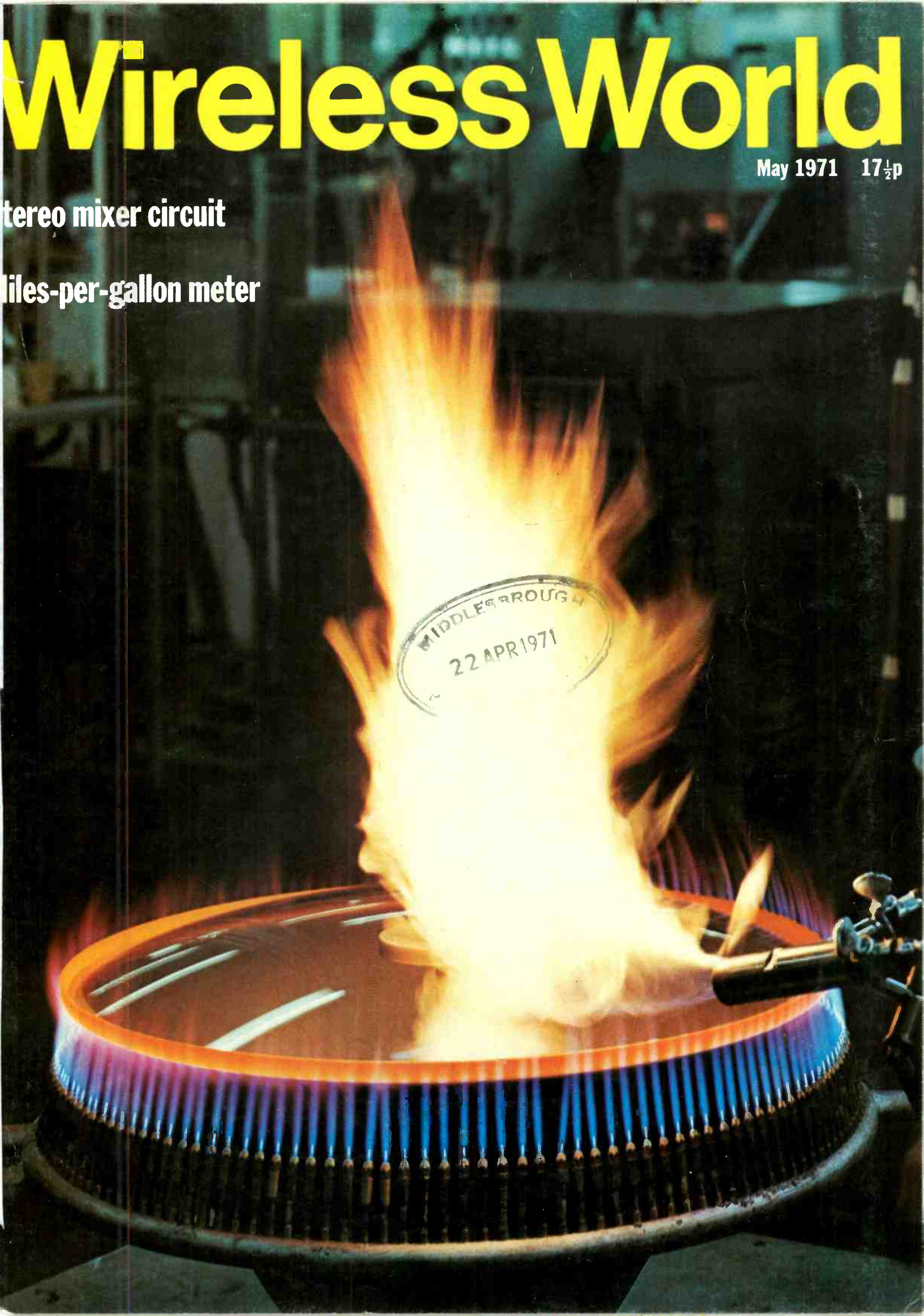
Wireless World

May 1971 17½p

tereo mixer circuit

iles-per-gallon meter

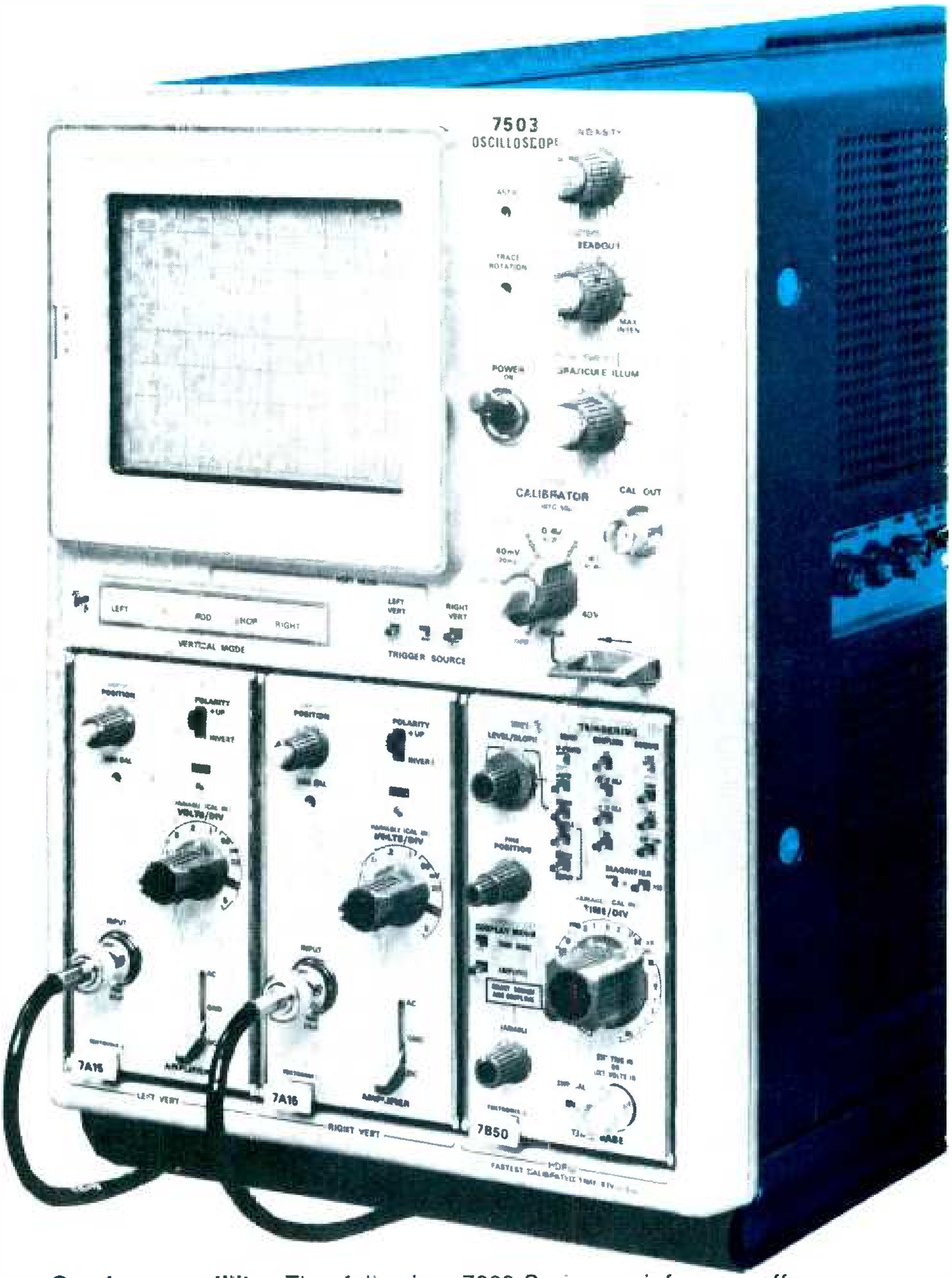


NEW

3-PLUG-IN OSCILLOSCOPE

- 60-MHz Bandwidth
- Dual-Trace, 5 mV/div
- 5 ns/div Sweep Rate
- 2% Accuracy
- 8 x 10 cm Display
- Solid State

£1119 COMPLETE WITH PLUG-IN UNITS



The TEKTRONIX 7503 THREE-PLUG-IN OSCILLOSCOPE offers *more* measurement capability per pound than any other quality oscilloscope.

Easier to use. An exclusive peak-to-peak auto-triggering mode provides a triggered sweep throughout the 360° range of the level/slope control. The front panel is uncluttered, illuminated push-button switches are extensively used to conserve space. Controls are conveniently related to function through the use of a colour-keyed front panel

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An Integrated Test System! With the introduction of the 7D13 and 7D14 digital plug-in units, the 7000-Series becomes an Integrated Test System. **ITS** much more than an ordinary oscilloscope. SEVENTEEN plug-in units covering a wide performance spectrum are available to solve virtually all of your measurement problems. Some of the features offered are: dual-trace, differential comparator, 10-µV differential, sampling, current amplifier, digital multimeter and digital counter. For instance, plug-in units can be chosen to give the 7503 delaying sweep and 90-MHz bandwidth.

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7503 Oscilloscope without readout, Option 1	£671	£76
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7503 Oscilloscope with readout	£854	£96

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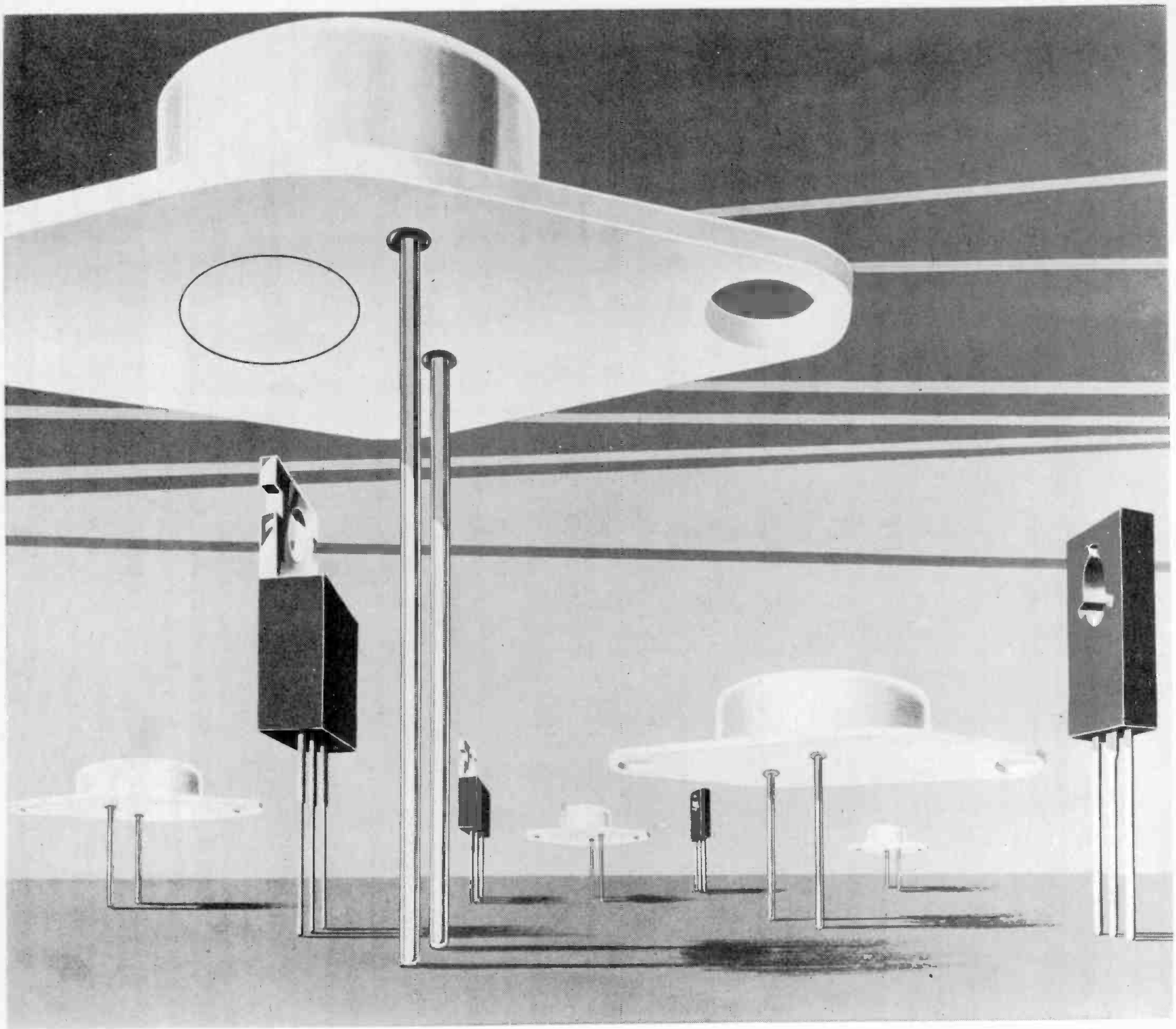

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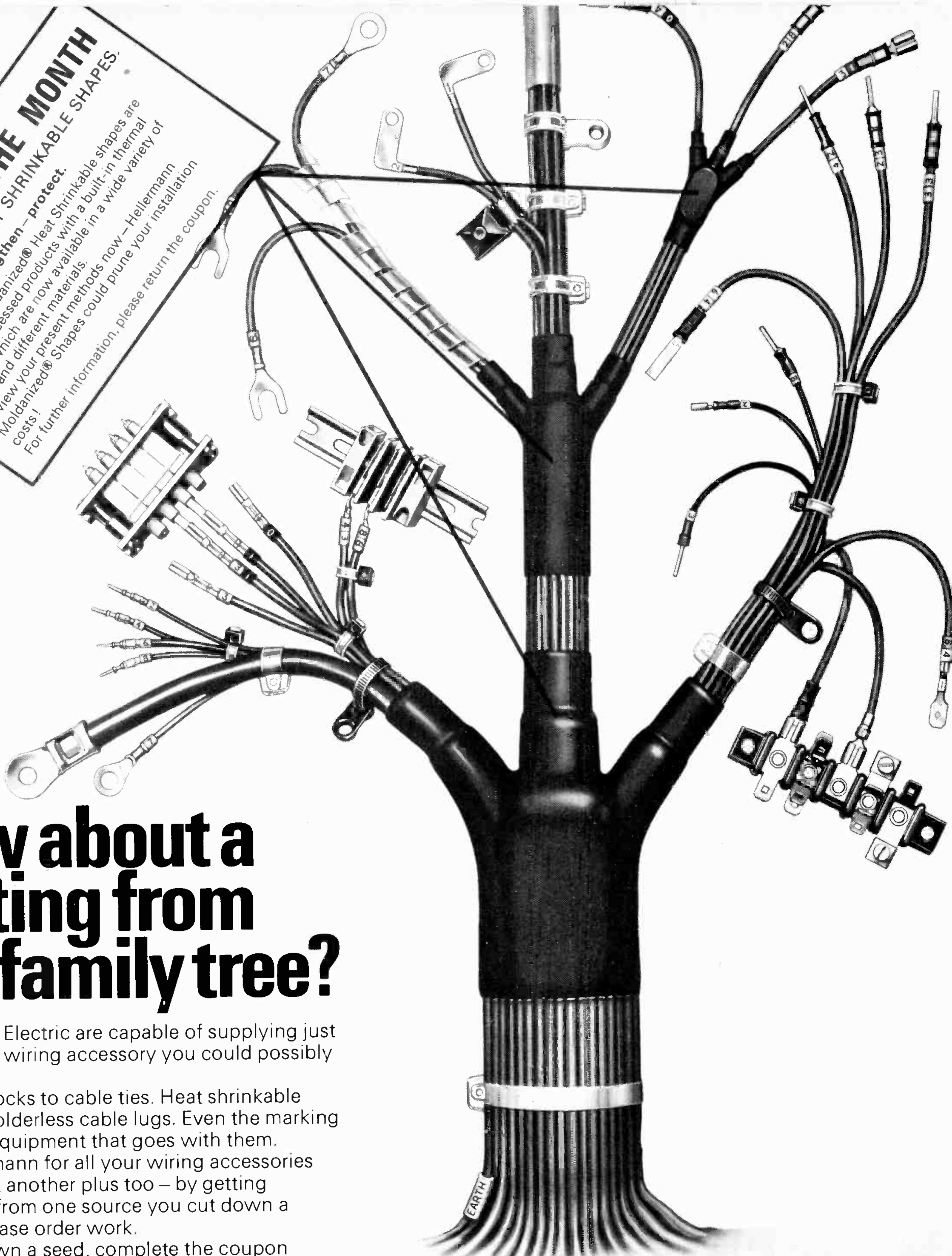

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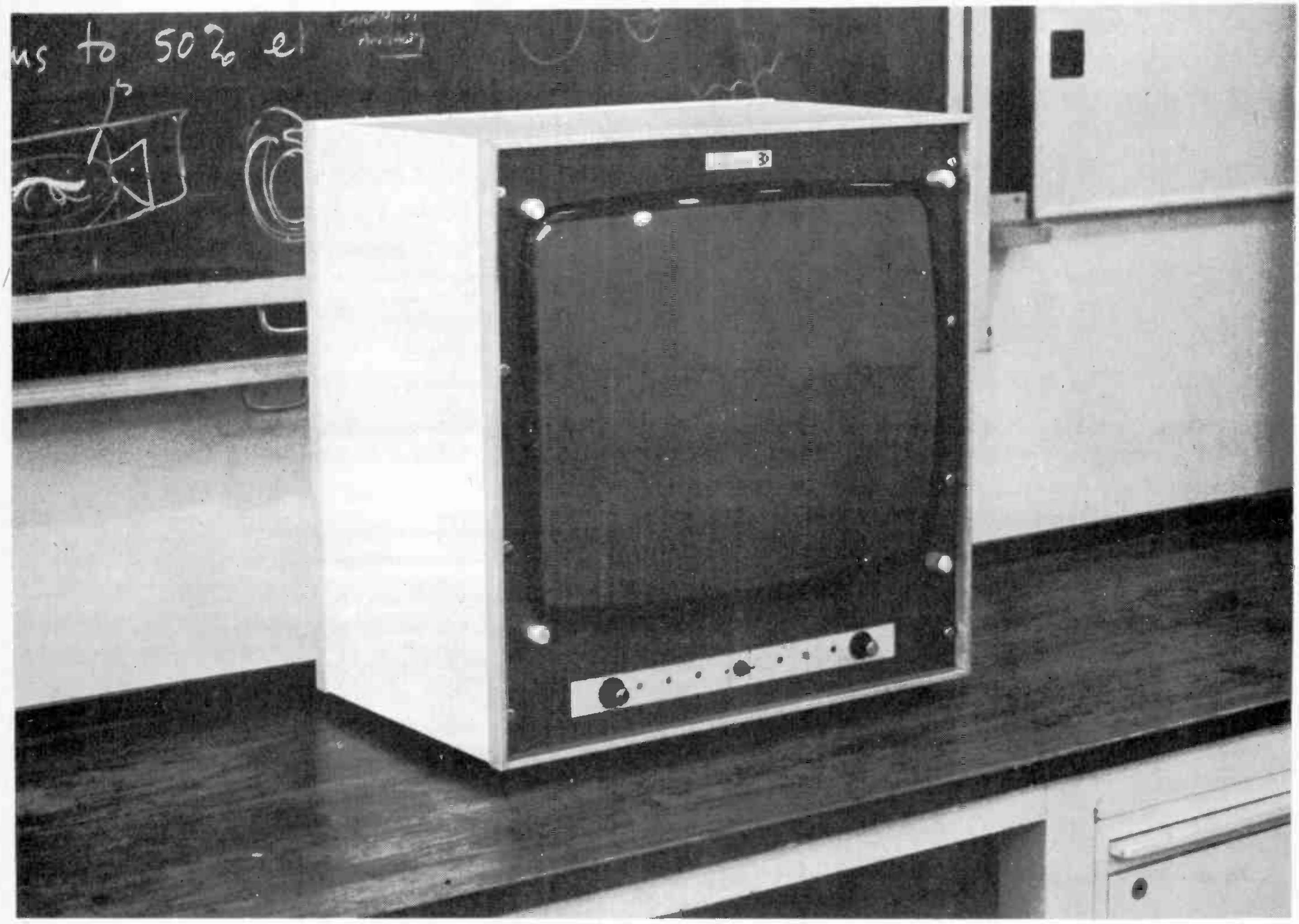
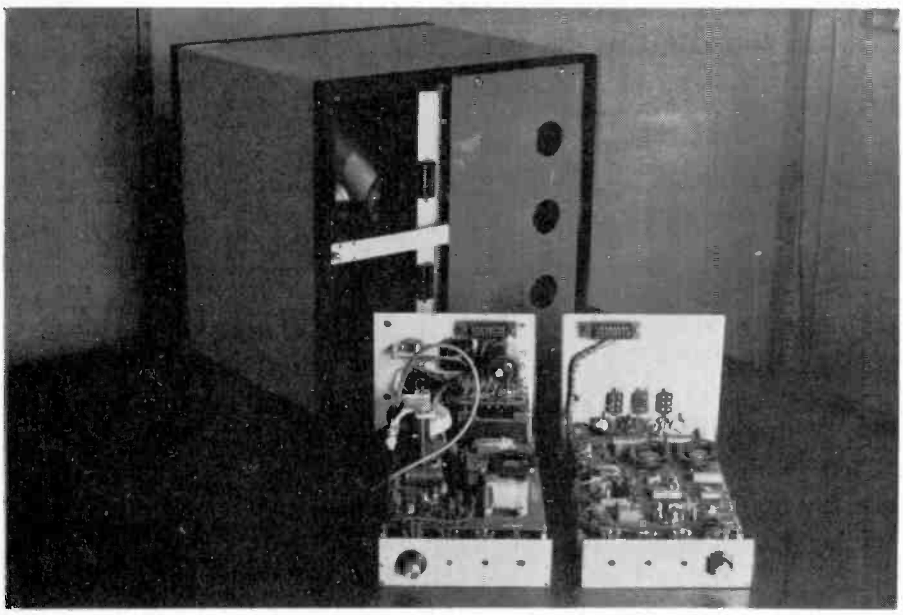
WW5/71

