainly with d.c. and frequencies within the audio range, and in such cases almost any amplifier will be satisfactory from the standpoint of frequency response, which will not then be a significant factor in amplifier selection. However, in wide bandwidth and transient applications frequency response, slewing rate and maximum frequency for full output signal are all of importance in amplifier selection. The significance of these parameters was considered in the second article of this series.

APPENDICES

1. Errors in inverting configuration



$$I_i = I_f + I' + I_b^- \quad \text{. eq. (a)}$$

Where $$I_i = \frac{e_s - (V_{io} + e_\epsilon + e_+)}{R_1},$$

$$I' = \frac{e_\epsilon}{R_{in}}$$

and $$I_f = \frac{V_{io} + e_\epsilon + e_+ - e_o}{R_2}$$

(Assuming $R_1 \gg R_s$)

But $$e_+ = -I''R_a = -(I_b^+ - I')R_a,\ e_\epsilon = -\frac{e_o}{A_{VOL}}$$ and substitution

gives $$I' = -\frac{e_o}{A_{VOL}R_{in}},\ I_i = \frac{e_s + \frac{e_o}{A_{VOL}} + I_b^+R_a - V_{io} + \frac{e_oR_a}{A_{VOL}R_{in}}}{R_1}$$

$$I_f = \frac{V_{io} - \frac{e_o}{A_{VOL}} - I_b^+R_a - \frac{e_o}{A_{VOL}R_{in}}R_a - e_o}{R_2}$$

Substitution in eq. (a) and rearrangement gives

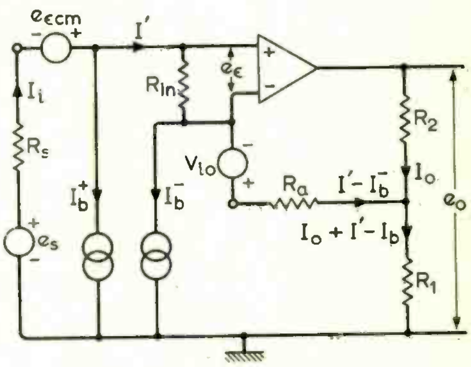
$$-e_o\left[\frac{1}{A_{VOL}}\frac{R_2}{R_1} + \frac{1}{A_{VOL}R_{in}}\frac{R_2}{R_1}R_a + \frac{1}{A} + \frac{1}{A_{VOL}R_{in}}R_a + 1 + \frac{1}{A_{VOL}}\frac{R_2}{R_{in}}\right]$$
$$= e_s\frac{R_2}{R_1} - V_{io}\left(\frac{R_2}{R_1} + 1\right) - I_b^-R_2 + I_b^+\left(\frac{R_2}{R_1}R_a + R_a\right)$$

Introducing the feedback factor β' and rearrangement gives the expression included in Fig. 2.

2. Errors in non-inverting configuration

It is assumed that $R_{cm} \gg R_s$ so that R_{cm} will have negligible effect on the errors and it is omitted from the equivalent circuit. Common-mode errors are represented by the equivalent input error voltage

$$e_{\epsilon cm} = \frac{e^+}{\text{c.m.r.r.}}$$



$$e_s - I_iR_s + e_{\epsilon cm} - e_\epsilon + V_{io} - (I' - I_b^-)R_a - (I_o + I' - I_b^-)R_1 = 0 \quad \text{. . . eq. (b)}$$

But $$e_\epsilon = \frac{e_o}{A_{VOL}},\ I' = \frac{e_\epsilon}{R_{in}} = \frac{e_o}{A_{VOL}R_{in}},\ I_i = I_b^+ + I' = I_b^+ + \frac{e_o}{A_{VOL}R_{in}}$$

Also $$(I_o + I' - I_b^-)R_1 + I_oR_2 = e_o$$

Whence $$I_o = \frac{e_o - (I' - I_b^-)R_1}{R_1 + R_2}$$

Substitution in eq. (b) gives

$$e_s - \left(I_b^+ + \frac{e_o}{A_{VOL}R_{in}}\right)R_s + e_{\epsilon cm} - \frac{e_o}{A_{VOL}} + V_{io} - \left(\frac{e_o}{A_{VOL}R_{in}} - I_b^-\right)R_a$$
$$-\left[\frac{e_o - \left(\frac{e_o}{A_{VOL}R_{in}} - I_b^-\right)R_1}{R_1 + R_2} + \frac{e_o}{A_{VOL}R_{in}} - I_b^-\right]R_1 = 0$$

Introducing the feedback factor β' and rearrangement gives the expression included in Fig. 3.

Personalities

Arthur A. Robinson, M.A., Ph.D., M.I.E.E., director of the University of London Computer Centre since 1968, is to succeed **Professor G. Black** as director of the National Computing Centre of the Ministry of Technology. Dr. Robinson graduated from Cambridge in 1945 and in 1949 obtained his Ph.D. at Manchester in computer circuits. From 1950 until 1962 he worked as a senior development engineer on computers and computer circuitry at Ferranti, Manchester, where he was associated with the design and development of the Mercury and Atlas computers and was latterly the project leader of the Ferranti Atlas team. In 1962 he joined the University of London Atlas Computing Service (Computers (Bloomsbury) Ltd) as manager where he remained until 1968, becoming its first general manager and a director.

Brian Lawrence has become general manager of Philbrick Nexus Research in Britain, in succession to **Martyn Culverhouse** who has been appointed western regional sales manager for the Philbrick Nexus Research Division of Teledyne Inc. at Dedham, Massachusetts, the parent company. Mr. Lawrence was previously a partner in James Lawrence Associates, the Philbrick Nexus distributors for the north of England and Scotland. Prior to that, he had been with Sydney S. Bird & Sons Ltd., Taylor Controls Ltd., and Cossor Radar & Electronics. Mr. Culverhouse, after service in the Royal Navy, worked with Decca Navigator, mostly in West Africa, and with Racal Communications before launching the U.K. operation for Philbrick Nexus Research in 1967.

B. Lawrence

M. Culverhouse

D. L. Davies has joined Racal-Milgo Ltd, of Reading, as managing director. To do so he resigned from S.T.C. where he was group general manager of the Transmission and Data Systems Group. He was at one time managing director of G.E.C. Computers and Automation Ltd prior to which he spent ten years with Solartron, latterly as systems director. Mr. Davies succeeds **E. B. Stuttard** who has relinquished the post for health reasons. The company, which is jointly owned by Racal Electronics Ltd of Bracknell and Milgo Electronic Corp. of Miami, was recently formed to manufacture high-speed data communications equipment.

Bernard Skinner has joined Millbank Electronics, of Hartfield, East Sussex, as technical sales representative responsible for the company's range of audio equipment and the SINUS range of industrial loudspeakers. After war-time service in the Merchant Navy Mr. Skinner went into the retail audio trade and since 1961 has been with Fi-Cord International.

The B.B.C. announces the appointment of **J. Duncan MacEwan,** B.Sc., M.I.E.E., M.I.E.R.E., to the new post of chief engineer, regions. He will be responsible for establishing and specifying operational improvements and for co-ordinating engineering developments in the B.B.C. regions. Since November 1968 Mr. MacEwan has been seconded from his post as head of engineering, Northern Ireland, to be the engineering member of the B.B.C. Policy Study Group. This was set up to provide the board of management with the information needed for the formulation of plans for the future shape of network radio and of television and radio in the regions. These plans were recently published under the title "Broadcasting in the Seventies". Mr. MacEwan joined the Corporation in 1947 in Glasgow. He was appointed a senior lecturer at the B.B.C. Engineering Training Centre, Evesham, in 1956 and engineer-in-charge, television, in Birmingham in 1960. He had been head of engineering in Northern Ireland since August 1961.

Recently announced appointments to the academic staff of the Department of Electrical and Electronic Engineering, Heriot-Watt University include **B. Salvage,** B.Sc., Ph.D., F.I.E.E., lecturer in the department of electrical and electronic engineering at Queen Mary College, University of London, to be senior lecturer; **A. McC. Close,** B.Sc., design/development engineer, Ferranti Ltd, Edinburgh, to be lecturer; and **G. T. Russell,** B.Sc., Ph.D., senior design engineer, Thorn Automation, Rugeley, Staffs, to be lecturer.

John Ayres, F.I.E.E., managing director of Standard Telephones & Cables Ltd since the end of 1968, has been appointed a vice-president of ITT Europe Inc and ITT Industries Inc. Mr. Ayres, who is 62, joined S.T.C. in 1966 as executive director of the Transmission Group at Basildon, Essex. He served his engineering apprenticeship with G.E.C. in Coventry, joined the Brush Electrical Company in 1945 and became director and general manager of Simms Motor Units in 1954. He has been with G.E.C. (Telecommunications) Ltd as managing director, since 1963.

E.D. McConnell is returning from the United States, where he has been technical manager in the Westinghouse Research and Development Center, Pittsburg, for the past six years, to become manager of the Broadcast Division of Rank Precision Industries Ltd. Mr. McConnell, who is 51, will be based at Leicester, where he will be responsible for technical aspects of Taylor Hobson lenses and special optics. He was at one time head of the television department at Rank Cintel.

Eddie Davies has joined Eurotherm Ltd, as applications engineering manager at their Worthing factory. A graduate of Imperial College, Mr. Davies received post-graduate training at A.E.I. Ltd, and was an industrial systems section leader concerned with applications of digital and analogue control systems to industrial drives.

David Collins has joined the staff of Abbey Electronics & Automation Ltd, as sales executive responsible to the board for the marketing of their new range of electronic weighers and graders. Mr. Collins was at one time a sales engineer for D. Robinson & Co. Ltd, and, more recently, was with the Electronic Controls Company.

Michael Campbell, B.Tech., has joined Transitron Electronic Ltd as manager of integrated circuit assembly and testing at their Maidenhead, Berks., plant. Mr. Campbell was previously with Marconi-Elliott Microelectronics Ltd, Glenrothes.

OBITUARY

Frederick Sherbrook Barton, C.B.E., M.A., B.Sc., F.I.E.E., who was director of radio engineering in the British Air Commission in Washington throughout the major part of the 1939-45 war and was later principal director of electronics research and development in the Ministry of Supply, died in June. After service in the Navy and Air Force in the first world war he returned to Cambridge University. On completing his studies he joined the Radio Dept. of the Royal Aircraft Establishment in 1922. He became head of the department in 1934. Among the posts he held, in addition to those already mentioned, was that of defence supply adviser to the High Commissioner, Ottawa, from which he retired in 1960. He had since served on the boards of several companies and was for some time secretary of the U.K.-Eire section of the I.E.E.E.

William Dubilier, who in 1912 formed what is now the Dubilier Condenser Company, died at the age of 81 at Palm Beach,Florida on July 25th. One of the early wireless pioneers he is best known for his invention of the mica capacitor, although he made many contributions to radio technology.

Harry Roberts, co-founder of Roberts' Radio in 1931, died in June at the age of 59. He was chairman of the company, which throughout has specialized in the manufacture of quality portable radio receivers, and he had been closely associated with the work of B.R.E.M.A.

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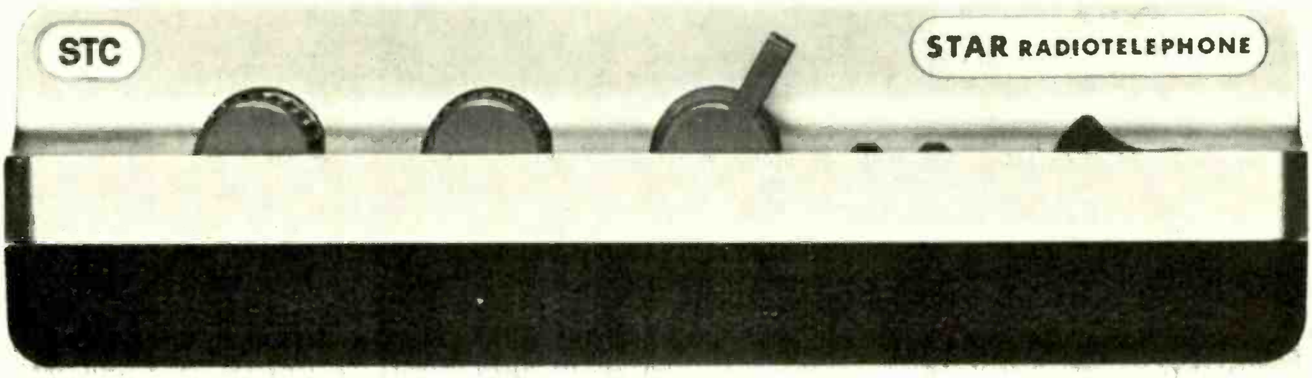
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World of Amateur Radio

could easily be driven into non-linearity by signals many MHz away from the frequency to which they are tuned—many amateurs suspect that a similar situation arises with television receivers. The B.B.C. report suggests that dealers should make it clear to customers buying portable Band II receivers that some sets may not be satisfactory when operated in close proximity to an unwanted transmitter; it also advocates that receivers of good selectivity should be available to the public.

Contests

The R.S.G.B. has announced that, by an extremely narrow margin, Guildford and District Radio Society has been adjudged winners of the 1969 National Field Day. Guildford scored 2375 points with Cannock Chase society only ten points behind. The Bristol Trophy goes to Durham City Amateur Radio Society; the Scottish Trophy to Glasgow City. Forthcoming contests include v.h.f. national field day, September 6th-7th; 3.5 MHz field day, September 14th; and 144 MHz contest, September 21st.

'en years of British adio-teleprinting

'he British Amateur Radio Teleprinter 'roup recently marked the tenth anniverary of its formation in the summer of 1959. lthough some overseas amateurs had been sing radio-teleprinter systems for some ears before this, it is largely to the credit of .A.R.T.G. that this type of operation has ecome firmly established—if still only as a ninority interest—in the U.K. Much of the arly enthusiasm was generated by such adio-teleprinter stalwarts as Dr. Arthur 'ee, G2UK, Bill Brennan, G3CQE, and rthur Owen, G2FUD, who encouraged ritish amateurs to search through scrap ards and surplus stores to find long-disarded teleprinter units, including battered 'reed 3X and 7B printers or odd finds of orenz, Siemens and Teletype units. Today, number of amateurs have acquired more odern machines, The Teleprinter group can ill claim this sector of amateur radio as ne of the fields which calls for individual fort, expertise and a do-it-yourself pproach. Landmarks in the B.A.R.T.G. istory include many demonstrations at the nnual Amateur Radio Exhibitions and the rst publication in the U.K. of an amateur R.T.T.Y.* Manual" in 1961.

The different band rates in use in various ountries have been largely catered for by sing dual-speed governors. Early freuency-shift was usually 850Hz but 170Hz now also becoming established. Present cretary of B.A.R.T.G. is Dennis Goacher, 3LLZ, 51 Norman Road, Swindon, 'iltshire.

The Canadian Amateur Radio Teletype roup has announced a "DX Sweepstake" take place from October 4th to 6th. pecial format log sheets (to allow processing results by computer) available from .A.R.T.G., 85 Fifeshire, Willowdale 430, ntario, Canada (s.a.e.).

mple or complex?

complaint sometimes heard in amateur cles is the increasing complexity and ofessionalism of stations; although fortutely it remains true that excellent results n still be achieved with quite modest transtters and aerials. A look through recent ges of my log book underlines the wide variation in powers and aerials in current use on the 14-MHz c.w. band. While many American West Coast stations—the traditional home of "Californian kilowatts"—run their full legal power input of 1kW, achieving effective radiated powers of up to about 10kW by using multi-element Yagi or cubical quad beams, it is possible to note excellent signals from station WB6HYM of Los Angeles using only 10 watts. Plenty of loud signals have been coming in also from stations using simple vertical aerials, dipoles or even the now relatively rare, but once very popular, "zepp" aerials. K2INP/VE1 in Nova Scotia is one of quite a number of stations putting out excellent signals from indoor h.f. aerials. On the other hand, HA5DI in Budapest has a dipole 150 ft high, and an unusually ambitious array is that of K6UYC near Los Angeles with a 14-MHz six-element Yagi beam at a height of 135 ft. But topping the height/effort league in recent weeks must be the enthusiasts at 5Z4RS/A operating 14,000 ft up on Mount Kenya. Typically, American input on this band and mode is around 300 watts with a beam aerial; European stations still average under 100 watts, with various forms of dipoles and vertical "ground plane" aerials in a substantial majority.

*adio-teletype

Increasing interest in n.b.f.m.

The number of British amateurs using narrow-band frequency-modulation, particularly on 70 and 144 MHz but also on 28 MHz, is rising steadily. The main attraction of this mode of operation, apart from transmitter simplicity, is the lower susceptibility of television receivers to interference from stations using n.b.f.m. compared with a.m. or s.s.b. Further support for this belief in greater immunity to television and/or broadcast interference is provided by a recent B.B.C. Research Report (No 1969/9 "The susceptibility of portable Band II f.m. receivers to interference by services operating in adjacent frequency bands" by C. R. G. Read). This report suggests that typical portable broadcast receivers used near base or mobile transmitters may tolerate a 10 to 20 dB higher level of local signal than for a.m. transmitters. One of the significant mechanisms by which loud a.m. signals can cause interference to a broadcast receiver is by "pulling" the local oscillator of the set. It was also noted that the receiver front ends

In Brief: A.R.R.L. plan to introduce a new five-band "Worked All States" award on the lines of the recent five-band DXCC. . . . South Birmingham Radio Society have announced a new "Worked All Birmingham Postal Districts Award"—details from R. A. Brice, 53 Leycroft Avenue, Tile Cross, Birmingham 33 (s.a.e.). . . . The Sheffield University beacon transmitter, GB3SU, on 70.695 MHS has a new omni-directional aerial 120 feet above ground. Reports are welcome, particularly from distances exceeding 100 miles, and should be sent to Tony Whitaker, G3RKL, Department of Electronic and Electrical Engineering, The University, Mappin Street, Sheffield S1 3 JD. . . . Lothians Radio Society will operate a demonstration station, GB3EIF, at Heriot-Watt University, Mountbatten Building, Grassmarket, Edinburgh 1, from September 1st to 12th during the Edinburgh International Festival—there will also be an exhibition of members' equipment and a demonstration of closed-circuit television. . . . A mobile rally is being held on September 28th at Magdalen Lower Village Hall near Harlow (details from B. G. King, G8CHC, 36 Upper Park, Little Parndon, Harlow, Essex). . . . Some Polish amateurs are now using the special prefix 3Z1 to 3Z9 to commemorate the 25th anniversary of the country's Liberation—this prefix will remain in use until July 1970. . . . A group of German amateurs in Munich are experimenting with a 144 MHz translator which will be carried to heights of about 30 km by a balloon permitting contacts between stations up to 1000 km from the translator. . . . A.R.R.L. headquarters station, W1AW, is to begin a beacon service on one or more v.h.f. bands. . . . Transatlantic auroral reception of B.B.C. Channel 1 television transmissions have been reported by American and Canadian amateurs. . . . GB3WRA is to be operated at the Wycombe Show, High Wycombe, on September 6th—visiting amateurs especially welcome.

PAT HAWKER, G3VA

Amateur Communications Receiver

3: Final circuit details and alignment procedure

by D. R. Bowman, A.M. Inst. E., G3LUB

Until the advent of the field effect transistor the overload performance of transistor r.f. and mixer stages has been shown to be much inferior to similar systems using valves. The single gate f.e.t. does have a drawback when used as an r.f. amplifier because superior cross-modulation performance is not maintained when reverse a.g.c. is applied. This is because at reduced drain currents the forward transfer characteristic deviates from a square law.

If two f.e.ts are connected in cascode reverse a.g.c. can be applied to the common gate stage. Circuits such as this have a very wide dynamic range which increases as the gain of the device is reduced. The application of a.g.c. causes very little detuning of the r.f. circuits.

The 3N140 consists of two metal-oxide transistors connected in cascode. The local oscillator drive is fed to one of the gates giving good isolation between signal and oscillator. The local oscillator drive power required is only of the order of 10μW.

The particular circuitry used to apply a.g.c. to the r.f. amplifier (Fig. 21) has a marked effect on the final front end large signal performance. The best overall performance requires reverse a.g.c. to be applied to gate two while partial forward a.g.c. is supplied to gate one. The simplest method of producing forward a.g.c. for gate one to include an r.f. bypassed resistor in the source circuit. This produces auto-biasing when the gate one return resistor is referred to the base of the 100Ω auto-bias resistor in exactly the same way as a valve auto-biasing system.

If the potential of gate two is varied over a range relative to the source of +2V to −1V then the overall r.f. gain will be controlled over at least 40dB. The a.g.c. line of the i.f. amplifier varies over a range of +5·5 to +0·5 volts. In order to make the r.f. stage a.g.c. requirements compatible with the i.f. it is necessary to refer the r.f. stage to a 2-V rail and not earth. This allows the a.g.c. rail at 1V to appear as −1V relative to the r.f. stage source electrode. The diodes D_1 and D_2 protect the circuit from stray r.f. fields which may be encountered when the receiver is used with a transmitter.

The mixer

The dual gate f.e.t. has a definite advantage over single gate devices when serving as a mixer. The single gate mixer depends upon non-linearity which occurs when drain current is small. This process is akin to the valve bottom bend mixer.

From Fig. 9 it can be seen that the conversion gain of the mixer is directly related to the local oscillator drive voltage. The diagram also shows that the spurious signals generated within the mixer are highly dependent upon oscillator drive voltage. As gain is of secondary importance to the reduction of unwanted signals the level of oscillator drive to the mixer is set to around 0·5V. The d.c. stability of the bias applied to gate two is very important and the potential divider is referred to the source electrode and not the earth line for this reason.

H.F. crystal filters tend to exhibit spurious responses and in order to eliminate these a 9MHz i.f. transformer is used to couple the mixer to the filter (Fig. 21).

The manufacturer suggests that the filter's input and outpu circuits should be brought into resonance with 30pF parall connected trimmers. In practice it was found that fixed 22p capacitors are adequate.

It is essential that the input of the filter is screened from th output. The filter has an out-of-band rejection in excess of 80d and it is essential that the h.t. supply decoupling is perfect. Whe the receiver is complete it is quite simple to disconnect the inpu lead and earth the exposed filter terminal. If the stop band adequate the input from a signal generator should be attenuated b at least 80dB.

This is the most exacting section of the receiver as it is essenti that the local oscillator waveform be as free from unwante components as possible. The synthesizer consists of a number sub-units which will be dealt with in turn.

Local oscillator synthesizer The v.f.o.

The variable frequency oscillator (Fig. 22) consists of a bas Colpitt's circuit with a very large *C* to *L* ratio. The large value of tends to smother any variation of capacitance in the transisto The stability of the completed receiver is almost entirely dete mined by this circuit and for this reason great care should b exercised during its physical construction.

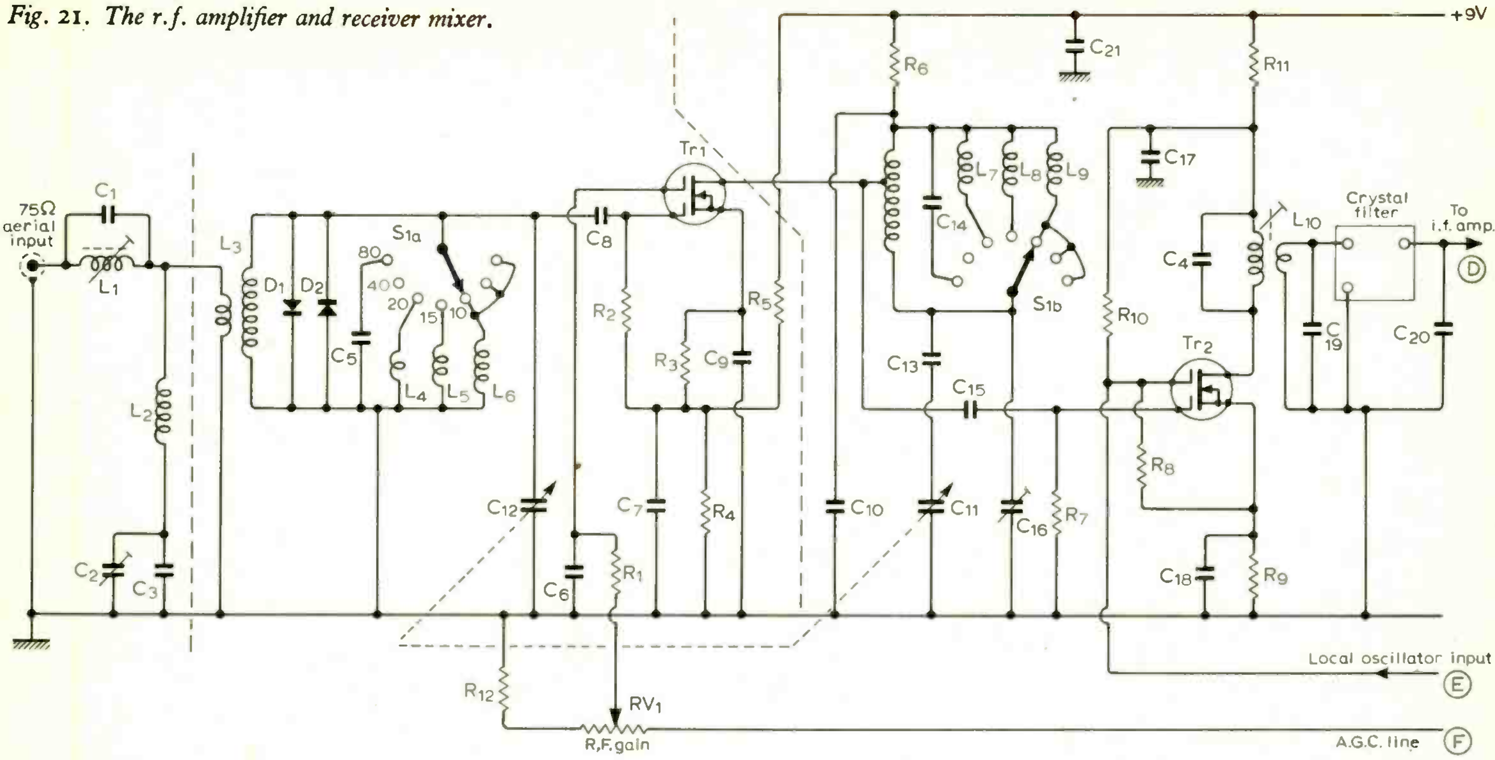
The author has found that the most linear dial calibration obtained if a straight line variable capacitor is used. The particul type recommended is a Polar or Jackson 6–75 pF double ball-ra variable which, with careful adjustment to the outside vanes, ca be made to track over the 500kHz required. The linearity further improved if only the first 140 degrees of rotation is use This is because the straight line capacitance law does not ho when the capacitor blades are well out of mesh.

The coil, which has an iron, not ferrite, core, should be wour with great care. The frequency drift with temperature is almo entirely determined by the changes in inductance of the coil. It fairly simple to temperature compensate using negative temperatu coefficient ceramic capacitors connected in parallel. The temper ture induced drift characteristics will differ from v.f.o. to v.f.o. the diagram includes only an approximate value for these ca acitors.

The only unwanted component that was measurable in the ou put of the v.f.o. isolation amplifier of the prototype was the secor harmonic which was greater than −50dB below the require signal.

This waveform is fed, via a wideband coupler (5–5·5MHz), the synthesizer mixer. This filter has the effect of reducing th v.f.o. harmonic content still further. From the check voltage tab it will be seen that the v.f.o. transistor has a rather large decouple collector resistor. This helps to restrict the output waveform wit a corresponding reduction in harmonic content. If the circu refuses to oscillate this resistor can be reduced.

Fig. 21. The r.f. amplifier and receiver mixer.



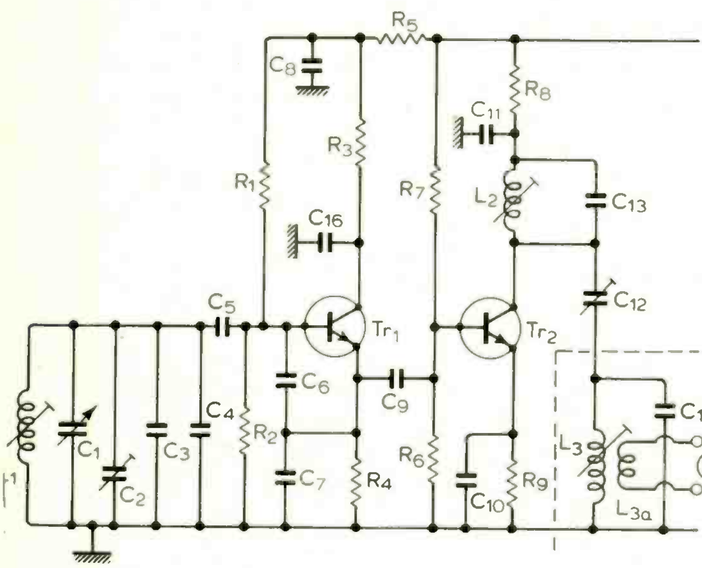


Fig. 22. The v.f.o. section of the local oscillator synthesizer.

H.F. crystal oscillator

The circuit used (Fig. 23) is reliable with new crystals, however the alignment instructions must be followed carefully as the circuit is really only a locked oscillator which will in certain circumstances oscillate at a frequency unrelated to the crystal frequency. The overtone frequency is determined by the collector resonant circuit which helps to reduce the unwanted harmonic outputs.

Frequency synthesizer mixer and S meter

The circuit shown in Fig. 23 is a balanced mixer using two junction f.e.ts. One disadvantage of this system is that the mixer has to be operated as a straight v.f.o. amplifier on the 20 and 80 metre bands. The gain can be expected to differ considerably from amplifier to mixer mode. If the steady state mixer drain current is increased from pinch-off it will be seen that the mixer gain decreases as the amplifier gain increases. This effect has been used to equalize the mixer and amplifier gains.

The S meter circuit (Fig. 24) is straightforward. Potentiometer RV_1 controls the sensitivity whilst RV_2 the meter zero. The two should be adjusted alternately until the S meter reads S9 with a

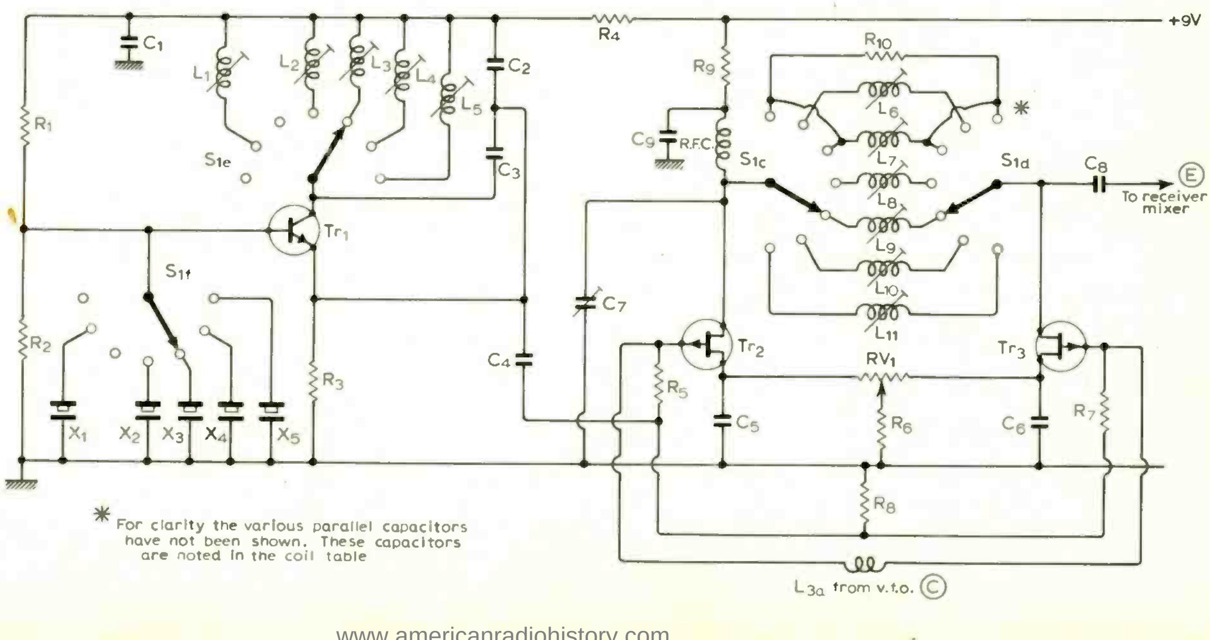


Fig. 23. The h.f. crystal oscillator and mixer section of the local oscillator synthesizer.

256μV signal at the aerial input socket. The author chose to use the convention of 6dB per S point. S1 being 1μV; S2, 2μV; S3, 4μV; etc. The range of the S meter should be S1 − S9 + 60dB.

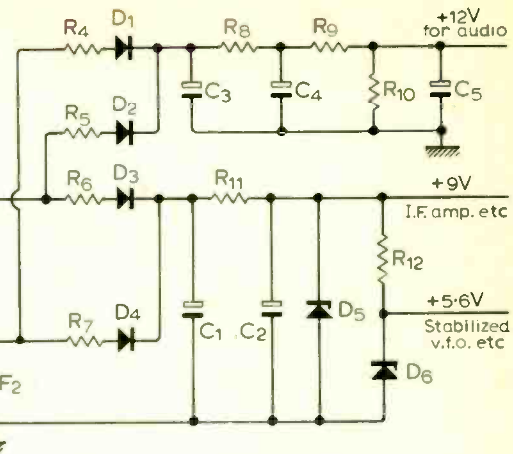
Fig. 26 shows the various sections of the prototype which have been described in this issue.

Power supply

The receiver's power requirements are as follows: +12V unstabilized at 75mA, +9V stabilized at 50mA, and +5·6V stabilized at 8 mA.

The +12V rail is required to power the audio amplifier and although it is not necessary for it to be d.c. stabilized it must have good dynamic regulation. The 9V supply (Fig. 25) is derived from a 9V zener stabilized line driven from a separate fullwave rectifier.

Fig. 25. Power supply circuit.



Alignment procedure

The following test equipment is required. A valve voltmeter or a f.e.t. voltmeter with an r.f. probe, and a signal generator or some other source of frequency calibrated r.f.

The d.c. conditions of all circuits should be checked first. The readings noted in the tables are those measured on the author's receiver and should be taken as a guide only. If the constructor's measurements are within ±10% of the figures given, then all can be assumed to be well.

The signal generator should be adjusted to supply about 100mV at a frequency of 9MHz and should be coupled via an 0·01μF capacitor to the i.f. amplifier's input terminals. The a.g.c. line should be temporarily disabled and fed from a variable potentiometer rather than the a.g.c. transistor. To do this a potentiometer around 25kΩ should be connected between the 9V supply and earth with the wiper taken to the a.g.c. line which should be disconnected from the collector of Tr_7.

The transformer cores of each stage should be adjusted for maximum output while progressively decreasing the i.f. gain by adjusting the potentiometer in the direction of earth. The alignment should progress through the i.f. amplifier from front to back. It will be necessary to reduce the signal generator output as this alignment proceeds.

Reconnect the a.g.c. line and monitor the a.g.c. voltage. As the signal generator output is varied the a.g.c. line voltage should swing from +2V to +5½V. The a.g.c. characteristic can now be studied. For an input signal reduction of 50dB below 200mV the output should change 3dB. For a further input signal reduction of 30dB the total output audio change will be less than 10dB.

Now the i.f. amplifier detector, crystal b.f.o. and audio amplifier can be coupled up together. With the signal generator adjusted to supply an output of 9MHz a c.w. whistle should be heard issuing from the loudspeaker.

The v.f.o. and amplifier comes next. The r.f. present on the collector of Tr_2 will be a function of the position of the tuning slug of L_2 and therefore is at this stage likely to have a different value to that noted in the tables. If this circuit should fail to oscillate, it may help to reduce the value of R_3.

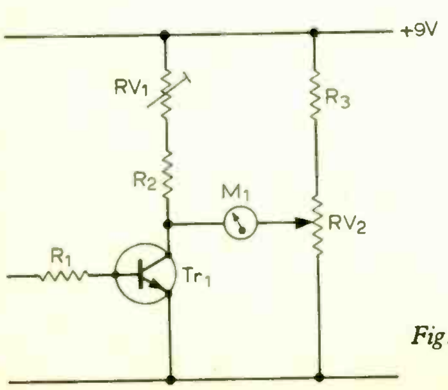


Fig. 24. The S metre circuit.

If a general coverage receiver is available the frequency at which the v.f.o. oscillates should be measured. With careful adjustment to the iron dust core of L_1 and trimmer C_2 the v.f.o. output signa should cover the range of 5·0 to about 5·6MHz. It will be notec that a range of 5·0 to 5·5MHz is the required range. The over-lap 100kHz being left unused as the oscillator exhibits an increasingly non-linear characteristic as the variable capacitor nears its minimum capacitance.

For the following adjustments the receiver tuning should be se to one end of the range where the v.f.o. frequency is 5·4MHz. To set up the wideband coupler C_{13} should be completely unmeshec (minimum capacitance) and with the diode probe and the valve voltmeter connected across L_3, the cores of L_2 and L_3 should b adjusted for a maximum indication. Bring C_{13} about half-way int mesh and as the v.f.o. is tuned a double output response should b evident similar to the curve shown in Fig. 4 (July issue). If thi response is unobtainable check that L_2 and L_3 are not in clos proximity to each other or alternatively, screen them from each other.

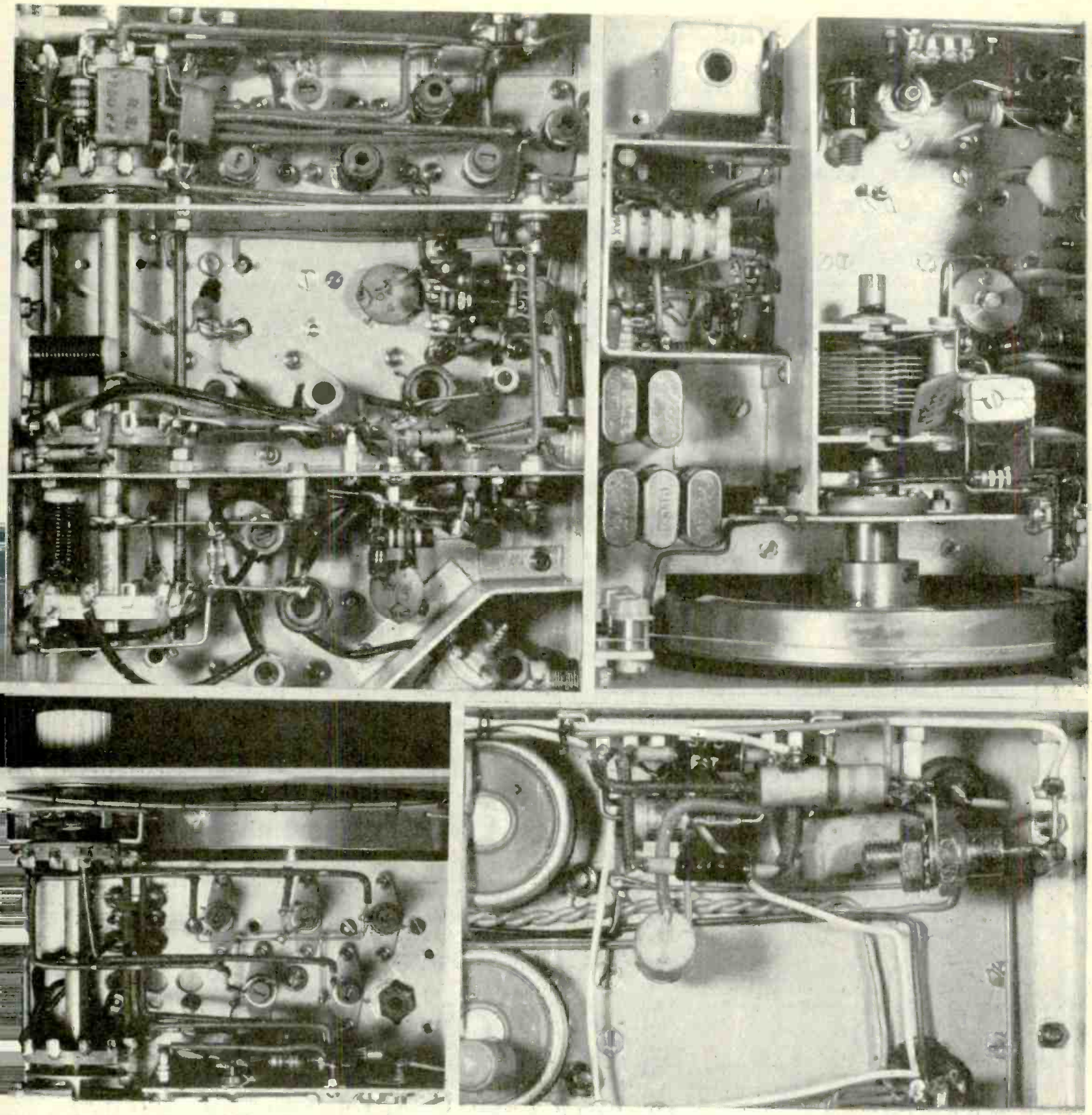
The next move is to check the d.c. state of the synthesizer mixe consisting of Tr_2 and Tr_3. Set RV_1 to the centre of its travel. A this stage only coil L_7 need be in situ in the mixer drain circuits With very great care, noting first to discharge the diode probe t earth, measure the 5·25MHz output of the mixer stage whic should be switched to either the 20 or the 80m range. The core o L_7 should be adjusted for maximum output indication. Make sur that the valve voltmeter is securely earthed to the receiver chassi prior to making the actual measurements.

Set the receiver range to the 20-metre band without tunin slugs in either L_3 or L_{11}.

The signal generator should be adjusted to deliver about 0·1V at a frequency of 14·25MHz to the receiver's r.f. input socket. A the receiver mixer is being driven with the amplified 5·25MHz v.f.o. signal a whistle can be heard from the loudspeaker as th v.f.o. tuning is swept across 5·25MHz. Having found the signa the front end pretuning control C_{11} and C_{12} should be peakec At this stage the v.f.o. calibration can be finally set. The v.f.o pre-mixer 5·25-MHz coil L_7 should be peaked for maximum receiver gain. The receiver should work on 80 meters if th bandswitch is changed appropriately.

Switch to 40 metres and, with the signal generator adjusted to 7·25MHz, the receiver tuning should be scanned until a signal about the dial centre is found. The tuning should be adjuste down in frequency to about 7·05MHz where the core of th synthesizer mixer L_6 should be adjusted for maximum receive gain. Now reduce the signal input to the receiver until the meter reading is about half-scale. While watching the S mete reading adjust the C_{11}, C_{12} and C_{17} front end tuning for maximum indication. It may be necessary to reposition C_{17} across the ga tuning capacitor.

Next set-up the i.f. filters as follows: Set the signal generator t 9MHz and with maximum output adjust the core of L_1 and C_2 for minimum S meter reading. It is now only necessary to adjust th



ʾig. 26. Various sections of the completed receiver; top left from top to bottom — local oscillator synthesizer, receiver mixer and r.f. stage; ottom left — h.f. crystal oscillator; top right — v.f.o. amplifier, and h.f. oscillator crystals; bottom right — underside of power supply.

alance of the synthesizer mixer. As the spurious response of the ‑econd section of 10 metres happens to be 42MHz (the sound hannel of BBC 1 television in the South of England) it is wise to set ıe balance for this range.

Select the 28·5–29MHz range and adjust the synthesizer mixer ıtput coil L_{10} for maximum receiver sensitivity. Next adjust the ont end tuning C_{11} and C_{12} whilst an iron dust core is first tried L_6 and in L_9 always adjusting for maximum S meter deflection. may be that no core will be required. It is sometimes of help have a brass coil core made of a small piece of 0B.A. brass bolt ith a slot in the end. The brass core will reduce the coil induct‑ ıce and if it is found to improve things do not leave it in use; ‑sert an iron dust core into the other coil instead.

Set the signal generator to about 42MHz until the spurious response is heard. If a signal generator is not available then the BBC 1 signal from a TV aerial could be used for this adjustment. The mixer should be balanced by adjusting RV_1 and C_7 for a minimum response. In practise it will be found necessary to make this adjustment a number of times, occasionally returning to re-adjust L_{10}. Although the mixer balance can be optimized for only one frequency, it will hold quite well over all the ranges.

The author strongly advises the constructor to resonate the mixer output coils in the way stated and not by using an r.f. probe to measure the output. It is quite easy to adjust for one of the many unwanted mixer or harmonic products present in the drain circuit. The remaining ranges should now be aligned using a similar technique to that already described. The appropriate mixer output coils should be adjusted for maximum sensitivity when the tuning is set to the centre of the required band, (7·05, 14·25, 21·2, 28·25, 28·75 and 29·25MHz).

It is now only necessary to set the two sideband crystal frequencies to about 20dB down either side of the i.f. crystal filter's characteristic. Set the signal generator to produce a known appropriate S meter reading, and increase the output power of the signal generator by 20 dB. Now tune the receiver until the S meter returns to the same reading. At this setting the appropriate trim capacitor either T_1 or T_2 should be adjusted until the audio zero beats change sidebands. Repeat for the other crystal.

The b.f.o. switch upper/lower sideband will be reversed on certain ranges. This can be overcome by noting on the front panel that on 20 and 80m the sideband is reversed.

On 80 metres it may be necessary to equalise the value of parallel capacitance appearing across L_3 and L_{11}. A small trimmer (2–10pF) should be tried alternately across C_5 and C_{15}. If after careful adjustment in either position an increase in sensitivity is noted on the S metre then permanently connect the trimmer.

COMPONENTS LIST

r.f. amplifier and receiver mixer

R_1	56kΩ	R_4	150Ω	R_7	330kΩ	R_{10}	1MΩ
R_2	330kΩ	R_5	430Ω	R_8	56kΩ	R_{11}	220Ω
R_3	100Ω	R_6	47Ω	R_9	100Ω	R_{12}	680kΩ

all resistors ±5%, 0·25W, carbon.

C_1	200pF*	C_8	100pF*	C_{15}	100pF*
C_2	8–30pF§	C_9	0·1μF†	C_{16}	12pF△
C_3	22pF*	C_{10}	0·1μF†	C_{17}	0·01μF†
C_4	50pF*	C_{11}	6–75pF≠ (with C_{12})	C_{18}	0·22μF
C_5	100pF*	C_{12}	6–75pF≠ (with C_{11})	C_{19}	22pF*
C_6	0·01μF†	C_{13}	0·01μF†	C_{20}	22pF*
C_7	0·01μF†	C_{14}	100pF*		

† disc ceramic.
§ Philips trimmer.
≠ Jackson U102 twin gang.
* silver mica.
△ trimmer.

F_1	KVG type XF-9B 9MHz crystal filter. Obtainable from: Lowe Electronics, 50/52 Wellington St, Matlock, Derbyshire.
Tr_{1-3}	3N140, 3N141, 40600, MEM554C or MEM564C.
D_{1-2}	BAY38 or 1N916.
$S_{1(a-b)}$	Two wafers each single-pole, 7-way. Range change switch.
RV_1	500kΩ log. potentiometer.

variable frequency oscillator

R_1	10kΩ	R_4	560Ω	R_7	47kΩ
R_2	10kΩ	R_5	100Ω	R_8	430Ω
R_3	1kΩ	R_6	22kΩ	R_9	1kΩ

all resistors ±5%, 0·25W, carbon.

C_1	6–75pF≠	C_6	3,000pF*	C_{11}	0·01μF†
C_2	5–30pF§	C_7	1,000pF*	C_{12}	2–8pF§
C_3	10pF‡	C_8	0·01μF†	C_{13}	68pF*
C_4	100pF*	C_9	50pF*	C_{14}	68pF*
C_5	100pF*	C_{10}	0·01μF†		

† disk ceramic.
§ Philips trimmer.
≠ Jackson U101 single-gang variable capacitor.
‡ approx. value; negative temperature coefficient ceramic.
* silver mica.

Tr_{-12} .. 2N706

overtone oscillator and balanced mixer

R_1	33kΩ	R_4	330Ω	R_7	1kΩ	R_{10}	4·7kΩ
R_2	10kΩ	R_5	1kΩ	R_8	22kΩ		
R_3	470Ω	R_6	560Ω	R_9	270Ω		

all resistors ±5%, 0·25W, carbon.

C_1	0·01μF†	C_4	25pF*	C_7	8–30pF§
C_2	47pF*	C_5	0·1μF†	C_8	10pF*
C_3	25pF*	C_6	0·1μF†	C_9	0·01μF†

† disk ceramic.
§ Philips trimmer.
* silver mica.

Tr_1	2N918, TIS48, ME3002, BFY90 or 2N4292.
Tr_{2-4}	MPF103.
RV_1	1kΩ, linear, preset.
r.f.c.	25mH r.f. choke.
S_1	6 wafer, single-pole, seven-way range change switch.
crystals	see table one, p. 299, July issue. New items should be used.

S meter

R_1	470kΩ	R_2	1kΩ	R_3	1·5kΩ

RV_1	20kΩ, 0·25W, skeleton potentiometer. Sensitivity
RV_2	500Ω, ,, ,, Set zero
Tr_1	BC109
M_1	1mA f.s.d. meter.

power supply

R_4	4·7Ω	R_7	4·7Ω	R_{10}	330Ω
R_5	4·7Ω	R_8	10Ω	R_{11}	56Ω
R_6	4·7Ω	R_9	10Ω	R_{12}	3·9kΩ

all capacitors (five) 1000μF 25V working.

D_{1-4}	BY100, FST 1/2, Rec 50A, Rec 52 or any 50 p.i.v. 250mA rectifiers.
D_5	5·6V, 0·25W, Zener. OAZ242, OAZ202.
D_6	9V, 1W, Zener. SZ91A, OAZ291.
T_1	Standard mains primary transformer with 9-0-9V secondary at 0·5A. Available from Haversons Surplus Co., Ltd, 170 High St, Merton, London S.W. 19.
F_1	500mA fuse.
F_2	1A fuse.

VOLTAGE CHECKS

Conditions: r.f. and i.f. gain controls at maximum unless otherwise stated. Al measurements taken with respect to chassis.

Equipment: d.c. readings taken with a Heathkit (Daystrom Ltd) valve voltmete type V-7Au. All r.f. readings made using a diode probe.

r.f. amplifier

junction R_3/R_4	2·5–2·8V	wiper RV_1	1·6–5·4V

both measurements depend upon signal strength and the position of the i.f. gai control.

receiver mixer

junction R_5/R_6	0.56V	gate two Tr_3	1·0
,, R_{10}/R_{11}	8·0V	junction R_9/R_{10}	8·8

overtone oscillator

junction R_1/R_2	1·5V*	emitter Tr_1	0·74V
,, R_3/R_4	8·8V*	switch $S_{1(f)}$ to X1	1·0V
switch $S_{1(f)}$ to X2	1·1V†	,, ,, ,, X3	1·2V
,, ,, ,, X4	1·2V†	,, ,, ,, X5	1·23V

* set to 15m band with 25MHz crystal out of circuit.
† r.f. output voltage measured at the junction of C_2/C_3 using diode probe.

local oscillator synthesizer mixer

source Tr_2	1·0V*	junction R_9/r.f.c.	7·(
,, Tr_3	1·6V*	across $L_{3(a)}$	0·2V

* depends on matching of Tr_2 and Tr_3.
† r.f. voltage.

variable frequency oscillator

junction R_1/R_2	2·6V	collector Tr_1	2·
,, R_6/R_7	1·6V	,, Tr_2	1·0
,, R_8/C_{11}	5·5V	emitter Tr_1	1·
,, R_1/R_5	5·6V	,, Tr_1	0·19
,, R_5/R_8	6·0V	,, Tr_2	1·

† r.f. voltage.

i.f. amplifier

junction R_1/R_2	2·4V	collector Tr_1	
,, R_6/R_7	8·5V	,, Tr_3	7·
,, R_8/C_{11}	2·2V	,, Tr_5	8
,, R_1/R_5	8·9V	,, Tr_7	8·7–0·2
,, R_5/R_5	1·8V	emitter Tr_3	1
base Tr_1	4–0·2V§	,, Tr_5	1
,, Tr_3	3·6–0·2V§	,, Tr_6	1
,, Tr_5	5V	supply voltage	9·
,, Tr_7	0·2V†		

§ i.f. gain varied.
† r.f. measurement made with a 100mV input signal at aerial socket.

product detector and b.f.o.

emitter Tr_1	0·33V	collector Tr_1	2·(
,, Tr_2	0·3V‡	,, Tr_1	5
,, Tr_3	0·34V	,, Tr_2/Tr_3	5
base Tr_1	0·96V	junction R_6/R_7	0·1
,, Tr_2	0·8V	detector	
,, Tr_3	0·83V	signal input	10m

† r.f. measurement.
‡ 0·06V with no b.f.o. crystal.

audio amplifier

collector Tr_1	0·1V≠	emitter Tr_1	6
,, Tr_1	5·8V	,, Tr_2	6
,, Tr_2	1·8V≠	junction R_1/R_2	4
,, Tr_3	7·0V	,, R_3/R_5	(
base Tr_1	0·02V≠	,, R_{10}/R_{11}	
,, Tr_2	1·5V	power supply	1(
,, Tr_3	7·8V	across 3Ω	
,, Tr_4	7·0V	loudspeaker	2·0

≠ peak to peak a.f. voltage measured with an oscilloscope with the a.f. gain cor at max.

Corrections: The following errors have occured in this ser The noise formula should have read: e^2 4KTBR Volts. T makes e=0·006μV, not 0·023μV as was stated, however argument which followed was not affected. No starting va was given for R_8 in the a.f. amplifier. The value should be 68

(conclusion)

Test Your Knowledge

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

16. Elementary circuit theory

1. The network shown in Fig. 1 has an alternating voltage applied between terminals 1 and 2. The waveform of the (steady-state) current which flows in each component will be the same as that of the applied voltage:
   (a) whatever the waveform of the applied voltage
   (b) only if the mean value of the applied-voltage waveform is zero
   (c) only if the applied-voltage waveform is symmetrical about the time axis (zero volts)
   (d) only if the applied-voltage waveform is sinusoidal.

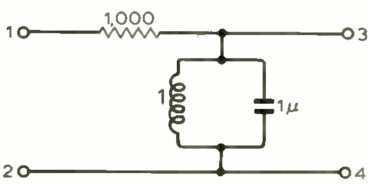


Fig. 1

2. A sinusoidal potential of 5 volts r.m.s., requency 40 Hz, is applied between terninals 1 and 2 of the circuit shown in Fig. 2. The reactance of a 1μF capacitor at his frequency is 4 kΩ. The current which flows will have r.m.s. value:
   (a) 1 mA (b) 5/7 mA (c) 7/5 mA
   (d) 5/3 mA.

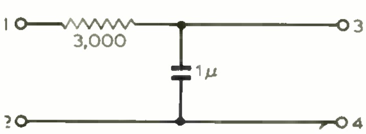


Fig. 2

. The power factor of the circuit of Fig. 2 when driven as specified in question 2 is:
   (a) unity (b) 3/5
   (c) 4/5 (d) 3/4.

4. The circuit of Fig. 2 is again driven as specified in question 2. If both voltages are referred to the common line, the voltage appearing at terminal 3:
   (a) is in phase with the applied voltage
   (b) is in phase-quadrature with the applied voltage
   (c) leads the applied voltage (by less than 90°)
   (d) lags the applied voltage (by less than 90°).

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

5. The input impedance between terminals 1 and 2 of the network of Fig. 1, at a frequency above the resonant frequency of the tuned circuit:
   (a) has a positive argument
   (b) has a negative argument
   (c) has zero argument
   (d) has π/2 argument.

6. A sinusoidal voltage generator is connected between terminals 1 and 2 of the circuit of Fig. 2. Its frequency is initially 1 kHz and is increased, while its voltage remains constant. The voltage between terminals 3 and 4:
   (a) remains constant
   (b) falls at the rate of 3 dB per octave
   (c) increases at the rate of 3 dB per octave
   (d) falls at the rate of 6 dB per octave.

7. A sinusoidal potential of r.m.s. value 10 volts is applied between terminals 1 and 2 of the circuit shown in Fig. 3 at a frequency (159 Hz) at which the reactance of a 1 μF capacitor is 1 kΩ. The voltage appearing between terminals 3 and 4 (the normal convention for comparing phases between input and output being adopted) is approximately:
   (a) 5 volts r.m.s.; leading by 45°
   (b) 5 volts r.m.s.; lagging by 45°
   (c) 7 volts r.m.s.; leading by 45°
   (d) 7 volts r.m.s.; lagging by 45°

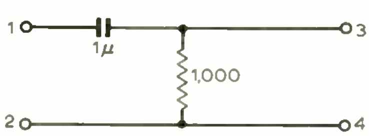


Fig. 3

8. The (complex) input admittance between terminals 1 and 2 of the circuit shown in Fig. 3 at any frequency:
   (a) has a positive real part and a positive imaginary part
   (b) has a positive real part and a negative imaginary part
   (c) has a negative real part and a positive imaginary part
   (d) has a negative real part and a negative imaginary part.

9. A two-terminal network is connected between terminals 3 and 4 of the circuit shown in Fig. 3. A sinusoidal generator applies a voltage $\hat{V}\sin\omega t$ between terminals 1 and 2 and drives a current $\hat{I}\sin(\omega t+2)$. The two-terminal network must:
   (a) have a purely capacitive input impedance
   (b) consist only of resistors and inductors
   (c) contain a source of electrical energy
   (d) be non-linear.

10. A sinusoidal constant-current signal generator of variable frequency is connected between terminals 1 and 2 of the circuit shown in Fig. 4. As the frequency of the signal generator is varied the power which it delivers to the circuit:
   (a) is constant
   (b) is greatest at the frequency at which the reactances of the inductor and capacitor are equal in magnitude
   (c) is least at the frequency at which the reactances of the inductor and capacitor are equal in magnitude
   (d) is zero at all frequencies.

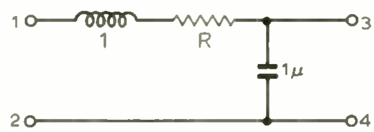


Fig. 4

11. A sinusoidal potential of r.m.s. value 1 volt is applied between terminals 1 and 2 of the circuit shown in Fig. 4. The frequency is such that the magnitudes of the reactances of the inductor and capacitor are equal (angular frequency 1000 radians per second). If R is 10 ohms the voltage appearing between terminals 3 and 4 will be:
   (a) 1/10 volt (b) 1 volt
   (c) 10 volts (d) 100 volts.

12. A battery is connected between terminals 1 and 2 of the circuit of Fig. 4 so as to charge the capacitor. The battery is removed and terminals 1 and 2 are shorted together. A sinusoidal voltage (of decreasing amplitude) will appear between terminals 3 and 4:
   (a) under all circumstances
   (b) under no circumstances
   (c) provided R is less than a critical value
   (d) provided R is greater than a critical value.

13. A battery is connected between terminals 1 and 2 of the circuit of Fig. 1. When the current is steady the battery is disconnected, whereupon an alternating potential appears between terminals 3 and 4. If now terminals 1 and 2 are shorted together the frequency of the oscillation:
   (a) will be unaffected
   (b) will fall
   (c) will rise
   (d) will become zero.