Video Monitors FOR INDUSTRY AND EDUCATION





SIZES 7″ 11″ 15″ 20″ 24″

FULLY SOLID STATE

10 mHz. BANDWIDTH

2% GEOMETRY

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SAME CIRCUITRY 7″ TO 24″

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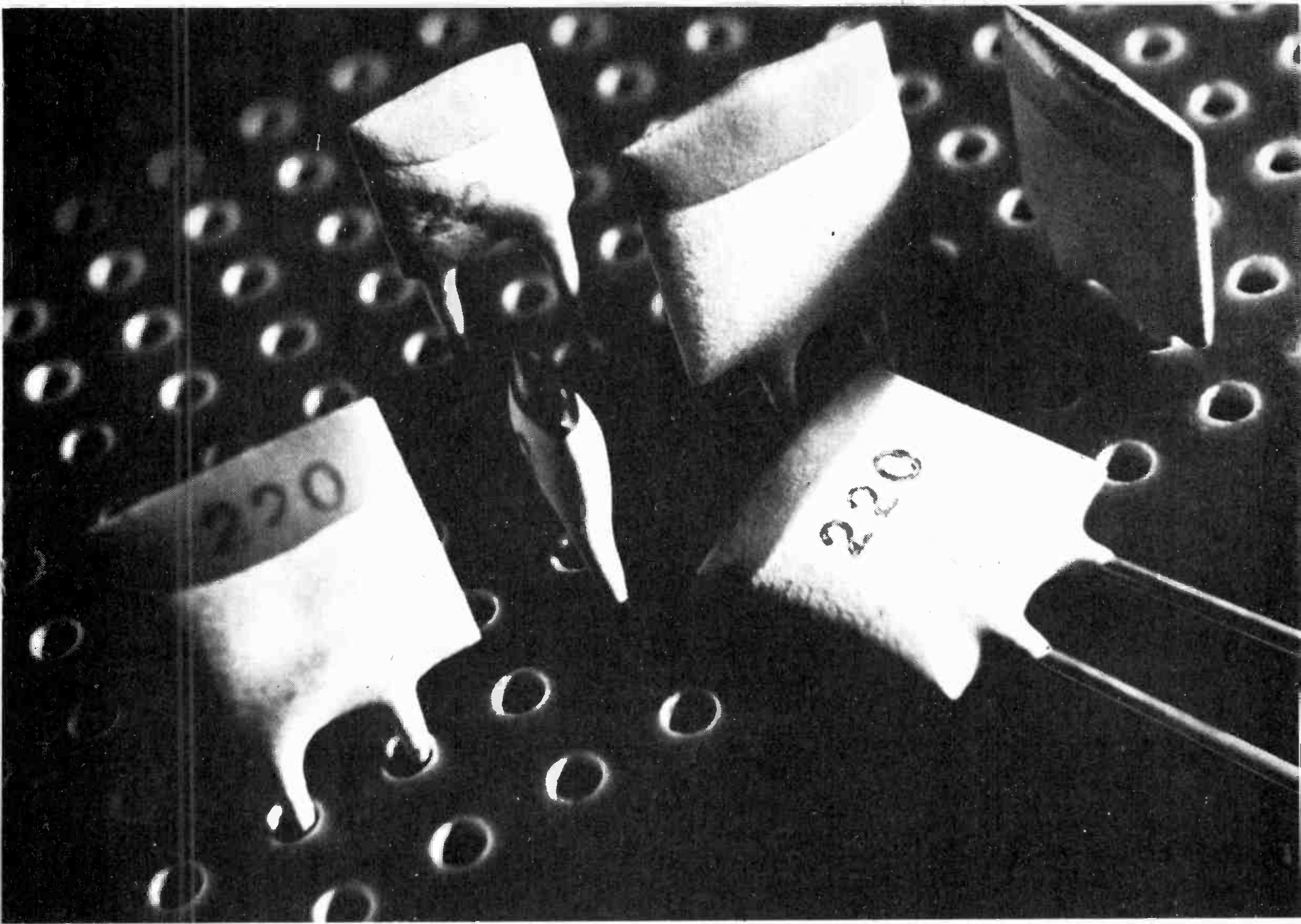
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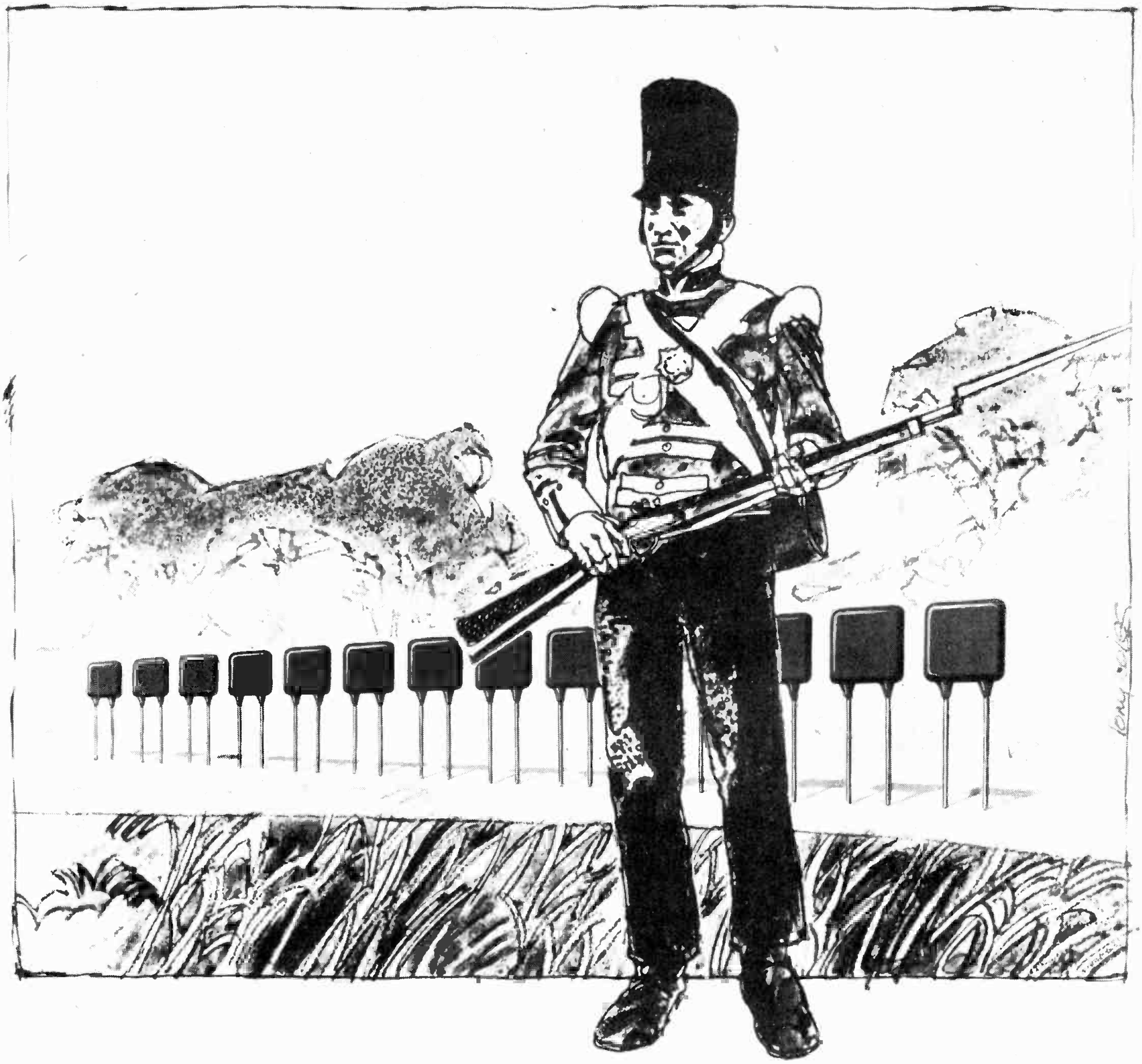
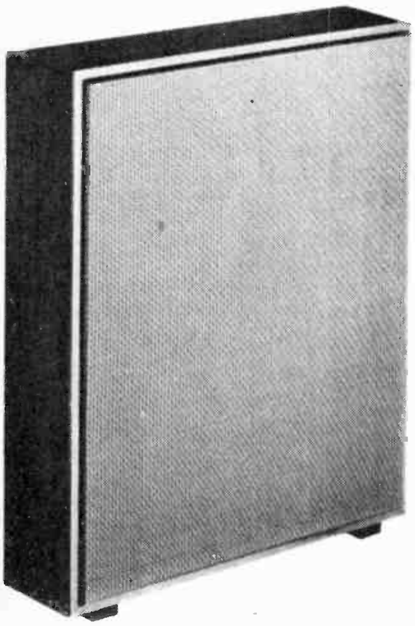
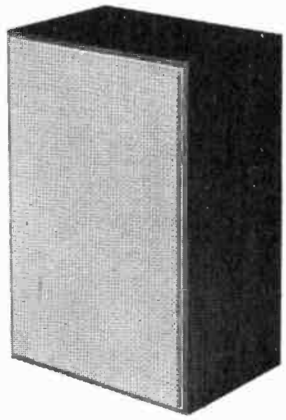


Stentorian
SPEAKER SYSTEMS



These superb new speaker systems make available even higher standards of performance in sound reproduction and uphold the high reputation gained by Whiteley Stentorian speakers throughout the world.
Attractively designed and soundly constructed, they are available in either Teak or Rosewood finish.

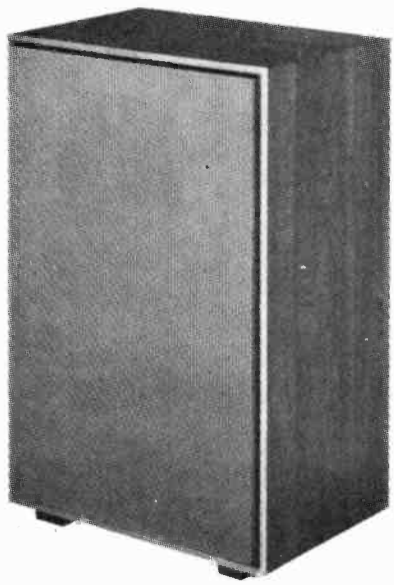


LC93

A $19'' \times 12\frac{1}{2}'' \times 8\frac{1}{2}''$ completely enclosed acoustically loaded cabinet housing a 9″ graded melamine paper cone with siliconized cambric suspension giving a frequency response of 60Hz to 20KHz.

LC94

A $29\frac{1}{2}'' \times 23\frac{3}{4}'' \times 6\frac{1}{8}''$ acoustic Labyrinth enclosure fitted with acoustic resistance in the pipe, using the same highly efficient 9″ speaker unit used in the LC 93. Frequency response 45Hz to 20KHz.



LC95

The LC95 loudspeaker system is an acoustically loaded Bass Reflex cabinet, measuring $31\frac{1}{2}'' \times 20\frac{3}{4}'' \times 13\frac{1}{2}''$, fitted with two loudspeakers and a crossover network. The bass loudspeaker being used is a newly developed 12″ unit having a Melamine treated paper cone with a cambric surround. The middle and high frequency unit is a new 8″ loudspeaker having a Melamine treated paper ribbed cone and surround.

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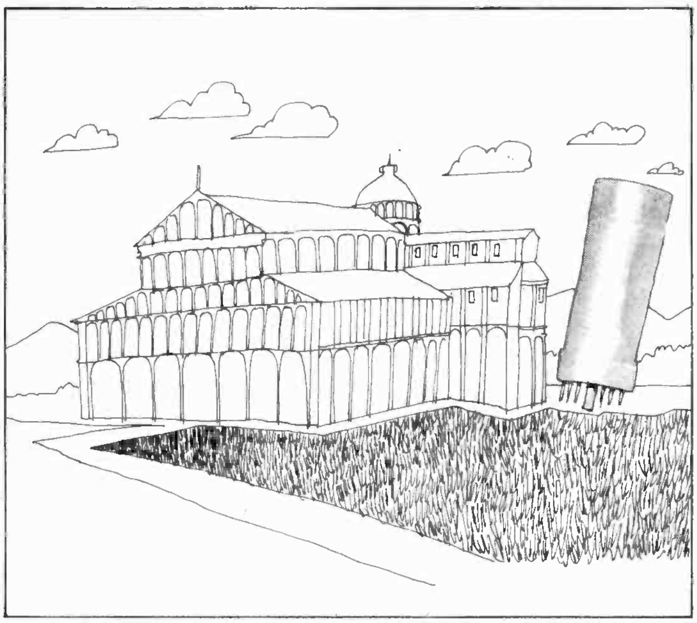

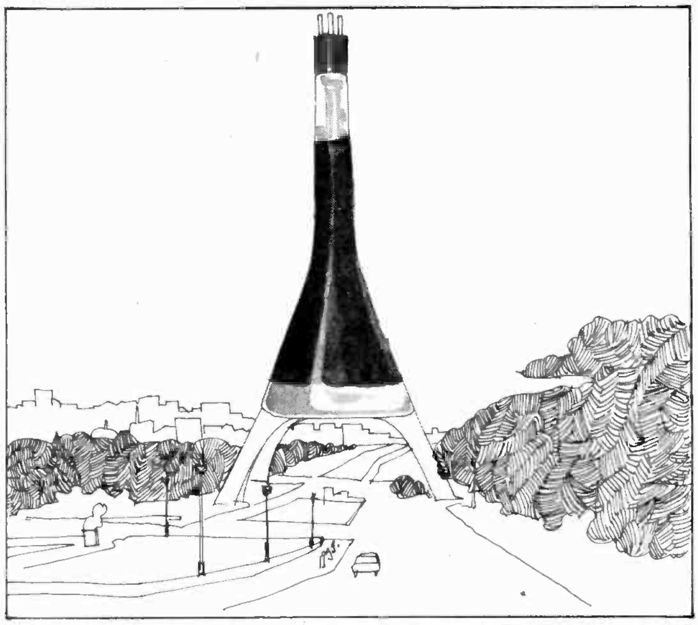

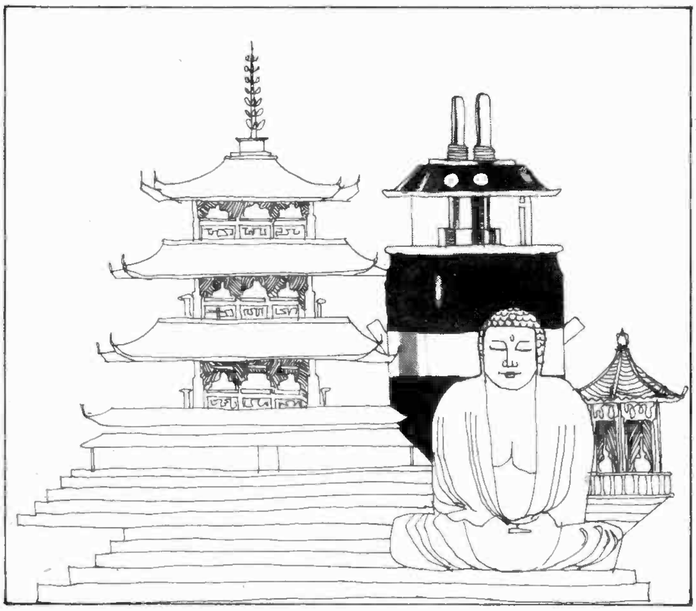

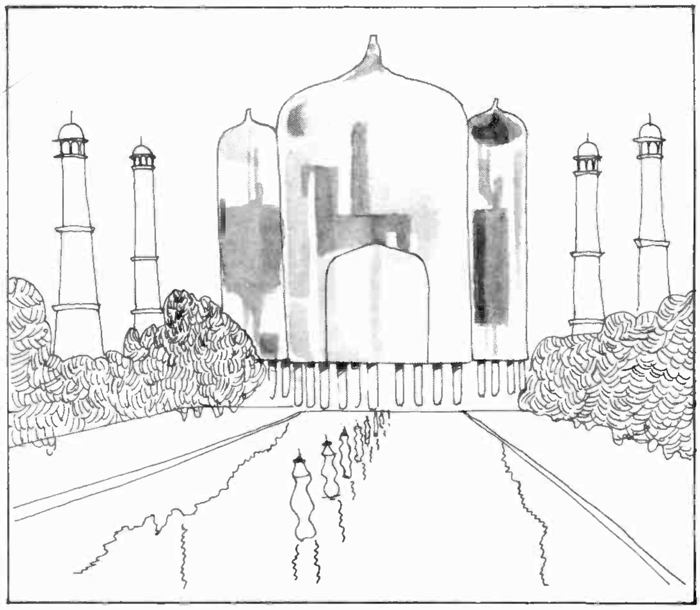

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ranges give 8 digit capability

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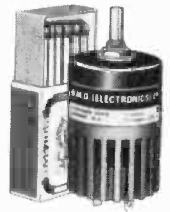

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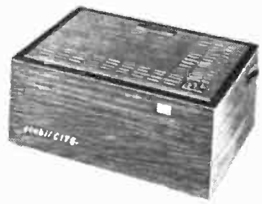

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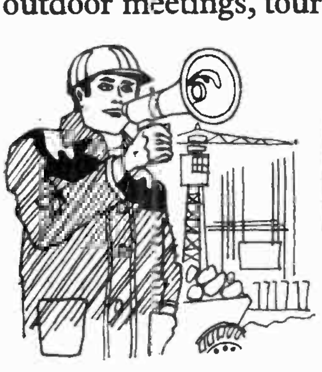

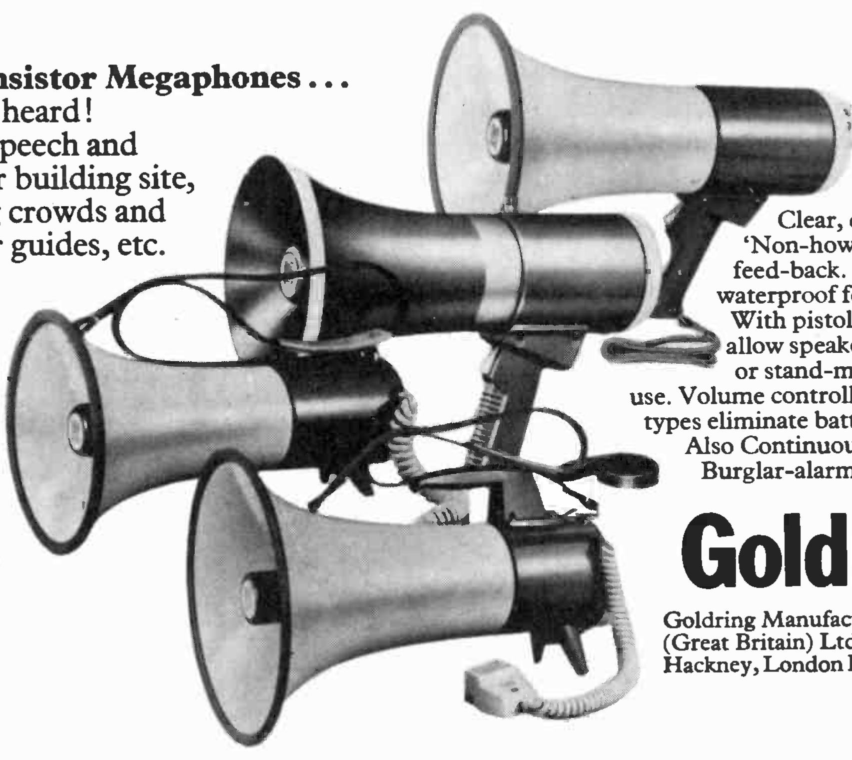

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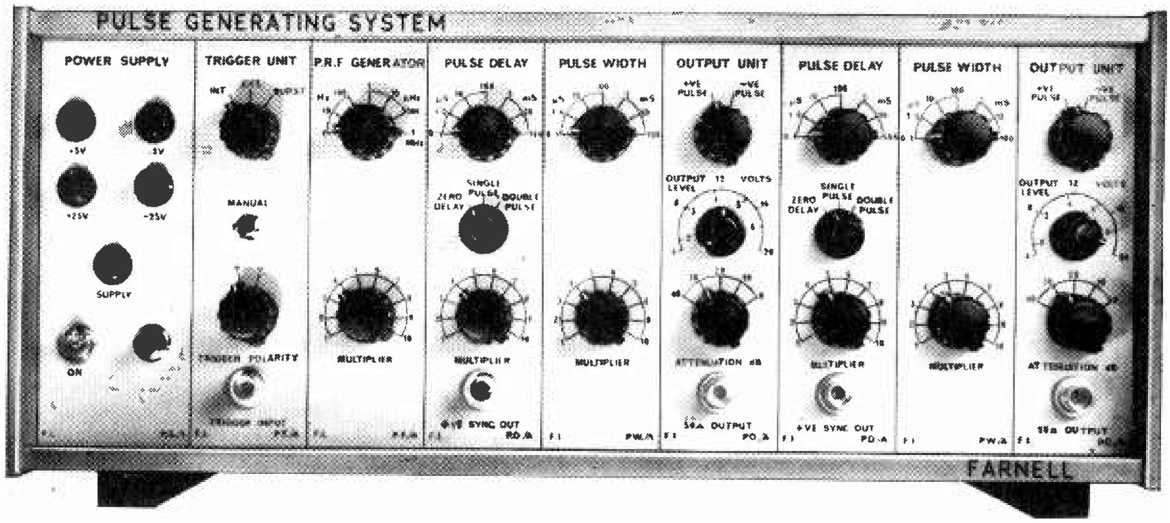
Farnell Modular Pulse Generating System
P.R.F.-0·01Hz to 10MHz



*SINGLE OR DOUBLE PULSE OUTPUT *TRUE DOUBLE PULSE OPERATION with independent control of output width, delay, amplitude and polarity. *RISE TIME 10 NANOSECONDS. *MAXIMUM PULSE AMPLITUDE is 20V into 'open circuit', or 10V into 50Ω *PRICES FROM £118.

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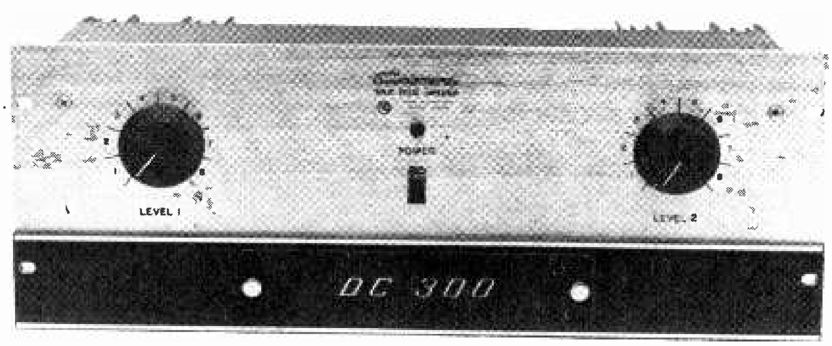
DC300

DUAL-CHANNEL POWER AMPLIFIER



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Phase Response	Less than 5° 0-10KHz.
Power Response	± 1db Zero-20KHz at 150 watts RMS into 8 ohms.
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19"
20"
(20" illuminant D)
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Screen Sizes
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14"
19"
24"
Series 3A

The economy range of monochrome monitors incorporating the already familiar Prowest high standards of construction and design. The attractive price, smart appearance and rugged construction make these displays suitable for a wide range of office and industrial environments.

Screen Sizes
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19"
Series 5A

Screen Size
22"
Series 7A

A keenly priced precision colour monitor in the grade 1 class using the latest 22" 4 : 3 aspect ratio shadow mask c.r.t. Excellent stability, remote operation of certain user controls, integral plug-in PAL or N.T.S.C. decoder, natural convection cooling and front panel purity control are some of the notable features.

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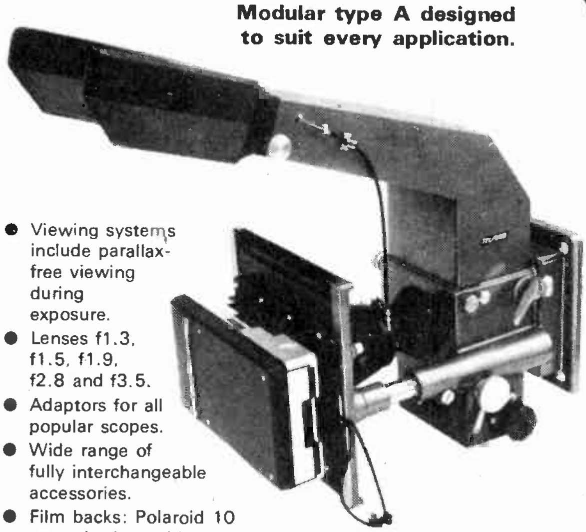
TELFORD RANGE OF Oscilloscope Cameras

Modular type A designed to suit every application.



- Viewing systems include parallax-free viewing during exposure.
- Lenses f1.3, f1.5, f1.9, f2.8 and f3.5.
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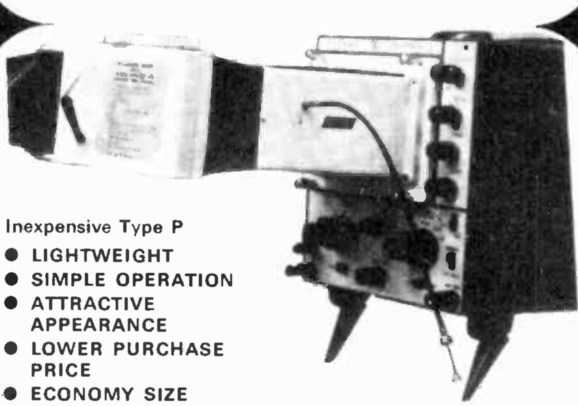
- Wide range of fully interchangeable accessories.
- Film backs: Polaroid 10 second prints with roll, pack or cut film, conventional photo materials including 35mm.