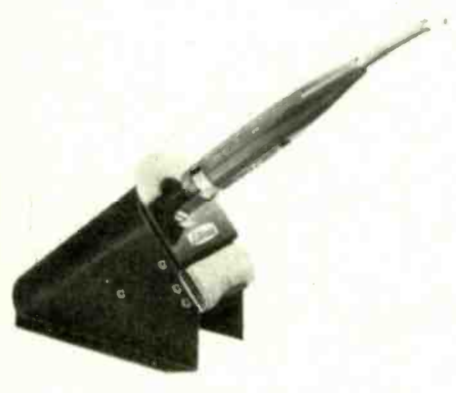
14. A square-wave generator of very high internal impedance, having a frequency of approximately 53 Hz, is applied between terminals 1 and 2 of each of the circuits shown in Figs 1, 2, 3 and 4. In one case the voltage appearing between terminals 3 and 4 is virtually sinusoidal. It is the circuit of:
   (a) Fig. 1 (b) Fig. 2
   (c) Fig. 3 (d) Fig. 4

Answers and comments, page 447

New Products

Soldering Iron Stand

The Litegard bench stand from Litesold is especially designed to hold safely a hot soldering iron, and to present the handle to the user in the attitude in which it is normally held. Both the element and bit are shielded for complete protection. The stand may be mounted on horizontal or vertical surfaces. Designed particularly for use with the Litesold range of soldering instruments up to 35 watts, the Litegard is nevertheless suitable for most other types. The aperture is 0.5in wide and is specially shaped to avoid damage to the



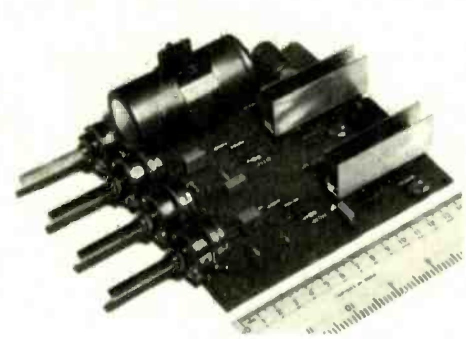
iron and to facilitate insertion. The interior of the stand is ventilated and is fitted with a black-anodised heat shield. These features ensure that the soldering iron is maintained at its normal operating temperature and that the external parts of the stand remain cool. Construction of the Litegard is of anodised aluminium throughout, and a conveniently placed and easily renewable bit cleaning pad is provided just below the aperture. Price 25s. Light Soldering Developments Ltd, 28 Sydenham Road, Croydon CR9 2LL.
WW306 for further details

Peak Programme Meter

Elcom have produced a new AE series peak programme meter—a compact self contained instrument designed to measure programme signal levels in balanced or unbalanced 600-ohm circuits, without affecting the signal levels in the circuit. The amplifying and detecting circuits are mounted on a printed circuit board which fits onto the back of the meter. The instrument can therefore be mounted on almost any panel without special mount arrangements other than the usual clearance holes for the meter body and fixing screws. Connection to the instrument is by way of a 10-way gold plated connector attached to the printed circuit card. The high speed moving coil meter is an Ernest Turner Model 643. Other types of meter in the Ernest Turner range can be supplied to order. Three meter scales are available: types A, B and E. These differ in the labelling of the scale. All three scales are calibrated in 4dB steps with white figures on a matt black background. Provision is made for the connection of an external 'slugging' capacitor and up to four slave meters. Elcom (Northampton) Ltd, Ross Road, Weedon Road Industrial Estate, Northampton NN5 5AD.
WW309 for further details

I.C. Stereo Amplifier

An integrated circuit stereo amplifier for use with gramophone turntable decks is announced by Britmac Electronics. The amplifier is capable of delivering a total power of 18W peak into two 8-ohm speakers at 1kHz. An input signal of 250mV is required to achieve this output power: input impedance is 2MΩ. The frequency response is flat to within 3dB from 30Hz to 20kHz. A full range of balance, volume—or gain—and both bass and treble tone controls is provided, ganged where appropriate. Each of the tone controls provides a range of adjustment of from −12 to +12dB relative to the gain curve of the amplifier itself. Distortion, noise and mains ripple are all low. At an output power level of 9.33W r.m.s. total, total harmonic distortion is 0.4% and the noise level is −75dB measured with a source impedance of 1MΩ. Ripple rejection at the output terminals with respect to the d.c. supply point



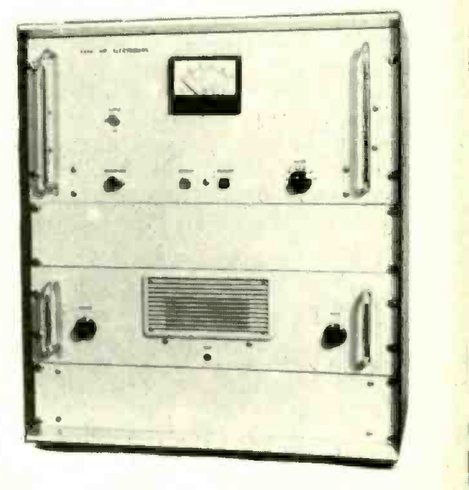
is 30dB. A printed circuit board only 152 × 140mm (6 × 5.5in.) in size supports all the components of the amplifier, controls, power supply rectifier and smoothing circuit. A.C. at 16V is required. Britmac Electrical Company Ltd, Electronics Division, Shelley Road, Preston, Lancs.
WW327 for further details

Double Resistors

Dubilier are now offering two ¼ watt resistors moulded into a single body measuring 9mm × 5mm × 3.5mm (DUO-BT). Designed for digital circuits and other applications where many resistances of equal value are required, considerable savings can be achieved by this highly compact design. Resistance values are in the E12 series between 10Ω and 22MΩ. Resistive tolerance 10%. The rupture voltage between the elements is >4.5kV, insulation resistance between elements 10MΩ and capacitance between elements approximately 1.5pF. The Dubilier Condenser Co. (1925) Ltd., Ducon Works, Victoria Road, North Acton, London, W.3.
WW308 for further details

Transmitter/Receiver Units

Park Air Electronics have developed ground to air transmitter/receiver units for use in airports. Two transmitter models with output powers of 25W or 50W are available, which may be paired with receiver units which use dual gate f.e.t. r.f. and mixer devices, and integrated circuit i.fs. Channelling at either 50 or 25kHz is available. The a.g.c. characteristic is ±2dB from 0 to 100dB



input levels. The units may be operated either locally, with or without extended control; or remotely controlled without switching. Illustrated is the 125ZA 50W output unit with receiver and remote control panel fitted to the same cabinet. The equipment panels fit standard 483mm (19 inch) racks, if required. Park Air Electronics Ltd, Red Lion Square, Stamford, Lincs.
WW301 for further details

Opto-electronic Devices

The MRD 210 and MRD 250 subminiature photo detectors, and the MRD 310 phototransistor, from Motorola, are available in custom-designed arrays or matrices as well as in discrete form. The MRD 210 is a photo detector designed for use in card and tape readers, pattern and character recognition, analogue-to-digital converters (shaft encoders), or any application requiring sensitivity to light, stable characteristics, and high density mounting. Minimum collector-emitter radiation sensitivity is 0.05mA/mW/cm², with a typical value near 0.15mA/mW/cm². The detector is sensitive to the visible and infrared spectrum. Guaranteed maximum rise time is 2.5µ sec, while maximum fall time is 4.0µ sec. The MRD 250 is similar to the MRD 210, but is in a slightly longer package. Sensitivity is 0.1mA/mW/cm² minimum. The MRD 310 phototransistor is contained in a case similar to the popular TO18 package for ease of handling and mounting. It is suitable for use in counters, sorters, industrial inspection, processing and control, alarm systems, switching and logic circuits, and analogue circuits requiring linear characteristics over a wide operating range. The MRD 310 has a minimum collector-emitter radiation sensitivity of 0.2mA/

AUDIO FROM GARDNERS

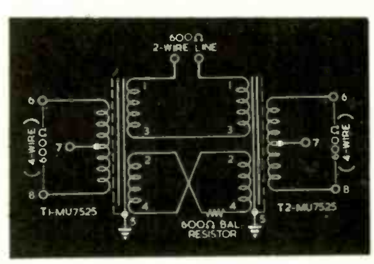
Exceptionally wide band microphone and audio line matching transformers

FREQUENCY RANGE
100 K.ohm models ±1 dB 30 c/s to 20 kc/s.
All other models ±0.5 dB 30 c/s to 20 kc/s.
MAXIMUM AUDIO LEVEL +12 dBm (16mW).
INPUT IMPEDANCE maintained to within ±10% (±20% j) at all frequencies within the range 50 c/s to 8 kc/s (to 5 kc/s only for 100 K.ohm models).
MAGNETICALLY SCREENED
—50 dB reduction in hum pick up.

For professional recording and broadcast transmission equipment, these Octal-based plug-in transformers have a frequency response extending well beyond the audio range. The design achieves dynamic performance with minimum distortion at all levels

Type No.	Input Z Ohms	Pin Nos.†	Output Z Ohms	Pin Nos.	Sec./Pri. Turns Ratio	Applications
MU.7521	3·75/15*	1-3, 2-4	600 (C.T.)	6-7-8	6·32:1/12·64:1	Low Z. Mic/Line
MU.7522	3·75/15*	1-3, 2-4	100K.	6-8	82:1/164:1	Low Z. Mic/Grid
MU.7523	75/300*	1-3, 2-4	600 (C.T.)	6-7-8	1·41:1/2·82:1	Line/Line
MU.7524	150/600*	1-3, 2-4	600 (C.T.)	6-7-8	1:1/2:1	Mixing: Bal./Unbal.
MU.7525	600 (C.T.)	6-7-8	300/1·2K*	1-3, 2-4	1+1:1·41 (C.T.)	Mixing: Hybrid‡
MU.7526	600 (C.T.)	6-7-8	2·5k/10k.*	1-3, 2-4	2·04:1/4·08:1	Line/Grid
MU.7527	150/600*	1-3, 2-4	100K.	6-8	13:1/26:1	Line/Grid
MU.7528	7·5/30*	1-3, 2-4	600 (C.T.)	6-7-8	4·47:1/8·94:1	Low Z. Mic./Line
MU.7529	50/200*	1-3, 2-4	600 (C.T.)	6-7-8	1·73:1/3·46:1	Mic. or Line/Line
MU.7530	10K. (C.T.)	6-7-8	10K.	1-4	1 (C.T.):1	600 Line Bridging
MU.7532	7·5/30*	1-3, 2-4	100K.	6-8	58:1/116:1	Low Z. Mic./Grid
MU.7534	50/200*	1-3, 2-4	100K.	6-8	22·4:1/44·8:1	Mic. or Line/Grid

Type MU.7525 may be used in "Hybrid" circuits, as shown, to establish 2 to 4 wire operation in telephony. Accurate balancing of the windings enable guaranteed rejection of better than — 55 dB from 50 c/s to 10 kc/s. Up to — 75 dB may be expected for normal rejection levels.



Gardners WRITE FOR LEAFLET GT 22 WITH PRICE LIST

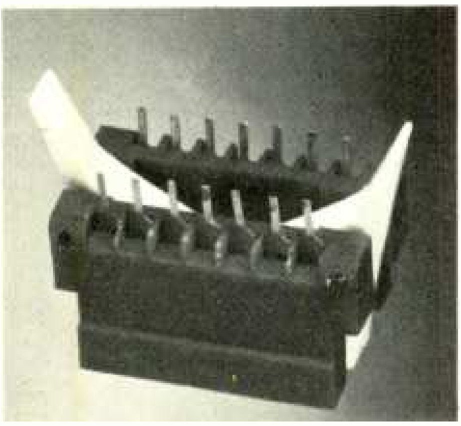
GARDNERS TRANSFORMERS LIMITED
Christchurch, Hampshire BH23 3PN. Tel. Christchurch 2284 (STD 0201 5 2284)
TELEX 41276 GARDNERS XCH

WW—091 FOR FURTHER DETAILS

mW/cm²; however, a connection is provided to the base for added control or improvement of sensitivity. The spectral response and rise and fall times are similar to those of the MRD 210 and MRD 250. Motorola Semiconductors Ltd, York House, Empire Way, Wembley, Middlesex.
WW324 for further details

I.C. Test Jig

A miniature jig for concurrent multipoint testing of 14 pin d.i.p. (TO 116) integrated circuit packages is available from W.E.L. Components. Having very small overhang dimensions it can be used in very high density i.c. assemblies with no disturbance to circuits adjoining the unit under test. Spring loaded clips hold the test jig firmly in place and have thin grip claws to engage with low



-profile mounted units. Gold plated beryllium upper contacts are used to minimize contact resistance which is normally less than 5 milliohms. The unit is moulded Kemetal with Delrin spring claws. The unit is also supplied without clips for mounting in multiples on p.c. boards when production printed circuit assemblies require multi function check and test. The price is 20s each for 100 or more. W.E.L. Components Ltd, 5 Loverock Road, Reading, Berks.
WW323 for further details

Lightweight Heatsinks

Jermyn have added to their range of heatsinks five different versions of lightweight printed circuit board mounted semiconductor coolers. These heatsinks are manufactured from aluminium extrusion and special consideration has been given to the radiating area and low weight of the finished products. Three devices are ready punched to accommodate the TO66 size semiconductor and other types are available undrilled but, in all cases, the products are black anodized to

ensure maximum cooling by radiation. The A25-2014 and A25-2016 are both drilled to accommodate one device and the A25-2017 is drilled to accommodate two TO66 devices. Jermyn Industries, Vestry Estate, Sevenoaks, Kent.
WW320 for further details

Tape-head Cleaning Kit

Bib Division of Multicore introduces a compact tape-head maintenance kit. The kit includes a 30 c.c. bottle of anti-static, non-flammable cleaner, 2 each applicator and polisher tools for applying the cleaner or alcohol for removal of oxide and dirt from the tape heads and all parts of the tape path. 10 double-ended cotton wool tipped sticks are included which may be used for the same purpose for recorders to which easy access cannot be achieved with the Bib tools. They are used also for removing oxide from baseplates of recorders, scraps of tape, etc. An absorbent cloth is provided for cleaning the soiled tools and sticks and the exterior of tape recorders. All these components are contained in a plastic wallet. The recommended retail price is 9s 9d, including 1s 11d purchase tax. Multicore Solders Ltd, Hemel Hempstead, Herts.
WW314 for further details

Incremental Capacitor with 1 pF Swing

A precision air spaced incremental laboratory capacitor box is now available from J. J. Lloyd Instruments with two ranges calibrated to an accuracy of plus or minus 1%.

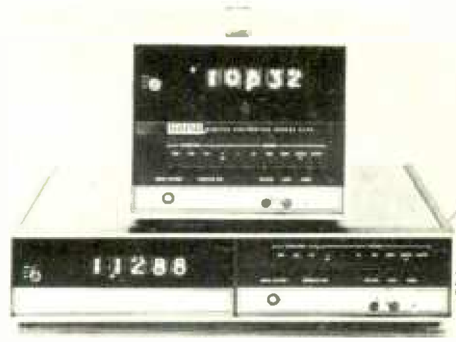
The instrument is primarily intended for applications requiring a very small but precisely known change in capacitance, and should be of particular use for applications involving the design of precision filters and other applications involving the measurement of small capacitance change by substitution methods.

The capacitor is fitted with a slow motion drive and a 6 in. diameter dial engraved with two directly calibrated scales. The first scale is marked 0 to 1 pF or plus or minus 0.5 pF, and the second 0 to 10 pF or plus or minus 5 pF. Each scale is sub-divided into one hundred divisions and the residual capacitance at mid-scale is clearly shown. The incremental ranges are ±0.5 pF and ±5 pF.

Accuracy of calibration at 20°C is ±1%. The maximum d.c. working voltage is 500V, and the maximum recommended frequency is 10MHz. J. J. Lloyd Instruments Ltd, Brook Avenue, Warsash, Southampton SO3 6HP.
WW317 for further details

D.V.M. with Long-term Accuracy

The model 4500 digital voltmeter from Dana is said to have the best long-term stability of any instrument in its price range. This dual-slope d.v.m. is a four-digit instrument with fifth-digit 20% over-range. The high accuracy (±0.01% of reading ±0.01% of full scale for ±5°C over three months) is combined with 75dB at 50Hz normal-mode rejection and 110dB common-mode rejection, to provide noise protection from any source. The exceptional noise rejection is achieved by using integrating techniques in conjunction with wideband active filters. The model has push-button operation and autoranging and autopolarity for all functions



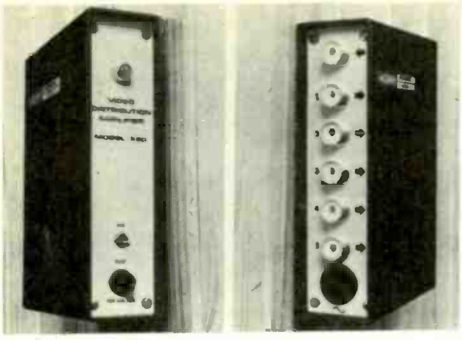
except ratio, and so can be used even by inexperienced operators. The basic five d.c. measuring ranges are from 100mV to 1,000V r.m.s., but these can easily be expanded with plug-in circuit boards to give four a.c. and five resistance ranges. A.B.C.D output is available to order; analogue output and d.c./d.c. ratio measuring are included as standard. The Dana 4500 is available for bench use or rack mounting. The two forms are shown in the photograph. Dana Electronics Ltd, Bilton Way, Dallow Road, Luton, Beds.
WW319 for further details

Sine-squared Pulse and Bar Generators

Two new sine-squared pulse and bar generators are announced by Marconi Instruments. Sine-squared pulse and bar generator TF 2905/4 is for use on 405 line monochrome and 625 line monochrome and colour systems, providing a comprehensive test signal to the most recent recommendations of the European Broadcasting Union and C.C.I.R. A version for 525 line monochrome and colour systems, TF 2905/5, is also available. This instrument can be used with a vertical interval test signal inserter to insert the waveform on to the correct line of the field. The comprehensive test signal produced by this instrument permits the checking of a number of parameters simultaneously. It generates bar, sine-squared pulse and staircase or sawtooth waveforms, and produces T, 2T, 10T and 20T pulses. It may be triggered internally from the crystal oscillator or externally from a television studio system, and costs £752 f.o.b. U.K. Type TF 2905/8 is for use on 625 line monochrome and colour systems; a version, TF 2905/9, is available for 525 line monochrome and colour systems. The instrument provides 5T, 10T and 20T pulses, plus a negative T or 2T pulse in the bar. The test waveforms can be produced either on a train of internally generated line sync pulses or as a composite television waveform, by feeding mixed synchronising and blanking pulses into the generator from external sources. Oscilloscope triggering pulses are available from a "trigger" socket on the front panel. The price of the TF 2905/8 series is £775 f.o.b. U.K. Marconi Instruments Ltd, St. Albans, Herts.
WW315 for further details

Video Distribution Amplifier

A completely self-contained video distribution amplifier, providing five independent 75 ohms signal outputs from one input, is announced by K.G.M. Vidiaids. At a cost of only £42 10s, the new Model 520 amplifier is suitable for the distribution of colour, monochrome or any other types of video signals. Overcoming the inconvenience of looping an input signal to widely spaced monitors, the Model 520 has an added advantage, in that moving or even removing an individual monitor will not affect the signal to other monitors which may be in use. With a bandwidth extending above 8MHz, the amplifier will not



introduce any detectable distortion to a standard video signal. Crosstalk at frequencies up to 4.43MHz is better than –40dB. The amplifier is extremely easy to use, the only control being a mains switch. All other controls have been eliminated. Built in a rugged case, the unit is suitable for wall or floor mounting. Without the case, it can also be rack mounted for use in large installations. K.G.M. Vidiaids Ltd, Clock Tower Road, Isleworth, Middlesex.
WW326 for further details

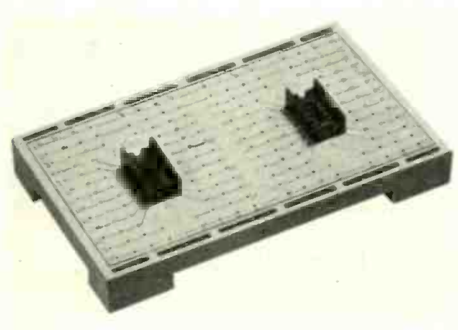
Industrial Video Monitor

Type "1100" monitor from Beulah is a fully transistorized unit employing an 11in direct viewing tube with metal-backed screen and reinforced envelope. The monitor, operating on a

625-line scanning system with a bandwidth of 5MHz, is claimed to have high definition. Construction is rugged. Negligible heat is dissipated so the monitor may be stacked or fitted in enclosures without special ventilation. All operational controls are on the front panel. Beulah Electronics Ltd, 126 Hamilton Road, West Norwood, London S.E.27.
WW328 for further details

Solderless Breadboards

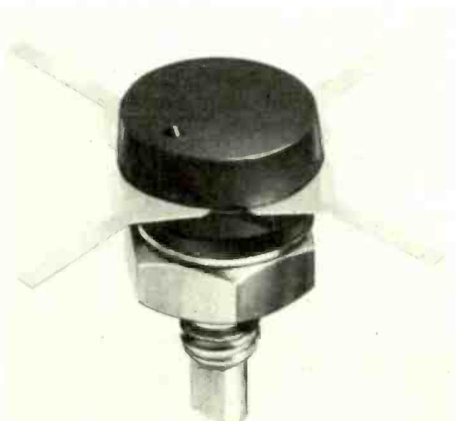
S.D.C. have extended their range of modular solderless breadboarding systems to include two new DeCs specifically designed to accommodate integrated circuits as well as modern short-lead



discrete components and having 208 contact points per DeC. The μ-DeCs, primarily for integrated circuits, can accommodate two 16-lead dual-in-line stations or four 10-lead TO-5 stations. The new T-DeCs, primarily for discrete components, can also accommodate one d.i.l. station or two TO-5 stations. The DeCs are formed from glass-filled nylon enabling temperature cycling tests to be carried out and contacts are either of heavy gauge phosphor bronze in natural finish or gold plate over nickel. The new DeCs may be interlocked to give a stable area of breadboard of any desired size and each DeC has slots to accommodate two control panels. S.D.C. Products (Electronics) Ltd, 34 Arkwright, Astmoor Industrial Estate, Runcorn, Cheshire.
WW338 for further details

V.H.F. Power Transistor

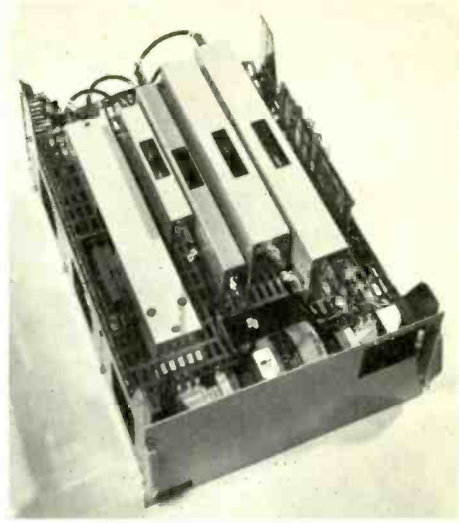
A new n-p-n silicon planar r.f. power transistor, type BLY53A, designed for use primarily in the 450 to 470MHz band is now available from Mul-



lard; it is intended for use in the f.m. transmitters of mobile radiotelephones. Under normal operating conditions with a supply voltage of 13.8V and a drive of 2W, the BLY53A gives an output of 7W into a matched load. The BLY53A can withstand the worst aerial load conditions with a supply voltage of up to 16.5V. The transistor is encapsulated in a silicon resin, and has a capstan outline. Its ambient temperature operating range extends from –30 to +70°C. An application note (TP1101) describing the use of the BLY53A in mobile radiotelephone transmitters is available on request on company headed notepaper. Industrial Electronics Division, Mullard Ltd, Mullard House, Torrington Place, London W.C.1.
WW332 for further details

Solid-state Microwave Link

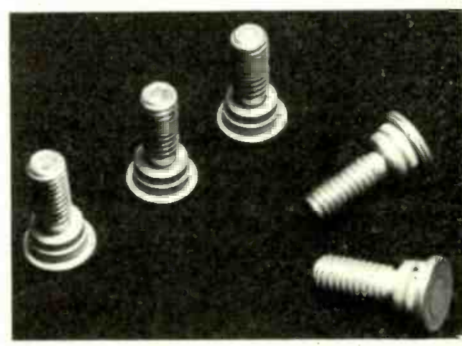
The Communication & Control Group of Ferranti have added a new microwave radio link to their type 14,000 series. The equipment is a solid-state 300-channel telephony and/or data link, suitable for long-haul trunk routes. Designated type 14,000/300, the new equipment comes in a variety of packages to suit the situation and environment of the link. The whole of the 5.9 to 7.9GHz band can be covered; and typical transmitter output is 23dBm from an all-solid-state source, upconverter and 70MHz modulator. The receiver is also all-solid-state. The equipment can be used in fully demodulating or non-demodulating modes. The system gives full C.C.I.R. quality; typically 40dB dynamic range to counter fading, linearity to better than 1% and equalization to better than 2ns over the bandwidth required for 300 channels. Automatic switching, control and supervisory facilities are available to provide for



complex links having, for example, space or diversity frequency, 'hot standby' etc., as well as for simple, low-cost installations. Automatic fault-reporting is a standard feature. Communication & Control Group, Ferranti Ltd, Silverknowes, Edinburgh 4.
WW318 for further details

Varactor Diode

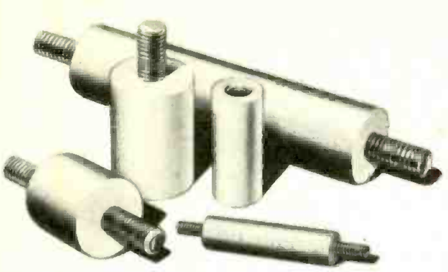
Microwave Associates have available a snap-varactor diode, the MA4-B300, providing a guaranteed minimum output of 8W at 2GHz, in a times-five multiplier circuit. Input power of 30W



is required to drive the multiplier. This is the first of a series with minimum breakdown voltage of 100V and capacitance units of 6-8pF. Maximum thermal resistance is 7°C/W. The MA4-B300 is intended for use in high power frequency multiplier circuits, harmonic generators, signal sources, and other signal processing applications. Microwave Associates Ltd, Cradock Road, Luton, Beds.
WW336 for further details

Insulating Pillars and Spacers

Manufacturers and users of electrical and electronic equipment often have a requirement for insulated pillars for use as spacers, stand-offs and terminal points. The usual ceramic pillars, besides having a limited range of application, are notoriously brittle. Industrial Instruments have produced a new range of nylon moulded insulating pillars known as Transipillars. The company say these are extremely robust, will resist stresses, strains, shock and vibration and can be used in many different ways; also that they can be considered to be unbreakable if subjected to normal use. The range comprises four diameters (from ¼in. to ⅝in.) of varying lengths (½in. to 2in.) and three combinations of stud/insert fitting ar



available, the fourth variation being a spacer, with a clearance hole. Transipillars of the stud/insert type can also be screwed into each other, thus forming extension pieces of any desired length. Prices are from £7 10s per 100 pieces. Industrial Instruments Ltd, Stanley Road, Bromley, Kent.
WW330 for further details

"Lock-in" Amplifier

Aim Electronics announce a simple and inexpensive "lock-in" amplifier (coherent detection system based on a phase sensitive detector). It is claimed to be capable of all the functions of an advanced lock-in amplifier but with slightly reduced specification. The unit will accept input signals as low as 10μ V and can handle amplitudes of up to 1 volt without distortion. Overload-free operation over a frequency range of one octave is possible. The frequency of operation can be specified by the user up tc 50kHz. An internal frequency reference may be used to tune the signal channel to the required frequency. Alternatively the frequency channel will accept any periodic input waveform between 50Ω V and 30V peak as a reference signal. The reference phase is

adjustable through 360°. The phase sensitive detector has three preselected time constants for optimum smoothing of the detected signals and will supply up to ±10 volts d.c. output into a 1kΩ load. A zero-set control allows ±5 volts d.c. zero adjustment so that output offsets may be used in conjunction with output recording instruments. The unit is designed to fit into the Aim modular system. Its price is £176 and, used in conjunction with the Aim Cas 11 and power supply PSU 101, gives a comprehensive system for the recovery of signals buried in noise for as little as £266. Aim Electronics, Cambridge.
WW329 for further details

Digital Read-out Meter

The Digital Avometer type DA112 is little larger than a traditional Avometer. Full multimeter facilities are available with an overall capability on d.c. voltage of 100μ V to 1500V and an accuracy of 0.1% of reading ±0.1% of full range value. On a.c. voltage the basic accuracy is 0.2% of reading ±0.2% of full range with operation up to 100kHz. The input impedance on the 10V range is greater than 1000MΩ and readily accessible controls enable immediate reference to be made to the internal calibration facilities. When mains supplies are not available the instrument may be operated from an internal re-chargeable cell which allows approximately three hours con-

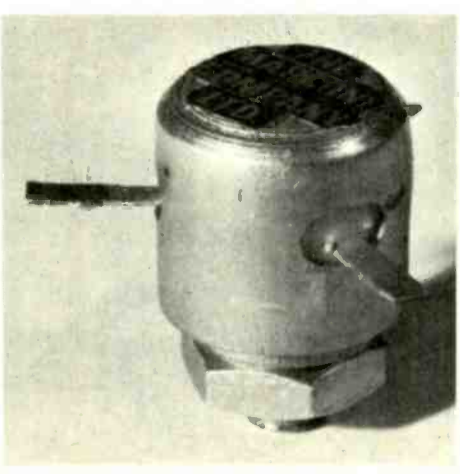
tinuous operation. The meter may also be operated from a 12V car battery. The measured value is presented on a 3½ digit display with automatic decimal point and over-range indication. A print-out socket (parallel BCD 1248 code) is available as an optional extra. Avo Ltd, Avocet House, Dover, Kent.
WW335 for further details

Printed Circuit Connector

Oxley Developments are producing an addition to their range of printed circuit connector pins, the type 050/RP/H for insertion in holes of 0.050 in. diameter (1.3mm). This component, available gold plated or spin-tinned, combines three features eliminating fixing by soldering or riveting. (1) It is tapered for ease of assembly into inaccurate holes. (2) It is splined to inhibit rotation and chipping of the board. (3) It is barbed in order to ensure good grip in both copper clad and unclad laminates. Oxley Developments Co. Ltd, Priory Park, Ulverston, North Lancs.
WW325 for further details

Non-reciprocal Ferrite Junction

A tiny v.h.f./u.h.f. non-reciprocal junction which can operate as a circulator, isolator or phase-shifter (the mode of operation being determined by the external circuitry connected to it) is introduced by Marconi. Only half an inch in diameter and half an inch high, it can easily be mounted on a printed circuit board. It is compatible in size with typical circuit elements currently in use in



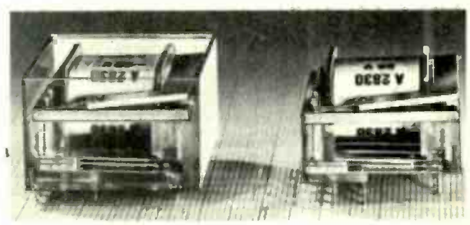
printed circuit and micro-strip work and is magnetically screened to minimize the effects of stray external fields. Its rugged construction enables it to operate in severe environmental conditions. Three types are available. Type F1024-04 has a range of 200-400MHz, F1024-05 a range of 250–500MHz, and F1024-06 a range of 300-600MHz. Instantaneous bandwidth is 3% typical for 20dB isolation. Insertion loss is less than 1dB. Power handling capacity is 10W. The Marconi Co. Ltd, Chelmsford, Essex.
WW333 for further details

Spectrum Analyser

A solid state spectrum analyser, type 150, available from Samwell and Hutton is intended particularly for the detection and measurement of spurious and interfering signals in the range 25 to 140MHz, for setting and analysing telephone/television link modulators, and measurement of the sideband spectra of v.h.f. transmissions. The range 25-140MHz is covered by a single tuning control. Measurements can be made in the range 85-200MHz using the image frequency. The equipment requires a mains supply of 200-260V 50Hz. The instrument can be supplied for standard 19in rack mounting (panel height 8¾in.) or fitted in a case for bench use. Samwell & Hutton Ltd, Delta Works, 54 Goodmayes Avenue, Ilford, Essex.
WW337 for further details

Miniature Relay for PCBs

A new member to the ITT family of relays for printed circuit boards is the Type PZ-6—a 6-changeover version of the well-known PZ style.



The 6-changeover contacts are twin type with a choice of silver/palladium or gold/silver surface. Maximum switched power per contact is 12VA (1A at 100V a.c. or d.c.). The relay is for d.c. operation with 1 or 2 coils. Dimensions of the PZ-6 are 30 × 34 × 20mm. The connections are for direct soldering on to printed circuit boards. ITT Components Group Europe, Standard Telephones and Cables Ltd., Electro-Mechanical Product Division, West Road, Harlow, Essex.
WW313 for further details

100MHz Oscilloscope

The comprehensive features of the TF 2210 from Marconi Instruments include 50mV/cm sensitivity from d.c. to 100MHz, 5mV/cm from d.c. to 75MHz or 500μ V/cm at reduced bandwidth; dual trace with internal triggering from either of two identical Y channels; comprehensive delayed sweep facilities; bright c.r.t. with internal graticule; active probe supplies for each channel; and a calibrator for voltage and current probes. Its 3.5ns rise time permits the display of high-speed waveforms, while its low drift, excellent triggering and bright trace remove the need for special operating skill. Having two identical timebase generators, it can be used for detailed examination of virtually any part of any waveform. The waveform can be displayed on a fast delayed sweep or a slow delaying sweep or both together on separate traces. The dual-timebase facility can be

combined with the dual trace Y input system to view each of two incoming waveforms at two sweep speeds, giving a display comprising four separate traces. Marconi Instruments Ltd, St. Albans, Herts.
WW302 for further details

D.C. Voltage Transformer

This new ConTech unit provides an isolated d.c. signal voltage proportional to its applied d.c. input voltage. It requires no external excitation and its input range is infinitely variable from 0-50 to 0-650 volts d.c. by means of an external series

resistance. Thus only one basic unit need be stocked to cover a variety of applications. The output is 0-10V at 10mA and the input impedance is typically 1.25kΩ. It is intended for use where an isolated d.c. signal voltage is required for measurement or control, in particular for applications such as thyristor drives and motor control. The unit is fully resin encapsulated and measures 44 × 51 × 63 mm. Control Technology Ltd, Meeching Road, Newhaven, Sussex.
WW334 for further details

Channel Search Facility

Pye Telecommunications has introduced a new dual channel search facility for its Westminster range of remote mounted radiotelephones. This allows automatic simultaneous monitoring of two radiotelephone channels, enabling a radiotelephone user to monitor a channel which may be allocated to priority or emergency calls in addition to operating any other channel selected by the channel switch. Dual channel search equipment, designed for use with the Westminster FM mobile radiotelephone, is housed in a compact unit which also includes the normal radiotelephone controls. One of the two channels monitored is that allocated to position "1" on the channel selector switch: the other channel monitored is that selected on the channel selector switch by the operator. With the "search" button pressed the equipment provides continuous sampling of the two channels alternately, each for a period of approximately one second, the receiver locking on to which ever channel first becomes operational. A lock button allows the operator to lock the equipment indefinitely on the channel in use, regardless of the channel switch position. To reset the equipment for dual channel monitoring, a button marked "search" is pressed. A manual override facility is also provided. A special version of the dual

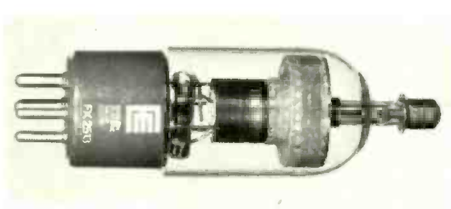
channel search unit can be provided for use with receivers covering widely spaced blocks of channels. Pye Telecommunications Ltd., St. Andrew's Road, Cambridge, CB4 1DP.
WW310 for further details

Tuning Diodes for U.H.F.

Frequency control (either remote or programmed) of u.h.f. circuits is made possible by a new series of high-Q tuning diodes from Motorola. Designated 1N5461 A, B, C to 1N5476 A, B, C these diodes operate over a 30-volt range and are available with a nominal capacitance tolerance of 2 per cent (suffix 'C'). This high uniformity is essential where stage-to-stage tracking in tuning is required or where minimum circuit-to-circuit alignment is a consideration. For less stringent uniformity requirements 5 and 10 per cent ('B' and 'A' suffixes respectively) units are also available. The nominal capacitance range of the series is 6.8 to 100pF over sixteen devices, nominal capacitance being measured at 4V reverse bias. Minimum Q at 4V reverse bias and 50MHz is 600 for the 1N5461A (6.8pF) and 200 for the 1N5476A (100pF). Minimum tuning ratio (capacitance at 2V/capacitance at 30V) is 2.7 for the 1N5461 and 2.9 for the 1N5476A. The abrupt-junction dice is of epitaxial structure, passivated, and packaged in DO-7 glass with the Motorola RamRod construction. Motorola Semiconductors Ltd., York House, Empire Way, Wembley, Middlesex.
WW312 for further details

Hydrogen Thyratron

The type FX2513 hydrogen-filled triode thyratron for pulse operation, recently introduced by English Electric, is specially designed to modulate magnetrons of the 25kW X-band type used in 25kW airborne weather radars. Whilst the FX2513



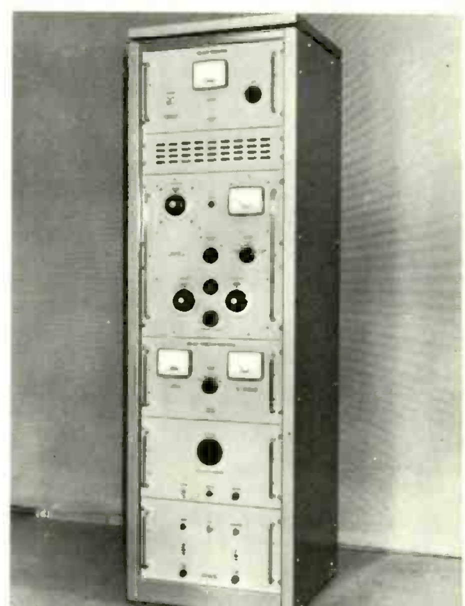
is a direct electrical equivalent to the KU82/7583, capable of handling peak pulse currents up to 35A at a peak forward anode voltage of up to 8KV, advance production techniques and the inclusion of an internally connected hydrogen reservoir give a much improved life expectancy. Warranty is for 1000 hours operation. English Electric Valve Co. Ltd., Chelmsford, Essex.
WW307 for further details

Sine Wave Oscillator

The 3120 sine wave generator from Dynamco is a source of pure sine waves (less than 0.005% distortion), for the calibration of precision a.c. instruments with r.m.s., mean or other characteristics. It also enables direct measurement of the distortion introduced by an amplifier or other system unit well beyond previous practical limits. Its good short term amplitude stability (better than 0.005%) makes it suitable for a.c. transfer systems and calibration rigs in standards laboratories. The frequency range is 10Hz to 109kHz, frequency accuracy is 1% from 10Hz to 10kHz, and 2% from 10kHz to 109kHz. The frequency temperature coefficient is typically 100 p.p.m. (0.01%) per C°. The output level is 5V maximum. A 0 to 60dB attenuator with fine adjustment gives control of output amplitude. The direct output is always available. The output impedance is 10Ω through 40μF into a 600Ω attenuator. The load must not be less than 600Ω or greater than 2000pF. Operation is from a.c. at 100-125V ±7% and 200-250V ±7% at 45 to 400Hz. Dynamco Ltd, Dynamco House, Hanworth Lane, Chertsey, Surrey.
WW303 for further details

R.F. Power Supply

Elliott Instruments announce their new laboratory transmitter type E.110. This equipment is



intended as a source of radio frequency power in the laboratory. The output is continuously variable from 0 to 500 watts continuous sine wave power. It operates in the band from 100kHz to 30MHz, with a standard output impedance of 75 ohms. The frequency can either be crystal-controlled, or set by a variable frequency oscillator. The equipment has been designed to be very reliable and flexible, and it is contained in a cabinet mounted on castors for ease of movement. Elliott Instruments Ltd, Station Industrial Estate, South Woodham Ferrers, Chelmsford, Essex.
WW331 for further details

Literature Received

For further information on any item include the appropriate WW number on the reader reply card

ACTIVE DEVICES

Semiconductor Quick Reference Data (does not include integrated circuits). A.E.I. Semiconductors Ltd, Carholme Rd., Lincoln **WW401**

Integrated circuit literature listed below available from Ferranti Ltd, Gem Mill, Chadderton, Lancs.

- Micronor-5, military range, data **WW402**
- Micronor-5, industrial range, data **WW403**
- Integrated circuit price list **WW404**

Short-form catalogue SWT-110B lists i.cs and thick-film hybrid circuits and ransistors. Sprague Electric (UK) Ltd, Trident House, Station Rd., Hayes, Middlesex **WW405**

Data received from Athena Semiconductor Marketing Co. Ltd, 140 High St., Egham, Surrey, on National Semiconductor devices as below:

- Integrated circuit short-form catalogue **WW406**
- Transistor short-form catalogue **WW407**
- Integrated circuit and transistor price list **WW408**

Mullard Ltd, Mullard House, Torrington Place, London, W.C.1, have issued the following 1969/70 industrial components reference guides:

- Semiconductors **WW409**
- Valves and tubes **WW410**

PIN diodes (series 5082-3000) are the subject of a leaflet from Hewlett-Packard, Bath Rd, Slough, Bucks **WW411**

PASSIVE COMPONENTS

Mechanical multiplex switches (MS 10000 series) are the subject of a leaflet from A & M Fell (Manufacturing) Ltd, F.G.A. Works, Denton, Newhaven, Sussex **WW412**

A selection chart for magnetic pickups can be obtained from Airpax Electronics, Cambridge, Maryland, U.S.A. **WW413**

Electro-mechanical switching components are described in a catalogue from FR Electronics, Wimborne, Dorset **WW414**

"Mullard industrial passive components" is the title of a catalogue received from Mullard Ltd, Torrington Place, London, W.C.1 . . . . **WW415**

The following publications are available from Sprague Electric (UK) Ltd, Trident House, Station Rd, Hayes, Middlesex.

- 8410, Heavy duty power line filters **WW416**
- 3703A, Hermetically sealed jelled-electrode sintered-anode Tantalex capacitors **WW417**
- 102, Radial-lead polycarbonate capacitors **WW418**
- 6170, Ceramic chip capacitors **WW419**

Glass-tin-oxide resistor wallchart, available from Electrosil Ltd, Pallion, Sunderland, Co. Durham **WW420**

Moulded track potentiometer leaflet can be obtained from Davall Electronics Ltd, Rothersthorpe Avenue, Northampton, NN4 9JL **WW421**

MICROWAVE

"Instruments and components for microwaves" is a catalogue available from Sivers Lab U.K. Office, 9 Forgefield, Westerham Rd, Biggin Hill, Kent **WW422**

"Concise catalogue of microwave equipment" has been produced by Marconi Instruments Ltd, Sanders Division, Gunnels Wood Rd, Stevenage, Herts. **WW423**

HARDWARE

Micrometer actuated micro-manipulators, positioners and probers are described in a leaflet from Research Instruments Ltd, Ace Works, Cumberland Avenue, London, N.W.10 . . . . **WW424**

"Ceramics for telecommunication engineering, high-frequency insulators" is the title of a leaflet available from Kőbányai Porcelángyár, Budapest, X., Tárna utca 4 . . . . **WW425**

A printed circuit lacquer is described in a leaflet from Electrolube Ltd, Oxford Avenue, Slough, Bucks. **WW426**

"I.C.M. plastics for industry" is the title of a booklet available from Insulating Components and Materials Ltd, Wellhead Lane, Perry Bar, Birmingham 22B **WW427**

Plastic fasteners (Spire fasteners, self-threading nuts, insets and rivets) are detailed in a catalogue FCF 3039 from Firth Cleveland Ltd, Stornoway House, Cleveland Row, St. James's, London, S.W.1 . . . . **WW428**

CIRCUITRY

Four books have been published by Tektronix and are available in this country from Tektronix U.K. Ltd, Beaverton Hse., Station Approach, Harpenden, Herts., at 10s each. The titles are:

- Television waveform processing circuits.
- Sweep generator circuits.
- Measurement concepts; semiconductor devices.
- Digital concepts.

"Differential operational amplifiers" briefly covers the theory and practice of these devices. Available from Fenlow Electronics Ltd, Whittet's Eyot, Weybridge, Surrey **WW429**

"High-fidelity audio designs" gives thirteen Ferranti audio designs with constructional information. Available from WEL Components Ltd, 5 Loverock Rd, Reading, Berks., price 5s.

An integrated light-to-frequency converter is described in a leaflet from Photain Controls Ltd, Randalls Rd, Leatherhead, Surrey **WW430**

EQUIPMENTS

Transducer meters of various kinds are the subject of a leaflet from Sangamo Controls Ltd, North Banstead, Bognor Regis, Sussex . . **WW431**

The following two leaflets are available from Telemechanics Ltd, 24 London Rd, Camberley, Surrey.

- Temperature measurement and thermometer equipment **WW432**
- Telemax chart recorders **WW433**

New equipment is described in literature from Lennard Developments Ltd, 497 Green Lanes, London, N.13

- Wow and flutter meter 102B **WW434**
- Wow and flutter meter 104 . . . . **WW435**

Wave analyser (1-330H_z) 301 . . . . **WW436**

GENERAL INFORMATION

Two new publications are available from the British Standards Institution, 2 Park Street, London W1Y 4AA.

3939: Section 21. Graphical symbols. Pure logic and functional symbols, price 12s.

4462: 1969 Guide for the preparation of technical sales literature for measuring instruments and process control equipment, price 6s.

Maps showing the estimated coverage, region by region, of the first phase of the U.K. independent television u.h.f. colour transmitter network have been published by the I.T.A., 70 Brompton Rd, London, S.W.3.

- Set of separate maps **WW437**
- Book of maps **WW438**

Technical service note TS/IS/6 "Chloro and chlorofluoro hydrocarbon solvents; their effects on polymeric materials" is available from I.C.I. Ltd, Thames House North, Millbank, London S.W.1 . . . . **WW439**

COURSES

The following 12 courses, which are to be held at Northern Polytechnic, Holloway Rd, London N.7, are described in pamphlets.

Electronic engineering—1.	Electronic engineering—2.
Intro. control engineering.	Network analysis.
Transistor circuit design.	Laplace transforms.
Medical techs electronics.	Digital computers.
I.C. logic systems.	I.C. applications.
Colour television.	Audio engineering.

We have received the 1969/70 prospectuses from the science and engineering departments of the following establishments: Norwood Technical College, Knights Hill, London S.E.27, and Twickenham College of Technology, Egerton Rd, Twickenham, Middlesex.

The "Bulletin of special courses in higher technology, management studies and commerce" (Autumn term) for London and the Home Counties is available from the Regional Advisory Council for Technological Education, Tavistock House South, Tavistock Square, London W.C.1. Price 10s.

Conferences and Exhibitions

Further details are obtainable from the addresses in parentheses

LONDON

Sept. 2–6 — Grosvenor House
Educational & Training Technology
(I.E.E., Savoy Pl., London W.C.2)

Sept. 8–12 — Savoy Place
Microwave Conference
(I.E.E., Savoy Pl., London W.C.2)

Sept. 15–19 — Festival Hall
Electronics for Civil Aviation
(Electronic Engineering Assoc., Berkeley Sq. House, Berkeley Sq., London W.1)

Sept. 22–23 — Imperial College
Face to Face with Metrication
(B.S.I., 2 Park St., London W1Y 4AA)

BELFAST

Sept. 9-12 — Queen's University
Nonlinear Optics
(I.P.P.S., 47 Belgrave Sq., London S.W.1)

BRIGHTON

Sept. 7-12 — University of Sussex
Atomic Collision Phenomena in Solids
(I.P.P.S., 47 Belgrave Sq., London S.W.1)

Sept. 24–26 — University of Sussex
Nuclear Structure & Elementary Particle Physics
(I.P.P.S., 47 Belgrave Sq., London S.W.1)

CAMBRIDGE

Sept. 8–12 — St. John's College
Man-machine Systems
(D. Whitfield, Applied Psychology Dept., University of Aston, Birmingham 4)

COVENTRY

Sept. 16–18 — Hotel Leofric
Electronic Instruments Show
(Industrial Exhibitions Ltd., 9 Argyll St., London W.1)

DURHAM

Sept. 16–18 — The University
Applications of Dynamic Modelling
(I.E.E., Savoy Pl., London W.C.2)

EXETER

Sept. 3–10 — The University
British Association Meeting
(Brit. Assoc. for the Advancement of Science, 3 Sanctuary Bldgs., 20 Gt. Smith St., London S.W.1)

Sept. 16–19 — The University
Solid State Devices
(I.P.P.S., 47 Belgrave Sq., London S.W.1)

LOUGHBOROUGH

Sept. 23–25 — University of Technology
Industrial Ultrasonics Conference
(I.E.R.E., 8–9 Bedford Sq., London W.C.1)

MANCHESTER

Sept. 23–25 — Hotel Piccadilly
Electronic Instruments Show
(Industrial Exhibitions Ltd., 9 Argyll St., London W.1)

Sept. 29–Oct. 3 — Belle Vue
Electronics, Instruments, Controls & Components Show
(Inst. of Electronics, Balderstone, Rochdale, Lancs.)

NOTTINGHAM

Sept. 17–19 — The University
High Magnetic Fields and their Applications
(I.P.P.S., 47 Belgrave Sq., London S.W.1)

OVERSEAS

Aug. 30–Sept. 8 — Paris
International Radio & Television Show
(Fed. Nat. des Ind. Electroniques, 16 rue de Presles, Paris 15e)

Sept. 6–11 — Milan
Italian Radio & Television Show
(Assoc. Nazionale Industrie Elettrotechniche ed Elettroniche, Via Donizetti 30, Milan)

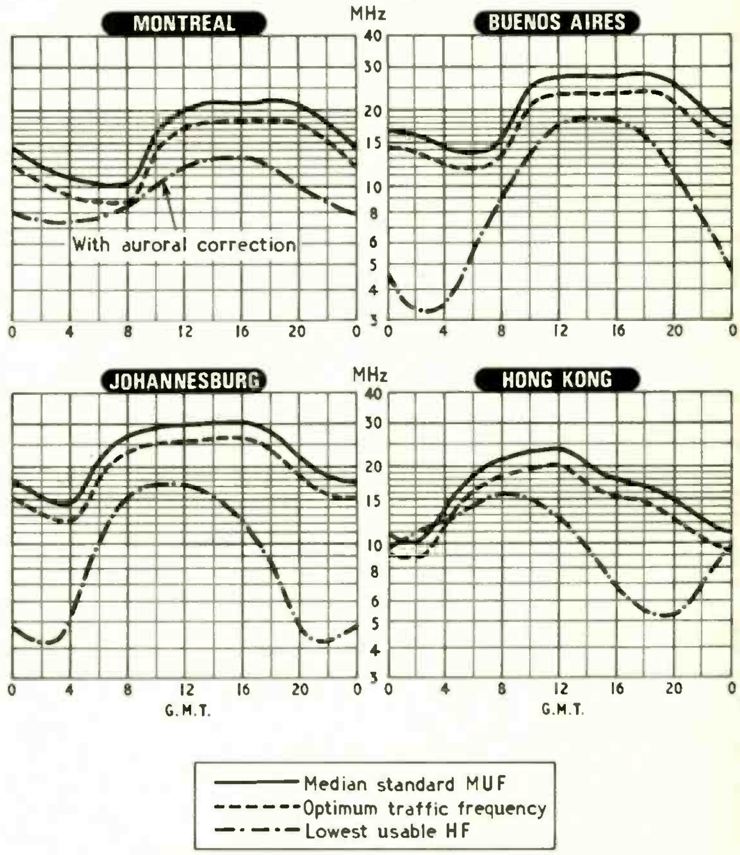
Sept. 6–11 — Milan
Electronic Components, Instruments & Accesories Show
(Secretariat, 20122 Milan, Via Luciano Manara 1)

Sept. 10–12 — Clayton, Mo.
Microelectronics Symposium
(I.E.E.E., 345 E.47th St., New York, N.Y.10017)

Sept. 16–18 — New York
Electro-Optical Systems Design
(Industrial & Scientific Conference Management, 222 W. Adams St., Chicago, Ill. 60606)

Sept. 19-28 — Amsterdam
Firato—Festival of Sound & Vision
(RAI Gebouw N.V., Europaplein 8, Amsterdam)

H. F. Predictions—September



Seasonal change is evident as a slight increase in peak MUFs. This is sustained during daylight on all the routes except Hong Kong which develops a continuously varying MUF. Day-to-day MUFs are assumed to be normally distributed about that shown, the optimum traffic frequency being the value exceeded on 90% of the days. This is of interest to the regular communicator whilst a curve displaced by the same linear amount above the MUF would be of interest to amateurs and listeners as the MUF exceeded on 10% of the days. It is not possible to predict, however, which actual three days these will be.

LUFs depend very much on e.r.p., those shown were drawn by Cable and Wireless Ltd for reception in this country of point-to-point telegraph using several kilowatts of power and rhombic aerials.

Answers to "Test Your Knowledge"–16

Questions on page 439

1. *(d)* This, together with the fact that any repetitive waveform can be built up from sinusoids (Fourier's theorem), is why the sinusoidal waveform is regarded as so fundamental.

2. *(a)* The total (complex) impedance is $(3000+j4000)$ ohms and thus has a modulus $\sqrt{3000^2+4000^2}=5000$ ohms. Hence the current is 5/5000 amps = 1 mA. This result, and the solutions to many of the other questions, can readily be verified by drawing a phasor diagram.

3. *(b)* The power factor is that by which the r.m.s. volt-amps must be multiplied to give the power dissipated (in the resistor).

4. *(d)* The current which flows is common to both components and leads the applied voltage by less than 90°. Since the voltage across the capacitor lags the current by 90° it must also lag the applied voltage.

5. *(b)* At a frequency above resonance the capacitor takes a greater current than the inductor. Hence the tuned circuit has a negative reactance so that the argument of the total impedance is negative.

6. *(d)* The ratio of voltage out to voltage in will easily be shown to be $1/(j\omega CR+1)$. Since here $CR=3.10^3$ at frequencies of 1kHz and above $\omega CR>1$ so that he output voltage is inversely proportional to frequency.

7. *(c)* This result is significant in determining the lower 3 dB point in *R-C* coupled amplifiers.

8. *(a)* Any capacitive circuit (current leading) has an admittance with a positive imaginary part. The real part of the input impedance or admittance of a purely passive circuit can never be negative.

9. *(c)* The current leads the voltage by 2 radians i.e. 114°, hence the input impedance has a negative real part. This means that the network delivers power to the generator and thus must contain a source of electrical energy. The network could be an active device with a negative resistance characteristic.

10. *(a)* Only the resistor dissipates power so the amount is the same at all frequencies since the current is the same.

11. *(d)* The voltage across the capacitor of a series-resonant circuit at its resonant frequency is Q times the applied voltage. Q here $(\omega_0 L/R)$ is 100.

12. *(c)* The circuit will only "ring" if R is less than $2\sqrt{L/C}$ i.e. if Q (using $\omega_0=1/\sqrt{LC}$) is greater than $\frac{1}{2}$.

13. *(b)* Assuming that the inductor has very small losses the initial oscillation will be at a frequency of $1/2\pi\sqrt{LC}$ in this case 159 Hz. With the given resistor in parallel the frequency drops to 138 Hz. Again the criterion is the value of Q at the nominal resonant frequency; if it is less than $\frac{1}{2}$ the circuit will not resonate, if it is greater than about 5 the ringing frequency is effectively $1/2\pi\sqrt{LC}$. Q here is 1.

14. *(a)* The square-wave generator is effectively a constant-current generator. The Fourier analysis of a square wave indicates that there are components at all odd harmonics. Since the tuned circuit resonates at approximately 159 Hz it will develop a large potential at this frequency, very small potentials at all the other component frequencies.

Real and Imaginary

by "Vector"

On banging the big drum

Do not press me to reveal the circumstances which necessitated me visiting the editorial sanctum sanctorum recently. As I think I have said before, the summons to attend is invariably reserved for the transgressor.

In the event the castigation was unexpectedly mild, a circumstance for which I found I had the German radio industry to thank. For it appeared that the editor had but lately returned from a sojourn as a guest of that institution and the aura of good living had not wholly departed.

The object of the exercise, it seemed, was that he should receive a verbal preview of the forthcoming Radio and TV Show at Stuttgart. This is the kind of occasion when Teutonic thoroughness comes to the fore and I must say that every stop appears to have been pulled out. On the evening of arrival a visit to Guttenberg castle was laid on. Dinner at the castle (said the Editor, absently swallowing two indigestion tablets) was in the best German traditions, going on for a good three hours. The evening wound up with a torchlight procession around the castle battlements, accompanied by the baron, his lady and their retinue dressed in period costume, then back to a first class hotel for what was left of the night.

The next morning, a well-managed Press Conference which, I gather, did not (unlike some functions of this character) consist of manufacturers' sales managers hogging the floor with blatant plugs for their companies' products. After lunch, at which the press men were joined by representatives of the industry and the Bundespost, a tour of the exhibition site on a miniature railway which runs around the grounds, and so to the airport and home. In short, said the Editor, graciously presenting me with a duty-free cigar, everything, including the air fare, was on the house and the standard of entertainment left absolutely nothing to be desired .... I pondered on this last but did not presume to ask to amplify. I did, on reaching the anteroom, ask the Editor's ravishing secretary whether she had been on the junket but she said no, she hadn't and added bitterly that there was one law for Sir and another for the poor.

Now, this little shindig, which gathered in nearly fifty editors or their representatives from all over Europe, was not done for peanuts. Question the value of it if you will, but the organisers obviously thought it was worth it, and with some justification in that the West Germany Radio show is to be increased in status from a 'national' to an 'international' exhibition when it is held in Berlin in 1971.

Ballyhoo? Of course it's ballyhoo, but we have to accept that modern radio and electronics industries are geared to it. All over Europe, large-scale radio and electronics exhibitions will be promoted during the coming months and all presented with similar brashness. Why is it that we are the only major European country which does not have a public radio and television show in which the majority (if not all) of the manufacturers, the broadcasting authorities and the Post Office participate?

You will be quick to point out that we did have such a show as an annual event and this died on its feet several years ago. But old-timers tell us that the pre-war radio shows were a rave, so what caused *rigor mortis* to set in?

Before we try to answer that, let's consider the viewpoint of those who would hold that it is the fault of the faceless 'They' of Whitehall and Westminster. The Government (they say) should come across with the generous financial backing that apparently the electronics industries get in other countries. Why doesn't it do a bit of breadcasting upon the waters by forking out the odd few millions for an exhibition site for which we would not have to apologize to overseas visitors?

Why not, indeed! It's tempting to make a whipping-boy out of the Government but let's have fair do's. Has the domestic electronics industry done anything to inspire Government confidence in its ability to sell overseas? The latest export figures of 2.5% of television receiver output and 8% of sound and car radio output tell their own story.

The unpalatable truth is that the domestic electronics industry has seldom passed up an opportunity to foul its own nest. It has consistently refused to recognize that markets exist outside the confines of the British Isles. It raped the concept of the f.m. service by sacrificing one of its biggest selling points —high-quality reproduction—to considerations of penny-pinching design. The industry has saddled itself with a dual-standards requirement in design of TV receivers and is at present inexpertly holding the colour television baby.

When the home market began to show unmistakable signs of saturation the British industry, instead of looking overseas, took the easy way out. Retrenchment and "rationalization" became the orders of the day and these found practical expression in the form of mergers. This was the biggest disaster of all. Hitherto, the design teams of each individual firm had made every effort to go one better than their rivals, with Radiolympia as the proving ground where the dealers and, to some extent the public, could make their choice. But with the advent of the merger mania, individual design ceased (so wasteful of effort, said the economists). As a result, the stands on the main avenues, while retaining their old-established names, exhibited receivers which were individual only in cabinet designs: inside the boxes lurked a common design of chassis. The whole point of an annual exhibition was thereby lost and so Radiolympia languished and died.

With such a dismal record to consider, no government (whatever its political hue) is going to back an international exhibition, for, far from attracting overseas buyers, it would encourage foreign firms to encroach on the home market. No punter, however sanguine, is going to back a horse which has no legs to stand on.

The capital goods side of the electronics industry, on the other hand, is in a much stronger position to press the Government for a worthy exhibition site, because it has a commendable export record already. Such a claim, allied to the needs of other British industries with a solid stake in exports, would be much more difficult to ignore. The U.K. needs an impressive shop window and needs it badly.

A touch of the moon

Whether you subscribe to the belief that the fantastic sums of money poured into the Apollo project could have been spent to better purpose or whether you feel that it was all worth while, there can surely be no two schools of thought about the courage of the space travellers.

From the purely electronics standpoint the exercise was a vindication of the startling claims for reliability made on behalf of microcircuits. (On second thoughts, one should qualify that by amending the sentence to *well-made* microcircuits.)

One point which so far hasn't been divulged (it may have been by the time this gets into print) is the degree of vacuum experienced in outer space and on the moon's surface. If it is as great as is generally believed then a thermionic device would presumably no longer have to be contained in a glass or metal envelope—a feature which could be pretty useful in designing high-power transmitters for use on the moon. Power supply problems might be solved by the use of mammoth photo emissive cells which again should operate very happily in the natural vacuum. There isn't space for me to consider the possibilities which stem from this freedom from the constraints of the evacuated envelope but I'll leave it to your imagination.

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Circuit Description

The circuit diagram of the IC-10 is shown on the right. The first three transistors are used in the pre-amp and the remaining 10 in the power amplifier. The output stage operates in class AB with closely controlled quiescent current which is independent of temperature. A high level of overall negative feedback is used round both sections and the amplifier is completely free from cross-over distortion at all supply voltages. Thus battery operation is eminently satisfactory.

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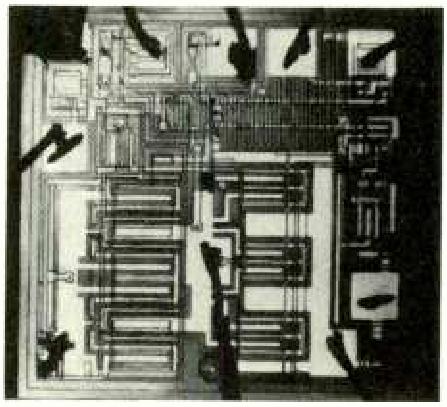
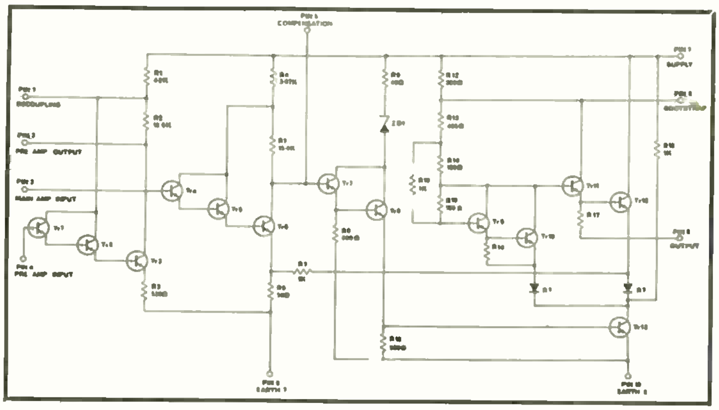
The monolithic I.C. chip is bonded onto a gold plated area on the heat sink bar which runs through the package. Wires are then welded between the I.C. and the tops of the pins which are also gold plated in this region. Finally the complete assembly is encapsulated in solid plastic which completely protects the circuit. The final device is so rugged that it can be dropped thirty feet on to concrete without any effect on performance. The circuit will also work perfectly at all temperatures from well below zero to above the boiling point of water.