Inexpensive Type P

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- SIMPLE OPERATION
- ATTRACTIVE APPEARANCE
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- ECONOMY SIZE POLAROID FILM TYPE 20
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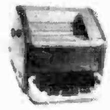

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2-5-6-7-8 TRACK AND MULTIWIRE EQUIPMENT

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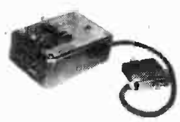

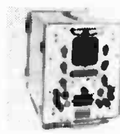

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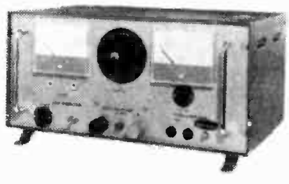

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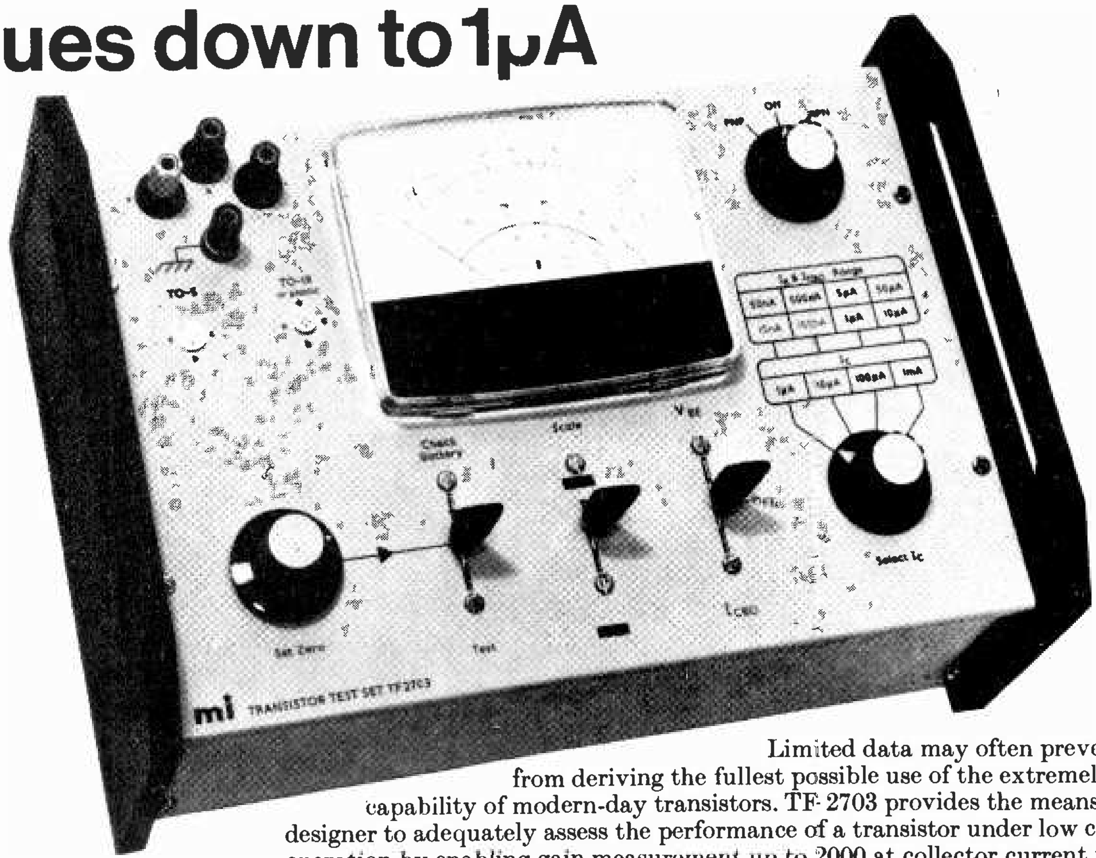

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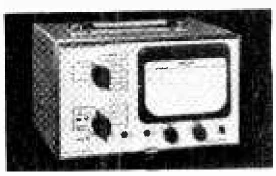

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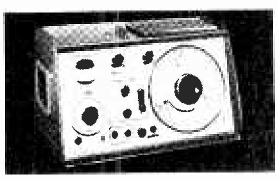

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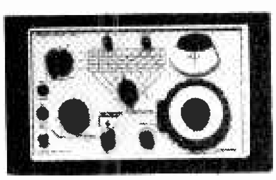

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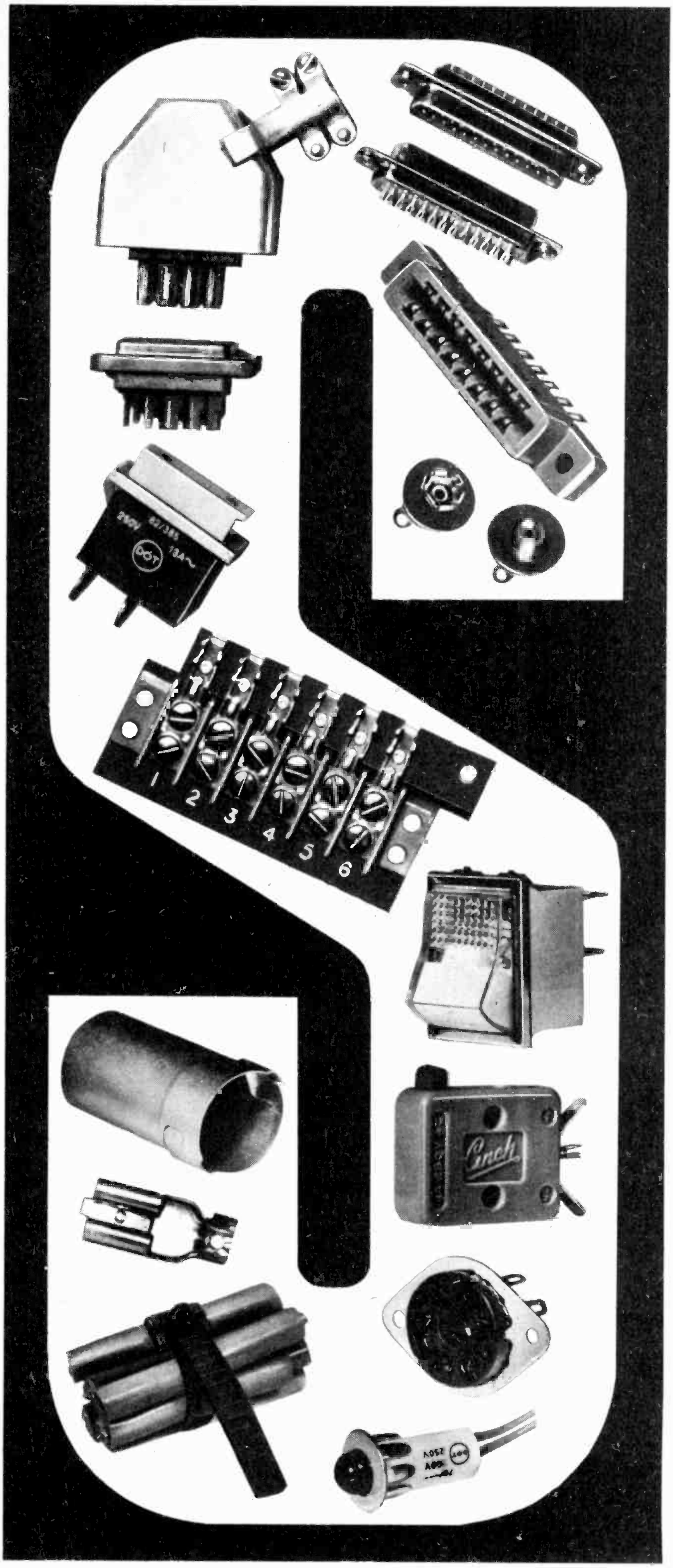

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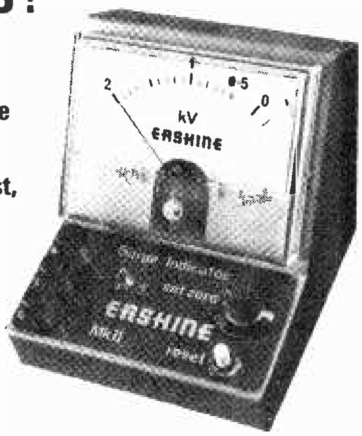

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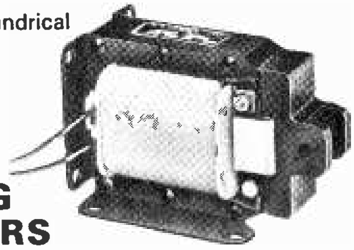

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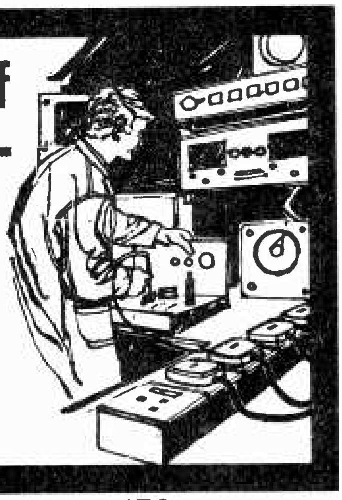

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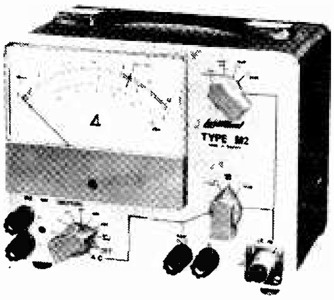

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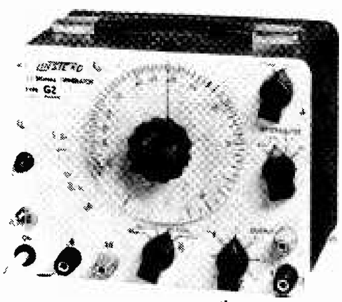

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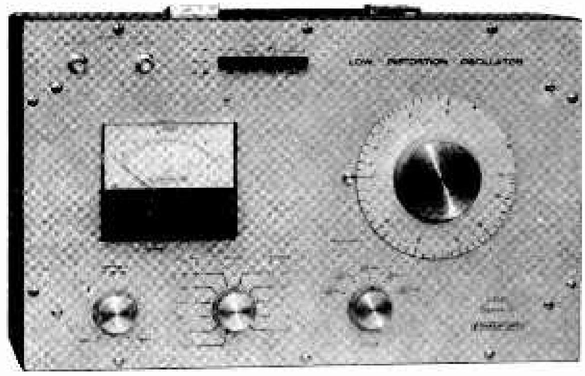

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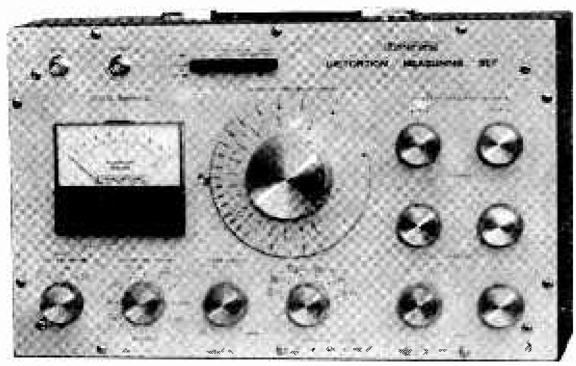

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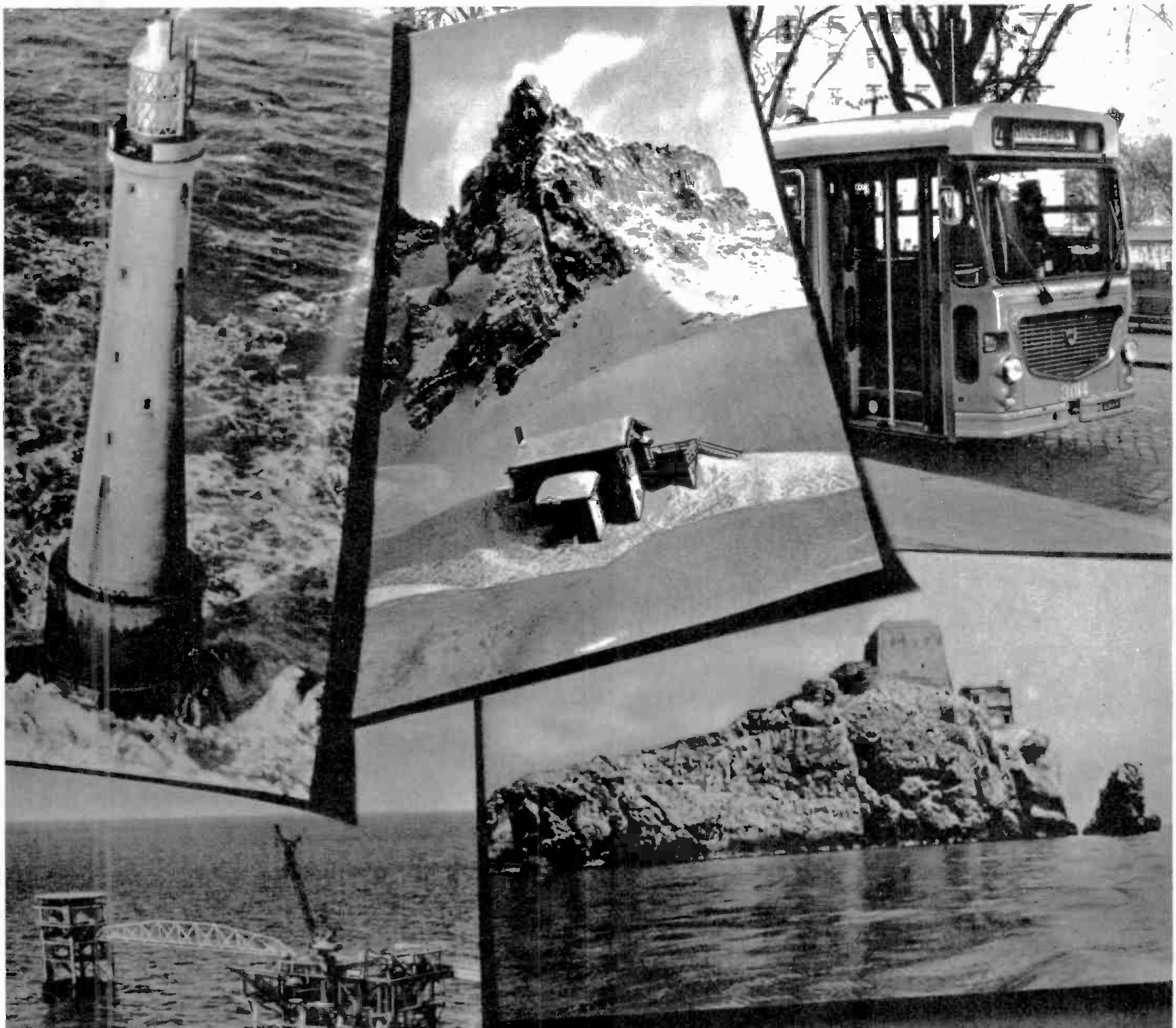

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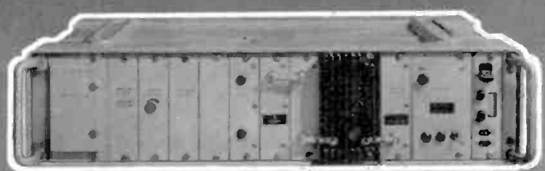

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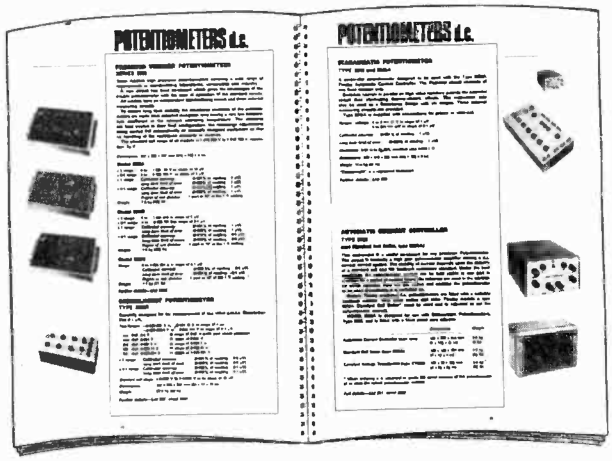

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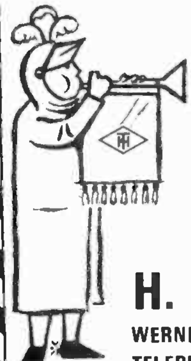

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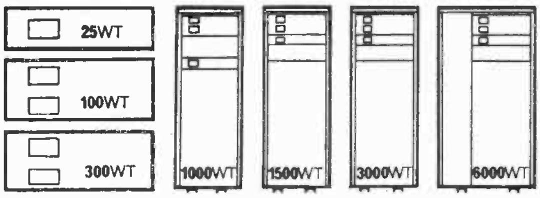

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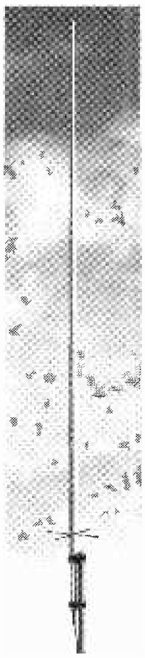

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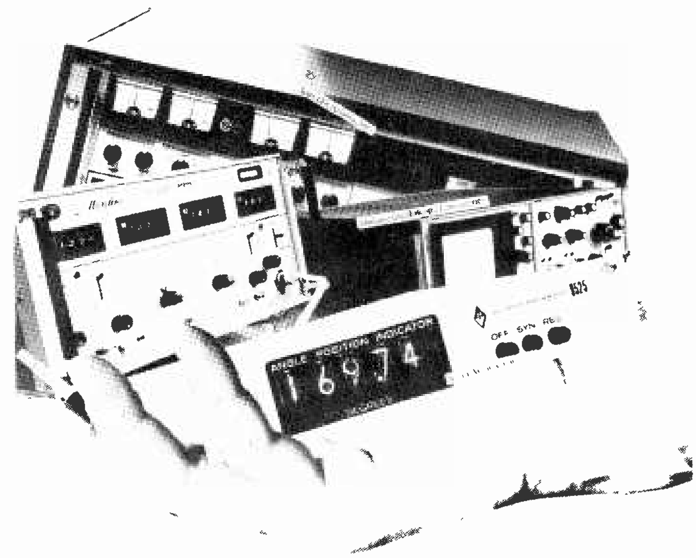

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Wireless World

Electronics, Television, Radio, Audio

Sixty-first year of publication **May 1971** **Volume 77 Number 1427**

This month's cover. Although not concerned with manufacturing processes we are not unmindful of their significance and our illustration shows 21-inch face-plate being sealed to a metal-coned c.r. tube at an E.M.I. factory.

IN OUR NEXT ISSUE

Do we want intelligent machines? What do we mean when we say a machine is intelligent? Can we build them? These are some of the questions discussed in one of next month's articles.

Transistor circuit analysis: The first of two articles which together form a complete introduction of transistor amplifier theory.

Contents

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Wireless World

Editorial Comment

First, a word of thanks to the many readers and organizations who have sent congratulatory messages on our completing 60 years of publication. The reception given to the April issue and the good wishes from readers in many parts of the world—some having read the journal for as many as fifty years—is heartening and deeply appreciated by members of the editorial staff. A few of the letters are included on p.231.

Browsing through volumes for references etc., for our birthday issue has prompted us to introduce, as a regular feature, quotations from the pages of *Wireless World* of 60 years ago. The first is on p.249.

Although, as Hugh Pocock mentioned in his guest editorial last month, there was a time when we published notices of broadcast programmes (albeit in self-defence) we are not concerned with the aesthetics and politics of broadcasts (sound or vision) or records. There are journals, and journalists, devoted to reviewing programme material. We have never seen this as a function of a technical journal. Having said that, we do not want to convey the idea that we are concerned only with frequency response and "entertaining the bats"!

Similarly in the field of broadcasting we are concerned with the means and not the matter broadcast. Any move, therefore, which will increase the use of broadcasting is to be applauded; as is the recent announcement by the Minister of Posts and Telecommunications to introduce local commercial radio independent of the B.B.C. The plans, as envisaged in the Government White Paper 'An Alternative Service of Radio Broadcasting' (Cmnd 4636), provide for a network of 60 stations (in addition to the 20 B.B.C. local radio stations authorized last year). They will be under the jurisdiction of the I.T.A. which it is proposed to rename the Independent Broadcasting Authority.

The 60 stations will serve about 75% of the country's population. What of the other 25%? To serve them with an independent service would need very many more stations. Provided one has the capital and the courage one can start up a local newspaper, but a local radio station is dependent on an essential commodity which is in limited supply, i.e., the frequency spectrum, and especially the m.f. section. It is proposed that the 60 new stations should operate both in the m.f. and the v.h.f. bands. Surely this is an uneconomic use of the already overcrowded frequency spectrum. An appendix to the White Paper points out that in the 121 medium-frequency channels there are already some 1440 stations operating in the European Broadcasting Area. Those readers who live in the S.E. corner of England will know that it is virtually impossible to receive a medium-wave broadcast free of interference after dusk. The planners, will of course, counter this criticism with the rejoiner that the local radio service will also be broadcast on v.h.f. They will thus be utilizing two slices of the spectrum cake to satisfy what one slice should be able to do. Why not v.h.f. only? According to the White Paper this could provide a population coverage of 65% in the United Kingdom by day *and* night, whereas on m.f. the coverage will be 70% by day but only 25% by night.

Those who will be financially involved in local broadcasting will doubtless argue that the number of v.h.f. receivers in use is small by comparison with the ubiquitous m.f. transistor portable and the potential audience would therefore be considerably smaller. Had this attitude been adopted by the B.B.C. engineers in 1955 we would never have had a v.h.f. service. They provided the service and the industry, after some heavy prodding, produced the receivers.

Artificial Vision

Microelectronic implant for directly stimulating the brain of blind people

The idea of implanting small electronic devices in the body has now become widely accepted through the use of the cardiac pacemaker. Here only two electrodes are required, to stimulate a part of the heart muscle. Extending this technique to apply a multiplicity of electrodes to a whole area of the central nervous system—in particular the brain—seems a very daring step indeed, both from the medical and the engineering point of view. Nonetheless this step is now being taken, by workers at the Medical Research Council's Neurological Prostheses Unit*, in an attempt to restore some degree of vision to people who have become blind, for example, through damage to the optic nerve. (Prosthesis means a man-made device for replacing a part of the body.) By stimulating the visual cortex of the brain with 180 electrodes, fed from a set of microelectronic inductive-loop receivers implanted between the skull and the scalp, it is hoped to produce visual patterns which can be organized electronically to enable a blind person to, say, avoid obstacles when walking or read print or handwriting at normal speeds. Preliminary experiments on a woman patient, who has had a visual prosthetic implant since 1968, suggest that this intention can be achieved.

*At the Institute of Psychiatry, Maudsley Hospital, South London

The principal M.R.C. workers concerned are a physiologist, Professor G. S. Brindley, who has done the preliminary experimental work (Refs 1 and 2), and an electrical engineer, Mr. P. E. K. Donaldson, who has specialized in electro-physiological research work for some years. Both were originally at the Physiological Laboratory, Cambridge University, where the project on visual prosthesis was begun. Professor Brindley constructed the first visual prosthesis, implanted in the woman patient mentioned above, which had 80 receivers and 80 electrodes applied to only one side of the visual cortex (the right cerebral hemisphere). Mr. Donaldson has been developing an improved implant, originally suggested by Professor Brindley, which uses a smaller number of receivers, 29, but arranged in a 20-column × 9-row matrix to give, in conjunction with logic AND gates, 180 stimulation outputs which will be applied to both hemispheres of the brain (90 electrodes on each side). This has not yet been used on a patient.

The interest of the electronic engineering development, apart from new circuit techniques, lies mainly in the environmental problems. These are to construct an implant which is small and neat enough to be carried by the patient without discomfort or change in physical appearance and which will work reliably for years while immersed in the body's fluid—virtually a bath of warm saline solution! To tackle these formidable problems the latest technology in hybrid microcircuits has had to be investigated—in particular the testing of conducting and insulating materials, encapsulation and hermetic sealing—and where necessary new techniques have had to be developed with the assistance of industrial firms.

Fig.1 shows in simplified diagrammatic form how the visual prosthesis will operate. The patterns to be conveyed to the cortex (e.g. letters of the alphabet) are sensed by a picture source, which could be an artificial retina or a scanning device, such as a television camera, combined with a storage system. This produces 180 simultaneous video signals from an ordered array of points on the optical field, each signal representing the light intensity at a given point. Thus the geometrical structure, and any light-and-shade features, of the pattern are conveyed by the information in the 180 signals. These

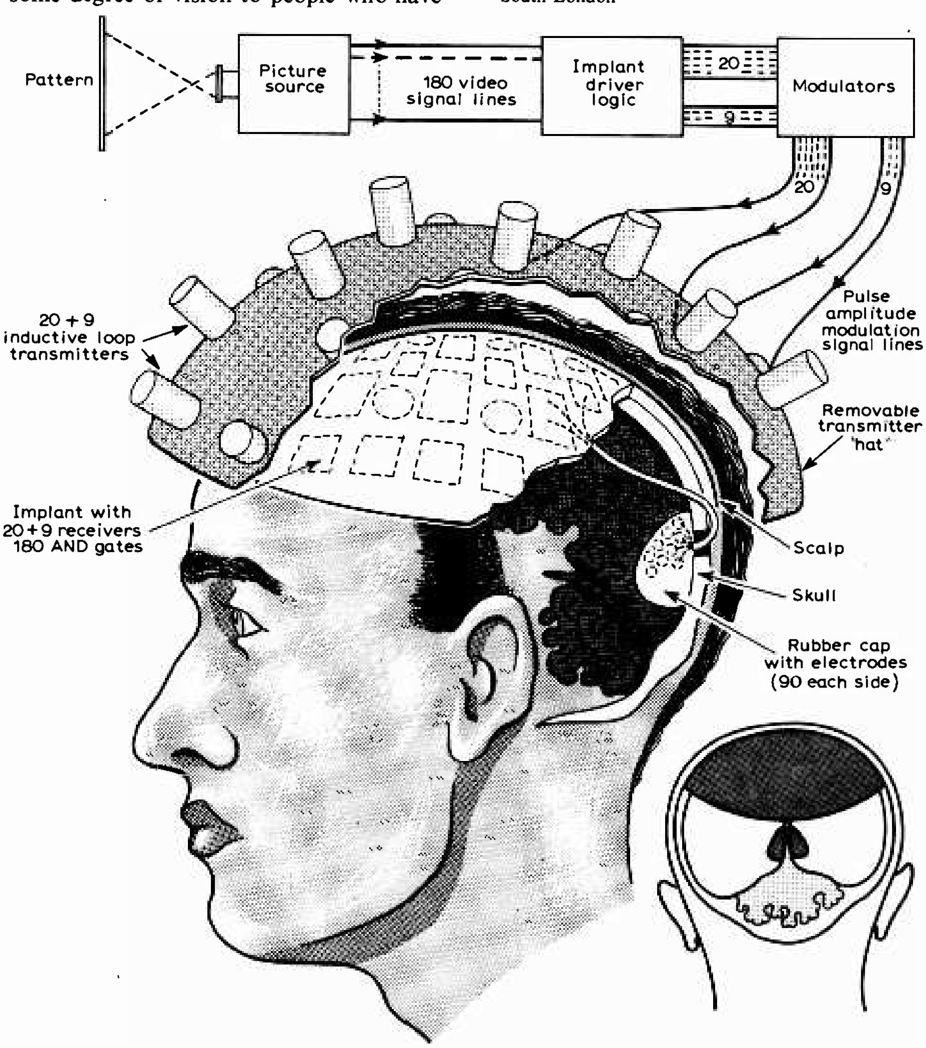


Fig.1. Principle of the visual prosthesis. The visual cortex of the brain is stimulated by electrodes fed from microelectronic receivers in an implant between the skull and the scalp. In practice the transmitter "hat" is in contact with the head.

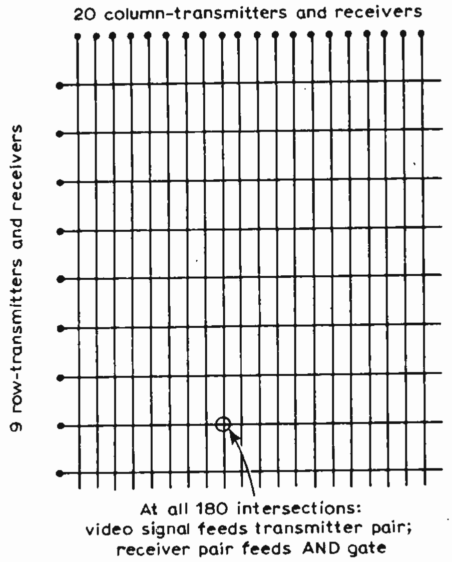


Fig.2. Electrical grouping of transmitters and receivers into a 20 × 9 matrix. By this means 180 points on the visual cortex can be stimulated from only 29 receivers.

signals are used to pulse-modulate a bank of 29 inductive-loop transmitters built into a hat-shaped plastics shell similar to a hair drying hood. The transmitters are arranged so that the inductive loop in each is located immediately above the loop of a corresponding receiver in the implant—the actual layout, in the 'hat' and in the implant, being a matter of physical convenience. Electrically, however, the transmitters are grouped to form a 20 × 9 matrix—that is 20 column-transmitters and 9 row-transmitters—so that 180 unique pairs of transmitters can be identified (see Fig.2). These pairs are modulated by the 180 separate video signals from the picture source. Row-transmitters generate 500μs pulses of r.f. at 10MHz, while alternate column-transmitters give 500μs amplitude modulated pulses at 8MHz and 6MHz (this arrangement of different frequencies for adjacent column-transmitters being a means of avoiding cross-talk).

Magnetic fields set up by the transmitter coils link with the corresponding receiver coils in the implant. Thus the pulse-modulated 10MHz, 8MHz and 6MHz r.f. signals are picked up within the patient's head and these signals provide not only information but the electrical power needed to operate the active devices in the implant. The receivers are electrically grouped to form a 20-column, 9-row matrix corresponding to that of the transmitters (Fig.2), and their outputs, 500μs unidirectional pulses, are fed to 180 two-input AND gates (that is, an AND gate at each intersection in Fig.2 of a column-receiver output and a row-receiver output). Thus any one of 180 AND gates in the implant can be opened by activating a particular column-row pair of transmitters in the 'hat'—that is, by turning on the column-transmitter and row-transmitter simultaneously with a 500μs modulating pulse.

Output signals from the AND gates—500μs d.c. pulses—are taken by a bundle of wires through a small orifice in the skull and are applied by 180 electrodes to the visual cortex of the brain—90 electrodes on each hemisphere. These electrodes, made of platinum, are mounted in two flexible silicone rubber caps which are moulded to fit round the two occipital lobes of the brain. They are distributed according to physiological knowledge of how the surface of the visual cortex responds to electrical stimulation at different points. Thus any of the 180 electrodes can be activated by pulse modulating a column-row pair of the transmitters, and so, looking at the whole system, any one of 180 points on the visual cortex can be stimulated by a signal from any one of 180 points on the optical field of the picture source.

Stimulating a given point on the visual cortex may result in any of several visual perceptions by the blind patient, including a single spot of light, a group of two or three spots and a whole cluster or cloud of dim spots. The commonest perception is of a single, very small spot of white light 'like a star in the sky' and this is obviously the most useful for organizing the transmission of patterns, such as letters of the alphabet, through the whole electronic-neurological system so that they are recognizable by the patient.† To achieve this organization it is necessary to correlate the stimulation of a given point on the visual cortex with the position in space of the resulting white spot perceived by the patient. This is done by activating a given electrode and asking the patient to point with his arm to where he 'sees' the white spot. By recording a series of patient's responses to stimuli in this manner it is possible to build up a map which correlates electrode positions on the cortex with white-spot positions experienced by the patient. Once this is achieved, with the apparatus now being developed, it will be possible to introduce a positional coding system to translate the pattern as sensed by the picture source into the particular distribution of electrode stimulation required for the patient to 'see' a similar pattern.

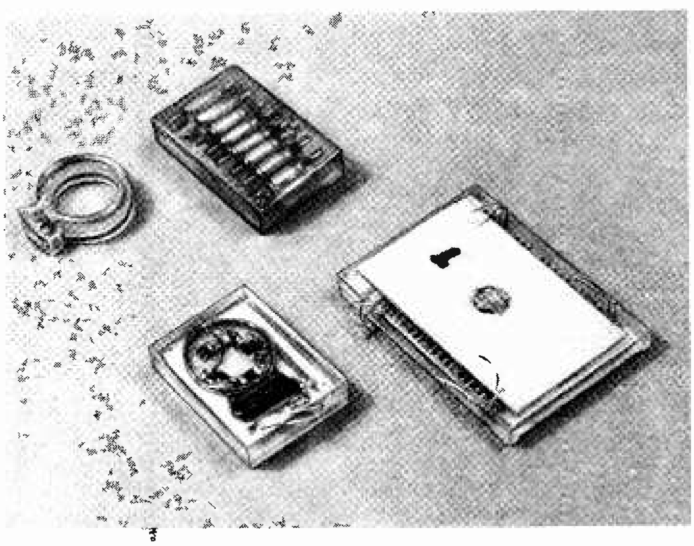


Fig.3. The four types of package used in the implant: (top left) row-receiver coil and capacitor; (top right) block of fifteen 1μ F tantalum capacitors; (bottom left) column receiver; (bottom right) hermetically sealed logic package.

The implant

In the implant are 29 receivers and 180 AND gates. The components for these are grouped into 44 packages which are sealed into a silicone rubber cap moulded to fit over the patient's skull. There are four different groups of packages, Fig.3: (a) twenty column-receivers, each containing passive components and semiconductor diodes and encapsulated in resin; (b) nine row-receiver pick-up coils with their tuning capacitors, each encapsulated in resin; (c) nine logic packages, each containing 20 transistor AND gates and associated components, hermetically sealed and resin encapsulated; and (d) six capacitor packages, each containing a block of 15 tantalum capacitors encapsulated in resin. The column receivers and logic units are constructed as hybrid microcircuits on thick-film circuits.

The three packages which are self-contained circuits are shown in Figs.4 and 5. A column-receiver, Fig.4, consists of a tapped pick-up coil tuned by a 150pF capacitor, two detector diodes in series, a 10,000pF smoothing capacitor, a 55-volt zener diode to limit the d.c. output voltage, and a diode to provide bias for the transistors in the logic package. The coil is 17 turns, tapped at 10 turns, for a 6-MHz receiver; or 13 turns, tapped at 10 turns, for an 8-MHz receiver. The purpose of the tapping is to match the impedance of the *LC* tuned circuit to that of the detector circuit and so achieve maximum power transfer. Two detector diodes, in series, are used because the maximum p.i.v. rating of a single diode would be insufficient to cope with the peak inverse voltage of the signal waveform (about 130V). The function of the zener voltage limiter is to protect the transistor AND gates.

When the receiver is energized by a pulse of r.f. from the transmitter (it can receive up to about 2 watts) a d.c. voltage pulse is developed across the zener diode. The positive terminal is connected to 'earth' (an

†The patient, having been once sighted, is able to correlate patterns with his previous visual experience: his brain has already been 'organized'. A person blind from birth would not be able to do this but only correlate the stimulus patterns with other sense data such as tactual experiences.

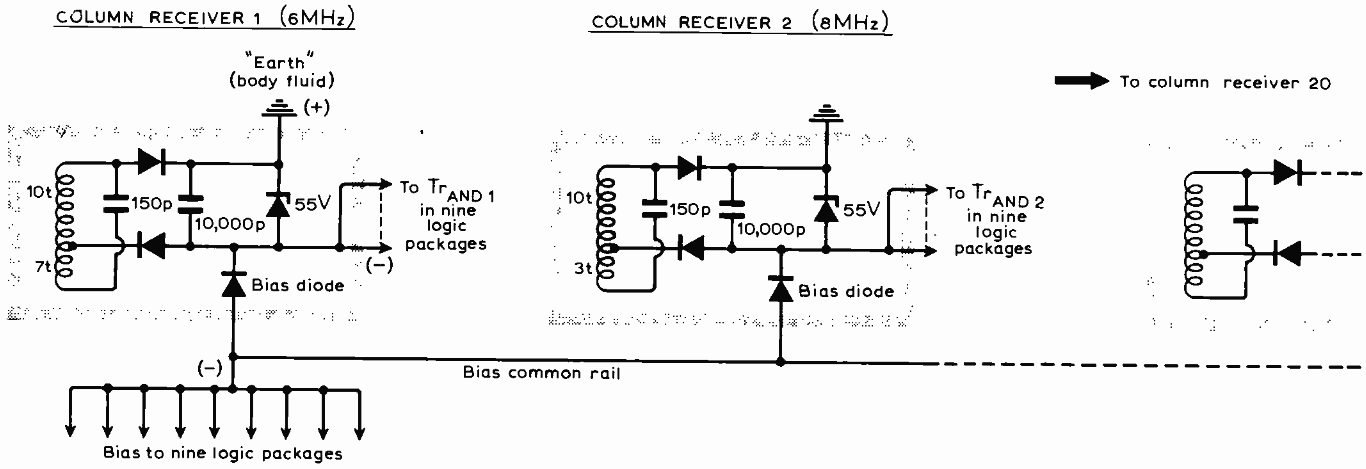


Fig.4. The column receivers (20 in all) with diodes feeding a bias common rail which provides a negative supply to the logic packages (one of which is shown below in Fig. 5).

electrode contacting the body fluid of the patient) and the negative terminal to nine AND gates (one gate in each logic package). At the same time, for the duration of the pulse of r.f., the bias diode provides a second d.c. voltage between 'earth' and a common rail, to which all the other bias diodes are connected. When any of the column-receivers is energized by its transmitter, the corresponding bias diode applies a negative voltage pulse to the common rail, taking it to a maximum potential of −55V less one diode voltage drop. This is fed to all the logic packages as a negative bias potential.

Fig. 5 shows a row-receiver pick-up coil and tuning capacitor connected to one of the logic packages. The coil has 11 turns, tapped at 2 turns, and is tuned by a 100pF capacitor to 10MHz. The row-receiver, as can be seen, differs from the column-receiver in that it consists of a tuned circuit and p-n-p transistor chip, Tr_{row}, which is housed in the logic package. The collector of Tr_{row}, and the bases of the n-p-n transistor-chip AND gates, Tr_{AND1}—Tr_{AND20} are biased by a negative potential which comes from the bias common rail in Fig. 4 and is present when one or more of the column-receivers is energized by a pulse of r.f. In the absence of an r.f. voltage from the row-receiver coil this bias on the collector of Tr_{row} is approximately −55V, and it biases off the transistor AND gates by at least −0.6V (base-emitter voltage).

When the row-receiver coil is energized by a 500μs pulse of 10MHz r.f. from the transmitter, an a.c. voltage is applied across the base and emitter of Tr_{row}. During the positive-going excursions of a.c. at its base, Tr_{row} is cut off and no current flows through it. During the negative-going excursions at the base the transistor is turned on and the 10-MHz half cycles of current discharge the collector-emitter capacitance so that in effect there is a d.c. flow maintained in the collector-emitter circuit for the duration of the 500μs pulse of r.f. As a result the collector-emitter p.d. falls and a positive-going 500μs pulse is applied to the bases of the transistor AND gates. This positive-going potential is sufficient to turn on the AND gate transistors. Which of them are actually turned on depends on which gates receive their second input, that is, emitter supply voltages through the diodes D_1-D_{20} from their corresponding column receivers. The diodes D_1-D_{20} are to protect the base-emitter junctions of $Tr_{AND1}-Tr_{AND20}$ in the condition when maximum negative potential is applied to a transistor base (row-receiver off) and the transistor emitter is almost at earth potential (corresponding column-receiver off).

Thus, particular gates are opened by the simultaneous energization of the row-receiver and one or more of the column-receivers in Fig. 4, and in this open state the transistor AND gates produce at their collectors a negative-going (with respect to 'earth') 500μs pulse at an amplitude of up to 55 volts (limited by the zener diodes in Fig. 4). This output is fed to an electrode on the visual cortex, which presents a load, mainly resistive, of about 3,000Ω. Half of the 180 electrodes are fed through series tantalum capacitors of 1.0μF (those in the six 'capacitor packages' referred to above). These capacitors are to maintain the net current through their corresponding stimulating electrodes at zero; this should be helpful in preventing electrolysis at the electrodes.

An important difference between row-receiver and column-receiver inputs to the AND gates is that the row-receivers supply 500μs pulses of constant amplitude but the column-receivers supply pulses which are varying in amplitude—the pulse amplitude modulation, corresponding to light intensity, applied to the column-transmitters. Essentially, then, the column-receivers supply controllable power to the stimulating electrodes while the row-receivers merely provide the signals for operating the gates.

The straightforward matrix principle is satisfactory for stimulating one point at a time on the cortex, by simultaneous energization of one column-receiver and one row-receiver. In order to create a useful pattern, however, it is necessary to be able

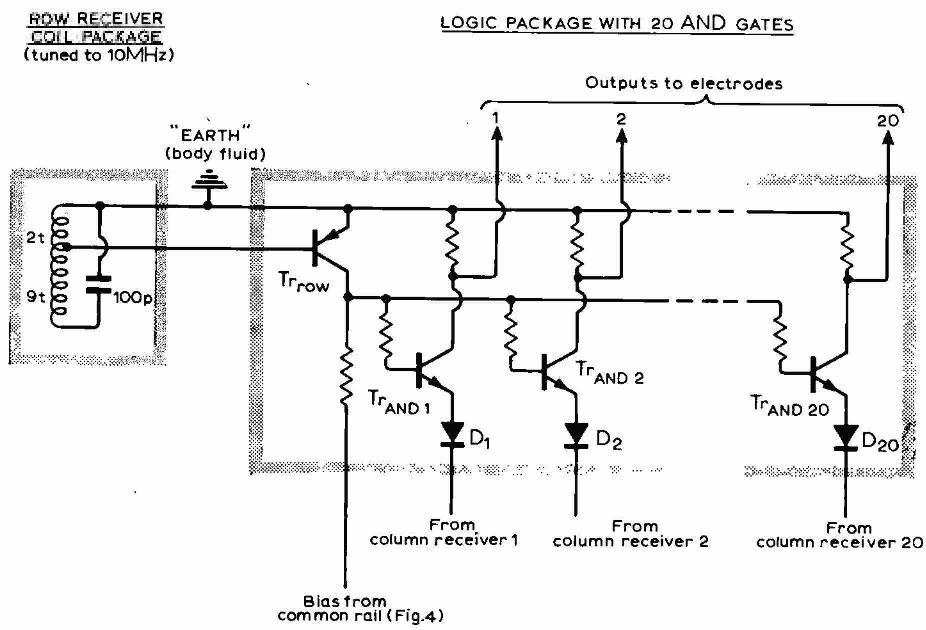
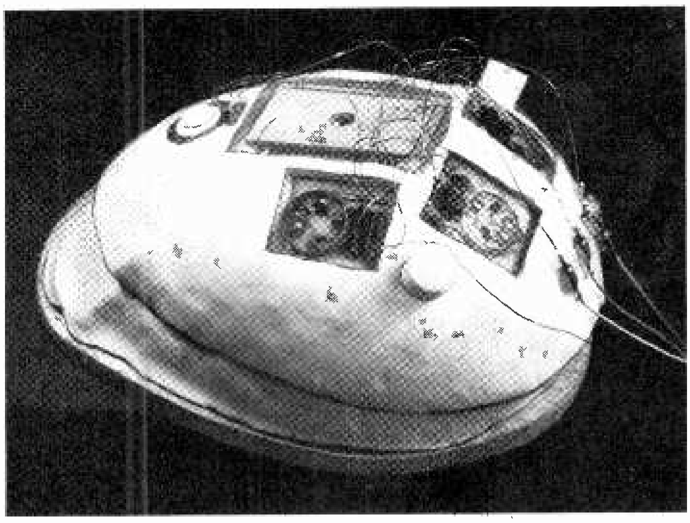


Fig. 5. One of the nine row-receiver coils feeding one of the nine logic packages. Tr_{row} is electrically part of the row-receiver but is in the logic package because active devices have to be hermetically sealed. The other transistors are two-input AND gates.



Mini implant for implantation into a baboon. This wired-up but as yet unsealed device was built to establish absence of toxicity and resistance to body fluid. One logic package, one row-receiver coil and three out of four column-receivers can be seen.

to select and stimulate several points at the same time. This cannot be achieved directly, but by the introduction of a repetitive scanning principle in the transmitting equipment the patient can be made to experience white spots which are apparently simultaneous though actually not (cf. the apparent simultaneity of picture points on a television picture). For this purpose the row-transmitters, and hence receivers, are energized in sequence at a scanning frequency of 2000 rows per second and as there are 10 of these (9 in use, 1 spare) this means that a given row transmitter is switched on by its 500μs modulating pulse every 5ms, giving a field frequency (cf. television) of 200 per second. As each row-transmitter is turned on by its 500μs modulating pulse the required column-transmitters for that row, determined by the pattern structure viewed by the picture source, are also turned on by simultaneous modulating pulses of appropriate strength.

In designing the packages for the circuitry in Figs. 4 and 5 the major requirements were: (a) small size, to make the implant as neat and unobjectionable to the patient as possible, and (b) ability to operate reliably for years in an atmosphere consisting of a warm saline 'mist'. (Although the packages are saved from direct immersion in the body fluid by the silicone rubber shell, this is by no means completely impervious to moisture.)

Monolithic integrated circuits were considered as a possibility but were not used because of the difficulty of getting special devices manufactured and environmentally tested for this unusual project, and because of their lack of flexibility, once fabricated, for experimental work. Instead hybrid microcircuits, using thick film conductors and resistors, were chosen. This technique permits experimental thick film circuits and experimental packages to be made in the laboratory, allowing flexibility of design and extensive environmental testing of devices, materials and completed packages in the conditions of a physiological laboratory.

From research into the environmental conditions it was found that, for reliable operation, discrete passive components and passivated micro-diodes need only be encapsulated in epoxy potting resin, but that thick film resistors and planar transistor chips should be hermetically sealed.

The resin-encapsulated packages, for the column-receivers, row pick-up coils and banks of tantalum capacitors, are fairly conventional (Fig. 3), but the nine hermetically sealed packages, for the transistor AND gates and row-receiver transistors, are unusual. Based on an aerospace package developed at the Royal Aircraft Establishment, they have a ceramic substrate on which metal film conductors are deposited by a screen printing process (see Fig. 6). A ceramic wall, fabricated as a complete component and slightly smaller than the substrate, is laid on the circuit and fused to the substrate with glass. This encloses all the components but leaves connecting tags projecting outside. When the components are all assembled on the conductors, a lid of the same material as the substrate is bonded on to the top edge of the ceramic wall with solder, thereby closing the package. This lid contains a small hole by which the package is subsequently filled with nitrogen and finally sealed by a blob of solder over the hole. The great advantage of this design of package is that it enables the circuit layout to be changed during development work—by screen printing a fresh pattern of metal film conductors—without affecting the overall structure of the package. After wires have been soldered to the external tags the hermetically sealed package is encapsulated in epoxy resin (Fig. 7), and it then measures 29mm × 20mm.

The completed packages are fitted into rectangular cavities moulded into the bottom part of the silicone rubber shell and are then wired up with Teflon insulated wire of 7 thou' outside diameter. The mass of wiring, which is extremely dense and complicated, is pulled flat by a Terylene net and impregnated by a layer of silicone rubber, which forms the top part of the shell and seals in the electronics.

An important part of the engineering development work has been the environmental testing of the implant packages. This is done by immersing them in a warm saline bath (1% sodium chloride solution at 50°C) and operating them continuously under normal electrical conditions until any deterioration of performance is observed. For this purpose the immersed receivers are inductively coupled to transmitter units applied to the outside walls of the bath. As an example, column-receivers which have been tested continuously for 6 months under these conditions have been found to have no visible corrosion of components or conductors and no measurable reduction in performance.

A great many electronics firms have gone out of their way to assist this remarkable project by providing specialized engineering knowledge and services. Notable among these is Newmarket Transistors, who have made all the hybrid logic microcircuits for the prototype implant, and Andermann and Ryder, who have overcome some tricky problems in the manufacture of the ceramic hermetically sealed packages.

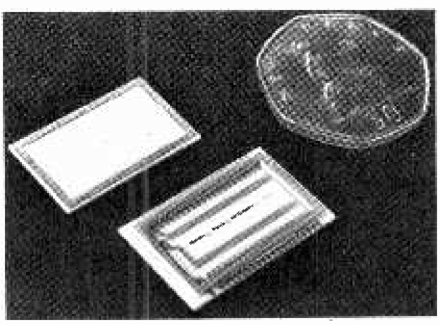


Fig.6. Hermetic package for the logic circuits compared in size with a 50p coin. On the right is the printed substrate with the ceramic wall attached (the high-light shows the solder glass); on the left is the lid, with metallizing for attachment and hole for filling with nitrogen.

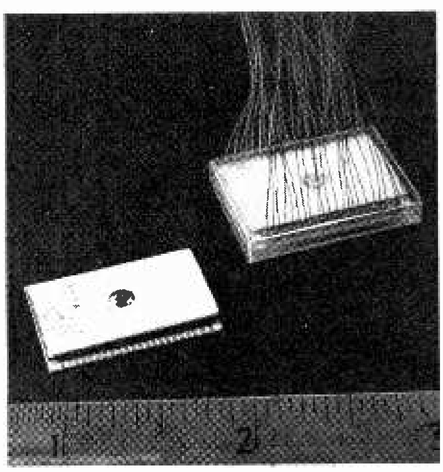


Fig.7. Completed hermetic logic package before and after wire attachment and encapsulation.

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Miles-per-gallon Meter

An instrument which can help you achieve maximum petrol economy

by S. C. Hambly

The instrument described here will give a continuous indication of miles-per-gallon (miles/gal) with an accuracy not worse than ±10% when connected to a motor vehicle. It must be stressed that the circuit is experimental and the calibration procedure is somewhat involved. However, calibration in terms of miles/gal is not essential because the meter can be used to adjust the vehicle's controls for maximum fuel economy, under a particular set of conditions, by driving to achieve the highest possible meter deflection. The device can only be used on vehicles which have an electrically driven fuel pump and, with the circuit given, a positive earth electrical system. The two factors which are needed to calculate miles/gal are the amount of fuel used and the distance travelled. It was found that on the author's vehicle, a two-litre short wheelbase Land-Rover, the volume of fuel delivered by each pump-stroke was constant over a range of pump operating rates; a fact that is made use of in the system being described.

A block diagram is given in Fig. 1. Contact-breaker operations are counted electronically, the total count at any time representing a distance which can be calculated from the overall gear-ratio in use and the circumference of the road wheels. The total count is reset to zero each time the fuel pump operates so that the count immediately prior to reset is a measure of the distance travelled for a specific volume of fuel.

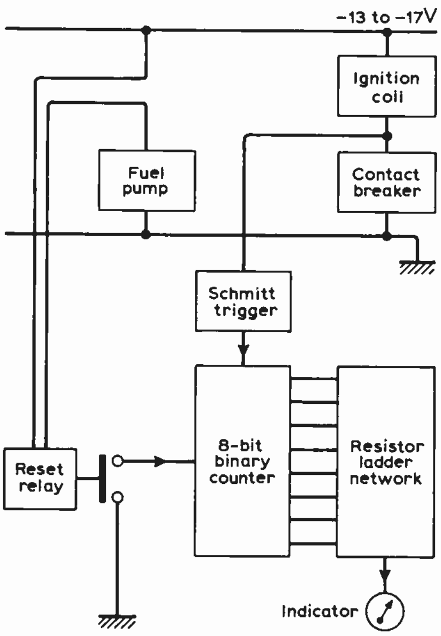

Fig. 1. Block diagram of the system. The ladder network converts the contents of the binary counter into an analogue voltage which is measured on the peak reading voltmeter.

For an engine running at constant speed and load, a plot of the contact-breaker count against fuel-pump operations has the form of a sawtooth as shown in Fig. 2(a). If the engine speed is now doubled the count will rise at twice the previous rate, but if the miles/gal does not change the count will be reset twice as frequently as before, with the result that the sawtooth will have exactly the same amplitude as before, as shown in Fig. 2(b).

In general the miles/gal will not be constant, and this will be reflected in the size of the count reached immediately before reset. An instrument arranged to follow the successive peaks of the converter output waveform will indicate successive values of miles/gal, the average of these being taken over the time interval between successive pump strokes. This time interval is not usually longer than a few seconds for an engine idling, and becomes smaller as the load on the engine increases.