The tiny black square on the right which is the smallest we could print without its getting lost is fractionally larger than the IC-10 before encapsulation.



Photograph shows the IC-10 magnified about 1,200 times. Below is shown the 13 transistor circuit of the Sinclair IC-10.



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Each IC-10 is sold with a very comprehensive manual giving circuit and wiring diagrams for a large number of applications in addition to high fidelity uses. These include public address, loud-hailers, use in cars, inter-com., stabilised power supplies, electronic organs, oscillators, volt meters, tape recorders, solar cell amplifier, radio receivers.
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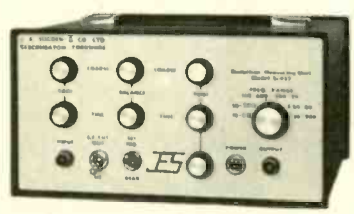

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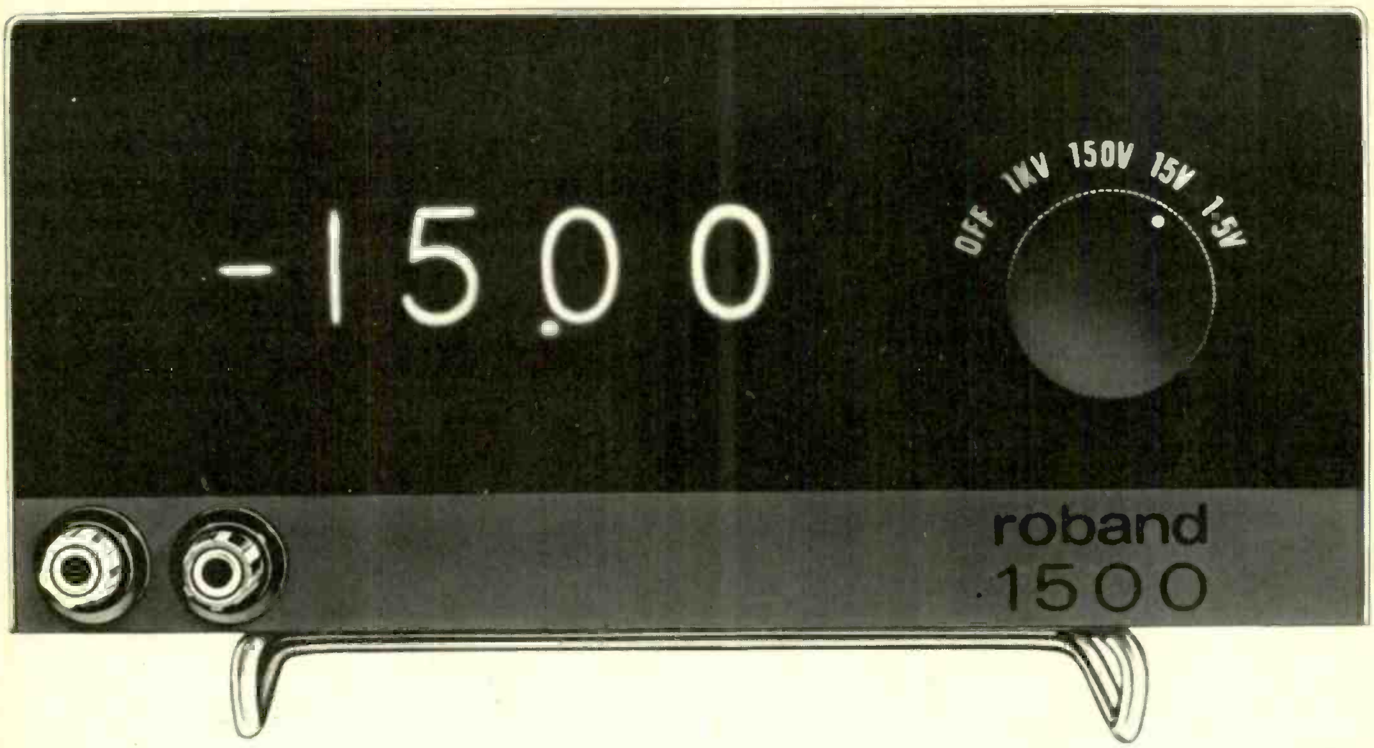

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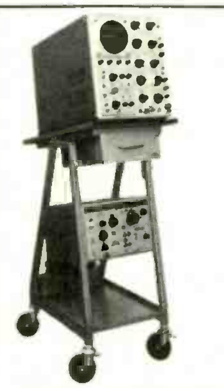

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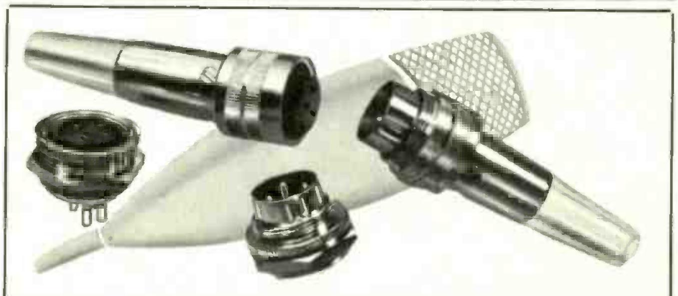

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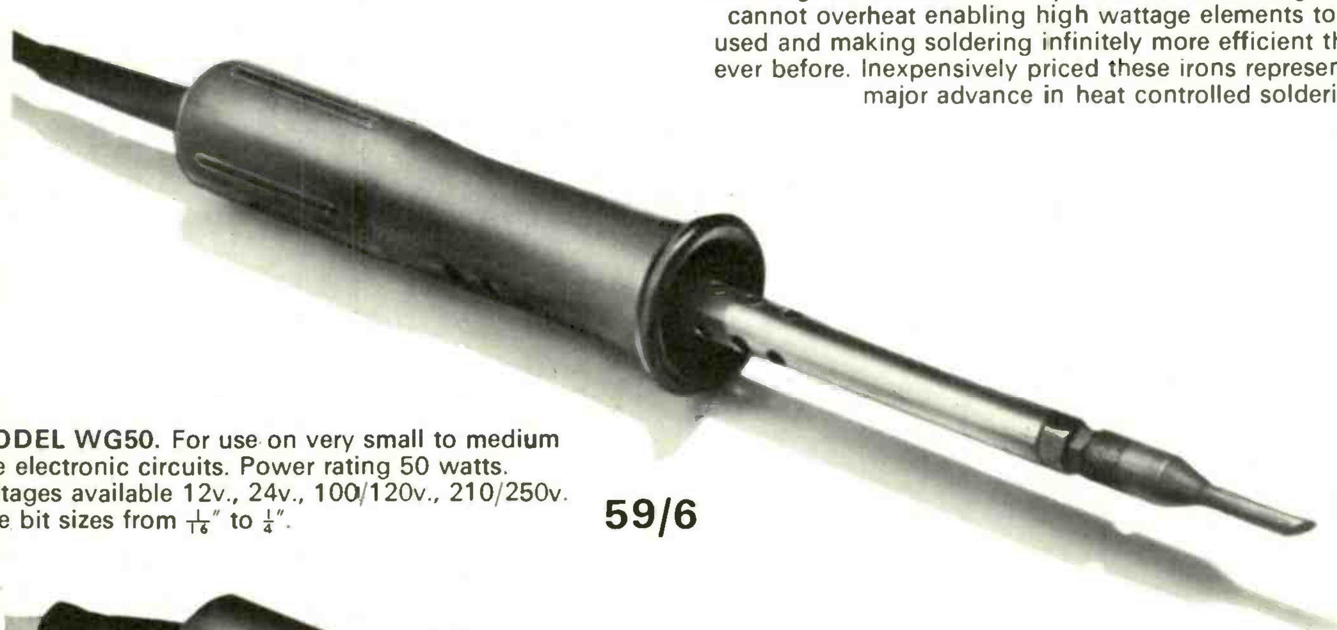

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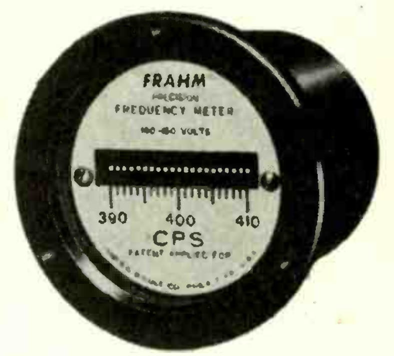

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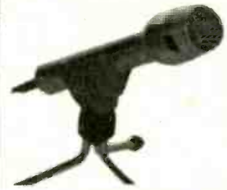

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The Duetto is a good quality amplifier, attractively styled and finished. It gives superb reproduction previously associated with amplifiers costing far more.
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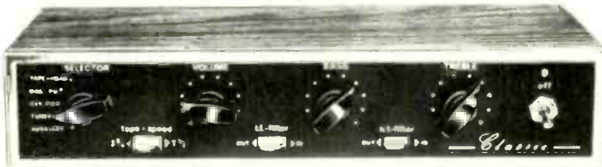
R.M.S. power output: 3 watts per channel into 10 ohms speakers.
INPUT SENSITIVITY: Suitable for medium or high output crystal cartridges and tuners. Cross-talk better than 30dB at 1Kc/s.
CONTROLS: 4-position selector switch (2 pos. mono & 2 pos. stereo) dual ganged volume control.
TONE CONTROL: Treble lift and cut. Separate on/off switch. A preset balance control.



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The Viscount **Integrated High Fidelity Transistor Stereo Amplifier 13½GNS.** +7/6 p. & p.

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INPUT: 6-position rotary selector switch (3 pos. mono and 3 pos. stereo). P.U., Tuner, Tape and Tape Rec. out. Sensitivities: All inputs 100mV into 1.8M ohm.
FREQUENCY RESPONSE: 40Hz-20KHz ± 2dB.
TONE CONTROLS: Separate bass and treble controls. TREBLE 13dB lift and out (at 15KHz) BASS 15dB lift and 25dB cut (at 60Hz).
VOLUME CONTROLS: Separate for each channel.
AC MAINS INPUT: 200-240v. 50-60Hz.
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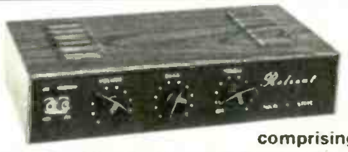

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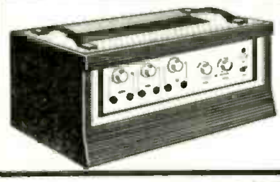

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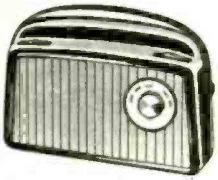

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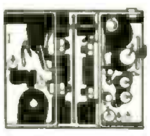

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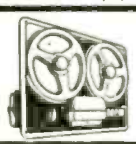

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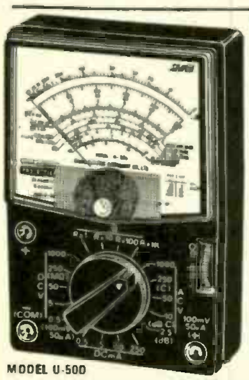

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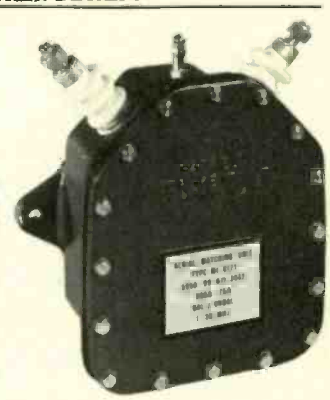

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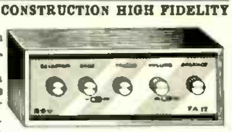

Designed for optimum performance with any crystal or ceramic Gram P.U. cartridge, Radio tuner, Tape recorder, 'Mike' etc. ★ 3 separate switched input sockets on each channel ★ Separate Bass and Treble controls ★ Slide Switch for mono use ★ Speaker Output 3-15 ohms ★ For 200-250 v. A.C. mains ★ Frequency Response 30-20,000 c.p.s. —2dB ★ Harmonic Distortion 0.3% at 1000 c.p.s. Hum and Noise —70dB ★ Sensitivities (1) 300 mV (2) 50 mV (3) 100 mV (4) 2 mV ★ Handsome brushed silver finish Facia and Knobs. Output rating I.H.F.M. Complete kit of parts with full wiring diagrams and instructions. 12½ GNS. Carr. 7/9. Factory built with 12 mth. gntee. 16 GNS. Or Dep. £5/2/6 and 9 mthly pymts. 31/6 (Total £19/6/0). Or in Teak or Afrormosia veneer housing 19½ GNS. or Dep. £5/10/6 and 9 mthly. pymts. 39/- (Total £23/1/6.)

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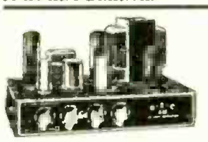
R.S.C. A10 30 WATT ULTRA LINEAR HI-FI AMPLIFIER



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425-0-425v. 200mA, 6.3v. 4a. c.t., 5v. 3a	69/9
425-0-425v. 200mA, 6.3v. 4a., 6.3v. 3a. 5v. 3a	79/11
450-0-450v. 250mA, 6.3v. 4a., ct., 5v. 3a.	93/6
TOP SHROUDED DROP-THROUGH TYPE	
250-0-250v. 70mA, 6.3v. 2a., 0-5-6.3v. 2a.	23/9
250-0-250v. 100mA, 6.3v. 3.5a.	25/9
250-0-250v. 100mA, 6.3v. 2a., 6.3v. 1a.	26/9
350-0-350v. 80mA, 6.3v. 2a., 0-5-6.3v. 2a	27/9
250-0-250v. 100mA, 6.3v. 4a., 0-5-6.3v. 3a.	37/9
300-0-300v. 100mA, 6.3v. 4a., 0-5-6.3v. 3a.	37/9
300-0-300v. 130mA, 6.3v. 4a., 0-5-6.3v. 1a. Suitable for Mullard 510 Amplifier	44/9
350-0-350v. 100mA., 6.3v. 4a., 0-5-6.3v. 3a.	37/9
350-0-350v. 150mA., 6.3v. 4a., 0-5-6.3v. 3a.	45/11

FILAMENT or TRANSISTOR POWER PACK Types 6.3 v. 1.5a. 7/9; 6.3v. 2a. 8/9; 6.3v. 3a. 10/9; 6.3v. 6a. 21/9; 12v. 1a. 8/9; 12v. 3a. or 24v. 1.5a. 21/9; 0-9-18v. 1½a. 17/9; 0-12-25-42v. 2a. 29/9.

CHARGER TRANSFORMERS 0-9-15v. 1½a. 14/11; 2½a. 17/9; 3a. 19/11; 5a. 23/9; 6a. 27/9; 8a. 33/9. 10a. 55/11.

AUTO (Step UP/Step DOWN) TRANSFORMERS
0-110/120v.-200-230-250v. 50-80 watts 15/9
150 watts, 29/11; 250 watts 49/9; 500 watts 99/9

OUTPUT TRANSFORMERS

Standard Pentode 5,000Ω or 7,000Ω to 3Ω	8/9
Push-Pull 8 watts EL84 to 3Ω or 15Ω	12/9
Push-Pull 10 watts 6V6 ECL86 to 3, 5, 8 or 15Ω	22/9
Push-Pull EL84 to 3 or 15Ω 10-12 watts	21/9
Push-Pull Ultra Linear for Mullard 510, etc.	39/9
Push-Pull 15-18 watts, sectionally wound 6L6 KT66, etc., for 3 or 15Ω	35/9
Push-Pull 20 watt high quality sectionally wound EL34, 6L6, KT66, etc. to 3 or 15Ω	59/9

SMOOTHING CHOKES
150mA. 7-10H, 250Ω 12/9; 100mA, 10H, 200Ω 10/9; 80mA, 10H, 350Ω, 8/9; 60mA, 10H, 400Ω 4/11.

R.S.C. TA6 6 Watt HIGH FIDELITY SOLID STATE AMPLIFIER

200-250v. A.C. mains operated. Frequency Response 30-20,000 c.p.s. —2dB. Harmonic Distortion 0.3% at 1,000 c.p.s. Separate Bass and Treble 'lift' and 'cut' controls. 3 input sockets for Mike, Gram, Radio or Tape. Input selector switch. Output for 3-15 ohm speakers. Max. sensitivity 5mV. Output rating I.H.F.M. In fully enclosed enamelled case, 9¼ × 2½ × 5¼in. Attractive brushed silver finish facia plate 10¼ × 3¼in. and matching knobs. Complete kit of parts with full wiring diagrams and instructions or factory built with 12 months' guarantee. £8.19.9. **£6.19.9** Carr. 7/6.

INTEREST CHARGES REFUNDED On Credit Sales settled in 3 months.

R.S.C. A11 HIGH FIDELITY 12-14 WATT AMPLIFIER

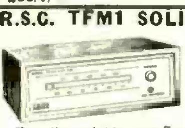
Push-pull ultra linear output "built-in" tone control pre-amp. Two input sockets with associated controls allowing mixing of "mike" and gram, etc. etc. High sensitivity. 5 valves—ECC83 (2), EL84 (2), EZ81. High quality sectionally wound output transformer. IND. BASS AND TREBLE CONTROLS. Frequency response ±3dB 30-20,000 c/s. Hum level —60dB. SENSITIVITY 40 millivolts. For Crystal or Ceramic PUs. High Impedance "mikes". For Musical Instruments such as String Bass, Electronic Guitars, etc. Size approx. 12 × 9 × 7in. For AC mains 200-250v. 50 cps. Output for 3 and 15 ohm spkrs. SAE for leaflet. Complete kit. Full instructions and point-to-point wiring diagrams. Carr. 11/6 (or factory built 12½ gns.) Twin handled metal cover 27/6. Terms on assembled units. Deposit 99/6 and 9 monthly payments of 23/-. (Total £15/6/6). RSC A11T transistorised version of above complete kit 9 Gns. (Assembled 13 gns.) **9½ Gns.**

R.S.C. COLUMN SPEAKERS

Covered in two-tone Rexine/Vynair, ideal for vocalists and Public Address. 15 ohm matching. Type C57 15 watts inc. five 7 × 4in. spkrs. £7/19/11. Type C48S. 30 watts. Fitted four 8in. high flux 8 watt speakers. Overall size approx. 42 × 10 × 5in. 16 Gns. Or deposit 67/- and 9 mthly pmts. 34/9 (Total £18/19/9). Carr. 10/-. Type C412s, 50 watts. Fitted four 12in. 11,000 lines 15 watt speakers. Overall size 56 × 14 × 9in. approx. 26 Gns. Or deposit £5/17/6 and 9 monthly payments Carr. 15/- of 54/6 (Total £30/7/-).

R.S.C. TFM1 SOLID STATE VHF/FM RADIO TUNER

Total cost of parts with detailed wiring diagrams & instruction. Inc. Carr. **14 Gns.** Or factory built 16½ gns. Or in Teak finished cabinet as illustrated 19½ gns. Terms: Deposit £5 and 9 monthly payments £2. Total £23.



★ High-sensitivity ★ 200-250v. A.C. Mains operation. ★ Sharp A.M. Rejection. ★ Drift-free reception. ★ Output ample for any amplifier (approx. 500 m.v.). ★ Simple alignment instructions. ★ Output available for feeding tuning meter. ★ Output for feeding Stereo Multiplexer. ★Tuner head using silicon Planar Transistors. ★ Designed for standard 80 ohm co-axial input. Visually matching our Super 15 and 30 amplifiers and of the same high standard of performance and reliability. The pre-wired tuning head facilitates speed and simplicity of construction. Printed circuitry. Only high grade transistors and components used. A quality product at considerably less than the cost of comparable units. Stereo version. All parts 20 gns. Inc. Carr. Assembled 22½ gns. Inc. Carr.

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In teak or afrormosia veneered cabinets. L13 13" × 8" 10 Watt Model. Gauss 10,000 lines. 3 or 15 ohms. **£4/19/9** Carr. 7/6
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TWO-WAY 'PHONE AMPLIFIER

Listen and speak with both hands free. Handsome black case. Battery operated. **59/9**

R.S.C. SUPER 15 HI-FI AMPLIFIER

SOLID STATE

FULLY TRANSISTORISED 200/250v. A.C. Mains.
OUTPUT 10 WATTS R.M.S. continuous into 15 ohms.
15 WATTS R.M.S. continuous into 3-4 ohms.
TRANSISTORS. 9 current types of high quality by leading manufacturers.
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 2.5 mV. Radio/Aux. or Ceramic P.U. 110 mV.
FREQUENCY RESPONSE: ±2 dB 20-20,000 c.p.s.
TREBLE CONTROL: +15dB to —14dB at 10 Kc/s. NEG. FEEDBACK: 52dB.
BASS CONTROL: +17dB to —15dB at 50 c/s. HUM LEVEL: —75dB.
HARMONIC DISTORTION at 10 watts 1,000 c.p.s. 0.2%
Complete Kit of parts with full constructional details and point to point wiring diagrams. Carr. 12/6. **12½ Gns.**
Supplied factory built. 15½ Gns. Carr. 12/6. Terms: Deposit 4 Gns. and 9 monthly payments 31/1 (Total £18/3/9). Or in Teak or Afrormosia veneer housing as ill. 19 Gns.
COMPONENTS ETC. ARE OF A HIGH STANDARD AND SUPPLIED BY LEADING MANUFACTURERS.

SPECIFICATIONS COMPARABLE WITH UNITS COSTING CONSIDERABLY MORE

R.S.C. SUPER 30 STEREO AMPLIFIER

A DUAL CHANNEL VERSION OF THE SUPER 15. Employing Twin Printed Circuits. High quality Ganged Pots. Matched Components. CROSS TALK:—52dB at 1,000 c.p.s.
CONTROL: 5 position Input Selector, Bass Control. Treble Control. Volume Control. Balance Control. Stereo/Mono Switch. Tape Monitor Switch. Mains Switch. IN PUT SOCKETS (Matched Pairs). (1) P.U. (2) Tape Amp. (3) Radio. (4) Mic. or R/P Head Operation of the Input Selector Switch assures appropriate equalisation. Rigid 18 s.w.g. Chassis. Size approx. 12in. wide, 3in. high and 8in. deep. Neon Panel indicator. Attractive Facia Plate and Spun Silver Matching Knobs. Above facilities, etc., except for Ganging and Balance control, apply also to Super 15.

THESE UNITS ARE EMINENTLY SUITABLE FOR USE WITH ANY MAKE OF PICK-UP OR MICROPHONE (Crystal, Ceramic, Magnetic, Moving Coil, Ribbon) CURRENTLY AVAILABLE. SUPERB SOUND OUTPUT QUALITY CAN BE OBTAINED BY USING WITH FIRST RATE ANCILLARY EQUIPMENT. All required parts, point to point wiring diagrams and detailed instructions. Carr. 15/- **21 Gns.**
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for Record Playing units. Teak finish cut for Garrard 1000, 2000, 3000, AT6, AT60, SP25 etc. etc. **59/9** Available with Transparent plastic cover. Inc. carr. **6 Gns.**

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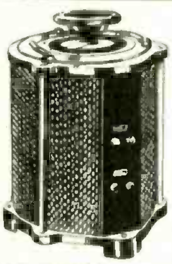

50 AMPS

1 AMP.

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BRAND NEW. Keenest prices in the country. All Types (and spares) from ½ to 50 amp. available from stock.

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Fully isolated, low tension Secondary winding. Input 230 v. A.C. OUTPUT CONTINUOUSLY VARIABLE 0-36 v. A.C.

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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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HIGH VOLTAGE HIGH FREQUENCY GENERATOR

Input 100/110 volts or 200/250 volts AC/DC. Output 19KV variable. Ideal for testing insulation, vacuum, leakage path, gas discharge lamps, neon etc. A useful ozone and HF supply. Manufactured by Edwards High Vacuum Ltd. Brand new in maker's polished wooden carrying case Offered at fraction of maker's price. £10.0.0 plus 7/6d. p. & p.

5Amp.AC/DC VARIABLE VOLTAGE OUTPUT UNIT

Input 230 v. A.C. Output 0-260 v. A.C. Output 0-240 v. D.C. Fitted large scale ammeter and voltmeter. Neon indicator, fully fused. Strong attractive metal case 15in. x 8½in. x 6in. Weight 24 lb. Infinitely variable, smooth stepless voltage variation over range. Similar in appearance to illustration below.

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Designed for Panel Mounting. Input 230 v. A.C. 50/60 Output variable. 0-260 v.

½ amp	£3 10 0
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P. & P. 7/6

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PORTABLE VARIABLE VOLTAGE TRANSFORMER

Input 230 v. A.C. Output variable 0-260 v. A.C. at 1.5 amp. Fitted in beautifully finished steel case. Complete with voltmeter, pilot lamp, fuse, switch, carrying handle. **£9/5/-.** P. & C. 10/-. Also 2.5 amp. as above. £11/7/6. P. & C. 10/-.

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LT constant voltage Transformer. Input 205/250 volts. Output 6.3 volts. RMS Load 7-10 amps. £3. 6/6 p.p.

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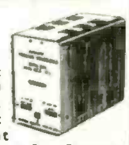
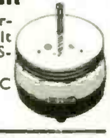


Input 185-250 v. A.C. Output constant at 230 v. AC. Capacity 250 watt. Attractive metal case. Fitted red signal lamp. Rubber feet. Weight 17lbs. Price **£11/10/-,** P. & P. 10/-.

LATEST TYPE SOLID STATE VARIABLE CONTROLLER



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5 amp model **£8. 7. 6**
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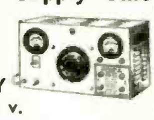
Test to I.E.E. Spec. Rugged metal construction, suitable for bench or field work, constant speed clutch. Size L. 8in., W. 4in., H. 6in. Weight 6lb. 500 volts, 500 megohms. Price £22 carriage paid. 1,000 volts, 1,000 megohms, £28 carriage paid.

36 volt 30 amp. A.C. or D.C. Variable L.T. Supply Unit



INPUT 220/240 v. A.C.
OUTPUT CONTINUOUSLY VARIABLE 0-36 v.

Fully isolated. Fitted in robust metal case with Voltmeter, Ammeter, Panel Indicator and chrome handles. Input and Output fully fused. Ideally suited for Lab. or Industrial use. **£55** plus 40/- p. & c.

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Kit and parts including ORP.12 Cadmium Sulphide Photocell. Relay Transistor and Circuit. Now supplied with new Siemens High Speed Relay for 6 or 12 volt operations. Price 25/-, plus 2/6 P. & P. **ORP 12 and Circuit 10/- post paid.**

220/240 A.C. MAINS MODEL incorporates mains transformer rectifier and special relay with 2 × 5 amp. mains c/o contacts. Price inc. circuit **47/6**, plus 3/6 P. & P.

LIGHT SOURCE AND PHOTO CELL MOUNTING

Precision engineered light source with adjustable lens assembly and ventilated lamp housing to take MBC bulb. Separate photo cell mounting assembly for ORP.12 or similar cell with optic window. Both units are single hole fixing. Price per pair £2/15/0 plus 3/6 P. & P.

VAN DE GRAAF ELECTROSTATIC GENERATOR

VAN DE GRAAF ELECTROSTATIC GENERATOR, fitted with motor drive for 230 v. A.C. giving a potential of approx. 50,000 volts. Supplied absolutely complete including accessories for carrying out a number of interesting experiments, and full instructions. This instrument is completely safe, and ideally suited for School demonstrations. Price £7/7/-, plus 4/- P. & P. L't. on req.

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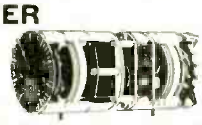

This precision Instrument is based on a 24 v. D.C. LOW INERTIA (Integrating) Motor. The Motor drives two precision pots through close tolerance gear-trains, including slipping clutch. Offered at fraction of manufacturer's price: 32/6, plus 6/- P. & P.

LATEST TYPE SELENIUM BRIDGE RECTIFIERS

30 volt 3 amp., 11/-, plus 2/6 P. & P.
30 volt 5 amp., 16/-, plus 2/6 P. & P.

NICKEL CADMIUM BATTERY

Sintered Cadmium Type 1.2 v. 7AH. Size: height 3¾in., width 2⅛in. × 1 1/16in. Weight: approx. 13 ozs. Ex-R.A.F. Tested 12/6. P. & P. 2/6.

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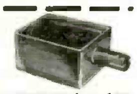
2 × lamp Dry Reeds (makes contacts) mounted in 870 ohm 9-18v coil. Size 3in. × 3½in. × ½in. New. Price **8/6** per pair. Post Paid.
6 of the above mentioned units (12 Reeds, 6 coils) fitted in metal box. Size 4in. × 3½in. × 1½in. Mfg. by Elliott Bros. New 45/- each. Post Paid.

Telephone Dials (New) 14/6d. Post Paid.

230/250 v. A.C. SOLENOID



Heavy duty type. Approx. 3lb. pull. **17/6** plus 2/6 P. & P.

12/24 v. D.C. SOLENOID Approx. 8 oz. push, 8/6 plus 1/6 P. & P.

AUTO TRANSFORMERS. Step up, step down. 110-200-220-240 v. Fully shrouded. New. 300 watt type £3/10/- each. P. & P. 4/6. 500 watt type £4/12/6 each, P. & P. 6/6. 1,000 watt type £5/15/- each, P. & P. 7/6.

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Brand new lever operated micro switch. 20 amp. A.C. Price **4/6** each plus 1/6 P. & P. 5 for £1 post paid.

COPPER LAMINATE PRINTED CIRCUIT BOARD. Large sheet 15½ × 5½in. 3 for 10/- post paid. (3 minimum order).

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7 adjustments, precision tooled, speed adjustable 10 w.p.m. to as high as desired. Weight 2½lb. £4/12/6 post paid.

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Adjustable tone control. Fitted with moving coil speaker, also earpiece for personal monitoring. Complete with morse key. 45/- plus 3/6d. p. & p.

34R SILICON SOLAR CELL

4 × .5 volt unit series connected, output up to 2 v. at 20 mA. in sunlight, 30 times the efficiency of selenium. As used in power Earth Satellites, 45/-. P. & P. 1/6d.

CONDENSERS

New at a fraction of maker's price.
2,500 mfd. 100 v... 12/6 — 4,000 mfd. 25 v... 10/
10,000 mfd. 35 v... 15/- — 4,000 mfd. 50 v... 15/

220/240v. A.C. COOLING UNIT

2,300 r.p.m. 6in. blade size. Smooth powerful motor. All metal construction. Continuously rated. Individually tested. Offered at fraction of maker's price, **£2/15/-**. P. & P. 7/6.

POWER RHEOSTATS

(NEW) Ceramic construction, winding embedded in Vitreous Enamel, heavy duty brush assembly designed for continuous duty. **AVAILABLE FROM STOCK IN THE FOLLOWING 11 VALUES: 100 WATT 1 ohm 10a., 5 ohm 4.7a., 10 ohm 3a., 25 ohm 2a., 50 ohm 1.4a., 100 ohm 1a., 250 ohm 7a., 500 ohm 45a., 1,000 ohm 280mA., 1,500 ohm 230mA., 2,500 ohm .2a.** Diameter 3½in. Shaft length ⅜in. dia. 7/16in., **27/6.** P. & P. 1/6.
50 WATT 1/5/10/25/50/100/250/500/1,000/1,500/2,500 ohm, **21/-**, P. & P. 1/6.
25 WATT 10/25/50/100/250/500/1,000/1,500/2,500 ohm, **14/6**, P. & P. 1/6.
Black Silver Skirted knob calibrated in Nos. 1-9. 1½ in. dia. brass bush. Ideal for above Rheostats, 3/6 each.

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THREE EASY TO BUILD KITS USING XENON WHITE LIGHT FLASH TUBES. SOLID STATE TIMING + TRIGGERING CIRCUITS. PROVISION FOR EXTERNAL TRIGGERING. 230-250v. A.C. OPERATION.
The Strobe is one of the most useful and interesting instruments in the laboratory or workshop. It is invaluable for the study of movement and checking of speeds. Many uses can be found in the psychiatric and photographic fields, also in the entertainment business. It is used a great deal in the motor industry and is a real tool as well as an interesting scientific device.

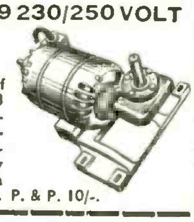
EXPERIMENTERS "ECONOMY" KIT
1 to 36 Flash per sec. All electronic components including Veroboard S.C.R. Unijunction Xenon Tube + instructions £5.5.0 plus 5/- P. & P.

NEW INDUSTRIAL KIT
Ideally suitable for schools, laboratories etc. Roller tin printed circuit. New trigger coil, plastic thyristor 1-80 f.p.s. Price 9 gns. 7/6 P. & P.

HY-LYGHT STROBE
This strobe has been designed and produced in response to wide public demand, for use in large rooms, halls and the photographic field. It has 4 times the light output at 30 f.p.s. and utilizes a silica tube for longer life expectancy, printed circuit for easy assembly, also a special trigger coil and output capacitor. Light output approx 4 joules. Price £10.17.6. P. & P. 7/6.

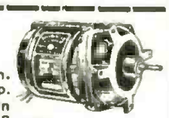
7-INCH POLISHED REFLECTOR. Ideally suited for above Strobe Kits. Price 10/6 & 2/6 p. & p. or post paid with kits.

PARVALUX TYPE SD19 230/250 VOLT AC REVERSIBLE GEARED MOTORS



30 r.p.m. 40 lb. ins. Position of drive spindle adjustable to 3 different angles. Mounted on substantial cast aluminium base. Ex-equipment. Tested and in first-class running order. A really powerful motor offered at a fraction of maker's price. **6 gns.** P. & P. 10/-.

BODINE TYPE N.C.1 GEARED MOTOR

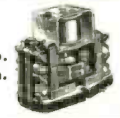


(Type 1) 71 r.p.m. torque 10 lb. in. Reversible 1/70th h.p. 50 cycle.38 amp.
(Type 2) 28 r.p.m. torque 20 lb. in reversible 1/80th h.p. 50 cycle .28 amp.
The above two precision made U.S.A. motors are offered in 'as new' condition. Input voltage of motor 115v A.C. Supplied complete with transformer for **230/240v A.C. input**
Price, either type **£2.17.6** plus 6/6 P. & P. or less transformer **£2.2.6** plus 4/6d. P. & P.
These motors are ideal for rotating aerials, drawing curtains, display stands, vending machines etc.

10 RPM GEARED MOTOR

230 volt. A.C. 10 r.p.m. non-reversible, approx. 1.7 lb. in. Price 45/- & 3/6 p. & p.

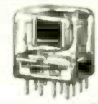
A.C. CONTACTOR



2 make and 2 break (or 2 c/o) 15 amp. contacts. 230/240 v. A.C. operation. Brand new. **22/6** plus 1/- P. & P.

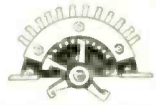
Latest American. New. Plastic THYRISTOR 400 P.I.V. 8 amp. Data sheet. 19/6 post paid.

SEALED RELAY



230 volt AC Coil. Three c/o 5 amp. contacts, 17/6 Post Paid.
Londex four c/o 3 amp contacts. 18/6. incl. base. Post Paid.

MINIATURE UNISELECTOR

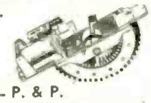


3 banks of 11 positions, plus homing bank. 40 ohm coil. 24-36 v. D.C. operation. Carefully removed from equipment and tested. 22/6, plus 2/6 P. & P.

UNISELECTOR SWITCHES *NEW*
4 BANK 25 WAY FULL WIPER

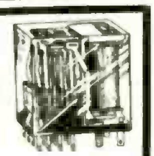
25 ohm coil, 24 v. D.C. operation. £5/17/6, plus 2/6. P. & P.

8-BANK 25-WAY FULL WIPER



24 v. D.C. operation, £7/12/6, Plus 4/- P. & P.

RELAYS



BULK PURCHASE ENABLES US TO OFFER THE FOLLOWING *NEW* **SIEMENS PLESSEY**, etc. MINIATURE PLUG IN RELAYS COMPLETE WITH BASE, AT A HIGHLY COMPETITIVE PRICE

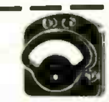
COIL Ω	WORKING VOLTAGE	CONTACTS	PRICE
280	6—12	2 c/o	14/6
280	9—18	4 c/o	15/6
700	12—24	2 c/o	12/6
700	16—24	4 c/o	15/6
700	16—24	4M 2B	12/6
1250	20—40	2 c/o Heavy Duty	12/6
2500	30—50	2 c/o Heavy Duty	12/6
9000	40—70	2 c/o	10/-

POST PAID

INSULATED TERMINALS

Available in black, red, white, yellow, blue and green. New 17/- per doz. P. & P. 2/-.

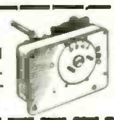
SANGAMO WESTON



Dual range voltmeter. 0-5 and 0-100 v. D.C. FSD 1 mA. In carrying case with tests prods and leads. 32/6. P. & P. 3/6.

A.C. AMMETERS 0-1, 0-5, 0-10, 0-15, 0-20 amp. F.R. 2½in. dia. All at 21/- each.
A.C. VOLTMETERS 0-25 v., 0-50 v., 0-150 v. M.I 2½in. Flush round all at 21/- each. P. & P. extra.
0-300 v. A.C. Rect. M-Coil 2½in. 29/–
0-300 v. A.C. Rect. M-Coil 3½in. Type W23 ...... 55/–

PRECISION INTERVAL TIMER



From 0-30 seconds (repetitive). Jewelled balanced movement. Lever re-set. Operates 230 v. A.C. 5 amp. c/o micro-switch. Brand New 17/6 plus 2/6 P. & P.

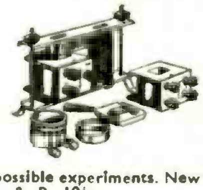
'AVO' MODEL 47A

Ex-Admiralty in first class condition, complete with instructions, leads and case. £9/19/6, P. & P. 10/-.

'AVO' MODEL 48A

Ex-Admiralty in good condition with instructions, leads, plus D.C. Shunts for 120 Amp and 480 Amp. A.C. Transformer for 60 Amp. and 240 Amp. Multiplier for 3600 volt. Complete outfit in fitted case. £15/0/0, P. & P. 10/-.

DEMONSTRATION TRANSFORMER (STENZYL TYPE)



Two removable coils are tapped at 0, 110, 220 volts, and 6, 12, 36 volts respectively. A composite apparatus designed for class demonstration. Electro magnetic induction, jumping ring, induction lamp, relationship between field intensity and ampere turns, induction melting, are just a few of the possible experiments. New modified model. £14/10/-. P. & P. 10/-.

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All primaries 220-240 volts.

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1	30, 32, 34, 36 v. at 5 amps.	£4 5 0	6/–
2	30, 40, 50 v. at 5 amps.	£6 5 0	6/6
3	10, 17, 18 v. at 10 amps.	£4 10 0	4/6
4	6, 12 v. at 20 amps.	£5 17 6	6/6
5	17, 18, 20 v. at 20 amps.	£6 12 6	6/6
6	6, 12, 20 v. at 20 amps.	£6 5 0	7/6
7	24 v. at 10 amps.	£4 15 0	5/6
8	4, 6, 24, 32 v. at 12 amps.	£6 10 0	6/6

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Precision Multimeter. V.I.R.W. E.L.L. Model 44. £15.
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V.H.F. "Q" Meter—Marconi TF 886B. £45.
Wide Band Millivoltmeter—Marconi TF 1371. £35.10.

POTENTIOMETERS
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Solartron AD 513.2 L.F. & Servos & CD 5238.2 Long Persistent Tube. £49.10.
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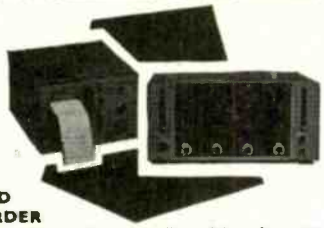
MAGNETIC TAPE STORAGE DECK
Half-inch tape, 7-bit read-write heads. 557-bit words per inch. Ex. equipment, but new condition. Would make ideal tape transport. Few only. £72.10.0. including vacuum blower assembly.

MODEL 72 MAGNETIC TAPE UNIT
This unit consists of 8 channel read-write head. One track contains sprocket pulse, one contains parity (Check-bits) pulse, and the remaining six contain data any six bit code can be used to record on and be read from the tape. Data can be read in either a backward or forward direction. The unit contains circuits for receiving and storing instruction signals. Recording density 250 characters per inch. Tape speed 100 in. per second. £195. Excellent condition.



FOUR CHANNEL HIGH SPEED PEN RECORDER
By Kelvin Hughes, with four channel amplifier, giving a frequency range of 0-100 c/s.
The Recorder consists basically of a magnet carrying in its poles four stiffly suspended moving coil units, each with a stylis arm attached. The stiffness of the coil unit suspension enables the instrument to withstand the effects of vibration and acceleration. Sensitivity ± 3V input for full scale deflection of ± 7.5 mm. Mains operated. 6 chart speeds: 0.5; 1; 2; 4; 8; and 16 cm/sec. Excellent condition. £149/10/0.
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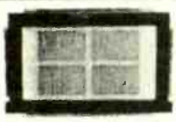
For use with thermocouplers, pyrometers and other e.m.f. sources. 6 point. Range (—100)—0—(+100) mV; 6½ in. chart width; pen speed 8 secs. Accuracy ±0.5%; 10 chart speeds 20-720 mm/hr. Tropicalised. Including tools and spares. Listed at over £200. Our price £79.10.0. Thermo couplers available.



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Computer complete with 126 line printer, 80 col. card sorter, punch. central processor, drum store, six tape storage units and tape synchroniser. £3.000.

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Ex-equipment but fully tested in our laboratory. Carr. 30/-.

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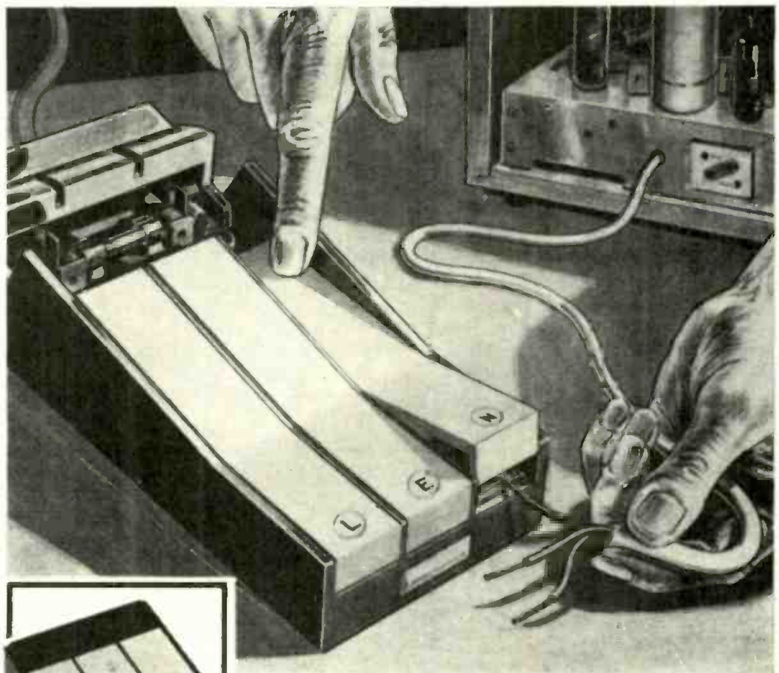

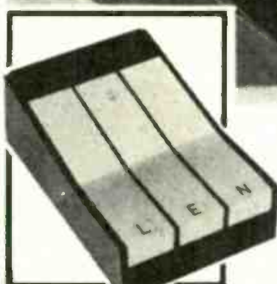

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For the handyman or do-it-yourself enthusiast, for shop demonstration or bench testing, the revolutionary Keynector now offers a very much SAFER and QUICKER way of connecting electrical equipment to the mains. No plugs—no sockets—no risk of bare wires. To connect anything electrical, from an oscilloscope to an electric drill, simply open the fuse housing, depress the keys, insert the wires and close the housing. A neon light on the front of the Keynector glows to indicate proper connection. Multi-parallel connections can be made up to 13 amps. Keys are colour coded and lettered LEN for quick identification. Note the safety features:

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* Keys cannot be depressed until the fuse housing is open.
* Circuit is protected by 13 amp replaceable fuse.
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The Keynector casing is in two-tone plastic and measures 5in. × 3in. × 1⅜in. It can be fixed to wall or bench.

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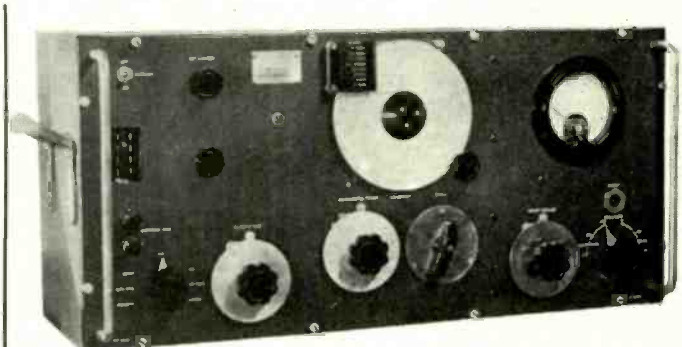
* *Available with Receiver only.*



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Freq. 85Kc/s-25Mc/s in 8 ranges. Incremental: +/— 1% at 1Mc/s. Output: continuously variable 1 microvolt to 1 volt. Output Impedance: 1 microvolt to 100 millivolts, 10 ohms 100mV-1 volt-52.5 ohms. Internal Modulation: 400 c/s sinewave 75% depth. External Modulation: Direct or via internal amplifier. A.C. mains 200/250V, 40-100 c/s. Consumption approx. 40 watts. Measurements: 19¼×12¼×10 in. The above come complete with Mains Leads, Dummy Aerial with screened lead, and plugs. As New, in Manufacturer's cases, £40 each. Carr. 30/-. DISCOUNT OF 10% FOR SCHOOLS, TECHNICAL COLLEGES, etc.

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COMMAND TRANSMITTERS, BC-458: 5.3-7 Mc/s., approx. 25W output, directly calibrated. Valves 2 × 1625 PA; 1 × 1626 osc.; 1 × 1629 Tuning Indicator; Crystal 6,200 Kc/s. New condition—£3/10/- each, 10/- post.
(Conversion as per "Surplus Radio Conversion Manual, Vol. No. 2," by R. C. Evenson and O. R. Beach.)

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MARCONI RECEIVER 1475 type 88: 1.5-20 Mc/s, second-hand condition **£10.0.0** each. New condition **£25.0.0** each, carr. 15/-.

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COSSAR 1049 Mk. 111, **£45** each, 30/- carr.

RELAYS: GPO Type 600, 10 relays @ 300 ohms with 2M and 10 relays @ 50 ohms with 1M., **£2** each, 6/- post.
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CALIBRATION TACHOMETER Mk. II: Maxwell Bridge Type 6C/869, **£25** each, £2 carr.

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AUTOMATIC PILOT UNIT Mk. 2. This complex unit of diodes and valves, relays, magnetic clutches, motors and plug-in amplifiers, with many other items, price **£7/10/-**, £1 carriage.

FOR EXPORT ONLY: B.44 Trans-ceiver Mk. III. Crystal control, 60-95 Mc/s. **AMERICAN EQUIPMENT**: BC-640 Transmitter, 100-156 Mc/s., 50 watt output. For 110 or 230 v. operation. ARC 27 trans-ceivers, 28 v. D.C. input. Also have associated equipment. BC-375 Transmitter. BC-778 Dinghy transmitter. SCR-522 trans-ceiver. Power supply, PP893/GRC 32A; Filter D.C. Power Supply F-170/GRC 32A: Cabinet Electrical CY 1288/GRC 32A; Antenna Box Base and Cables CY 728/GRC; Mast Erection Kits, 1186/GRC; Directional Antenna CRD.6; Comparator Unit, CM.23; Directional Control CRD.6, 567/CRD and 568/CRD; Azimuth Control Units, 260/CRD. Test Set URM.44, complete with Signal Generator TS.622/U.

VARIABLE POWER UNIT: complete with Zenith variac 0-230 v., 9 amps.; 2½in. scale meter reading 0-250 v. Unit is mounted in 19in. rack, **£16/10/-** each, 30/- carr.

SOLENOID UNIT: 230 v. A.C. input, 2 pole, 15 amp contacts, **£2/10/-** each post 6/-.

CONTROL PANEL: 230 v. A.C., 24 v. D.C. @ 2 amps., **£2/10/-** each, carr. 12/6.

AUTO TRANSFORMER: 230-115 v.; 1,000 w. **£5** each, carr. 12/6. 230-115 v.; 300VA, **£3** each, carr. 10/-.

OHMITE VARIABLE RESISTOR: 5 ohms, 5½ amps; or 2.6 ohms at 4 amps. Price (either type) **£2** each, 4/6 post each.

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UNISELECTORS (ex equipment): 5 Bank, 50 Way, 75 ohm Coil, alternate wipe, **£2/5/-** each, post 4/-.

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1·25μF	16 volt	6μF	6 volt	30μF	6 volt		
2μF	3 volt	8μF	3 volt	30μF	10 volt		
2μF	350 volt	8μF	12 volt	50μF	6 volt		
2·5μF	16 volt	8μF	50 volt	64μF	2·5 volt		
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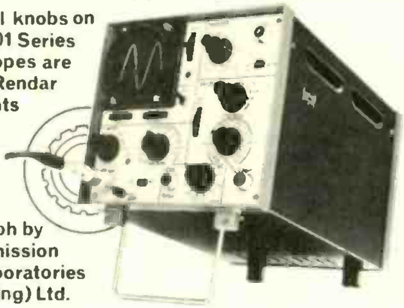

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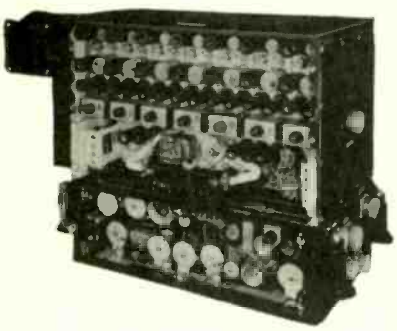

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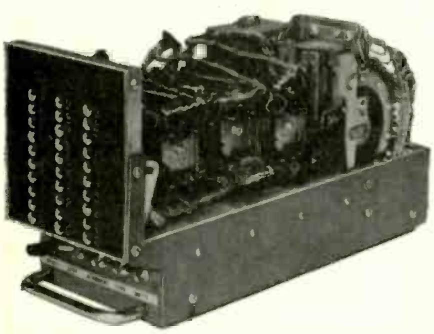

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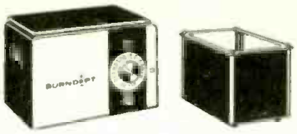

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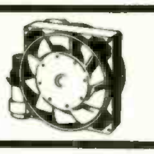

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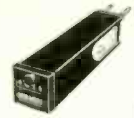

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L.T. TRANSFORMER 60v. 8 amp. **£5.** P.P. 15/-.
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L.T. TRANSFORMERS Prim. 240v. Sec. 8/12/20/25v. 3.5 amp models **20/-**; 5 amp model **25/-**. P.P. 5/6.
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ELECTRIC SLOTMETERS (1/-) 25 amp. L.R. 240v. A.C. **85/-** ea. P.P. 5/-.
QUARTERLY ELECTRIC CHECK METERS, 40 amp 240v. A.C., **20/-** ea. P.P. 5/-.

COPPER LAMINATE PRINTED CIRCUIT BOARD (8½ × 5½ × 1/16 in.), **2/6** sheet, 5 for **10/-**. Also 11 × 9 in., **4/-** ea., 3 for **10/-**.

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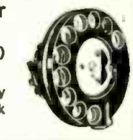
100 Capacitors (latest types) 50pF to .5μF.
250 Resistors ¼ and ½ watt.
250 Resistors ½ and 1 watt.
150 Hi-Stab Resistors, ¼, ½ and 1 watt.
25 Vitreous W/W Resistors, 5%.
12 Precision Resistors .1% (several standards included).
12 Precision Capacitors 1 and 2% (several standards included).
12 Electrolytics (miniature and standard sizes).
ANY ITEM 12/6. ANY 5 ITEMS 50/-.

TELEPHONE DIALS (New) 20/- ea.



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REED RELAYS 4 make 9/12v. (1,000 ohm.) **12/6** ea. 2 make **7/6** ea. 1 make **5/-** ea. Reed Switches (1¾ in.) **2/-** ea. £1 per doz

SUB-MINIATURE REED RELAYS (1in. × ¼in.). Weight ¼ oz. Type 1. 960 ohm, 3/9v. 1 make. **12/6** ea. Type 2. 1800 ohm, 3/12v. 1 make. **15/-** ea.

PRECISION CAPACITANCE JIGS. Beautifully made with Moore & Wright Micrometer Gauge. Type 1. 18.5pf-1220pf. **£10** ea. Type 2. 9.5pf-11.5pf. **£6** ea.

STC CRYSTAL LOCKED OSCILLATOR (Synthesiser). 1K/c-20M/c. Output 0 dbm. 80 db att. in 1 db steps. Precision crystal oven. Locks oscillator at each 100K/c. Separate locked oscillator from 0-100K/c. **£150** in excellent condition.

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WW—131 FOR FURTHER DETAILS

NEW PRICES ON NEW COMPONENTS

RESISTORS
High stability, carbon film, low noise. Capless construction, molecular termination bonding.
Dimensions (mm.): Body: ¼W: 8 × 2·8
½W: 10 × 4·3
Leads: 35
10% ranges; 10 Ohms to 10 Megohms (E12 Renard Series).
5% ranges; 4·7 Ohms to 1 Megohm (E24 Renard Series).
Prices—per Ohmic value.

		each	10 off	25 off	100 off
¼W	10%	2d.	1/6	3/3	10/4
¼W	5%	2½d.	1/9	3/8	11/8
½W	10%	2½d.	1/9	3/8	11/7
½W	5%	3d.	2/-	4/-	12/10

CAPACITORS
Subminiature Polyester film. Modular for P.C. mounting. Hard epoxy resin encapsulation. Radial leads.
±10% tolerance. 100 Volt working.
Prices—per Capacitance value (μF)

	each	10 off	25 off	100 off
0·001, 0·002, 0·005, 0·01, 0·02	6d.	4/3	8/4	30/-
0·05	8d.	6/-	12/6	41/8
0·1	10d.	7/1	15/6	51/-
0·2	1/2	10/-	20/10	68/6

Polystyrene film. Tubular. Axial leads. Unencapsulated ±5% or ±1pf tolerance, 160 Volt Working.
Prices—per Capacitance value (μμF)

	each	10 off	25 off	100 off
10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68, 82, 100, 120, 180, 220, 270, 330, 390	5d.	3/7	7/9	24/-
470, 560, 680, 820, 1,000, 1,500	6d.	4/-	8/8	26/8
2,200, 3,300, 4,700, 5,600	7d.	5/-	10/10	33/4
6,800, 8,200, 10,000, 15,000	8d.	6/-	13/-	40/-
22,000	9d.	6/9	18/-	45/4

POTENTIOMETERS (Carbon)
Superior grade enclosed controls. Low rotational noise. Body dia., 1in. Spindle, 2in. × ¼in. Tolerance, 20%.
Linear: 1K to 2M. (¼W at 40°C).
Logarithmic: 5K to 2M. (¼W at 40°C).

Prices per ohmic value	each	10 off	25 off	100 off
	2/-	18/4	41/8	150/-

GANGED STEREO POTENTIOMETERS (Carbon)
¼W at 70°C. Long Spindle.
Logarithmic and Linear: 5k + 5k to 1M + 1M.

Prices per ohmic value	each	10 off	25 off	100 off
	8/-	70/-	162/6	575/-

SKELETON PRE-SET POTENTIOMETERS (Carbon)
High quality pre-sets suitable for printed circuit boards of 0·1in. P.C.M. 100 ohms to 5 Megohms (Linear only). Miniature: 0·3W at 70°C. ±20% below ½M, ±30% above ½M. Horizontal (0·7in + 0·4in. P.C.M.) or Vertical (0·4in. × 0·2in. P.C.M.). Subminiature: 0·1W at 70°C. ±20% below 2·5M, ±30% above.

Prices—per ohmic value	each	10 off	25 off	100 off
Miniature (0·3W)	1/-	8/9	18/9	66/8
Subminiature (0·1W)	10d.	7/1	14/7	46/8

ELECTROLYTIC CAPACITORS (Mullard.) —10% to +50%.
Subminiature (all values in μF)

4V	8	32	64	125	250	400
6·4V	6·4	25	50	100	200	320
10V	4	16	32	64	125	200
16V	2·5	10	20	40	80	125
25V	1·6	6·4	12·5	25	50	80
40V	1	4	8	16	32	50
64V	0·64	2·5	5	10	20	32
Price	1/4	1/3	1/2	1/-	1/1	1/2

Small (all values in μF)

4V	800	1,250	2,000	3,200
6·4V	640	1,000	1,600	2,500
10V	400	640	1,000	1,600
16V	250	400	640	1,000
25V	160	250	400	640
40V	100	160	250	400
64V	64	100	160	250
Price	1/6	2/-	2/6	3/-

POLYESTER CAPACITORS (Mullard)
Tubular 10%. 160V: 0·01, 0·015, 0·022μF, **7d.** 0·033, 0·047 μF, **8d.** 0·068, 0·1 μF, **9d.** 0·15 μF, **11d.** 0·22 μF, **1/-.** 0·33 μF, **1/3.** 0·47 μF, **1/6.** 0·68 μF, **2/3.** 1 μF, **2/8.**
400V: 1,000, 1,500, 2,200, 3,300, 4,700pF, **6d.** 6,800pF, 0·01, 0·015, 0·022 μF, **7d.** 0·033 μF, **8d.** 0·047 μF, **9d.** 0·068, 0·1 μF, **11d.** 0·15 μF, **1/2.** 0·22 μF, **1/6.** 0·33 μF, **2/3.** 0·47 μF, **2/8.**

SEMICONDUCTORS: OA5, OA81, **1/9.** OC44, OC45, OC71, OC81, OC81D, OC82D, **2/-.** OC70, OC72, **2/3.** AC107, OC75, OC170, OC171, **2/6.** AF115, AF116, AF117, ACY19, ACY21, **3/3.** OC140, **4/3.** OC200, **5/-.** OC139, **5/3.** OC25, **7/-.** OC35, **8/-.** OC23, OC28, **8/3.**

SILICON RECTIFIERS (0·5A): 170 P.I.V., **2/9.** 400 P.I.V., **3/-.** 800 P.I.V., **3/3.** 1,250 P.I.V., **3/9.** 1,500 P.I.V., **4/-.** (6A): 200 P.I.V., **3/-.**, 400 P.I.V., **4/-.** 600 P.I.V., **5/-.** 800 P.I.V., **6/-.**

PRINTED CIRCUIT BOARD (Vero).
0·15in. Matrix: 3¾in. × 2½in., **3/3.** 5½in. × 2½in., **3/11.** 3¾in. × 3¾in., **3/11.** 5in. × 3¾in., **5/6.**
0·1 Matrix: 3¾in. × 2½in., **4/-.** 5in. × 2½in., **4/6.** 3¾in. × 3¾in., **4/6.** 5in. × 3¾in., **5/3.**

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No.	SEC. TAPS	AMPS	PRICE	CARR.
1A	25-33-40-50	15	£9 10 0	10/6
1B	25-33-40-50	10	£6 19 6	8/6
1C	25-33-40-50	6	£5 19 6	8/6
1D	25-33-40-50	3	£3 12 6	7/6
2A	4-16-24-32	12	£6 10 0	7/6
2B	4-16-24-32	8	£4 17 6	7/6
2C	4-16-24-32	4	£3 5 0	6/–
2D	4-16-24-32	2	£2 2 6	5/–
3A*	25-30-35	40	£14 17 6	15/–
3B*	25-30-35	20	£9 7 6	9/6
3C	25-30-35	10	£6 10 0	7/6
3D	25-30-35	5	£3 15 0	6/6
3E	25-30-35	2	£2 15 0	6/6
4A*	12-20-24	30	£11 15 0	10/–
4B	12-20-24	20	£7 10 0	8/6
4C	12-20-24	10	£4 15 0	7/6
4D	12-20-24	5	£3 5 0	6/6
5A	3-12-18	30	£8 15 0	7/6
5B	3-12-18	20	£6 10 0	7/6
5C	3-12-18	10	£3 17 6	6/6
5D	3-12-18	5	£2 12 6	6/6
6A	48-56-60	2	£3 5 0	5/6
6B	48-56-60	1	£2 7 6	5/6
7A*	6-12	50	£9 7 6	9/6
7B	6-12	20	£5 10 0	7/6
7C	6-12	10	£3 10 0	6/6
7D	6-12	5	£2 10 0	5/6
8A	12-24	1	£1 9 6	5/6
9A	17-32	8	£5 12 6	5/6
10A*	9-15	2	£1 5 0	5/6
11A	6·3	15	£2 5 0	5/6
12A	30-25-0-25-30	2	£3 5 0	5/6

Note: By using the intermediate taps many other voltages can be obtained.