Circuit details

The voltage across the vehicle's contact-breaker provides the input to the system. Because this waveform is a series of damped oscillations, due to the inductive load, a low-pass filter R_2C_4 in Fig. 3 is inserted bet the contact-breaker and the Schmitt trigger (Tr_1 and Tr_2). The Schmitt provides clean input pulses for the first stage of the binary counter.

The binary counter has eight stages and a maximum count of 255. Increasing the number of stages to nine gives a maximum count of 511 with ample margin for no-load conditions, but it must be remembered that, if a full-scale deflection is associated with a count of 511 instead of 255, the meter deflection for (say) 30 miles/gal will be only one-half that produced by the eight-stage counter. In the author's vehicle the eight-stage counter was found to be best.

The resistive ladder network which translates the counter content to an analogue voltage has eight sections corresponding to the eight stages of the counter. Each section of the ladder network receives an input from one collector of the counter via an emitter follower. A voltage directly proportional to the total count appears across R_{34} and has the form of a staircase which reaches a maximum value for a count of 255.

Each time the fuel pump solenoid is energized, the counter must be reset to zero. This is brought about by momentary connection of the reset line to ground. The connection is made by a pair of normally open contacts on a reset-relay, which has an operating coil wired in series with the fuel pump. A P.O. relay frame provided with a specially wound low-resistance coil has proved quite satisfactory for the purpose, but there would be advantages in replacing this by a reed relay.

Series connection requires the low-resistance coil, but this is considered preferable to connecting the reset relay coil in parallel with the fuel pump solenoid which would mean that connections have to be

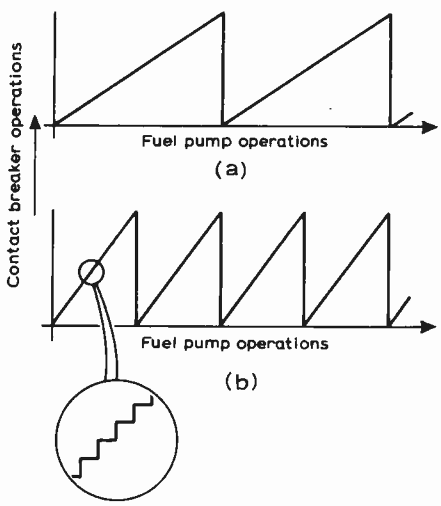

Fig. 2. Waveforms showing the output of the ladder network for two different engine speeds. Note how the same peak value is reached in each case. This is because although the contact breaker is operating at twice the rate the fuel pump is also working at twice the speed, giving the same fuel consumption.

made inside the fuel pump housing and additional leads brought out.

Ideally the indicator should display the peak value of the ladder network output voltage at the moment just before reset, and it should hold this reading until the next reset occurs. Instead, a simple peak-reading voltmeter is used. The time constant C_3, R_{35} is a compromise that gave best results. The 9V power supply is zener stabilized against car electrical system voltage variations.

Calibration

In order to prove the feasibility of this method of assessing miles/gal, a considerable number of measurements were made, extending over a period of about five months. Much of this time was spent on the fuel pump. Tests were made using a calibrated measuring cylinder to collect the fuel passing through a controlled leak introduced at a point between the pump and carburetter.

The time for a fixed number of pump strokes was recorded for a range of leak settings designed to cause the pump to operate at speeds in the range 0.08 to 3.0 strokes/second, a range which embraces stroke rates found in normal use for the author's vehicle. For these tests the engine was switched off and the ignition disconnected; changes in pump supply voltage were made as required by introducing an additional battery.

The results of these tests are summarized in Fig. 4 where the volume of fuel delivered per pump stroke is shown as a function of stroke rate.

Measurements were made for supply voltages in the range 13 to 17V, and at ambient temperatures from 0 to 20°C approximately.

The conclusion reached was that in the range 0.08 to 2.8 strokes/sec., the volume of fuel delivered on every stroke was $(4.34 \pm 0.1) \times 10^{-4}$ gallon. Beyond the range quoted, the vol./stroke increases. No attempt was made to assess the effects of the level of fuel in the vehicle tank or of the attitude of the vehicle.

As mentioned earlier the instrument can be used as described, without calibration, to achieve maximum fuel economy, by driving in such a way as to keep the meter as near full-scale deflection as possible.

If you wish to calibrate the meter proceed as follows:

1. Introduce the coil of the reset relay into the fuel pump circuit, and observe the rate at which the pump operates with the engine idling, and when climbing a hill in low gear.
2. Measure the volume of fuel/stroke at a few points in the range of stroke rates found in (1), as described above. The result should be a curve similar to that shown in Fig. 4.

An expression for miles/gal can be developed as follows in terms of:

C: representing number of contact-breaker operations recorded by the counter before reset.

V: representing the volume of fuel delivered per pump stroke (expressed in gallons).

R: overall gear ratio. Crankshaft revolutions divided by road wheel revolutions.

D: diameter of road wheels in feet.

For a four-cylinder engine C contact-breaker operations means $C/4$ camshaft revolutions and $C/2$ crankshaft revolutions.

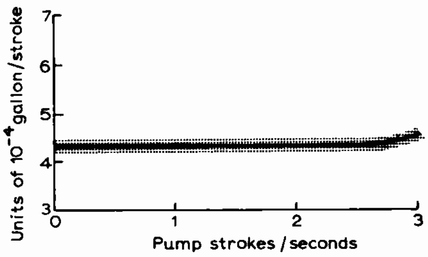

Fig. 4. Characteristic of the fuel pump in the author's car which is a short wheelbase Land-Rover.

The distance travelled by the vehicle in miles is therefore:

distance (miles) $= 29.75 \times 10^{-5}\ CD/R$

and the vehicle's fuel consumption is:

miles/gal $= 29.75 \times 10^{-5}\ CD/RV$

The road-wheel diameter in feet is substituted for D, and assuming for the moment operation in top gear the appropriate ratio is entered for R.

This leaves miles/gal as a multiple of C, the count of contact-breaker operations between one reset and the next. The binary counter and ladder network operate from a nominal supply voltage of −9V, and the ladder output for the maximum count of 255 is 2.1V.

If the ladder output voltage at the moment before reset is E then the corresponding count is $(E \times 255)/2.1$, which replaces C in the expression for miles/gal.

$$\text{miles/gal} = 29.75 \times 10^{-5}\ \frac{255ED}{2.1RV}$$

For the vehicle used in these tests, wheel dia = 2.3 ft; (top) gear ratio = 5.4; vol./stroke = 4.34×10^{-4} gal, giving miles/gal = 35.6 E, where E is the ladder-network

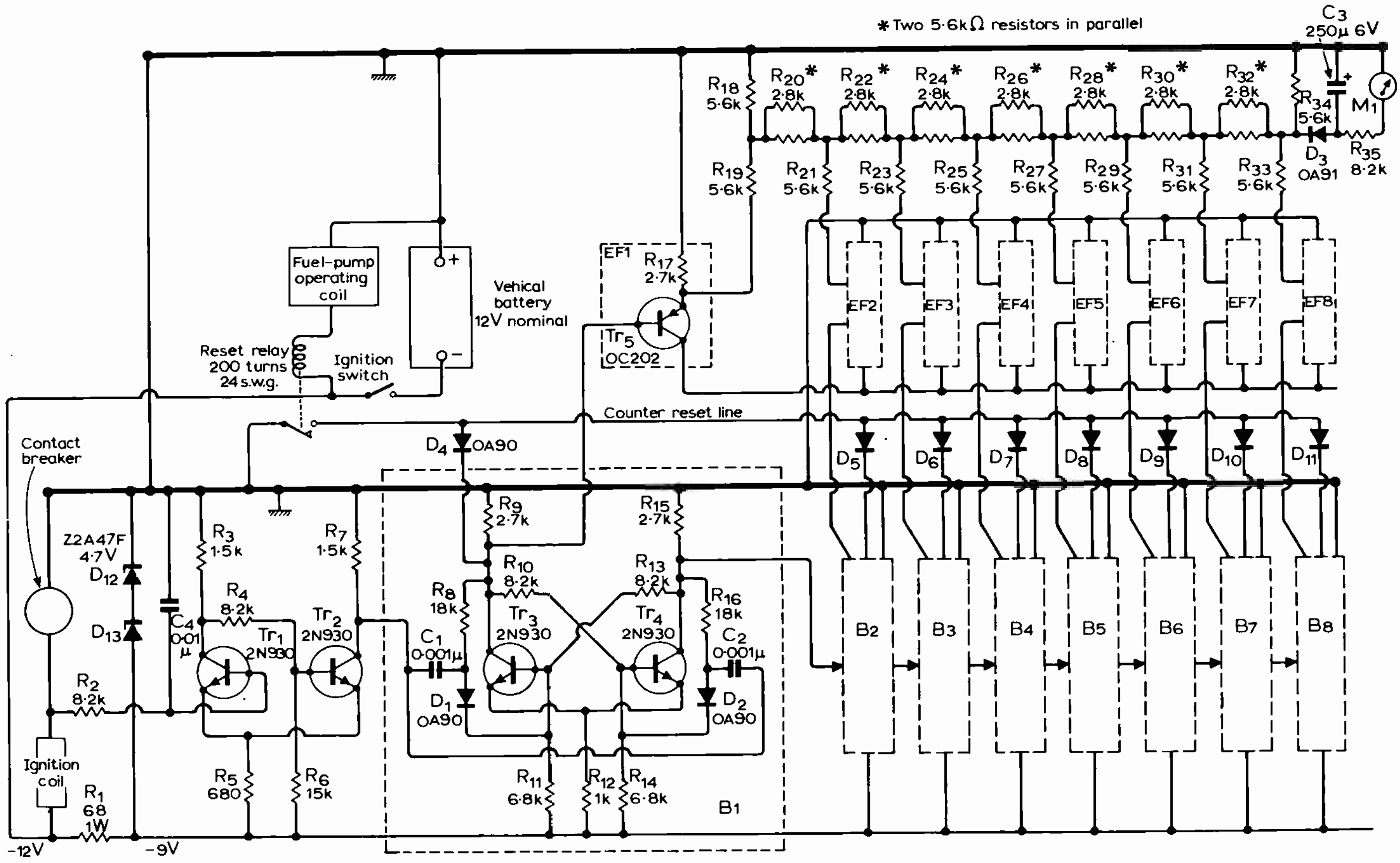

Fig. 3. Full circuit diagram. Some resistors (2.8k Ω) are made up of two 5.6k Ω resistors in parallel.

output voltage immediately prior to reset.

For other than top gear operation, provision can be made by marking the indicator scale separately for each gear ratio, in the same fashion as multi-range voltmeters; but it would be exceptional for a long journey to be negotiated mainly in low gear, and it could be argued there is no necessity to consider anything lower than third gear.

Overall accuracy

The main sources of error are variation in the volume of fuel/pump stroke and variation in supply voltage causing small changes in zener voltage and therefore in the ladder-network output. Under steady conditions the absolute accuracy is expected to be not worse than ±10%, for pump operating rates not exceeding approx. three strokes/sec.

Shopping List

Resistors

Qty	value	Qty	value
1	68Ω*	24	5.6kΩ
1	680Ω	16	6.8kΩ
8	1kΩ	3	8.2kΩ
1	1.5kΩ	1	15kΩ
24	2.7kΩ	16	18kΩ

*1 watt all others 0.5W

Capacitors

Qty	value	Qty	value
16	1nF	1	10nF
1	250μF, 6V working		

Semiconductors

Qty	type	Qty	type
18	2N930†	25	0A90
8	0C202	2	Z2A47F‡

† any n-p-n silicon transistors can be used as long as they have a current gain of at least 50

‡ 4.7V, 400mW zener diodes.

Other parts

The reset relay used a P.O. relay frame with the bobbin wound with about 200 turns of 24 s.w.g. enamelled copper wire.

Meter: 0.2mA f.s.d., 380Ω.

Binding of "Wireless World"

Our publishers will undertake to bind readers' copies of *Wireless World.* The cost, including postage on the completed volume, is £2. Copies should be sent to IPC Business Press Ltd, Binding Department, c/o 4 Iliffe Yard, London S.E.17, with a note of the sender's name and address. A separate note confirming despatch and enclosing the remittance, should be sent to the Binding Department, Dorset House, Stamford Street, London S.E.1.

For those who wish to bind their own copies cloth binding cases are available price 50p (10s) including postage and packing. Readers will have noticed that the index for volume 76 (1970) was included in the December issue.

Announcements

B.I.M.C.A.M. officer. L. R. Price, chairman and managing director of Honeywell Ltd, has accepted the invitation to be president of the British Industrial Measuring & Control Apparatus Manufacturers' Association. The vice-president is L. S. Yoxall (chairman, Foxboro-Yoxall Ltd) and W. H. Medcalf (managing director, Leeds & Northrup Ltd) is the chairman of Council.

Highgate Acoustics ceased to be Arena's sole distributors in the United Kingdom on March 31st. This follows the formation of **Rank Arena A/S** in Denmark last year by Rank Bush Murphy with 80% of the shares and Hede Nielsen A/S with the remainder. R. B. M. will in future market the Danish products under the trade name Bush Arena.

Licensing agreements have been signed by three more Japanese manufacturers planning products using the **Dolby noise reduction system.** Dolby Laboratories have acquired an office in Japan situated at Tiger Building, 20-7, 4-chome, Kuramae, Taito-ku, Tokyo.

A new company has been formed, Barrie Electronics, 11 Moscow Road, London W.2., which stocks over 100 styles of standard transformers and offers a **production winding service.** Valves, semi-conductor devices and metal oxide resistors are also distributed.

EMI has purchased 50% interests in two Italian domestic electronics companies—Voxson S.p.A. of Rome and Eergon S.p.A of Anagni.

Cadmium Nickel Batteries Ltd has recently changed its name to SAFT (United Kingdom) Ltd, Castle Works, Station Road, Hampton, Middx. Tel: 01-979 7755.

Tekmar Electronics Ltd, the U.K. components sales division of Tekmar S.A. of Geneva, have completed negotiations which give them exclusive sales agreements for the U.K. distribution of electrolytic and tantalum capacitors, printed circuit boards and custom built integrated circuits manufactured by **Elna Co. Ltd,** of Tokyo, Japan.

The Semiconductor Division of **MCP Electronics Ltd** has signed sole U.K. representation and distribution agreements with the Swedish Institute of Semiconductor Research (Hafo) and with Tekelec Airtronic.

The **M-O Valve Co. Ltd** have concluded a technical agreement with **Telecommunications Industries Inc,** of Farmingdale, New York, under which the American company is licensed to manufacture M-O Valve surge arresters in the U.S.A. and to sell these throughout North and South America.

Semicomps Ltd, 5 Northfield Estate, Beresford Avenue, Wembley, Middx, have been appointed distributors of the range of **optoelectronic devices** and associated integrated circuits manufactured by Monsanto's Electronic Products Division.

Tape cassette manufacturer Magnetofoni Castelli of Italy are represented in the U.K. by Trusound Manufacturing Ltd, Crittal Road, Witham, Essex. Tel: Rivenhall 4101.

An agreement has been reached under which the electronics division of Allhabo, Stockholm, will be solely responsible for the **sales and marketing in Sweden** of the range of components produced at the Emihus Microcomponents plant at Glenrothes, Scotland.

Auriema Ltd have concluded a distribution agreement with Nurad Inc, of Baltimore, U.S.A., to market their range of **custom designed aerials,** feedhorns, arrays and structures in the U.K.

The French company E.C.E. **(L'Equipment et la Construction Electrique)** have appointed FieldTech Ltd as sole U.K. sales agents for their range of switches and all other equipment.

Steatite Insulations Ltd, Hagley House, Hagley Road, Birmingham B16 8QW, have been appointed exclusive U.K. distributors for **Resista GmbH;** part of the West German Roederstein Group, who manufacture passive electronic components.

Radiodiffusion Television Algérienne has awarded a contract worth £250,000 to Marconi's Broadcasting Division for the supply and installation of a complete **television and sound broadcasting studio** complex in Oran, Algeria.

Plessey are to supply action data automation equipment worth £750,000 to the British Royal Navy, as part of the new **training simulators** to be installed at H.M.S. Dryad, the naval tactical training school near Portsmouth.

Ericsson Marine have received an order from Cunard, valued at around £250,000, to provide **fully automatic radio stations** for 13 new Cunard ships, the first to be completed by the middle of this year.

The Broadcasting Division of Marconi has been awarded a transmitter contract worth more than £1M by the **Independent Television Authority.** Marconi will supply 15 sets of u.h.f. transmitting equipment for installation in various parts of the country.

Conferences and Exhibitions

Further details are obtainable from the addresses in parentheses

LONDON

May 18-21 Olympia
Electronic Component Show
(Industrial Exhibitions Ltd, 9 Argyll St., London W1V 2HA)

May 18-21 Royal Garden Hotel
Electronic Components Conference
(Electronic Components Board, Carrier House, Warwick Row, London S.W.1)

May 28 & 29 Horticultural Hall
APRS 71 Exhibition
(Assoc. of Professional Recording Studios, c/o 3 Strathray Gdns, London NW3 4PA)

EASTBOURNE

May 18 & 19 Grand Hotel
Design and Control of Manufacture
(Sira Institute, South Hill, Chislehurst, Kent BR7 5EH)

OVERSEAS

May 10-12 Washington
Electronic Components Conference
(I.E.E.E., 345 E. 47th St., New York, N.Y. 10017)

May 12-14 Boulder
Electron, Ion & Laser Beam Technology
(I.E.E.E., 345 E. 47th St., New York, N.Y. 10017)

May 17-19 Dayton
Aerospace Electronics Conference
(I.E.E.E., 124 E. Monument Avenue, Dayton, Ohio 45402)

May 17-20 Washington
Microwave Symposium
(I.E.E.E., 345 E. 47th St., New York, N.Y. 10017)

May 21-27 Montreux
Television Symposium
(Case-Box 97, 1820 Montreux)

May 28-30 Geneva
Amateur Television Convention
(J. Richez, 1 rue Samuel-Constant, 1201 Geneva)

Stereo Mixer

A comprehensive range of high-quality input stages with mixing, filtering, and tone-control facilities

by H. P. Walker, B.A.

The stereo mixer to be described, in this and next month's issues, is shown in the block diagram of Fig. 1, and its specifications are given in Table 1. Although the author's equipment was built with five stereo channels, there is in principle no reason why it should not be expanded to many more with a more complex system of mixing and group faders, or simplified to a high-quality pre-amplifier with no mixing facilities. Similarly, the nominal output levels can be altered as required.

Table 1. Input facilities

Source	Max. Sensitivity	Noise	Overload margin	Comments
Magnetic pickup	1.5 mV @ 1kHz	−67.5 dB ref. 1.5mV @ 1kHz	>30dB	Normal R.I.A.A. equalization
Ceramic pickup	15 mV @ 1kHz	−70 dB ref. 15mV @ 1kHz	28dB	Utilizes mechanical equalization, input impedance ∼200kΩ
Crystal pickup	70 mV @1kHz	−85 dB ref. 100mV @ 1kHz	>26dB	Economical circuit input impedance = 2MΩ
Microphones	Various depending on type		30dB	Several circuits are described for different requirements
Auxiliary	230 mV 100K Ω input impedance	<−70 dB	Infinite	Preset sensitivity control preceding amplifier

Pre-Mixing circuits

For an overload margin of 30dB for the input pre-amplifiers, and a residual noise level of better than 80dB below full output, the nominal signal level at mixing should be 120mV, requiring an output of about 250mV from the pre-mixing circuits. This defines the gain of the input circuits for the basic sensitivities.

The stereo balance and mono/stereo switch, shown in Fig. 2, is a common feature of all the pre-mixing amplifiers. The balance control should be a wire-wound potentiometer to avoid the crosstalk which would result from a high contact resistance at the slider (e.g. with a carbon-track potentiometer). The inclusion of the 4.7kΩ resistors, before the mono/stereo switch, provides a properly mixed version of the two stereo channels for mono operation. If one wishes to mix a monophonic signal stereophonically (e.g. for a point source of sound, movable in a stereo field) the signals must be paralleled at the input or at the presensitivity control.

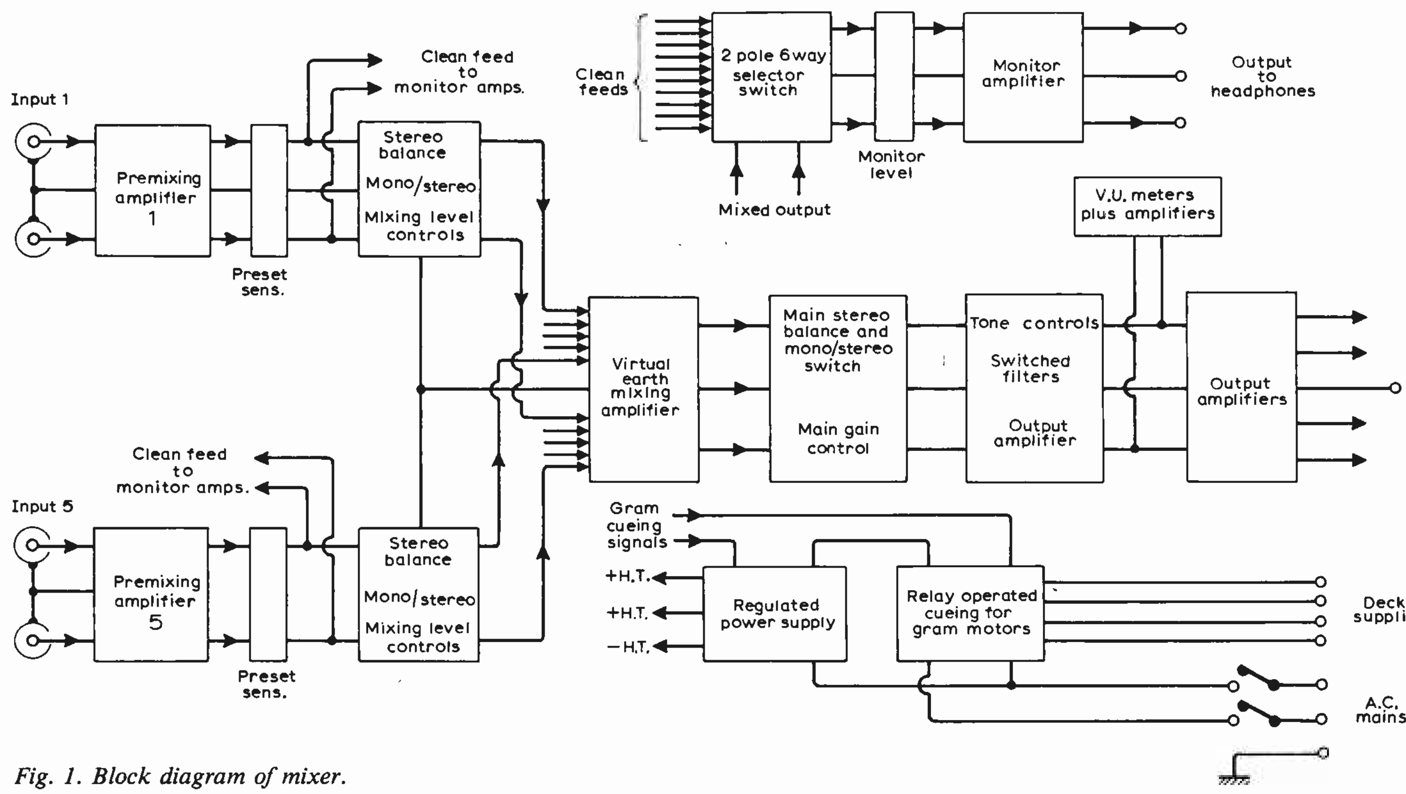

Fig. 1. Block diagram of mixer.

High-quality magnetic and ceramic pickups: While it is possible to design a virtual-earth feedback amplifier suitable for a magnetic pickup, signal-to-noise ratio is inferior to that of the series input of the feedback pair when the source impedance is less than the input resistance. It was required that the input of the mixer be switchable between a microphone and a ceramic pickup so there was a further advantage in using the feedback pair, since input impedance can be changed without altering gain. The final circuit for this amplifier is shown in Fig. 3. and the equalization curve in Fig. 4.

Although a field-effect transistor will give a good noise figure when operated with a ceramic pickup it will give a poor flicker noise performance when the source resistance is low. This is exactly the case with a magnetic pickup and the effect is worsened by the bass-boost of the R.I.A.A. characteristic. It was considered most important to cater for a high-quality magnetic pickup, and for this reason a bipolar transistor is used as the input device. When operating a low-noise silicon transistor at about 80-100μA collector current, the noise figure is 2dB or less over the effective range of source resistances from 1kΩ-50kΩ. However, this optimizes the noise figure for a source resistance of about 5kΩ and as the stage must also be operated with a 200kΩ source resistance for ceramic pickups it was decided, in the interests of low flicker noise, to reduce the standing current to 35-40μA. This increases the noise figure to 3dB at low frequencies with the magnetic pickup.

Ceramic pickups operating into about 200kΩ require bass boost in the pre-amplifier to balance the falling bass response caused by the input time constant[1]. The component values for C_{12}, R_{15}, and R_4 are suitable for pickups having a self-capacitance of about 600pF—which includes the majority of better cartridges. This results in turnover at about 1.5kHz and is approximately the same as that of the treble tone-control (discussed later) which can be used to compensate for different cartridge capacitances and degrees of mechanical equalization. The input resistance or feedback time constant can also be adjusted to suit other types, provided that the feedback resistor R_{15} is not made less than 5kΩ otherwise serious loading of the emitter-follower will result.