Example: No. 1. 7-8-10-15-17-25-33-40-50V.
" 2. 4-8-12-16-20-24-32V.
" 5. 3-6-9-12-15-18V.

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240v.-110v. or 100v. Completely Shrouded fitted with Two-pin American Sockets or terminal blocks. Please state which type required.

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1	80	2½ lb	£1 17 6	4 6
2	150	4 lb	£2 7 6	5 0
3	300	6½ lb	£3 7 6	6 0
4	500	8½ lb	£4 15 0	6 6
5	1000	15 lb	£6 12 6	7 6
6*	1750	25 lb	£13 10 0	10 6
7*	2250	30 lb	£16 10 0	12 6

*Completely enclosed in beautifully finished metal case fitted with two 2-pin American sockets, neon indicator, on/off switch, and carrying handle.

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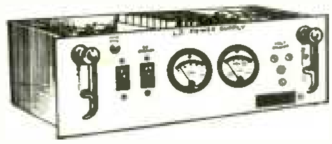
AMERICAN HIGHLY STABILISED POWER SUPPLY UNIT



Regulation between 7-15 volts D.C. at 20 amps. Fitted 0-30 D.C. ammeter, 0-15 D.C. voltmeter and overload protection switch. Built to a very high specification. Bench or rack mounting. Size 19 × 8 × 17 ins. A.C. input 110v. 50 cycles. Ex equipment but guaranteed in perfect condition. Maker's price in excess of £200. Our price £25. Carr. 30/- 240/110 volt, 400 watts, Mains Transformer available if required. £3 extra.

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Pri 110-120v.-200-240v. Sec. tapped 12, 18, 24, 30 v. 8a. Table top connections. Fully tropicalised. 75/-. Carr. 7/6. As above 5 amp rating. 59/6. Carr. 6/-. Supplied brand new manufactured for the Phoenix Telephone Co.

Pri tapped 200-250v. Sec. 46v. Very conservatively rated at 29 amps. Size 11×7×7ins. Weight 75 lbs. approx. Manufactured by Partridge. £12.19.6. Carr. 15/-.

Pri tapped 110v. 220-250v. Sec. 55v. 24a., 14v. 10a., 60v. 2a. All windings very conservatively rated. Tropically finished. Terminal connections. Size 9×7½×7ins. Weight 65lbs. £10.19.6. Carr. 15/-.

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Manufactured by famous makers. Offered at a fraction of List Prices, all Primaries tapped 200-240v. Table Top connects "C" core type. No. 1 sec. 600v. 220 m/a. 52/6 carr. 7/6.
No. 2 Sec Tapped 630-650v. 150 m/a 52/6 carr. 7/6.
No. 3 Sec 125v. 265 m/a Twice 35/-, P. & P. 5/-.
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No. 6 Sec 450-350-350-450v. 100 m/a 27/6, P. & P. 4/6
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2,000 "C" Core, Potted Type HT Transformers and Chokes by famous manufacturers in stock, callers only. FRACTION OF MAKER'S PRICE.

ONE ONLY ZENITH L.T. TRANSFORMER Pri 230v. Sec 10 volts 170 amps Twice. Conservatively rated £35 Ex Warehouse.

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6 figs inc. 1/10ths, 1/100ths 40v. A.C. but complete with transformer for 240v. A.C. operation. All in plastic case. Size 6¼ × 6¼ × 3in. Condition as new 45/-. P. & P. 5/-.

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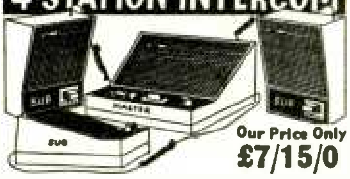

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Solve your communication problems with this new **4-Station Transistor Intercom** system (**1 master** and **3 subs**), in de luxe plastic cabinets for desk or wall mounting. Call/talk/listen from **Master** to **Subs** and **Subs** to **Master**. Operates on one 9 v. battery. On/off switch. Volume control. Ideally suitable to modernise Office, Factory, Workshop, Warehouse, Hospital, Shop, etc., for instant inter-departmental contacts. Complete with 3 connecting wires, each 66ft. and other accessories. Nothing else to buy. P. & P. 7/6 in U.K.

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(1 MASTER & 6 SUB-STATIONS) in strong metal cabinets. Fully transistorised. 3½in. Speakers. Call on Master identified by tone and Pilot lamp. Ideally suitable for Office, Hotel, Hospital and Factory. Price **27 gns.** P. & P. 14/6 in U.K.

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CV4004	10/-
CV4005	8/-
CV4006	18/-
CV4007	7/-
CV4014	7/-
CV4015	10/-
CV4024	6/-
CV4025	7/-
CV4031	7/-
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CV4044	12/-
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CV4046	90/-
CV4048	12/6
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DET22	110/-
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DF91	4/-
DF96	7/6
DH63	6/-
DH77	4/9
DK32	7/9
DK91	6/-
DK92	9/-
DK96	7/9
DL66	25/-
DL92	6/3
DL94	6/9
DL96	7/6
DL810	12/6
DL816	30/-
DL819	30/-
DY86	6/-
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DY802	9/6
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ECC33	15/-
ECC40	17/6
ECC70	15/-
ECC81	6/-
ECC82	5/9
ECC83	6/3
ECC85	5/-
ECC88	7/6
ECF80	6/6
ECF82	6/6
ECH35	11/6
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ECL83	10/3
ECL86	9/-
ECLL800	30/-
EF9	20/-
EF37A	7/-
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EF41	10/-
EF50	5/-
EF80	4/3
EF86	6/6
EF89	5/6
EF91	2/9
EF92	2/6
EF98	15/0
EF183	6/6
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EH90	7/6
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EL36	9/3
EL41	10/6
EL42	10/6
EL81	9/-
EL84	4/9
EL85	7/9
EL86	8/3
EL90	6/3
EL95	6/6
EL360	24/-
EL820	6/-
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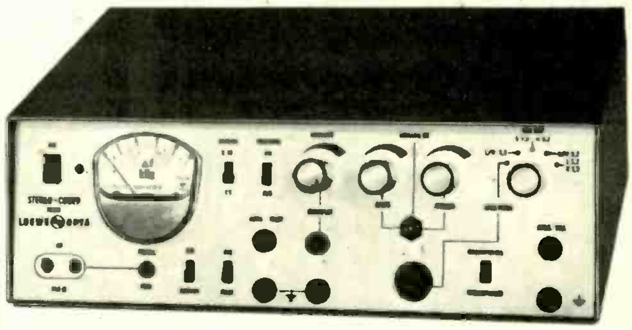

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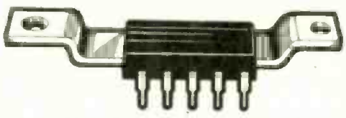

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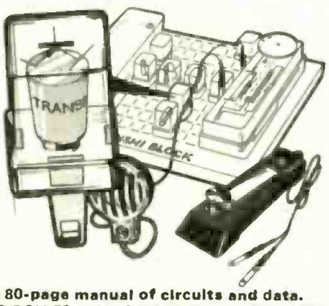

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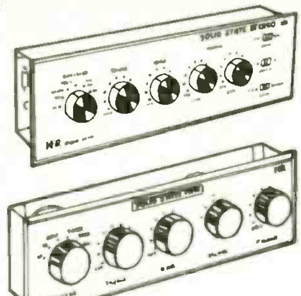

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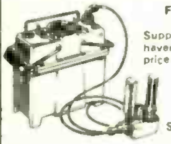

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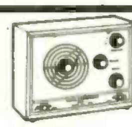

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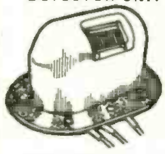

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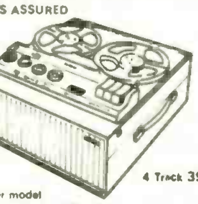
9 volt. 6 transistor unit complete with volume control. Output to 3 ohms. Ideal for use with Staar record Deck. 45/- post 3/-. Send for leaflet 2.

BUILD A QUALITY TAPE RECORDER

To get the best out of your **MAGNAVOX DECK**, you need a **MARTIN RECORDAKIT**. This comprises a special high quality 6 valve amplifier and pre-amplifier which comes to you assembled on its printed circuit board—in fact everything needed down to the last screw **FOR MAKING A SUPERB TAPE RECORDER**, which, when built, will compare favourably with instruments costing twice as much, yet you need no experience or technical skill to bring this about. **THE INSTRUCTIONS MANUAL MAKES BUILDING EASY AND SUCCESS ASSURED**



4 Track 39 gns.

P.P. 22/6 either model

Kit comprises: Deck, Amplifier, Cabinet and speaker, with MICROPHONE 7 in 1,200 ft. tape, spare spool.

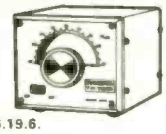
ALL UNITS AVAILABLE SEPARATELY. Today's Value £60.

ASK FOR BROCHURE 6.

VHF FM SUPERHET TUNER MKII

•5-MULLARD TRANSISTORS & 4 DIODES • 300 Kc/s BANDWIDTH • PRINTED CIRCUIT CONSTRUCTION •HIGH FIDELITY REPRODUCTION MONO AND STEREO

A popular VHF FM Tuner now used throughout the country for quality reception of monophonic and, with the decoder stereophonic broadcasts. There is no doubt about it—VHF FM gives the the *real sound*. Excellent stability economically priced.



PARTS TOTAL COST £6.19.6.

DECODER £5.19.6.

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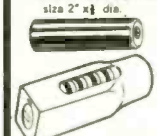
NEW—MALLORY LONG LIFE MERCURY BATTERIES 50% OFF LIST PRICES

•RM12 1.35 volts 3600 m/aH size 2" x ⅝ dia. **OUR PRICE 5/- each**



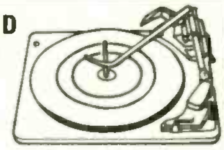
• RM625 10.35 volts 350 m/aH Pack of 8. Size 2¼ x ⅝ dia.

OUR PRICE 10/- each

Easily split into eight 1.35v. cells. These cells are ideal for any application where SMALL SIZE HIGH CAPACITY and LONG LIFE are required.

QUANTITIES AVAILABLE.

GARRARD RECORD DECKS



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2025 Mono/Stereo GKS 25	8	8	0
3000LM Mono/Stereo 9 TAHC	9	16	6
SP25 Mk II	9	19	6
AT60 Mk II	13	0	0
AP75	19	0	0
SL55	11	19	6
SL65	14	14	0
SL75	29	0	0
SL95	35	0	0
A70 Mk II	12	12	0
B.S.R. UA25 Mono	5	19	6
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MA70	12	12	0
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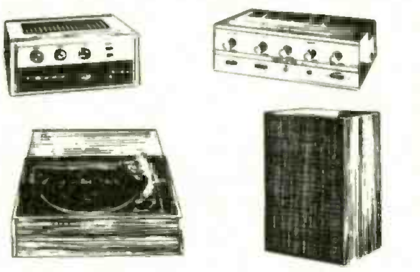

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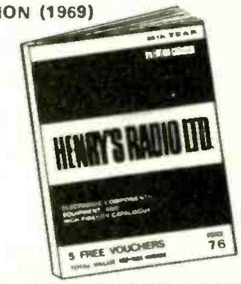

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12, 14/0076 copper cores, each one insulated by coloured P.V.C. then separately screened, the 12 metal braided cores laid together and P.V.C. covered overall making a cable just under ½ in. dia. but quite pliable. Price **7/6** per ft. Any length cut.

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Screened 3 Core Flex. Each core 14/0076 Copper P.V.C. insulated and coloured, the 3 cores laid together and metal braided overall. Price **£3.15** per 100 yds. coil.
15 Amp 3 Core Non-kink Flex. 70/7076 insulated coloured cores, protected by tough rubber sheath, then black cotton braided with white tracer. A normal domestic flex as fitted to 3 Kw fires. Regular price 3/6 per yd. 50 yd. coil **£4.10**, or cut to your length **2/6** per yd.
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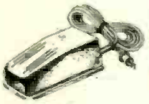
23/0076 triple core P.V.C. covered, circular, normally sold at 1/6 yd. Our price 100 yd. coil **£3.19.6**. Post and ins. 6/6.



15A FOOT SWITCH

Suitable for Sewing Machine Motor, Drilling Machine or in fact to switch any job where both hands are to be left free. Rated at 13 amps, 250 volts. Price **22/6**.

3 DIGIT COUNTER

For Tape Recorder or other application, re-settable by depressing button. Price **8/6**.

TRANSDUCER

Made by Acos, reference No. 1.D.1001. For measuring vibration, etc., to be used in conjunction with "G" Meter. Regular price £5. Our price **49/6**. Brand new and unused.

ISOLATION SWITCH

20 Amp D.P. 250 Volts. Ideal to control Water Heater or any other appliance. Neon indicator shows when current is on, **4/6** **48/-** per dozen.

LIGHT CELL

Almost zero resistant in sunlight increases to 10 K. Ohms in dark or dull light, epoxy resin sealed. Size approx. 1in. dia. by ¼in. thick. Rated at 500 MW. wire ended. **8/6** with circuit.

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6-12 volts, adjustable tone, a very neat metal cased U.S.A. made unit approx. 1¼in. × 1in. × ¾in. thick. **6/6** each.

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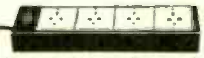
For energizing Reed Switches, etc., size approx. 1¾in. long by 1½in. diameter. Hole through Solenoid approx. ¾in. **8/6** each.

THE FULL-FI STEREO SIX

The amplifier sensation of the year

You will be amazed at the fullness of reproduction and at the added qualities your records or tuner will reproduce. Built into metal cabinet elegantly styled and teak finished to blend with modern furnishings, this amplifier uses an integrated solid state circuit with an output power of 6 watts R.M.S. split over the two channels. The amplifier is ideal for use with normal pickups and tuners, it has a double wound mains transformer and ganged volume and tone controls—also switching for Mono to Stereo, tuner or pick-up. Other controls include "treble lift and cut," "balance" and separate mains on/off switch. Price is **£9.9**, plus 7/6 post & insurance. Speakers (with tweeters) in oiled teak finish cabinets to match amplifier. **£8.8** pair.

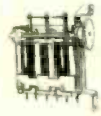
DISTRIBUTION PANELS



Just what you need for work bench or lab. 4 × 13 amp sockets in metal box to take standard 13 amp fused plugs. Supplied complete with 6 feet of heavy cable and 13 amp plug. Similar panels advertised at £5. Our price **39/6**, plus 3/6 post and insurance.

THIS MONTH'S SNIP

3 Stage Permeability Tuner.



This Tuner is a precision instrument made by the famous "Cyldon" Company for the equally famous Radiomobile Car Radio. It is a medium wave tuner (but set of longwave coils available as an extra if required) with a frequency coverage 1,620 Kc/s-525 Kc/s and intended to operate with an I.F. value of 470 Kc/s. Extremely compact (size only 2¼in. × 2in. × ⅞in. thick) with reduction gear for fine tuning. Snip price this month, **12/6**. with circuit of front end suitable for car radio or as a general purpose tuner for use with Amplifier. Post Free.

ELECTRIC CLOCK WITH 25 AMP. SWITCH

Made by Smith's these units are as fitted to many top quality cookers to control the oven. The clock is mains driven and frequency controlled so it is extremely accurate. The two small dials enable switch on and off times to be accurately set. Ideal for switching on tape recorders. Offered at only a fraction of the regular price—new and unused only **39/6**, less than the value of the clock alone—post and insurance 2/9.

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A must for every busy man, gives almost instant heat also illuminates job. 100 watt 220/240v. **39/6** (saves you over 30/-) post and ins. 4/6. BIG JOB 250 watt model **99/6** (saves you over £3.10) post and ins. 6/6.

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(A 15 Amp Switch). Just the thing if you want to come home to a warm house without it costing you a fortune. You can delay the switch on time of your electric fires, etc., up to 14 hours from setting time or you can use the switch to give a boost on period of up to 3 hours. Equally suitable to control processing. Regular price probably around £5. Special snip price **29/6**. Post and ins. **4/6**.

DEAC RECHARGEABLE BATTERIES

6v., 500 mA/hr. size 2¼in. × 1½in. dia. Really powerful, will deliver 1 amp for ½ hour. Regular price 65/-—our price **29/6**. New and unissued.

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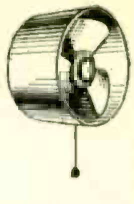

Cleans the air at the rate of 10,000 cubic feet per hour. At the pull of a cord it extracts grease, grime and cooking smells before they dirty decorations. Suitable for kitchens, bathrooms, factories, changing rooms, etc., it's so quiet it can hardly be heard. Compact, 6 in. casing with 5¼ in. fan blades. Suitable wherever it is necessary to move air fast. Kit comprises motor, fan blades, sheet steel casing, pull switch, main connector and fixing brackets.
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Designed to operate transistor sets and amplifiers. Adjustable output 6v., 9v., 12 volts for up to 500mA (class B working). Takes the place of any of the following batteries: PP1, PP3, PP4, PP6, PP7, PP9, and others. Kit comprises: mains transformer rectifier, smoothing and load resistor, condensers and instructions. Real snip at only **16/6**, plus 3/6 postage.

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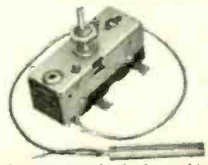
Suitable for dozens of different applications, such as burglar alarms, conveyor-belt switching. These are simply glass-encased switches which can be operated by a passing permanent magnet coil. A special buy enables us to offer these at **2/6** each, or **24/-** a dozen. Suitable magnets are **1/-** each.

THERMOSTAT WITH PROBE



This has a sensor attached to a 15A switch by a 14in. length of flexible capillary tubing—control range is 20deg.F. to 150deg.F. so it is suitable to control soil heating and liquid heating especially when in buckets or portable vessels as the sensor can be raised out and lowered into the vessel. This thermostat could also be used to sound a bell or other alarm when critical temp. is reached in stack or heap subject to spontaneous combustion or if liquid is being heated by gas or other means not controllable by the switch. Made by the famous Teddington Co., we offer these at **12/6** each.

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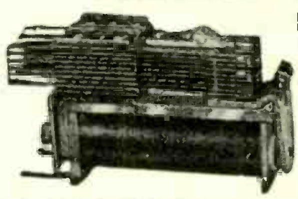

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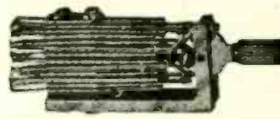

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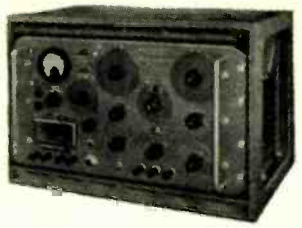

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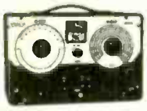
ARF-100 COMBINED AF-RF SIGNAL GENERATOR



AF. SINE WAVE 20-200,000 cps. Square wave 20-30,000 cps. O/P HIGH IMP. 21 v. P/P 600 Ω 3.8 v. P/P. R.F. 100 kc/s-300 Mc/s. Variable R.F. attenuation. Int./Ext. Modulation. Incorporates dual purpose meter to monitor. AF output and % mod. on R.F. 220/240 v. A.C. **£30.** Carr. 7/6.

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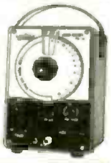

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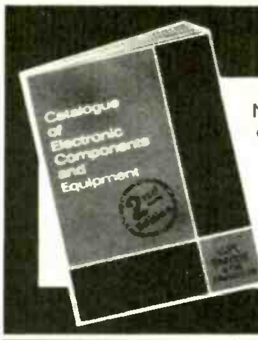

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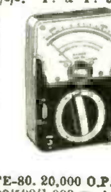

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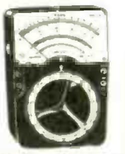

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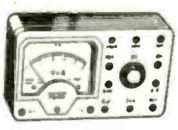
TE-51. NEW 20,000Ω/VOLT MULTIMETER, with overload protection and mirror scale, 0/6/60/120, 1,200 v. A.C. 0/3/30/60/300/600/3,000v. D.C. 0/60μA/12/300m A.D.C. 0/60K/6 meg. ohm. **92/6.** P. & P. 2/6.



MODEL PT-34. 1,000 O.P.V. 0/10/50/250/500/1,000V. a.c. and d.c. 0/1/100/500 mA. d.c. 0/100 K Ω **39/6.** P. & P. 1/6.

MODEL TE-10A. 20kΩ/Volt 5/25/50/250/500/2,500 v. D.C. 10/50/100/500/1,000 v. A.C. 0/50μA/2.5 mA/250 mA D.C. 0/6K/6 meg. ohm. —20 to +22 dB. 10-0, 100 mfd. 0.100-0.1 mfd. **69/6.** P. & P. 2/6.

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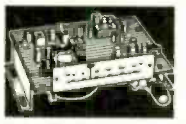
TRANSISTOR FM TUNER



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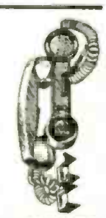

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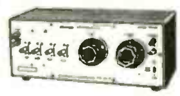
TE111 DECADE RESISTANCE ATTENUATOR



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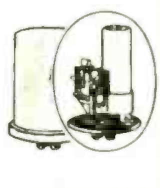

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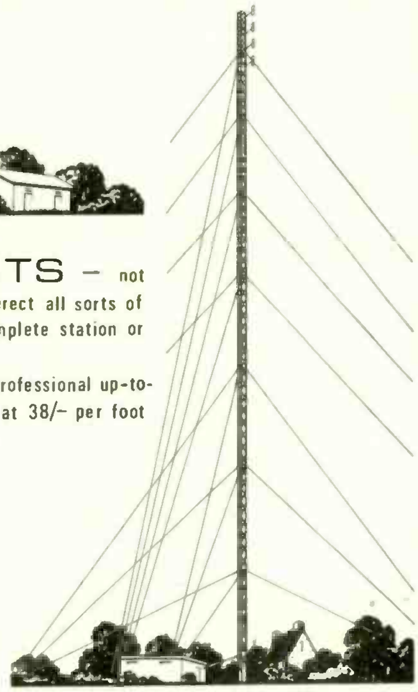

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200µA	55/-	1 amp.	49/6
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500-0-500µA	49/6	15 amp.	49/6
1mA	49/6	30 amp.	49/6
1-0-1mA	49/6	20V. D.C.	49/6
5mA	49/6	50V. D.C.	49/6
		150V. D.C.	49/6
		300V. D.C.	49/6
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		8 Meter 1mA	55/-
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		1 amp. A.C.*	49/6
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Type MR.52P. 2½in. square fronts.

Range	Price	Range	Price
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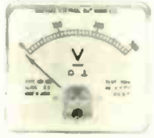
50-0-50µA	49/6	20V. D.C.	37/6
100µA	49/6	50V. D.C.	37/6
100-0-100µA	45/-	300V. D.C.	37/6
500µA	42/6	15V. A.C.	37/6
1mA	37/6	300V. A.C.	37/6
5mA	37/6	8 Meter 1mA	39/6
10mA	37/6	VU Meter	59/6
50mA	37/6	1 amp. A.C.*	37/6
100mA	37/6	5 amp. A.C.*	37/6
500mA	37/6	10 amp. A.C.*	37/6
1 amp.	37/6	20 amp. A.C.*	37/6
5 amp.	37/6	30 amp. A.C.*	37/6

Type MR.38P. 1 21/32in. square fronts.



Range	Price	Range	Price
50µA	37/6	150mA	25/-
50-0-50µA	35/-	200mA	25/-
100µA	35/-	300mA	25/-
100-0-100µA	32/6	500mA	25/-
200µA	32/6	750mA	25/-
500µA	27/6	1 amp.	25/-
500-0-500µA	25/-	2 amp.	25/-
1mA	25/-	5 amp.	25/-
1-0-1mA	25/-	3V. D.C.	25/-
2mA	25/-	10V. D.C.	25/-
5mA	25/-	20V. D.C.	25/-
10mA	25/-	100V. D.C.	25/-
20mA	25/-	150V. D.C.	25/-
50mA	25/-	300V. D.C.	25/-
100mA	25/-	500V. D.C.	25/-
		750V. D.C.	25/-
		15V. A.C.	25/-
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		300V. A.C.	25/-
		500V. A.C.	25/-
		8 meter 1mA	29/6
		VU meter	39/6

Type MR.45P. 2in. square fronts.

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100µA	39/6	50V. D.C.	27/6
100-0-100µA	35/-	300V. D.C.	27/6
500µA	29/6	15V. A.C.	27/6
1mA	27/6	300V. A.C.	27/6
5mA	27/6	8 meter 1mA	35/-
10mA	27/6	VU meter	42/6
50mA	27/6	1 amp. A.C.*	27/6
100mA	27/6	5 amp. A.C.*	27/6
500mA	27/6	10 amp. A.C.*	27/6
1 amp.	27/6	20 amp. A.C.*	27/6
5 amp.	27/6	30 amp. A.C.*	27/6

Type MR.65P. 3½in. × 3½in. fronts.

Range	Price	Range	Price
50µA	65/-	20V. D.C.	39/6
50-0-50µA	52/6	50V. D.C.	39/6
100µA	52/6	150V. D.C.	39/6
100-0-100µA	49/6	300V. D.C.	39/6
500µA	45/-	15V. A.C.	39/6
1mA	39/6	50V. A.C.	39/6
5mA	39/6	150V. A.C.	39/6
10mA	39/6	300V. A.C.	39/6
50mA	39/6	500V. A.C.	39/6
100mA	39/6	8 meter 1mA	45/-
500mA	39/6	VU meter	65/-
1 amp.	39/6	50mA A.C.*	39/6
5 amp.	39/6	100mA A.C.*	39/6
10 amp.	39/6	200mA A.C.*	39/6
15 amp.	39/6	500mA A.C.*	39/6
20 amp.	39/6	1 amp. A.C.*	39/6
30 amp.	39/6	5 amp. A.C.*	39/6
50 amp.	45/-	10 amp. A.C.*	39/6
10V. D.C.	39/6	20 amp. A.C.*	39/6
		30 amp. A.C.*	39/6

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BAKELITE PANEL METERS

Type MR.65. 3½in. square fronts.

Range	Price	Range	Price
25µA	67/6	100mA	32/6
50µA	45/-	500mA	32/6
50-0-50µA	42/6	1 amp.	32/6
100µA	42/6	5 amp.	32/6
100-0-100µA	42/6	15 amp.	32/6
500µA	39/6	30 amp.	32/6
1mA	32/6	50 amp.	32/6
1-0-1mA	32/6	5V. D.C.	32/6
5mA	32/6	10V. D.C.	32/6
10mA	32/6	20V. D.C.	32/6
50mA	32/6	50V. D.C.	32/6
		150V. D.C.	32/6
		300V. D.C.	32/6
		30V. A.C.*	32/6
		50V. A.C.*	32/6
		150V. A.C.*	32/6
		300V. A.C.*	32/6
		1 amp. A.C.*	32/6
		5 amp. A.C.*	32/6
		10 amp. A.C.*	32/6
		20 amp. A.C.*	32/6
		30 amp. A.C.*	32/6
		50 amp. A.C.*	32/6
		VU meter	59/6

EDGWISE METERS

Type PE.70. 3 17/32in. × 1 15/32in. × 2¼ in. deep.

Range	Price	Range	Price
50µA	57/6	500µA	49/6
50-0-50µA	55/-	1mA	45/-
100µA	55/-	300V. A.C.	45/-
100-0-100µA	52/6	VU meter	62/6
200µA	52/6		

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MODEL MD-120

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D.C. Volts: 30, 60, 300, 600, 3,000V.
A.C. Volts: 6, 120, 1,200V.
D.C. Current: 60µA, 12, 300mA.
Resistance: 60K, 6 MEGΩ.
Decibels: —20 to + 63db.
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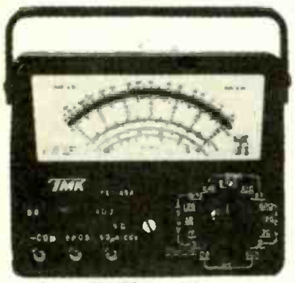

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MODEL PL-436

Features Mirror Scale and Wood Grain Finish Front Panel.
Sensitivity: 20KΩ/Volt D.C. 8KΩ/Volt A.C.
D.C. Volts: 0.6, 3, 12, 30, 120, 600V.
A.C. Volts: 3, 30, 120, 600.
D.C. Current: 50, 600µA. 60, 600mA.
Resistance: 10K, 100K, 1MEG, 10MEGΩ.
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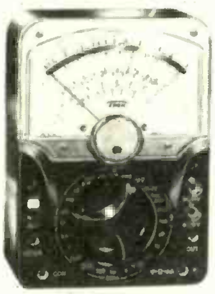

MODEL 500

MODEL 500

Features Mirror Scale and Buzzer Short Circuit Check.
Sensitivity: 30kΩ/Volt D.C. 15kΩ/Volt A.C.
D.C. Volts: 0.25, 1, 2.5, 10, 25, 100, 250, 500, 1,000V.
A.C. Volts: 2.5, 10, 25, 100, 250, 500, 1,000V.
D.C. Current: 50µA, 5, 50, 500mA, 12 amp.
Resistance: 60K, 6MEG, 60MEGΩ.
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A.C. Volts: 1.5, 3, 5, 10, 25, 50, 125, 250, 500 1,000V.
D.C. Current: 25, 50µA., 2.5, 5, 25, 50, 250, 500mA, 5, 10 amp.
Resistance: 2K, 10K, 100K, 1MEG, 10MEGΩ.
Decibels: —20 to +85db.
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Features Unique Range Selector, 6¼in. Scale, Buzzer Short Circuit Check.
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A.C. Volts: 3, 10, 50, 250, 500, 1,000V.
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Closed Sat. 1 p.m.

WW—147 FOR FURTHER DETAILS

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No responsibility accepted for errors.

Advertisements accepted up to SEPTEMBER 5 for the OCTOBER issue, subject to space being available.

UNIVERSITY OF BIRMINGHAM

University Television Service

Vacancy for a CHIEF TECHNICIAN or SENIOR TECHNICIAN. Candidates should have had wide experience in the electronics/television fields and preferably practical experience of broadcast television equipment and procedures. Initial grading will depend on the age, experience and qualifications of the successful candidate.

Salary: Chief Technician £1,385 to £1,578, higher in special cases. Senior Technician £1,056 to £1,311. Plus shift allowance as appropriate.

Applications to Personnel Adviser, University of Birmingham, P.O. Box 363, Birmingham 15, quoting reference 113/CT/693.

2387

CENTRAL MIDDLESEX GROUP HOSPITAL MANAGEMENT COMMITTEE

NEW POST— ULTRA-SONIC TECHNICIAN

This is the first post of its kind and will attract a man with a strongly developed interest in electronics who wishes to consider the application of ultra-sonics to medical examinations. The successful applicant will be required to work on his own initiative, be capable of handling patients and prove able to conduct ultra-sonic examinations single-handed on occasions. He will also be required to develop, under supervision, new electronic apparatus. The salary scale is £916-£1,172, plus £90 p.a. London Weighting. Possession of a car is essential and a car user allowance will be payable. Further details and application forms available from: Group Secretary, Central Middlesex Hospital, Park Royal, London, N.W.10.

2382

UNIVERSITY OF SOUTHAMPTON DEPARTMENT OF ELECTRONICS

An

EXPERIMENTAL OFFICER

experienced in digital techniques is required to take charge of the day-to-day running of a number of Research and Teaching Projects linked to a Honeywell 516 computer. Familiarity with a computer or similar system is essential. There is real opportunity to make a positive contribution to the scientific work. Ample career prospects exist. Applicants should be graduates or hold associate membership of a relevant professional institution. Salary scale £1,240-£2,045 plus F.S.S.U.

Applications giving a brief curriculum vitae and the names of two referees should be sent to the Deputy Secretary, University of Southampton, Highfield, Southampton, SO9 5NH, quoting ref: W.W.

2404

Technician (Communications)

Eastern Gas are at present engaged in expanding their Communications facilities. A microwave trunk radio system with UHF Spurs is being installed to provide facilities for the control and supervision of the gas distribution network. Concurrent with this, the existing fleet of vehicles equipped with mobile radio is being converted to operate on a new frequency band.

A vacancy for a Technician in the Headquarters Group of the Communications Department has occurred through internal promotion. The successful applicant will be required to assist with the conversion of mobile radios and with the planning of the Communications facilities for the Board's natural gas conversion programme. He should be conversant with VHF and UHF radio practice and will be given opportunity to gain experience in microwave techniques.

The salary for this post, which will be based initially in Harpenden then at Potters Bar, will be between £1140—£1460 according to previous experience of the candidate.

Please write giving full details to: **Appointments Officer, Eastern Gas, 49 Clarendon Road, Watford, Herts.** within 10 days of the appearance of this advertisement.

Eastern GAS

RADIO SYSTEMS DIVISION

Electronic Instrumentation Calibration Engineers

Vacancies exist in our Ilford Test Gear Department for Engineers experienced in calibration testing of electronic measuring instruments. Candidates must have a wide knowledge of basic electronic measurements covering Bridges, D.V.M's, Counters, C.R.O's, S.S.G's, RF and Power Measurements, and it is desirable that they be qualified to O.N.C. or equivalent level.
Realistic salaries will be negotiated and there are attractive staff benefits.

Letters of application giving details of experience and quoting Ref. ILF/843/E to: The Technical Staff Manager, The Plessey Company Limited, Ilford, Essex.

PLESSEY ELECTRONICS

2442

GOVERNMENT OF ZAMBIA

MINISTRY OF INFORMATION, BROADCASTING AND TOURISM

SENIOR MAINTENANCE ENGINEER

A.M. TRANSMITTERS RC 237/132/05

To design short and medium wave transmitting aerials, together with the associated matching networks for transmitters up to 120KW and to be responsible for the satisfactory operation and maintenance of all transmitters including Staff Supervision. Contract 30 to 36 months. Candidates age 25-55 years, minimum qualifications as follows: (1) City and Guilds Telecommunication Technician's Certificate or acceptable equivalent (preference will be given to candidates with a higher qualification). (2) Eight years experience on a broadcasting transmitter station including the installation and maintenance of short and medium wave transmitters of low, medium and high power. Additional experience of Television and F.M. transmitters installation and maintenance an advantage. Basic salary Kwachas 3,948 or 4,056 (£2,303 or £2,366 p.a.) plus inducement allowance £433 or £452 p.a. both subject to local income tax. In addition a tax free supplement payable direct by the British government of £291 p.a. Terminal gratuity of 25% on basic salary and inducement allowance.

3 TELEVISION ENGINEERS

(1) MAINTENANCE ENGINEER
TELEVISION STUDIOS RC 237/132/03

To maintain without supervision all types of technical equipment including telecine apparatus, cameras, etc., associated with a small T.V. Studio. Candidates, age 25-50 years, should have either (1) City and Guilds Telecommunication Technician's Certificate or an acceptable equivalent plus a minimum of 5 years' practical experience in T.V. Studios, or, (2) City and Guilds Intermediate Telecommunication Certificate or acceptable equivalent plus a minimum of 7 years' practical experience. In addition, experience in detailed operation and maintenance of helical scan video tape recorders an advantage.

(2) MAINTENANCE ENGINEER
SOUND STUDIOS RC 237/132/04

To install and maintain all types of studio equipment required for Master Control Rooms, Continuity and Recording Suites. Candidates age 25-50 years should have either (1) City and Guilds Telecommunications Technician's Certificate or acceptable equivalent plus a minimum of 5 years practical experience in broadcasting sound studios, or, (2) City and Guild Intermediate Telecommunication Certificate or acceptable equivalent plus a maximum of 7 years practical experience in broadcasting sound studios. In addition, experience in the detailed operation and maintenance of a wide range of sound recording equipment an advantage.

(3) MAINTENANCE ENGINEER
A.M. TRANSMITTERS RC 237/132/02

To install and undertake the complete maintenance of sound broadcasting short and medium wave transmitters of low, medium and high power, including line programme input equipment. Instruction of junior technicians in practical maintenance. Candidates age 25-50 years should have either (1) City and Guilds Telecommunications Technician's Certificate or acceptable equivalent plus a minimum of 5 years' practical experience on a broadcasting A.M. transmitter station, or, (2) City and Guilds Intermediate Telecommunication Certificate or acceptable equivalent plus a minimum of 7 years' practical experience on a broadcasting A.M. transmitter station. In addition extra experience of T.V. and F.M. transmitter installation and maintenance an advantage.

MAINTENANCE ENGINEERING POSTS

One tour 30-36 months. Basic salary Kwachas 3,300 to 3,840 (£1,925 to £2,240 p.a.) plus inducement allowance of £403 to £583 p.a., both subject to local tax. In addition a tax free supplement payable direct by the British Government of £268 or £291 p.a. according to basic salary. Terminal gratuity 25% on basic salary and inducement allowance.

Candidates who should be citizens of the United Kingdom should apply quoting RC 237/132/02, 03, 04 or 05, giving full name, age, qualifications and experience to:—

The Appointments Officer,
Ministry of Overseas Development,
Room 301, Eland House, Stag Place, London, S.W.1.

computer engineering

NCR requires additional ELECTRONIC, ELECTRO MECHANICAL ENGINEERS and TECHNICIANS to maintain medium to large scale digital computing systems in London and provincial towns.

Training courses will be arranged for successful applicants, 21 years of age and over, who have a good technical background to ONC/HNC level, City and Guilds or radio/radar experience in the Forces.

Starting salary will be in the range of £900/£1,250 per annum, plus bonus. Shift allowances are payable, after training, where applicable. Opportunities also exist for Trainees, not less than 19 years of age, with a good standard of education, an aptitude towards and an interest in, mechanics, electronics and computers.

Excellent holiday, pension and sick pay arrangements. Please write for Application Form to
Assistant Personnel Officer
NCR, 1,000 North Circular Road,
London, NW2
quoting publication and month of issue.

Plan your future with **NCR**

GEC-Marconi Electronics

Electrical Testers Electrical Inspectors

Elliott Flight Automation, Rochester, Kent, have the following vacancies for experienced personnel.

ELECTRICAL TESTERS

Capable of carrying out functional tests on complete equipment and sub-assemblies, making adjustments or calibrating, reporting faults and diagnosing their causes.

ELECTRICAL INSPECTORS

Able to read drawings and circuit diagrams and be capable of inspecting airborne equipment to ministry specifications.

Interested persons should apply by completing the form below.

ELLIOTT FLIGHT AUTOMATION

To: P. Webb, Personnel Officer, Elliott Flight Automation, Airport Works, Rochester, Kent.

Name ....

Address ....

....

PW/W

Member of GEC-Marconi Electronics Limited

AIRWORK (OVERSEAS) LIMITED

We have a continuing requirement for experienced men who are leaving the Service or who have had the appropriate training in industry. In return for a good salary and annual bonus (both of which can qualify for income tax concessions) we ask our staff to work overseas for a year or so. The period spent abroad is broken by generous holidays with free air passages.

Accommodation, laundry and a very high standard of catering are supplied by the Company without charge. This enables many of our overseas staff to save a considerable sum during their period of service abroad.

Our immediate requirement includes the following vacancies :–

CHIEF TECHNICIAN AIRCRAFT
(Ref. CTA)
and
SECTION LEADER AIRFRAME/ENGINE
(Ref. SLA/E)

Ideal candidates will be ex-RAF Senior N.C.O. Aircraft Fitters with at least two years' experience on Lightning airframes and Avon Mk 300 series engines.

SECTION LEADER RADIO
(Ref. SL/R)

Suitable for an ex-RAF Senior N.C.O. Electronic Fitter with at least two years' experience on Lightning aircraft.

SECTION LEADER INSTRUMENT/ ELECTRICAL
(Ref. SL/IE)

We are looking for an ex-RAF Senior N.C.O. qualified in Instruments and Electrics, and experienced on Lightning aircraft.

TECHNICIAN RADIO/RADAR
(Ref. TR/R)

Experience is required in the servicing and calibration of Airfield Aids, GCA equipment and TACAN.

GENERAL FITTERS
(Ref. GF)

Experience must include the servicing of airfield ground equipment, LOX equipment and in gas production methods.

We are also interested in applications from junior technicians in any of the above trades, including Armament Fitters who have experience in first and second line servicing on Lightning aircraft.

Please write, quoting where appropriate the reference number, to:

THE PERSONNEL MANAGER
AIRWORK (OVERSEAS) LIMITED
BURLINGTON ARCADE
BOURNEMOUTH . HANTS

2447

SOUTHERN
INDEPENDENT TELEVISION

require

ASSISTANT ENGINEERS AND TECHNICAL ASSISTANTS

for the operation and maintenance of television equipment at their SOUTHAMPTON studios. The successful applicants would be required to live in the Southampton area and would be employed on shift duty.

The company are expanding and have occupied a new studio centre fully equipped for colour television.

An Ordinary National Certificate in Electrical Engineering or equivalent is a necessary qualification together with normal colour vision.

Rates of pay:

Assistant Engineers	Technical Assistants
A.C.T.T. Grade 'E'	**A.C.T.T. Grade 'H'**
£1,729 p.a.	**£1,415 p.a.**

Canteen facilities and excellent pension.
Widow's pension.
Life assurance and accident insurance schemes are in operation.

Please apply, in writing, to the

Personnel Officer,
Southern Television Limited,
Northam, Southampton,
S09 4YQ

2456

Computicket want

MAINTENANCE TECHNICIANS

Computicket are moving rapidly towards the full implementation of their entertainment seat booking system. This service, which operates in real-time, will ultimately involve hundreds of on-line C.R.T. terminals sited in a wide variety of public places.

Computicket are now recruiting Maintenance Technicians for the Greater London area to perform a vital role in this exciting new service.

Applicants should have had experience in the maintenance of electro-mechanical and electronic equipment situated in the field and should be happy to find themselves part of a technically advanced but none-the-less consumer orientated team.

Conditions of employment are attractive and salary will be in the region of £1,500 p.a.

Write with resumé of career to: Colin Roberts, Chief Engineer,

Computicket Limited
30 FINSBURY SQUARE, EC2
Member company of International Publishing Corporation

CHALLENGING OPPORTUNITIES in CANADA

Radio and Electronic Technicians with a desire to see more of the world can find rich rewards by joining Canadian Marconi Company. Technicians are required for maintenance duties on Northern installations.

Successful applicants will enjoy minimum salaries of $7,600 plus first-class prospects for rapid advancement and further substantial rises during the first year. There are also genuine opportunities for promotion to supervisory grades with salary ranges of over $13,500 per annum.

Food and accommodation is provided free for the employee (no family accommodation), in addition to heavy duty clothing. Assistance with air passage is available.

A chance of a lifetime is offered to accrue substantial savings.

CAN YOU QUALIFY?

Formal training and experience in maintenance of communications type equipment is required with special emphasis on:

Microwave
Tropospheric Scatter
Communications Systems
Telephone and Carrier (Multiplex)

If you have three or more years' experience in installation or maintenance on this type of equipment together with recognized qualifications, i.e. City and Guilds, Higher National or equivalent, the answer is Yes! Interviews will be held in London in the near future. Please send brief career details, quoting WW2988J, to Mr. D. S. Howell, **Canadian Marconi Company, P.O. Box 540, Station "O", Montreal 379, Quebec, Canada.**

CMC CANADIAN MARCONI

CANADIAN MARCONI COMPANY

2440

SHIFT INSTRUMENT CRAFTSMEN

required at

BRADWELL POWER STATION

This post offers excellent opportunity for mechanics to broaden their experience. Applicants with experience of industrial instruments, electronic or telecommunications equipment will be considered.

Housing may be available to successful applicants.

Gross weekly rate £26.5.10 for a 40 hour 5 day week on shift working, plus service increments after 2 and 3 years' service.

Good conditions and holidays, with sick pay and optional superannuation schemes; canteen and Sports and Social Club facilities.

Applications, giving age, details of experience, etc., should be sent to the Station Superintendent, Bradwell Power Station, Bradwell-on-Sea, Southminster, Essex quoting Vacancy No. 5504/69. 2454

AGRICULTURAL RESEARCH COUNCIL

Unit of Invertebrate Chemical Physiology

Applications are invited for the post, described below, in the newly formed Unit of Invertebrate Chemical Physiology under the Hon. Directorship of Professor A. W. Johnson, F.R.S., of the University of Sussex. The appointment would however be to the Sub-Unit which is under the direction of Dr. J. E. Treherne and is situated at the University of Cambridge.

Electronics Technician

(Assistant Experimental Officer) required to work with a group carrying out research on biophysics and electrophysiology in the University of Cambridge.

Qualifications. A.E.O., age 22 and over—pass degree, H.N.C. or equivalent: under 22, G.C.E. in 5 subjects including 2 at advanced level.

SALARY SCALE: Assistant Experimental Officer £683 (at age 18) to £1,208 (maximum starting salary at age 26 or over) to £1,454.

Applications including details of previous experience and names of two referees should be sent to:

Dr. J. E. Treherne,
A.R.C. Unit of Invertebrate Chemistry and Physiology,
Department of Zoology,
Downing Street,
Cambridge.

2389

Television Broadcasting

The Independent Television Authority Engineering Information Service is expanding its service to both the trade and the general public. To do this we now require the following staff who will be involved with the organisation of exhibitions and meetings concerned with Colour Television and assisting in the field survey work throughout the U.K.

INFORMATION OFFICER

£1,485–£2,365

Candidates should have a good knowledge of Television theory plus wide experience of television broadcasting techniques. Public speaking and writing ability are also essential. (Ref. no. ww/6104/1198)

INFORMATION ASSISTANT

£1,090–£1,790

Candidates should have good technical ability and experience of the radio and television trades, and be able to drive large exhibition vehicles. (Ref. no. ww/6105/1199)

Starting salaries will be in the ranges indicated depending on experience and qualifications, plus fringe benefits. Both posts will be based in London but will involve travel to all parts of the country.

Please write or telephone for an Application Form, quoting the appropriate reference, to:

ITA

The Personnel Officer
INDEPENDENT TELEVISION AUTHORITY
70 Brompton Road
London SW3
01-584 7011 Ext. 482.

2448

ELECTRONIC ENGINEERS

Service Engineers required for Offices, throughout the United Kingdom, of well-known Company manufacturing Electronic Desk Calculating Machines. Applicants should possess a sound knowledge of basic Electronics with experience in Electronics, Radar, Radio and T.V. or similar field. Position is permanent and pensionable. Comprehensive training on full pay will be given to successful applicants. Please send full details of experience to the Service Manager, Sumlock Comptometer Ltd., 102/108 Clerkenwell Road, London, E.C.1.

82

MINISTRY OF TRANSPORT

Electrical Engineering Assistants

There are vacancies for Electrical Engineering Assistants (Grades II and III) in the Traffic Engineering Division of the Ministry of Transport, St. Christopher House, Southwark Street, London, S.E.1.

DUTIES To assist Professional Engineers engaged on the design and provision of signal and surveillance systems for motorways. This is an expanding project offering challenging opportunities in the fields of computing, data acquisition and transmission, and in optical, magnetic and radar detection systems.

QUALIFICATIONS AND EXPERIENCE It is essential that candidates should have some knowledge in one or more of the fields referred to above. Candidates should hold technical qualifications in appropriate subjects (Ordinary National Certificate or equivalent). Candidates for Grade II posts should preferably hold higher qualifications.

SALARY Grade II £1,543 on entry rising by four annual increments to a maximum of £1,771. Grade III £1,114 (at age 21) to £1,395 (at age 28 or over) to £1,543.

Good working conditions. Five-day week. Annual paid holiday allowance of 18 working days for Grade III and 22 days for Grade II in addition to the usual public holidays (8½ days).

Applicants aged 21 or over may apply. Application forms can be obtained from Establishment Staffing 3 Division, Room 8/121, Ministry of Transport, St. Christopher House, Southwark Street, S.E.1.

2383

RADIO AND INSTRUMENTATION ENGINEERS

Required for WEST AFRICAN PROJECTS

C.O.D.E.C.O.

62 STEPHYNS CHAMBERS · BANK COURT
MARLOWES · HEMEL HEMPSTEAD · HERTS

2403

GEC-Marconi Electronics

ELECTRONIC TECHNICIANS

Marconi can offer you

Attractive salary. Annual salary reviews

Good working conditions. 37-hour working week

Non-tied housing in a new town in certain circumstances

At Basildon we have a number of vacancies for technical test staff to work on advanced aeronautical electronic systems, maintenance and building of test equipment and other major projects. These positions will be of particular interest to men with experience of transmitters, receivers, aerials, closed circuit T.V. or digital systems.

Marconi

THE QUEEN'S AWARD TO INDUSTRY 1966 1967 1968 1969

Please telephone or write for an application form to: Mr. R. McLachlan, Personnel Officer, The Personnel Dept, The Marconi Company Limited, Christopher Martin Road, Basildon, Essex. Phone: Basildon 22822.

Member of GEC-Marconi Electronics Limited

2444

Government of ZAMBIA

Department of Meteorology, Ministry of Power, Transport and Works require

Radar Engineer

On contract for one tour of 36 months in the first instance. Commencing salary according to experience in scale Kwacha 2736 (£Stg. 1596) rising to Kwacha 3216 (£Stg. 1876) a year, plus an Inducement Allowance of £Stg. 568-£Stg. 615. A Direct Payment of £Stg. 268-£Stg. 291 is also payable direct to the officer's bank in the U.K. Gratuity 25% of total salary drawn. Both Gratuity and Direct Payment are normally TAX FREE. Free passages. Accommodation at moderate rental. Education allowances. Liberal leave on full salary or terminal payment in lieu. Contributory pension scheme available in certain circumstances.

Candidates, preferably between 22-35, must have served a five year apprenticeship in radio and radar engineering, or, possess a Service Trade Certificate or a City and Guilds Intermediate Certificate in Telecommunications or its equivalent.

Preference will be given to candidates with experience of H.F. R/T transmitters, radio facsimile and radio-sonde and S and X-band radar equipment.

Duties include the repair and maintenance of all radar sets and communications equipment for which he is responsible and the care and maintenance of appropriate spares and stores. The officer may be required to assist in installation work.

Apply to CROWN AGENTS, 'M' Division, 4 Millbank, London, S.W.1, for application form and further particulars stating name, age, brief details of qualifications and experience and quoting reference number M2Z/690222/WF.

2451

SITUATIONS VACANT

AIRCRAFT RADIO ENGINEERS and Mechanics with specific workshop experience in one of the following: VHF/HF, ILS/VOR, ADF or WEATHER RADAR. Pension Scheme. 3 weeks holiday per year. Apply: MANAGING DIRECTOR, Air Transport (Charter) (C.I.) Ltd., Willow Road, Colnbrook, Bucks. Tel.: Colnbrook 2654. [2291

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

CLARKE & SMITH MANUFACTURING CO., LTD., have vacancies for Audio Electronics and Small Mechanism Design Engineers to work on language laboratory systems, tape copying machines and electronic equipment for education projects. Applicants (who should have qualifications equivalent to H.N.C. standards) should apply to: Mr. T. H. Julian, Clarke & Smith Manufacturing Co. Ltd., Melbourne Road, Wallington, Surrey. Tel.: 01-669 4411. [2411

ELECTRONICS TECHNICIAN required for Language Laboratory in West End. Must be capable of working without supervision. The work involves maintenance of the Language Laboratory Equipment. There is a pleasant working atmosphere and good salary. For interview phone 580 4085. [2406

MAINTENANCE ENGINEER required by the CENTRAL OFFICE OF INFORMATION for their Radio Division. Essential qualifications are a thorough knowledge of mains and battery operated professional tape recording equipment (including Leevers Rich, Uher and Nagra recorders) and ancillary studio equipment; ability to construct all kinds of audio amplifiers, equalisers and relay circuits, and experience in fault finding in electro-mechanical equipment. Knowledge of G.P.O. line plant would be an advantage. Salary £1,325 to £1,700 p.a. Please send postcard for application form to Manager (PEA/260/EW), Department of Employment and Productivity, Professional and Executive Register, Atlantic House, Farringdon Street, London, E.C.1, closing date for completed application forms 29 August, 1969. [2408

MARINE RADIO ENGINEER, fully conversant with Yacht RT/DF, Auto Pilots, Radar, Sounders, etc., installations and service. Willing to live in or near London. Salary in region of £1,350 p.a. Start immediately.—Telesonic Ltd., 92 Tottenham Court Rd., London, W.1. 01-636 8177. [2390

MEDICAL RESEARCH COUNCIL. JUNIOR TECHNICAL OFFICER required to assist with research on cell membranes in Division of Physiology and Pharmacology. Applicants should preferably have had experience in an electrophysiological laboratory and have a science degree or its equivalent; a suitably qualified candidate with two "A" levels will be considered. Initial salary according to age and experience will be on scale £727 to £1,440 per annum. Please make early application quoting our reference WW9 to: The Personnel Officer, National Institute For Medical Research, Mill Hill, London, N.W.7. [2407

QUALIFIED MAINTENANCE ENGINEER and Trainee Maintenance Engineers required for Recording Studio in W.11.—Telephone for interview 01-229 1229. [2391

TV RETAIL BUSINESS of the highest standing, established over 40 years N.W. London. Owner requires PERSONAL ASSISTANT with servicing experience. Good position and prospects for keen and capable man. State age and details of experience. Box W.W. 2396 Wireless World.

WE HAVE VACANCIES for Four Experienced Test Engineers in our Production Test Department. Applicants are preferred who have Experience of Fault Finding and Testing of Mobile VHF and UHF Mobile Equipment. Excellent Opportunities for promotion due to Expansion Programme. Please apply to Personnel Manager, Pye Telecommunications Ltd., Cambridge Works, Haig Road, Cambridge. Tel. Cambridge 51351, Extn. 327. [77

ARTICLES FOR SALE

BBC2 KITS and T.V. SERVICE SPARES. Suitable for Colour: Leading British Makers dual 405/625 six position push button transistorised tuners £5 5s. 0d., 405/625 transistorised sound & vision IF panels £2 15s. 0d. incl. circuits and data, P/P 4/6. Basic dual purpose 405/625 transistorised tuners incl. circuit £2 10s. 0d., P/P 4/6. UHF list available on request. UHF tuners, PYE/EKCO incl. valves 55/-, P/P 4/6. EKCO/FERRANTI 4 position push button type, incl. valves, leads, knobs £5 10s. 0d., P/P 4/6, SOBELL/GEC UHF tuner kit incl. valves, right angle slow motion drive assy, leads, fittings, knobs, instructions £5 18s. 6d., P/P 4/6. FERGUSON 4 position push button transistorised UHF tuners incl. leads & knobs £5 15s. 0d., P/P 4/6. SOBELL/GEC 405/625 IF & output chassis incl. circuit 42/6, P/P 4/6. Ultra 625 IF amplifier plus 405/625 switch assy incl. circuit 25/-, P/P 4/6. New VHF tuners, Cyldon C 20/-, Ekco 283/330 range 25/-, Pye CTM 13 ch. incremental 25/-, P/P 4/6. Many others available incl. large selection channel coils. Fireball tuners, used good cond. 30/-. Push button tuners RGD 612/619 type used good cond. 30/-, P/P 4/6. LOPTs, Scan coils, Frame output transformers, Mains droppers etc., available for most popular makes. TV signal boosters transistorised PYE/Labgear B1/B3, or UHF battery operated 75/-. UHF mains operated 97/6, UHF masthead 85/-, post free. Enquiries invited, COD despatch available. MANOR SUPPLIES, 64 GOLDERS MANOR DRIVE, LONDON, N.W.11. CALLERS 589B, HIGH ROAD, N. FINCHLEY, N.12 (near GRANVILLE RD.). Tel. 01-445 9118. [60

REDIFFUSION

COLOUR TELEVISION FAULTFINDERS & TESTERS

We have a number of vacancies in our Production Test Departments for experienced faultfinders and testers.

Knowledge of transistor circuitry and experience with Colour Receivers together with R.T.E.B. Final Certificate or equivalent qualifications required.

These will be staff appointments with all the expected benefits.

Applications to:

Works Manager,
Rediffusion Vision Service Ltd.,
Fullers Way South,
Chessington, Surrey (near Ace of Spades).
Phone: 01-397 5411

83

GEC-Marconi Electronics

ELECTRONIC TECHNICIANS

are required to work on calibration, fault-finding and testing of telecommunications measuring instruments. The work is varied and will enable technicians with experience of r.f. circuits to broaden their knowledge of the latest techniques employed in the electronics and telecommunications industries by bringing them into contact with a wide range of the most advanced measuring instruments embracing all frequencies up to u.h.f.

Entrants may be graded as Testers, Test Technicians or Senior Test Technicians according to experience and qualifications. Our expanding production programme geared to our recognised export achievement provides security of employment combined with good prospects of advancement, not only within these grades, but into other technical and supervisory posts within the Company.

Salaries are attractive and conditions excellent. A Pension Scheme includes substantial life assurance cover provided by the Company. Assistance with removal may also be given in appropriate cases. Please apply in writing, giving brief details including age, experience and salary to:

The Recruitment Manager,
Marconi Instruments Ltd.
Longacres, St. Albans, Herts.

mi

Member of GEC-Marconi Electronics Limited

2445

BRAND NEW MINIATURE ELECTROLYTICS with long wires, 15/16 volts, 0·5, 1, 2, 5, 6, 8, 10, 15, 20, 30, 40, 50, 100, 200 mfds. 8s. per dozen, postage 1s. per order.—The C.R. Supply Co., 127 Chesterfield Rd., Sheffield S8. [397

BUILD IT in a DEWBOX quality plastics cabinet. 2 in. × 2½ in. × any length. D.E.W. Ltd. (W), Ringwood Rd., FERNDOWN, Dorset. S.A.E. for leaflet. Write now—Right now. [76

COSSOR CC 40 International Marine Band V.H.F. transmitter receivers. 10 channels fitted with 5 channels transmit and receive, 6-8-10-16-26; Simplex and Duplex, 230V, a.c. power supply. In working order (G.P.O. approved, 50 khz channelling), £125 each. Packing £2. Coastal Radio Nimbus 100 75 W output 1,600 khz-3,800 khz transmitter receivers suitable export or Irish Free State. 1 brand new £250. 1 shop-soiled, £200. 2 Microwave Cookers 2kW, £360 each. COSALT LTD., Fish Dock Road, Grimsby. [2399

FOR SALE. Leak F.M. Trough Line Tuner. Perfect condition. £15. Letchworth 4079. [398

HOW to Use Ex-Govt. Lenses and prisms. Booklets. Nos. 1 & 2, at 2/6 ea. List Free for S.A.E. H. W. ENGLISH, 469 RAYLEIGH RD., HUTTON, BRENTWOOD, ESSEX. [87

INTEGRATED CIRCUITS at lowest price GE Type PA234 1 Watt Audio Amplifier 17/6d. each inc. data. Newest GE Silicon NPN planar transistor 2N5172. Epoxy for economy Passivated for reliability. 25 Volt 200 mW hfe 100 min. 1/9d. each. C.W.O. P. & P. 1/-d. per order. JEF ELECTRONICS, 12 York Drive, Grappenhall, Warrington, Lancs. Mail Order Only. [399

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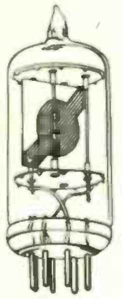

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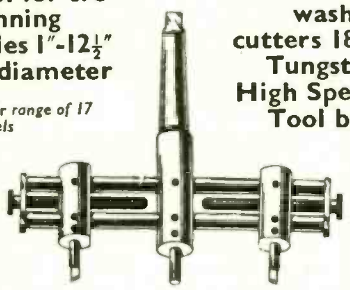

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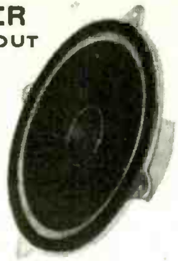

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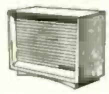

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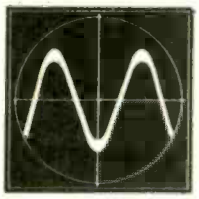

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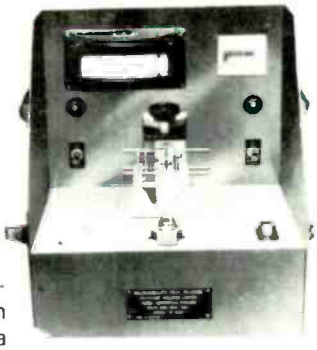

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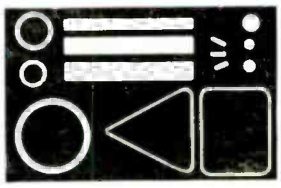

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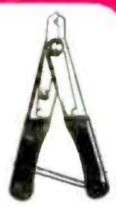
Made in a wide range of solid or cored alloys. Tape, rings and pellets are the most economical to use.

Arax 4-core acid cored solder

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

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

automatic opening wire stripper and cutter, model 6



Fitted with automatic opening spring for quick repetitive flex and cable stripping. Screw adjusts stripper for usual wire sizes. Easy grip plastic covered handles and handle-locking ring.

recording tape splicer

model 20

Precision made, chrome plated complete with razor cutter. Provides quick and accurate tape editing. Standard model for ¼" tape. NEW ½" type is available for computer and video tape. Model 21

instrument cleaner

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

tape head maintenance kit size E

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

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