The second transistor is operated under conditions of low distortion; C_5, R_{12} and R_{18} are included to improve the high-frequency stability and only affect the performance outside the audio range. The filter comprising R_1 and C_4 is essential to prevent r.f. appearing at, and being detected by, the base-emitter junction of the first transistor. Inevitably the presence of R_1 in series with the base of Tr_1 causes a poorer noise performance (particularly at low frequencies with a magnetic pickup) but it should not be omitted if a wide variety of gramophone equipment is likely to be used.

The microphone input will match a 50kΩ high-impedance dynamic microphone. In conjunction with a transformer it is suitable for a low-impedance type. This is, however, only a useful secondary function of this circuit and the noise performance will be slightly inferior to circuits specifically designed for this kind of input.

About 20dB of n.f.b. is applied at mid-frequencies, reducing distortion to less than 0.1%. The purpose of C_9 is again to improve the high-frequency stability of the circuit.

The R.I.A.A. feedback-loop time constants are:

$$R_{19}C_8 = 82\mu s \quad R_{19}C_{11} = 240\mu s$$
$$R_{14}C_{11} = 3000\mu s$$

The values shown in Fig. 3 approximate these time constants, with the exception of the l.f. turnover*[2] (sub-audio frequencies being attenuated by a rumble filter later in the mixer), and the gain at 1kHz is given by R_{19}/R_5†. The basic sensitivity (at 1kHz) is then 2mV for 240mV output, allowing more than 30dB of feedback at mid-frequencies, falling to 10dB at very low frequencies.

High-output crystal and ceramic pickups: Pickup cartridges having average outputs in excess of 100mV r.m.s. will overload the ceramic pickup input unless

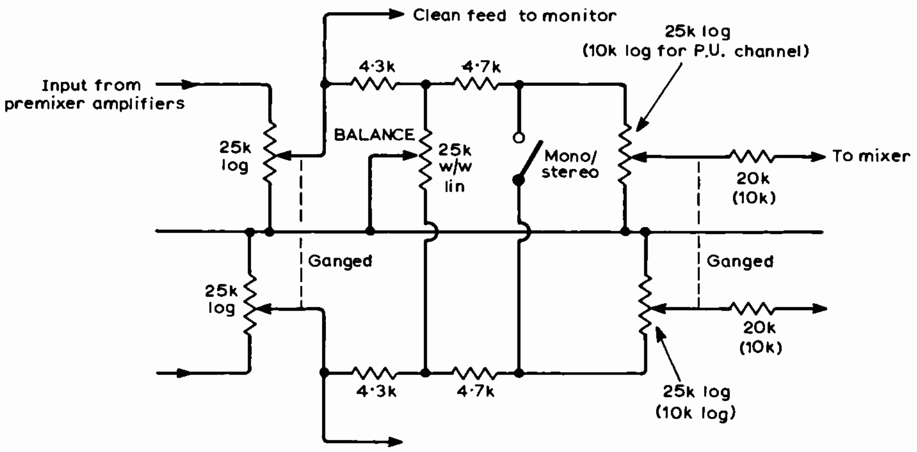

Fig. 2. Stereo balance and mono/stereo switch.

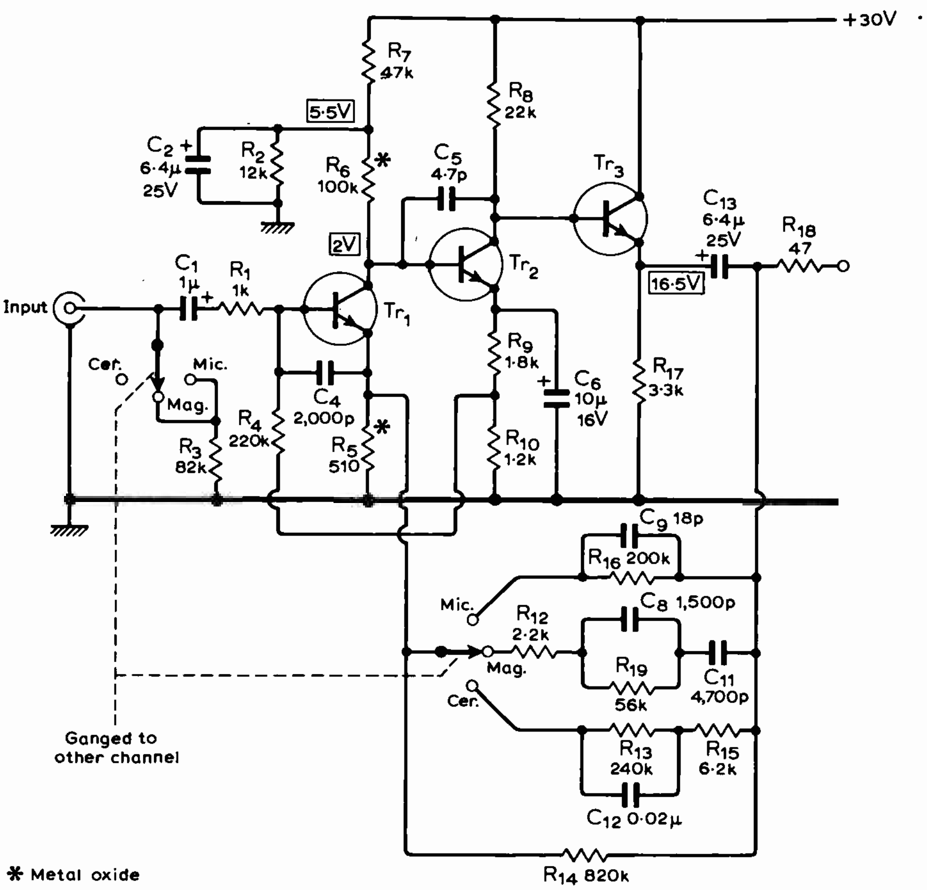

Fig. 3. Gramophone pickup amplifier with switched equalization for magnetic and ceramic cartridges, and for use with a microphone. Tr_1 BC184LC or BC109C; Tr_2 2N3707 or BC167; Tr_3 BC167 or BC107.

* It was pointed out by Mr. Linsley Hood[2] that record manufacturers do not boost the frequencies below 50Hz in accordance with the R.I.A.A. characteristic and therefore a larger l.f. time constant will allow the fuller reproduction of these rather 'dubious' signals. Making $R_{14} = 620k\Omega$ would restore the correct 3180μs time constant.

† Altering R_5 is the simplest way of adjusting the basic sensitivity.

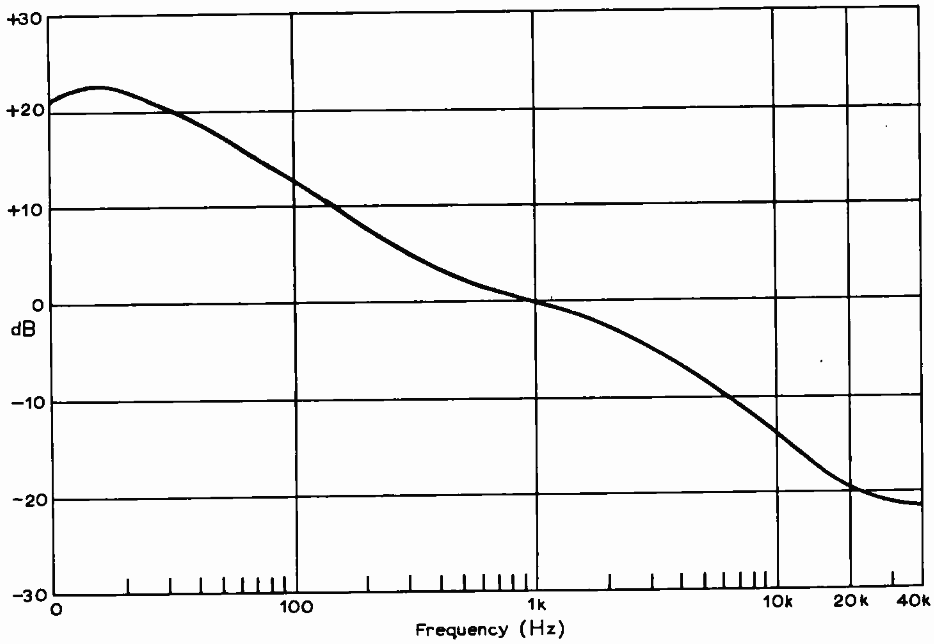

Fig. 4. Measured R.I.A.A. characteristic for magnetic pickup input of Fig. 3.

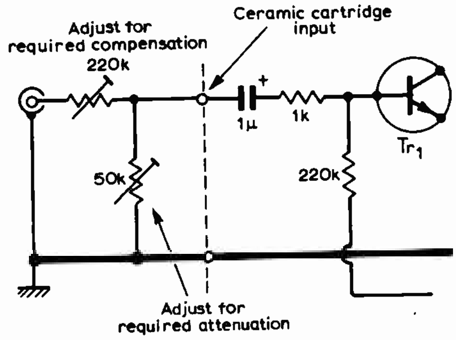

Fig. 5. Attenuator for use with high output ceramic cartridge when employing Fig. 3.

Table 2. Performance characteristics of Fig. 3

Specification:	Magnetic p.u.	Ceramic p.u.	Microphone
Sensitivity	1.4mV r.m.s. at 1kHz	15mV at 1kHz	0.7mV at 1kHz
Input impedance	60kΩ	220kΩ	60kΩ
Distortion at nominal levels	<0.02%	<0.02%	<0.02%
Overload margin (0.1% dist.)	>30dB at 1kHz & 10kHz	28dB	30dB
Signal-to-noise ratio referred to max. sens.	67.5dB input shunted with 420mH	70dB input shunted with 680pF	42dB input open circuit

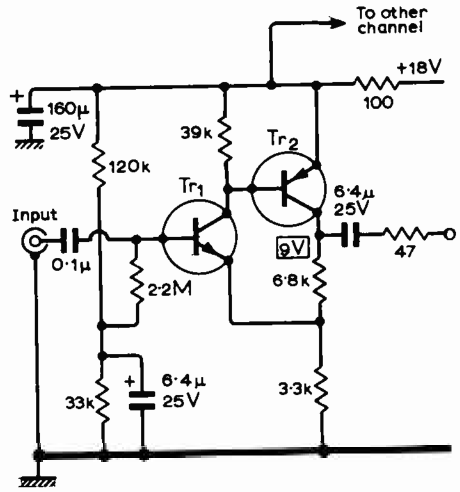

Fig. 6. Amplifier for high-output ceramic cartridge. Tr_1 BC169, BC184LC, etc.; Tr_2 2N4058, 2N4062, etc.

resistive attenuation is placed between the cartridge and the input. A suitable circuit is shown in Fig 5.

The circuit of Fig. 6 has the merit of costing very little to build. The first transistor is run at a collector current of 10-20µA and current-drives the second transistor, whose collector voltage is defined by the d.c. and a.c. feedback to the emitter of the first transistor. Using the normal Darlington connection would achieve the high input impedance but would result in gross distortion because of the effective voltage drive at the base of the second transistor.

Performance

Input impedance (measured) 2MΩ in parallel with 2pF
Max. sensitivity 70mVr.m.s.
Max. input 1.8Vr.m.s. (overload margin > 26dB)
Distortion for an input of 600mVr.m.s. at 1kHz <0.02% not exceeding 0.1% for input of 1.5Vr.m.s. in audio band
Signal-to-noise ratio ref. to input of 70mV (1000pF on input) > 80dB.

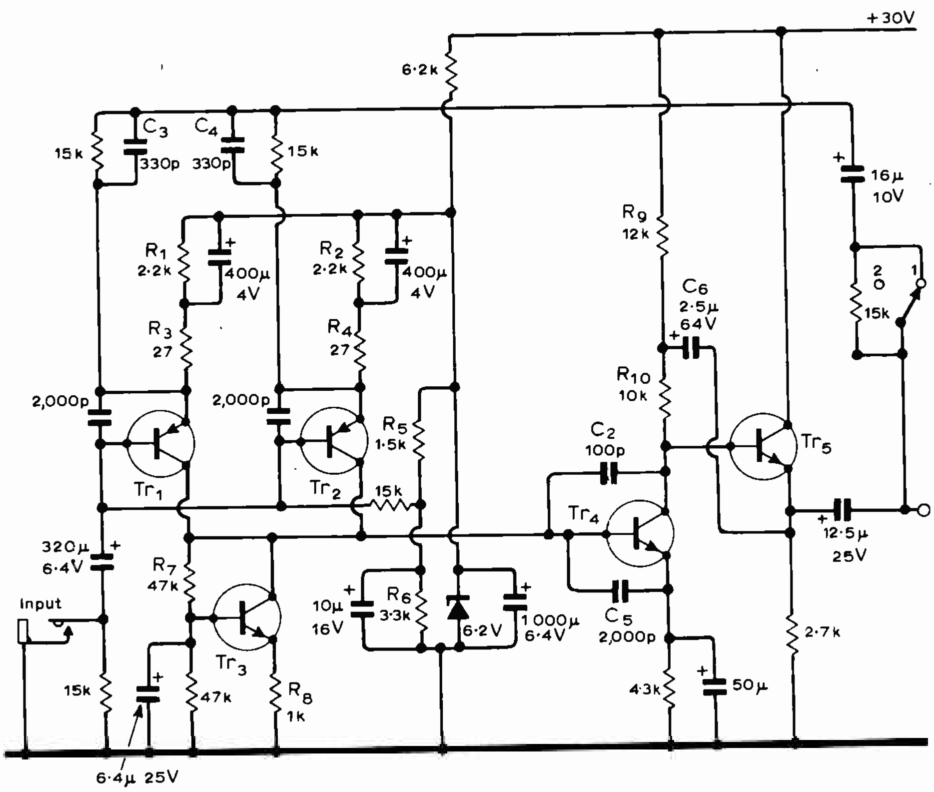

Fig. 7. Amplifier for medium impedance microphone. The approximate maximum sensitivities are 400 to 500µV (600Ω mic.) and 150-200µV (200Ω mic.). The overload margin is 30dB (0.1% distortion). Frequency response is 20Hz-25kHz (—3dB) and s/n ratio not less than 60dB (66dB with 200Ω mic.). Tr_1 Tr_2 2N4058, 2N4126 or 2N4289; Tr_3 BC109, etc; Tr_4 2N3707, Tr_5 BC167, etc.

Microphone amplifiers

First, a brief summary of the types of microphones which are likely to be encountered. Crystal microphones will not be considered because of their low sound quality.

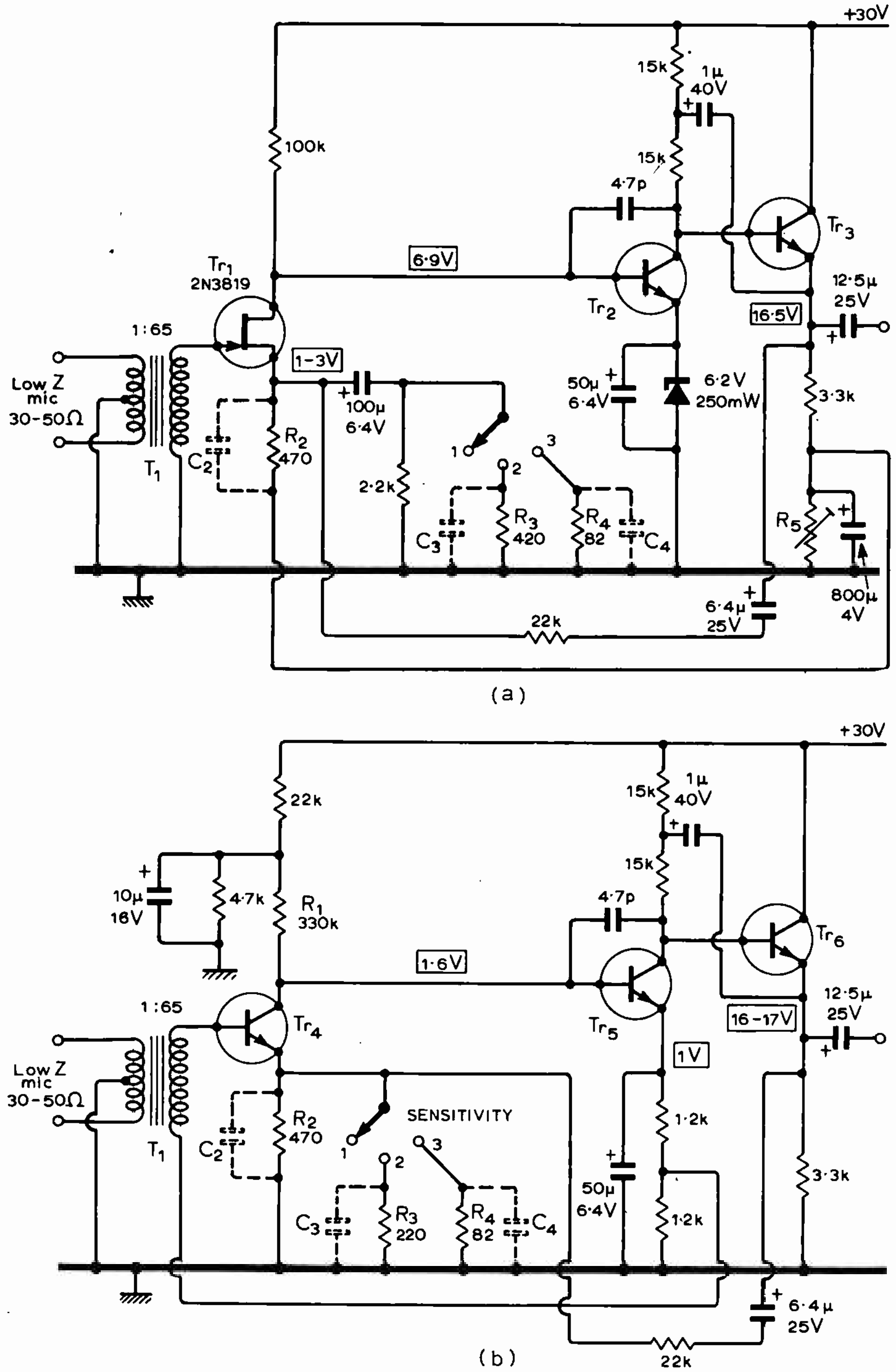

Fig. 8. Low-impedance microphone amplifiers. The overload margin is 30dB for 0.1 % distortion. Sensitivity for a 30Ω input impedance is determined by the three-position switch—(1) 80-100µV, (2) 25-30µV, (3) 12-20µV. Distortion ≙ 0.02%. S/N ratio 63.5dB. T_1 in the prototype was Radiospares 'Hygrade' type. Tr_1 2N3819; Tr_2 and Tr_5 2N3707; Tr_3 and Tr_6 BC167, BC107 or 2N3707; Tr_4 BC169, BC1841C or BC109. C_2, C_3 and C_4 will have to be added to compensate for transformer losses.

Capacitor microphones: These have their own head-amplifier within the microphone case, the output signal of about 1mV being sent down a low-impedance line (typically 200 or 600Ω).

Ribbon microphones: Depending on the step-up transformer supplied with the microphone, the impedance and signal levels could be low Z 30-50Ω (typical open-circuit voltage 100-200µV) or. 200-600Ω (200-500µV), med. Z 1k-1.5kΩ (600-800µV), and high Z 50kΩ (2-4mV.)

Moving-coil microphones: Again, the impedance of these depends on the transformer supplied, but generally are either med. Z 200-600Ω (typical open-circuit voltage 200-800µV), and high Z 50kΩ (2-4mV.)

We will now consider various low-noise amplifiers suitable for the last three categories. High impedance types suffer losses at high-frequencies because of the length of cable which can be used between microphone and amplifier. If used, they should be connected directly to the circuits of Fig. 8(a) or 8(b), omitting the transformer but including a resistor (e.g. 220kΩ) in place of the transformer secondary—an isolating capacitor, say 1µF, will be required with circuit of Fig. 8(b).

The medium impedance versions ($200\Omega < Z_{mic} < 1.5k\Omega$) are suitable for direct connection to the circuit of Fig. 7. This rather unusual circuit makes use of the principle suggested by E. A. Faulkner[3] of paralleling several transistors to overcome the limitation on achievable noise-figure for low source resistances. Also, p-n-p transistors have lower "effective" base resistances[4] (which determines the minimum n.f.); the greater circuit complexity results from the d.c. voltage requirements of these devices. The point of interest in this circuit is the collector load of the paralleled Tr_1 and Tr_2, which by means of Tr_3 presents a low d.c. resistance of about $2R_8$ and a high a.c. resistance of R_7. The effectively constant-current collector load for a.c. signals current-drives the base of Tr_4—a requirement for low distortion. The current of about 0.5mA in Tr_1 and Tr_2 is set by R_1, R_2 and the base voltages derived from the 6.2V sub-rail by the potential divider R_5 and R_6.

The switched sensitivity control in the feedback loop makes the circuit suitable for both the medium-impedance versions of the ribbon and moving-coil microphones and the more sensitive capacitor microphones with approximately 1mV output. By paralleling more p-n-p transistors, this method could be extended to the design of a low-impedance microphone amplifier. However, the greater circuit complexity is not justified when one considers the added advantage of a transformer input, namely the cancellation of extraneous signals picked up on a balanced line.

With regard to step-up transformers, mounted close to the microphone amplifier, one is most likely to encounter the high-impedance transformers (1:50) prevalent in the valve days and still made by most firms. The objection to the large turns ratio on these transformers is the degrading effect on the high-frequency response caused by the high secondary impedance, leakage inductance and winding capacitance. However, the circuits in Figs. 8(a) and 8(b), which are suitable for this type of transformer, can offset this limitation by including high-frequency compensation.

The f.e.t. used as the input device in Fig. 8(a), gives a good noise figure with the high secondary impedance of 100-200kΩ, and, because of its high input impedance, results in negligible attenuation of the microphone signals. The d.c. conditions for this circuit are set by the 6.2V zener in the emitter of Tr_2 and by the negative feedback from the tapping in the emitter-follower load (Tr_3) to the source of Tr_1. Unfortunately the value of R_5 must be adjusted for each f.e.t. because of the spreads in V_{GS}/I_{DS} characteristics.

The circuit of Fig. 8(b) is a modified form of the gramophone pickup amplifier shown in Fig. 3. The bipolar transistor, Tr_4, is operated at a very low collector current ($\approx 10\mu A$) to provide a good noise figure. The transformer secondary acts as the d.c. feedback loop, replacing the usual resistor —e.g. R_4 in Fig. 3—and thereby avoiding unnecessary attenuation of input signals. Both circuits employ the 'bootstrapping' technique to improve the linearity; a fact which is reflected in the excellent overload margin. A switched feedback sensitivity control makes the circuits suitable for most low-impedance microphones and the addition of a suitable capacitor in parallel with the feedback resistor, R_2, R_3, R_4, compensates for high-frequency losses in the transformer. The performance of the two circuits is almost identical except that when used in the most sensitive condition, the f.e.t. input is superior because with bipolar transistors the non-linearity of the V_{BE}/I_B characteristic is very marked at low collector currents; ultimately we depend on this part of the circuit to perform the subtraction of feedback from signal voltage.

The most suitable microphone transformer for the bipolar circuit of Fig. 8(b) would have a turns ratio of between 1:15 and 1:30 giving a secondary impedance of 10-30kΩ. For these transformers the collector current in Tr_4 should be set at about 30-40μA by reducing R_1 to 100kΩ. The higher sensitivity required under these conditions can be achieved by halving the values of feedback resistors R_2, R_3, R_4.

Microphone transformers with secondary impedances of 1-1.5kΩ could be used with the circuit of Fig. 7 though now only one p-n-p transistor operating at 0.5mA would be necessary instead of the two in parallel. As a suggestion, readers might like to try paralleling two n-p-n transistors and modifying the circuit of Fig. 8(b).

Finally, two constructional points. When designing a component layout for any of the above circuits, one must take care to keep input leads as short as possible and adequately screened, particularly for the high-impedance transformer-secondary connection to the inputs of Figs. 8(a) and 8(b). Switched jack sockets should be used, and wired so that when not in use the input is shorted.

Auxiliary amplifier

So that the auxiliary input can handle a very wide range of input signal levels, the preset sensitivity control is placed at the front of the pre-amplifier, as shown in Fig. 9. The amplifier gain is given by $(R_8+R_4)/R_4 \approx 8$ making the basic sensitivity about 30mV. Although the maximum signal-to-noise ratio is no longer obtainable, because of the resistive attenuation, the worst possible noise level is still better than 70dB below a 30mV input.

When large signals are applied to the base of Tr_1 (as is the case when a large amount of feedback reduces the gain to less than ten), insufficient collector-base voltage may cause distortion due to saturation in the first transistor. To avoid this, the d.c. feedback resistor, R_2, is connected to a tapping in the emitter resistor, (R_6+R_7), of Tr_2 to increase the collector-base voltage of Tr_1.

The r.f. filter, R_1 and C_3, is present, as before, to prevent radio breakthrough, and C_4 serves to improve the h.f. stability.

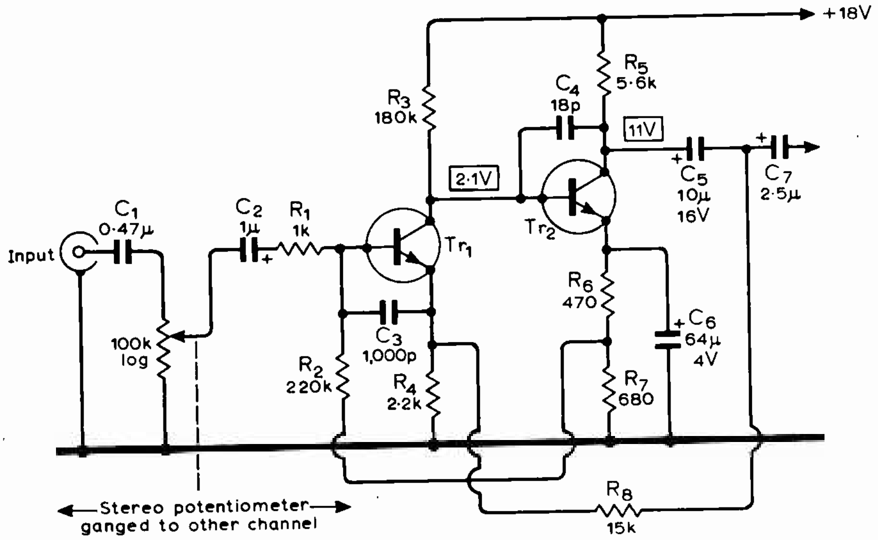

Fig. 9. Auxiliary amplifier. Tr_1 Tr_2 BC109 etc.

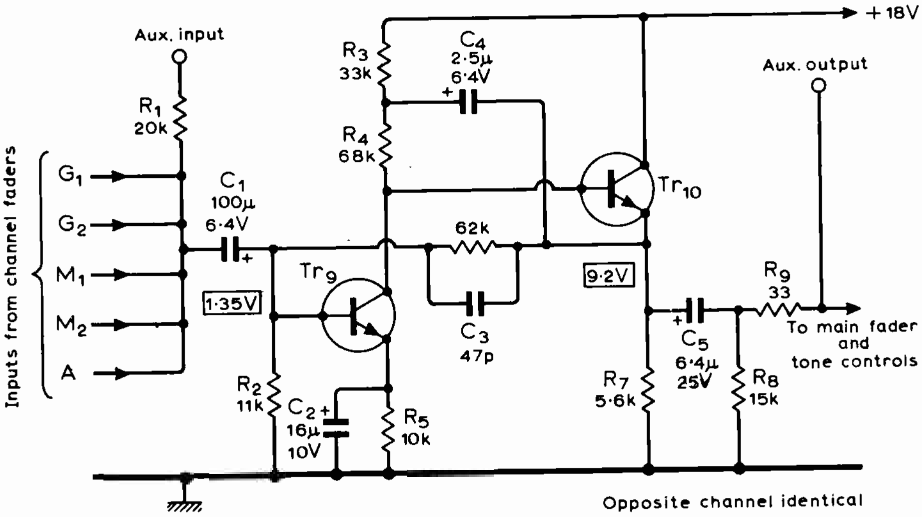

Fig. 10. Virtual earth mixer. Tr_9 Tr_{10} BC109 etc.

A feedback factor of greater than 30dB ensures that the distortion is much less than 0.02% at working output levels over the whole audio frequency range. The minimum input impedance is about 70kΩ.

Virtual-earth mixer

Fig. 10 shows the complete circuit of the mixer. The bootstrap capacitor, C_4, increases the amplifier gain to over 4000 and reduces harmonic distortion to less than 1% for a 3Vr.m.s. output. About 60dB of n.f.b. is applied; this reduces distortion to quite negligible proportions (<0.01%) and ensures proper mixing of the signals from the channel faders with no interaction. The capacitor, C_3, in parallel with the 62kΩ feedback resistor, curtails the very extended high-frequency response which might cause instability with some layouts.

The provision for five stereo channels in the present design should satisfy most requirements; the more versatile system of several virtual-earth mixers and group faders is preferable when mixing a greater number of channels. The nominal signal level at the output is about 350mV and residual noise is 84dB down (measured on a bandwidth of ~ 20kHz).

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1. Burrows, B.J.C., 'Ceramic Pickups and Transistor Pre-amplifiers', *Wireless World*, February 1970.

2. Linsley Hood, J.L., 'Modular Pre-amplifier Design', *Wireless World*, July 1969.

3. Faulkner, E.A., 'Optimum Design of low-noise Amplifiers', *Electronics Letters (I.E.E.)*, Vol.2, No.11. pp.426-427 November 1966.

4. Faulkner, E.A. and Harding, D.W., 'Some Measurements on Low-noise transistors for Audio-frequency Amplification'. *The Radio and Electronic Engineer*, 36, No.1. pp.31-33. July 1968.

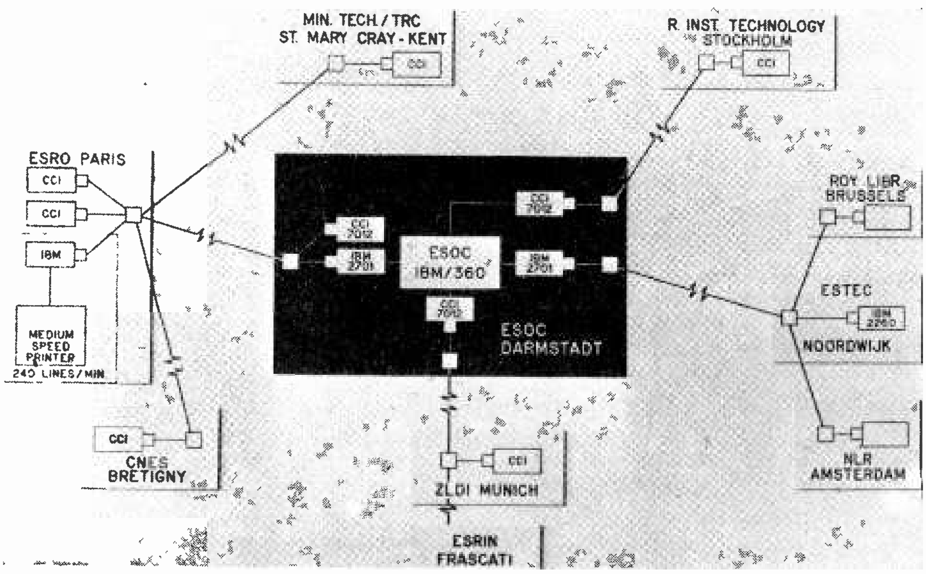
(To be concluded)

Apology

We regret the printer's error in the April issue which resulted in the concluding four lines of the article on Mediator (p.200) appearing at the beginning of "Circuit Ideas" (p.204).

News of the Month

European information retrieval network



The European Space Research Organization's computer at Darmstadt, West Germany, is now linked to a terminal at the Technology Reports Centre at St. Mary Cray in Kent. In addition the Darmstadt computer, an I.B.M. 360/65, is linked to many other terminals scattered around Europe. The whole forms an information retrieval network available to any engineer or organization who would care to use it. In the computer's store are details of about three-quarters of a million reports, documents and articles all cross referenced in numerous ways. Of this total, half-a-million are reports of the American National Aeronautics and Space Administration's scientific activities, many of which have not been published. The remainder of the documents consist of papers submitted by E.S.R.O. and by various research establishments as well as numerous magazine articles.

To use the service one writes to the Technology Reports Centre, Station House Square, St. Mary Cray, Orpington, Kent BR5 3RE, for an application form. The details needed on this form is the subject heading and various 'Keywords' that will assist the terminal operator, and the computer, to search for all the relevant published reports. The service is fast and costs £37.50 to industry (£23 to academic institutions) per search.

Most of the stored reports deal with aerospace activities but there are a large number of other subjects covered. There is a great deal on electronics and communications.

The programme used by the computer is a modified version of RECON which is a programme developed for N.A.S.A. by the Lockheed Missiles and Space Company in the United States. The E.S.R.O. store of information is continuously being added to on a monthly basis.

Sales of Japanese colour TV receivers hit by boycott

A recent issue of the journal *Business Week* reports that as a result of American accusations that the Japanese are 'dumping' colour television sets on the American market consumers are refusing to buy Japanese and as a result profits are falling steeply. Dumping is the practice of selling goods in a foreign market at a lower price than on the home market.

However, the fall in sales is not so much in America, as one would expect, but in Japan where the organization Shufuren (Japanese Housewives Federation) on hearing of the dual pricing arrangements initiated a boycott. A 19-inch colour television set in Tokyo retailing for $411 sells in New York for less than $300 and Japanese consumers were understandably upset.

As a result of pressures in Japan the price on the Japanese market was lowered while the price to the American market was increased. However, one does not offset the other and Japanese manufacturers are faced with falling profits and the need to cut back on production.

Detecting oil slicks

We are used to hearing how the technological revolution is destroying our environment so it is refreshing to hear of work that, while not combating the trouble at its source, detects a hazard before it does any damage.

The hazard in this case is oil slicks at sea. The results of experiments carried out off the West coast of America using an airborne sensor to detect slicks have been most encouraging. It was found that with an airborne radiometer spilled oil stood out starkly in the near ultraviolet (0.38μm) and in near red light (0.6μm). Polarization measured from the reflected light of the oil spill also showed a sharp contrast.

The tests showed that not only was it possible to detect oil but the type and quantity of oil could also be established. The work was carried out by the National Aeronautics and Space Administration's Ames Research Centre in California and was sponsored by the U.S. Coast Guard.

Such sensors could be carried on earth resources, and other satellites, to monitor the oceans around the world. This would mean that oil slicks could be detected before they did damage and could perhaps lead to the culprits being apprehended. The first court case using evidence obtained by an orbiting satellite should be interesting.

I.E.E. Centenary

A week's celebrations in London, starting on 17th May, will mark the centenary of the founding of what is now the Institution of Electrical Engineers. It was on this date in 1871 that the Society of Telegraph Engineers was formed, the objects of which were 'the general advancement of electrical and telegraphic science and more particularly for facilitating the exchange of information and ideas among its members'. The present title of the Institution was adopted in 1888 and it was as long ago as 1921 that it was granted a Royal Charter entitling its corporate members to describe themselves as chartered electrical engineers.

Membership now exceeds 63,000 of whom nearly 12,000 have permanent addresses overseas. In collaboration with the Civils and the Mechanicals, the Institution assists in the formation of national engineering bodies in emerging commonwealth countries.

The institution has had a close link with the radio and electronics sector of electrical engineering for many years; its first specialized group was the Wireless Section. From 1923 to 1932 the B.B.C. occupied part of the Institution building in Savoy Hill.

The centenary-week programme includes a Service of Thanksgiving at Westminster Abbey; an extensive programme of lectures built around the theme, "Electrical Engineering in the Service of Man"; a banquet at the City of London Guildhall; a conversazione at the Royal Festival Hall, which Her Majesty the Queen, and H.R.H. the Duke of Edinburgh will attend; and a dinner at the House of Commons intended mainly for younger members of the Institution.

C.Eng. and retired?

If you are a chartered engineer in one of the fifteen institutions constituting the C.E.I. and you still feel like work a register being compiled by the Engineers Guild may interest you. The register, which is open to all corporate members over the age of 55, is intended to assist companies to cover temporary absences, to help during peak demands or to allow the companies to carry out special investigations or tasks which would not be economical with permanent staff.

Engineers who qualify and who would like to be placed on the register should obtain an enrolment card by sending a 9 × 5in envelope with the request to Mr. G. M. Stephens, 1414 Warwick Road, Solihull, Warwickshire.

Companies wishing to use the service should write to the Chartered Engineers Register, The Engineering and Building Centre, Broad Street, Birmingham 1, to select the engineer who is most suitable for the job in hand. The Guild has no responsibility as far as deciding fees or dealing with tax and National Insurance matters are concerned.

C.E.I. have also announced that it has been granted a Royal Charter to set up a composite register and an engineers registration board. The register in addition to listing chartered engineers will also list technician engineers and engineering technicians. Entry to the register permits technicians to use the designatory initials T.Eng. (CEI) or Tech. (CEI).

Radiation hazards

Instances of unpredicted effects have been noted in the vicinity of high-power radars—among them accidental detonation of explosive devices. In February the Ministry of Defence issued a warning to mariners about effects from a high-power over-the-horizon radar being constructed at Orfordness, Suffolk. Among the effects which might occur are 'mild and harmless electric shock from metal rigging or metal structures, accompanied by slight sparking'. Radio equipment may be damaged if connected to an external aerial and certain electrically triggered devices may switch themselves on–possibly including motorway warning lights. We understand that hazard monitors are installed on this site.

The Medical Research Council has just endorsed earlier recommendations on exposure to r.f. radiation. Radiation levels throughout this region of the electromagnetic spectrum have assumed importance in the last decade or so because of the high power levels being used for r.f. heating and in radar transmitters, and also because of the growing use of microwave ovens for cooking. Maximum radiation levels recommended are

- $100W/m^2$ ($10mW/cm^2$) power density from 30MHz to 30GHz for continuous exposure, and
- $10Wh/m^2$ ($1mWh/cm^2$) energy density during any 0.1-hour period for discontinuous exposure from 30MHz to 30GHz.

The M.R.C. recommendations include the warning that a sensation of warmth at frequencies between 10MHz and 100GHz should be avoided and a simple means of monitoring possible leakage of power should be available, especially where industrial microwave heating equipment is used. (These M.R.C. recommendations do not apply to therapeutic exposure under medical supervision.)

In the U.S.A. similar levels have been incorporated into legislation for product radiation, which also deals with television set x-radiation and laser radiation. In the U.S.S.R. and East European countries however authorities recommend a power density level of $10W/m^2$ ($1mW/m^2$) and recently health authorities in the U.S.A. have been sounding out interested parties on this lower level.

Irradiation of biological tissue can produce body heating and can cause damage where the vascular system is not well developed–so that heat is not conducted away quickly enough. This applies particularly to the eyes, where cataracts can be formed (in a similar way to 'glass blowers cataract'), and to the testes where temporary infertility can occur. (An introductory article on the effects of r.f. and laser radiation appeared in *Non-ionizing Radiation* vol.1 no.1, June 1969, pp.5-7.)

Precision oscillator agreement

The Ministry of Aviation Supply and Racal Instruments have entered into a

The photograph shows GB3WW, Wireless World's *60th anniversary amateur radio station, which is on the air in the evenings during the month of April. We are using a trap-dipole about 100 feet above street level here at Dorset House. The equipment is, left to right, an Eddystone receiver, K.W. transceiver and linear amplifier, and the receiver described in our July to September 1969 issues by D. R. Bowman. The microphone is from Shure and the morse key, which belongs to Pat Hawker who is in charge of the station, is of first world war vintage. All the stations who have made contact with us will be sent our QSL card which is a reproduction of last month's front cover.*

partnership agreement, the first of its kind, for the design and manufacture of a precision v.h.f. synthesized signal generator with a performance an order better than anything that is currently available.

The generator will cover the range 100kHz to 160MHz with an accuracy of better than two parts in 10^9. The noise content of the output signal will be between -140 and -150dB/Hz bandwidth as against the -120dB/Hz bandwidth now normal. The instrument will be capable of operating with automatic measurement systems being fully programmable and capable of being remotely controlled. The 140dB thick film attenuator will have a near-unity voltage standing wave ratio. The purity of the output waveform will be as good as a high quality standard oscillator that does not use synthesized techniques.

Details of the agreement cannot be obtained and all that is known for certain is that Racal started on the design of a new method of frequency synthesis some time ago and subsequently made an approach to the Ministry.

Entrepreneur-engineers

'Britain's future lies in new skills, and not in providing handcarved crutches for old industries. . . . The Government should encourage investments in new ideas by allowing income invested in new ventures to be free of income tax as is already done in the U.S.A.' So Tim Eiloart, chairman of Cambridge Instruments, said in London recently. He went on to point out that Britain's top-ten exporting companies, which accounted for one-sixth of British exports, had been built up by engineer-entrepreneurs. Mr. Eiloart thinks that British industrialists should be taught entrepreneurial drive as a necessary managerial skill as is already done in the U.S.A. and India.

Electrostatic gyroscope

A new kind of gyroscope, the result of eight years' development work, is being tested in the air. Gyroscopes consist of a heavy spinning mass, usually disc shaped or in the form of a solid cylinder, held in high quality pivots. Such a device when held in suitable gimbal rings will tend to maintain its plane of spin when the gimbals are moved. A gyroscope is therefore often used as a direction reference in navigational equipments. Such gyroscopes tend to slowly drift due to, among other things, pivot friction and the effect of various electronic pick-off devices which are used to sense the gyroscope's position.

Honeywell and the U.S. Air Force Avionics Laboratory at Ohio have developed a gyroscope which uses no bearings at all. It consists of a highly polished beryllium ball about 38mm in diameter which is spun at high speed suspended in an electrostatic field in a vacuum chamber. We have not heard how the spin plane is measured.

The electrostatic gyroscope is being developed as part of a new inertial navigation system for aircraft.

S.T.C. engineer wins contest

A young engineering graduate at Standard Telephones and Cables Pty. Ltd (Australia) has won a competition conducted by the American Institute of Electrical and Electronics Engineers for a paper he prepared on static inverters. He is twenty-four years old David Coward, a graduate in electrical engineering at Queensland University, who is currently working in the Industrial Division Laboratory of S.T.C. at Liverpool. The prize for winning the competition, is $100 in cash and an all-expenses paid trip to America to attend the International Convention of I.E.E.E. in New York in March next year. Static inverters, electronic devices capable of converting large quantities of d.c. power to a.c., are employed in power supplies which are essential for important computer complexes and critical electronic equipment which may be disrupted by loss of power for even a few milliseconds. For such applications a number of independent inverters are connected in parallel to form a redundant system in which one or more inverters may fail without affecting continuity of supply. Parallel redundant systems offered now rely on a single oscillator or reference signal line to synchronize all inverters. Failure of this oscillator or signal line causes the whole system to fail. In his paper David Coward described a system developed by himself and an S.T.C. senior development engineer, Mr. Christopher Walker, in which each inverter incorporates an oscillator, and a detector which statistically analyses all oscillator outputs and develops a control signal for its inverter which is identical to that of all the other detectors. Any faulty oscillator is rejected and an alarm condition raised, but its corresponding inverter continues to function normally.

Ionospheric satellite

The third satellite in a joint Canada-U.S.A. project is called ISIS-B (International Satellite for Ionospheric Studies). The 582-pound, Canadian-built satellite is the largest and most advanced ionospheric spacecraft yet developed and it carries twelve experiments to investigate the ionosphere. Eight of these were provided by Canadian universities and government agencies and the remaining four were provided by the NASA Goddard Space Flight Center and the University of Texas.

The ionosphere is important from a purely scientific standpoint and is also very important to communications engineers since it reflects certain radio waves and the selection of the best frequency depends on a detailed knowledge of it.

The ionosphere is an electrified gas curtain beginning about 35 miles above the Earth and is divided into four regions or layers—the *D*, *E*, F_1 and F_2 layers. The electron density of each layer varies with altitude and amount of ionization with the time of day, the degree of solar activity, the season of the year and geographical location.

ESRO satellite repeater contract

The European Space Research Organization has placed a contract, worth about £700,000, with the newly formed STAR consortium (Satellites for Telecommunication, Application and Research consisting of AEG-Telefunken, Thompson-CSF, CGE-Fiat, L. M. Ericsson and Montedel). The contract is for the initial definition and design of a satellite repeater operating at 12GHz with a bandwidth of 500MHz which is intended for a European communications satellite.

Decca win American awards

Decca Radar received two awards at the New York Boat Show from the American National Marine Electronics Association. The first, the Radar Award, is presented for the best single product and was given to Decca for the super-101 small boat radar. The second was the Design and Engineering Award which was presented for 'the continued excellence of design, performance and reliability of Decca's whole range of radars'.

I.T.U. activities for space conference

The International Telecommunication Union are to mark the occasion of the World Administrative Conference for Space Telecommunications (Geneva, 7th June-17th July) with a special issue of *Telecommunication Journal*. The journal will have 200 pages and will carry articles on all aspects of space communications. It will also contain a list of all the satellites which have been launched so far and a planisphere showing the regions covered by geostationary satellites as a function of their position over the equator. Single copies of the issue will cost 2.50 Swiss Francs or U.S. $3.50.

International Component Show

Highlights of the Paris exhibition held March 31-April 6

Among the most eye-catching of components at the Paris show were liquid crystal displays. Based on an effect known since 1888, activity in recent years—notably by RCA and Texas—has been motivated by their low power consumption and immunity from high ambient illumination. Recent development of crystalline liquids with low melting points has made usable devices possible. Above the melting point crystals are randomly dispersed and form electric dipoles. In one kind of device, the dipoles are at a fixed angle to the fibre axis, so that, under the influence of an applied electric field, their resulting alignment causes a change in overall refractive index making the material opaque. Thus a big advantage over other displays is gained—greater incident illumination results in more light being returned. Devices are made by sandwiching a 15 μm layer of liquid between two transparent plastics layers, coated with 0.5 μm of transparent and conductive tin oxide.

At the exhibition, two three-digit modules were shown—by the Vienna firm Electrovac and by Tekelec Airtronic (France) who showed the American Optel 1003. Degree of opacity depends on applied field—threshold field is 5kV/cm, corresponding to 7.5V for a thickness of 15μm, and saturation value is 50kV/cm.

Quartz crystal and integrated circuit comprise new Marconi oscillator housed in a TO-5 package (type F3187).

Between these values, opacity is roughly proportional to the field. Power needed is 150μW/cm^2 of display area and the Optel module consumes 120μW at 20 volts.

Applications for this kind of device include greenhouse windows, windscreens, camera lenses, advertising displays, traffic signs, watches, as well as in electronic instrumentation. Optel device needs a minimum operating voltage of 15V which makes driving a little awkward. Hughes make a suitable driver/decoder (type HCTR 0107) believed to cost around £3. Cost of the three-digit module is about £15. RCA are believed to have one for around £11-12. Temperature range of the Optel display is limited to +10 to 50°C working and 0 to 80°C storage. Life is given as 10,000 hours (for a 20 to 100Hz supply). On-time is 15 to 20ms and off-time 100 to 200ms.

Many extensions to both m.o.s. and t-t logic ranges were seen—too many to list here. Motorola alone for example introduced 68 digital m.o.s. i.cs. More semiconductor device manufacturers say they'll be introducing silicon-gate m.o.s. products later this year or in 1972, and nearly everyone claims to specialize in custom design—one wonders whether there are enough customers at present to support all of them. (In the silicon-gate technique the conventional aluminium gate electrode is replaced with silicon, reducing the threshold voltage by about two volts and allowing lower supply voltage and lower logic levels. This allows compatibility with bipolar circuits, increased packing density and also results in better reliability.)

Motorola announced an agreement to 'second-source' with SGS—amid rumours of a takeover of SGS. Motorola will provide a second-source of the SGS high noise-immunity logic circuits—H100 and H200 series—and the SGS range of linear integrated circuits for the entertainment market. SGS will second-source the industrial high threshold logic—MHTL series—and entertainment linear i.cs. We understand that SGS might also second-source the new Motorola MECL 10,000 high-speed logic series.

In this range of emitter-coupled elements chief selling points are a power dissipation of 25mW per gate and a propagation delay-dissipation product of 50 picajoules. Currently available devices include OR/NOR and OR-AND gates and line drivers, a line receiver, 256-bit read-only memory, and a 64-bit random-access memory. Prices of the basic gates are around £1 in 100-up quantities.

The i.f. section of the new Siemens TBA 460 integrated circuit for f.m./a.m. receivers is a copy of the TAA991. Addition of dual audio stages allows a complementary output stage to be driven up to ten watts. This makes possible a technique which may develop in stereo equipment—i.e. using two of these i.cs, one for a.m. and the other for f.m. with the a.f. sections for left and right audio channels. Other new linear i.cs are TBA830 microphone amplifiers (Siemens), TBA 651 a.m. tuner circuit (SGS), TBA 810 5-watt audio amplifier for car radio (Ates, Milan), TBA570, TBA690 and TBA700 for sound receivers (Philips group), H652TAA and H696TAA a.f. circuits (Telefunken), SAK 110 tachometer (ITT-Intermetall) plus others for television receivers—already known to set makers.

There were plenty of new discrete semiconductor devices too—most are included in the quick-reference table on this page with makers identified.

There were also too many new products from the 200-odd exhibitors in the instru-

New transistors

	feature	maker's code
BC413/414, BC415/416	low-noise amplifiers	T
BC424-7	60 & 80V complements	M
BD135-140	6.5W, 1.5A complements	I
BD150A-C	high-voltage video	SGS
BD181-3	a.f. power	P
BD201-4	a.f. power complements	P
BD306/307	10W, 2.5A, n-p-n	I
BDX14-20	complements to 2N3054/3055	TC
BDY90-8	high-voltage switches	P
BF198/199, BF240/241	i.f. amplifiers	I
BF314	low-noise v.h.f. n-p-n	T
BF316	u.h.f. mixer p-n-p	SGS
BF366/367, BF371/373	television i.f. stages	M
BF377/378	u.h.f. complements	T
BF394/395	a.m./f.m. i.f.	M
BF414	low-noise v.h.f. p-n-p	T
BFR14	$f_T = 3.5$GHz	S
BFR36	v.h.f./u.h.f. n-p-n	SGS
BFR63-5, BFW92	low-noise, low-distortion h.f.	P
BLX13	driver for BLX14	P
BLX14	50W, 27MHz	P
BLY61-3	13-volt power, 175MHz	TI
BLY90	50W, 175MHz	P
BLY94	50W, 175MHz	P
BLY95/96	v.h.f. power n-p-n	T
806BLY	25W, 400MHz	P
814BLYA-D	up to 6W, 1.7GHz	P
BSS23	switching n-p-n	T
BSV69	switching n-p-n	T
BLX69	20W, 470MHz	P
BU105	tv deflection	T,P
BU108	110° deflection	T,P
BU126	stabilizer	P
BUY47-9	power n-p-n	SGS
BCW62-64, BCW81-84	a.f. miniature	TI
2N5400/5401, 2N5550/5551	number tube drivers	M
2N5913-9	400MHz power	RCA
2N5993	88MHz power	RCA
2N5995/5996	174MHz power	RCA
2N6105	400MHz power	RCA
TA7701	700MHz miniature	RCA
TA7486/8104	2GHz	RCA

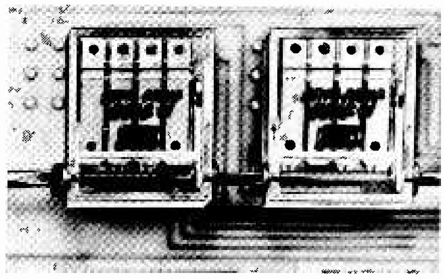
T ≙ AEG-Telefunken; P ≙ Philips group; S ≙ Siemens; I ≙ ITT-Intermetall; TI ≙ Texas Instruments; M ≙ Motorola; TC ≙ Thomson-CSF.

mentation sections to report all of them. In oscilloscopes, for instance, there were at least 18 newish models. We say newish because many had been seen before and exhibitors' claims of 'new' really meant they hadn't been shown at earlier Paris exhibitions. Most of the oscilloscopes had a bandwidth of less than 20MHz. The Heath-Schlumberger 15-MHz dual-trace scope has a rise time of 24ns and a phase difference of less than 1° in the *x-y* mode, useful for phase measurements, curve-plotting, and vectorial displays. The recently introduced Hewlett-Packard 1700 oscilloscope has 35-MHz bandwidth with 10-ns rise time. Battery-powered, this is probably the fastest of its kind, and is available with or without a delayed sweep facility. New Philips 25-MHz model, PM3210, with 14-ns rise time has a conventional timebase. A dual-trace oscilloscope, it also has an *x-y* display facility with a phase difference of 2° up to 0.5MHz. Sensitivity on the most sensitive range is 1mV/cm.

It's not only in solid-state devices of course that developments are taking place. Vacuum tubes are still supreme for high-power transmitters and for broadcast imaging devices. A triode developed for a French Army Doppler radar by Thomson-CSF has come off the classified list and will be marketed in the USA later this year (TH591). Main feature is its in-circuit 50-MHz bandwidth at L-band. Peak output power of 500kW has been achieved with this valve. It is vapour cooled using the Hypervaportron technique in which a thin water-vapour layer surrounds the anode. With it anode dissipation can reach 2kW/cm². Another tube developed specially for u.h.f. television transmitters in the USA, is TH290. Forced-air cooled, it can deliver 2kW in class A with a cross-modulation between sound and vision carriers of better than 52dB.

Most of the electro-optical devices had been already announced—those shown included E.E.V. and RCA image isocons for low light levels, E.E.V. ½-in vidicon, EMI and E.E.V. short-length 1in vidicons, M-O Valve head-up display c.r.t. RCA silicon-intensifier-target camera tube, RCA III-V compound photomultipliers, EMI image intensifiers and the EMI intensifier vidicon.

New generation of photomultipliers by RCA Electronic Components use group III-V compounds as a secondary electron emitter. Results of investigations into more efficient emitters were announced two years ago by RCA, and now a range of photomultipliers is in production using gallium phosphide—up to ten times more efficient than materials used in conventional tubes. For an applied potential of 600V, gallium phosphide will produce 30 secondary electrons from one primary electron as opposed to, typically, five. With tubes using a gallium phosphide dynode in the first stage it is possible to discriminate between events producing one, two, three and more primary electrons. The Quantacon family of 16 tubes includes some with the multi-alkali photocathodes giving response up to 930nm and an improvement of three or four times that of an S-20 cathode at 694nm. Use of III-V compounds as photoemitters gives response up to 1.1μm. Some are very fast—type C31024 has a rise time of 0.8ns.



Low-profile switch for printed circuit boards (ITT type PZ) can handle one amp at 100 volts. Switch is 8-mm high and suitable for sandwiching between p.c. boards and ganging. Philips 14-ns rise-time oscilloscope PM3210 has x-y facility with phase difference of 2°

New television components centre mainly around i.cs and the introduction of 110° colour tubes—notably from Philips subsidiaries. Sylvania have two 67-cm 110° tubes, one with a large neck and one with a thin neck—this last allowing components with lower power ratings to be used, because deflection coils are closer to the electron beam. Narrow-neck tubes also mean that the corner convergence generator is no longer needed, a dynamic focusing voltage is not needed and for convergence correction only a simple passive circuit is needed. Length of the 110° tube is of course shorter than 90° tubes—nearly 10cm in the case of the large-neck tube. A new 50-cm 110° tube is also much shorter. ITT components group have also produced a 110° colour tube with a narrow neck, saving 11cm in depth, and allowing 67-cm receiver depth to be reduced to 43cm. Deflection yokes and convergence units are also available from tube makers. Combined u.h.f. and v.h.f. varicap tuners are now on the Continental market.

Developments in capacitors centre on improving dielectrics—with high dielectric strength, low losses, wide temperature range, low sensitivity to humidity—as well as smaller physical size. Many makers were showing new ranges of tantalum capacitors and improved plastics capacitors. Wima have improved encapsulation of polyester and polycarbonate capacitors to give better water and solvent resistance by sealing in cast resin. A new low-loss polypropylene capacitor for 110°-tube circuits is under development by Wima who plan to show it at Hanover. An Italian company, Arco, were showing printed-circuit-mounting polypropylene capacitors for use in series heater chains.

ITT components group announced a range of close-tolerance thin-film capacitors for low-voltage applications. Tolerances as close as ±0.1% for 300pF to 10,000pF have been achieved by successive vacuum deposition followed by their computer-controlled micro-engraving technique. They have stability of 0.01% per 1000h at 70°C, an insulation resistance of 10^{12}ohm and a temperature coefficient of ±30p.p.m./degC.

With over 1,000 exhibitors, this year's exhibition was larger than last year's by about 30%. France had 469 technical exhibitors and there were 558 from outside France. Even so most of the literature was in the French language. Major exhibitors after France were USA (167), Federal Germany (143), UK (80), Switzerland (41), Italy (34), Spain (24) and Japan (21).

● Philco-Ford confirmed withdrawal from the semiconductor business.

● New beam-tetrode power amplifier CCS1 by M-O Valve Co. gives 200 watts at 500MHz or 400 watts at 175MHz in f.m. transmitters. Gives 300 watts (p.e.p.) s.s.b. up to 175MHz.
WW 450 for further details

● New Miniflux heads for cassette recorders combine record, play and erase functions in one head (type CKL3). Available in stereo and mono versions.
WW 451 for further details

● Combined signal and erase heads for 8 and 16-mm film sound tracks are made by Miniflux (type FN 566).
WW 452 for further details

● A quartz oscillator, Marconi type F3187, is housed in a TO-5 can. Covering 10-22MHz it has stability of 1 part in 10^8 short term and works from a 5-volt source taking 145mW.
WW 453 for further details

● New modulation meter, AFM3 by Radiometer of Copenhagen, is designed for v.h.f. and u.h.f. narrow-band measurements. Frequency coverage is from 6MHz to 1GHz with a 3-dB bandwidth of 600kHz and sensitivity is 3mV up to 200MHz and 30mV above. Calibration accuracy is 3%.
WW 454 for further details

● First double-insulated cooling fans for electronic equipment are made by Rotron N.V., Netherlands (U.K. agents Auriema Ltd). Made to European standards, they are in three kinds and based on fans made by the U.S. parent company.
WW 455 for further details

● New Lenco products–8000 turntable unit, tuner-amplifier and loudspeakers, and Octet automatic cassette changer. Lenco 85 professional turntable and pickup arm will be shown at Berlin later this year.

● Ates, of Milan, who specialize in semi-conductor devices for cars, introduce the TBA800 5-watt audio amplifier and the TBA810 5-watt amplifier for car audio equipment. They supply a 400-volt, 7-amp 40655 s.c.r. for capacitor-discharge ignition systems.
WW 456 for further details

Letters to the Editor

The Editor does not necessarily endorse opinions expressed by his correspondents

Our birthday issue

Extracts from a very long and interesting letter received from John Scott-Taggart.

In your 60th birthday number H. S. Pocock wrote: "We later received from the former proprietor of the Radio Press (John Scott-Taggart) a generous tribute to *The Wireless World.* (We hope he reads this in his Beaconsfield retreat!)" That hope has been realized. May I ask you to show equal generosity by letting me recall some of my share in the history of amateur and professional radio and my contribution to the story of *The Wireless World* itself.

I started as an amateur in 1912. My transmitter had the call-sign LUX. In 1914 at the age of 17 I had my first article published in *The Wireless World.* I also joined the Army in that year and in due course I was commissioned in the Royal Engineers as a wireless officer, having worked for a time in Major Rupert Stanley's lab. and learnt 'all' about valves.

I experimented and contributed articles on valve techniques to *The Wireless World,* the first appearing in 1917 under the initials D.J. Later I bravely used my own name.

In 1919-1920 I took charge of valve manufacture at Ediswan's who made valves for the Services and for Marconi's. In Dec. 1919 I designed, and Ediswan marketed, the ES2 and ES4 valves for the amateur (*W.W.* 15th May 1920). As a very active member of the committee of the Wireless Society of London (later the Radio Society of Great Britain) I frequently contributed to the Society's proceedings and exhibited in late 1919 valves I had developed (*W.W.* December 1919).

Altogether I have written some 800 articles in various journals and a dozen textbooks on radio. I was not, however, a writer except as a side-line. From 1917 onwards I took out more than thirty patents on valves and valve circuits and these were sold to various companies throughout the world.

In 1920 I became Head of the Patent Department of Radio Communication Company Ltd who became very successful competitors to Marconi's. I did the research in the defence of the patent action brought by Marconi's on the H.J. Round valve patent and the French R valve patent. We won. Had we lost there would have been a Marconi valve monopoly.

During the period 1920-1923 I was professionally linked with all those around the world who were in competition with Marconi companies. My relations with *The Wireless World* inevitably ceased. I started my own radio publishing business and on January 9th 1923 I published the magazine *Modern Wireless.* Its success decided my activities for the next four years. I left Radio Communication Company. In June 1923 I launched *Wireless Weekly* which was a more technical paper, the only direct competitor with *The Wireless World.* Other magazines followed. The trade depression (winter 1926/27) made me decide to quit not only publishing but radio. I sold out to Amalgamated Press Ltd. In four years I had made enough to retire on and I was 29.

I had not lost touch with patent work. For two years I was special patent adviser to the Gramophone Company (H.M.V.), later incorporated in E.M.I. and I acted in an advisory capacity to other concerns. I retired in 1927 and wasted my time flying aeroplanes. In 1932 Amalgamated Press asked me to write and design six sets a year for my former journals. This I did as a spare-time job at home and I produced the ST300 and successive sets ending in late 1937 with ST900.

I served in the R.A.F. throughout the 1939-45 war, and I was responsible as senior technical officer of 73 Wing for the installation, maintenance and operation of all the R.A.F. radar stations in two-thirds of England and Wales. Civilian service at the Admiralty Signal and Radar Establishment completed a technical career ending in 1959.

The Wireless World was always the equivalent of *The Times* in radio publishing, and its steady relentless technical integrity owes everything to Hugh Pocock and his able successors and to its equally brilliant contributors such as Cocking, Scroggie, James*, Haynes, Roddam. I have never ceased to read and respect it.

I have enjoyed the friendship of many of the radio pioneers such as Dr. W. H. Eccles, C. S. Franklin and H. J. Round—and equally enjoyed the hostility of Fleming for my legally accurate description of him as the inventor of the diode valve detector. (The courts declared his 1904 British patent invalid.)

Hugh Pocock's reference to my 'Beaconsfield retreat' is accurate only as regards my twelve years as a has-been of radio. In that period I have written ten non-technical books, three of them on Renaissance art.

I would like to be remembered not for my competition with *Wireless World* but for my early writings and inventions and later my radar activities.

The Wireless World on its 60th birthday has deservedly the good wishes of all of us. It does not show its age because it is ageless and forward-looking.

JOHN SCOTT-TAGGART,
Beaconsfield,
Bucks.

*Credit should have been given to W. James as the designer of the Everyman Four in 'Milestones in Receiver Evolution' in our April issue.—ED.

The reproduction of the photograph of my station TXK of long ago (April p. 173) was excellent and brought back a horrid surge of nostalgia. At about that time I was presented with a de Forest Audion valve which I was playing about with, in the ignorance of those days, using it first as a normal detector of signals and subsequently as an audio amplifier behind a crystal detector. At one stage of the proceedings I succeeded in making the system produce a loud howl which intrigued me. I sought advice from my tutor of those days, as my only academic reference, but he could offer no explanation. Little did I think until later that I must have achieved a regenerative feedback set up which may have preceded the work of Reinartz & Co, and the reaction patents of that period .... How near can one get to fame, and yet, who, nowadays, ever speaks of Reinartz!

An item of some interest in the picture is the very large inductance at the back. With it I received the German 'empire' station in Togoland on a crystal detector, working Nauen near Berlin. This must rank with the modern concept of DX reception at something over 4000 miles!

Wishing continued success to the *Wireless World* in its leading role.

W. KENNETH ALFORD,
Shaftesbury,
Dorset.

Telegram from the Radio Society of Great Britain

Members of Council join me in offering congratulations to *Wireless World* on occasion of 60th birthday celebrations. Please also convey to Hugh Pocock to whom the R.S.G.B. owes much of the success of the early years our appreciation of his guest editorial.

F. C. WARD,
President R.S.G.B. 1971.

I have been reading with very great interest your April issue. One of the articles which I found particularly interesting was that of W. T. Cocking, called 'Milestones in Receiver Evolution'.

One statement which Mr. Cocking makes I found of interest and would like to query, if I may. He says the term 'Hi-Fi' was not invented in May 1934. I am still using an H.M.V. model 800 radiogram which I believe was built in 1934 and advertised then as 'The model 800 High Fidelity Autoradiogram'.

Also amongst its features was a bass system using positive feedback in the output stage a volume expander using negative feedback which was controlled by the crescendos in musical passages, and lastly amplified/delayed a.g.c. which Mr. Cocking says in his article came around 1936. This stage also operated a q.a.g.c. stage, which is a receiver refinement I am sure many people do not realise was present as far back as 1934.

I feel I must give one further statement of proof for my claims as to the age of this receiver and the term Hi-Fi, which is a service manual published in December 1934 for the Model 800.

TERRY I. ROBERTS,
Llanfeckell,
Anglesey,
N. Wales.

The author replies:
I do seem to have slipped up about the date of a.g.c. The first article on it in *W. W.* was 23rd September, 1932, and this referred to the use of a.g.c. in the U.S.A. It did not become at all common in this country until a year or two later, but it was certainly prior to 1936.

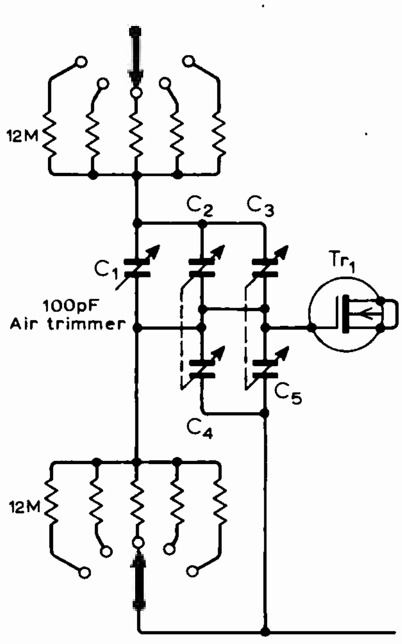
With regard to 'Hi-Fi', I think I am literally correct although I would not dispute that 'high fidelity' may have been used earlier than 1934.—W.T.C.

Wien-bridge audio oscillator

The only practical advantage to use capacitive, instead of resistive, elements for the fine frequency control in the Wien-bridge audio oscillator (March issue) is its long life.

The extremely high input impedance gives some trouble round 50Hz mains frequency and very good screening and layout are necessary. The frame of the four-gang variable capacitor must be carefully insulated from ground by ceramic, long-leakage path, insulators. Otherwise the calibration will not hold.

Since the frame is at a.f. potential, it is necessary to balance its comparatively large capacitance to ground by connecting a capacitor C_1 across the upper section C_2 C_3 of the four-gang variable capacitor.



T. GAJ-LARISCH,
Renhold,
Bedfordshire.

The author replies:
I can appreciate Mr. Gaj-Larisch's concern over the use of a variable capacitor for the fine tuning control in the design of my Wien-bridge audio oscillator. I, too, was a little apprehensive over the mounting and screening of the large four-gang variable capacitor. I attached ⅛in thick sheets of Perspex to the back and front plates of the capacitor extending them vertically well below the working area of the capacitor. The capacitor was attached to the base of the metal cabinet by means of aluminium brackets mounted on the extended Perspex insulators. The capacitor and the switched resistive, coarse frequency control were carefully screened from the rest of the oscillator circuitry. The oscillator amplifier of Fig. 3 was also screened from the remaining circuits of the completed amplifier and no problems were encountered with the oscillator around the mains frequency.

Although 5% resistors were used for the coarse frequency control, and therefore the relationship between alternate ranges was not precise, the relationship was constant between the lower and upper ends of adjacent ranges, for all ranges. Therefore, if 1% resistors are used, the calibration between alternate ranges will hold.

I did not find it necessary, as Mr. Gaj-Larisch suggests, to incorporate the capacitor C_1 as shown in his figure; possibly because both pairs of the four-gang tuning capacitor were padded with 330pF fixed capacitors to give a 3:1 ratio of fine frequency control.

A. J. EWINS,

To have been dead 33 years already is bad enough, without having to endure the knowledge that my name, which I had hoped would live after me, is being corrupted (see your March issue) by the very people who make use of my bridge circuit.

Permit me to remind you, sir, that WIEN is the name not only of the humble physicist who was once me but also of a great and noble city, which still flourishes. That city,* it is true, has many associations also with WEIN (coupled, of course, with women and song), but for all that WEIN is not WIEN nor WIEN WEIN.

Remembering, as I lie here cold in my grave, the beautiful and useful bridges of that same great city, I have constructed in my mind an intellectual bridge, or eselsbrücke† as we say it in German, so that English engineers who honour my bridge by using it in their low-distortion oscillators may be assisted to remember its inventor's name also without distortion:

Don't be mean
call me Wien.

The late MAX WIEN,
Churchyard, Germany.

The Editor replies:
Sorry, Max,
To have been so lax.

* Wien = Vienna

† Better known to British readers by its Latin equivalent, *pons asinorum*.

'Cathode Ray'

May I be permitted to take 'Vector' lightly to task? In his April contribution he paid a well-deserved tribute to 'Free Grid' but I think he might also have mentioned another stalwart who did much for *Wireless World*, namely 'Cathode Ray'.

It was a great treat to find the familiar pseudonym again appearing in your columns. It led me to a prolonged browse through old volumes and the re-reading of many of the 'Cathode Ray' articles. In an era when there was a strong school of thought which held that if a technical article was comprehensible it must be a failure (a school which, alas, is still to some extent with us), 'Cathode Ray's' essays came as draughts of pure air into the stuffy rooms of textbook terminology. Who but 'C.R.' would have had the effrontery to describe reactance in terms of blow-football? We lapped it up. And in the process he taught us that, while some things were simpler than we supposed, there were others which were not nearly so cut-and-dried as we had been led to believe.

As most of his articles dealt with fundamentals and are therefore timeless, would it be possible to consider a re-publication of some of them in future issues? I feel that this would be beneficial in two ways. It would be of considerable help to your student readership and at the same time would serve to cut some of us old-stagers down to size by reminding us of how much we have forgotten.

W. J. BAKER,
Great Baddow,
Essex.

Thank you for the suggestion. We will look into the possibility.—ED.

Boxcar detector

I am grateful to Dr. Smith-Saville for clarifying, in his letter in the March issue, a point raised in my December 1970 article on the Boxcar Detector. He explains that in recovering a signal of bandwidth f_s from noise of bandwidth f_n, where $f_n \gg f_s$ there are two equivalent ways of limiting the noise bandwidth so that it includes f_s but not excessively so. The first and perhaps most obvious way is to roll-off the input at some frequency suitably above f_s, in which case is it satisfactory to carry out the sampling process using virtually infinitesimal sampling times, t_s. In the second system the input is not rolled-off but instead a suitably longer t_s is used.

My own firm's Boxcar Detector Type

415/425A uses the second system. As will be seen below there are quite separate considerations in the design of a practical boxcar detector which make the provision of a variable t_s essential. (These considerations do not apply in the design of oscilloscope sampling adaptors.) Thus, given that variable t_s is available anyway, obviously its use is the correct method for limiting f_n.

Considerations which make variable t_s a necessity are, among others, area measurement in single-point sampling, linearity and duty factor.

In certain single-point mode applications it is the area of the obscured pulse which is required, rather than its amplitude. For instance, this may be so because the pulse is of irregular or variable shape with no obvious top and in such circumstances has to be characterized by its mean level over a known interval. In such a case the boxcar detector is so set that the sampling pulse is known to include the whole signal pulse and the latter's area is computed as $V out \times t_s$.

Linearity requirements militate in favour of variable t_s: any sampling system is likely to go through a non-linear period in the process of switching from one state to the other and the greater the ratio of t_s to the switching time the less will be the overall effect of this non-linearity.

The boxcar detector must be able to operate with t_{rep} at least as large as 1 second and if it is also to use a t_s fixed at a figure suitable for the highest frequency for which the instrument is designed, then at this large t_{rep} the duty factor of the sample-and-hold system will be very large. In the case of the 415/425A it would be 10^8. While this performance can be achieved it is unnecessarily expensive since it can be avoided by the provision of variable t_s.

J. D. W. ABERNETHY,
Brookdeal Electronics Ltd.,
Bracknell,
Berks.

Soldering and p.c.bs

Like most good, simple ideas the one for solder removal, described in the letter from Dr. G. W. Sutton in your January issue, is not new. In fact one can buy a solder-wick material* which performs the task exactly as he mentions. One can also use a piece of coaxial cable braid in a similar way. Tests have shown the proprietary material to be excellent.

A second point is in connection with printed circuit boards. Regretfully, the situation in respect of transparency is going to worsen as we now demand non-flammable boards which are opaque in preference to the 'high electrical' quality boards which were sometimes translucent; this reflects the change in electronic equipments which on the whole are working at low voltages and low impedances. We now want better mechanical properties and dimensional stability together with increased bond strength between the copper and the base material; one of the penalties for all this is decreased translucency.

HENRY MANFIELD,
Malvern,
Worcs.

*'Soder-wick' made by Solder Removal Co., Covina Calif., U.S.A.

U.H.F. log-periodic aerial

Since the publication of our article on a u.h.f. log-periodic receiving aerial in the January issue it has been drawn to our attention that you published two articles by M. F. Radford in September and October 1964 entitled 'Logarithmic Aerial for Bands IV and V'.

The Radford aerial was longer than ours (19 dipoles as against 15) so that the upper end of its frequency range was at 960 MHz while ours is designed to operate up to 860 MHz. It is interesting to note that the T and σ parameters chosen were 0.944 and 0.16 respectively which which correspond closely to the values we arrived at by experiment (T = 0.93 σ = 0.17). It is not surprising, therefore, that the performances of the two aerials are very similar and either version should give equally satisfactory results.

Mr. Radford based his construction on the use of metal strip and we think that your readers should be aware of this alternative method if they are thinking of making a log-periodic aerial.

J. L. EATON
and R. D. C. THODAY,
B.B.C.,
London.

Stereo decoder using sampling

It would appear that in predicting the performance of the sampling section of my decoder (described in the February issue), Mr. Portus is relying entirely on theory in spite of his excellent spectrum photography (April issue, p.184). However, his theory does not take account of the fact that the sample-and-hold circuit used is effectively a gated peak detector and not a multiplier. In order to verify this I checked the difference-frequency output at harmonics up to over 10 MHz using the circuit both as it stands and with diodes connected across the differentiator capacitors so that the sampling waveform had a 1:1 mark/space ratio. At every frequency tested (both odd and even harmonics!) I found that the output obtained with the narrow sampling pulse was twice that obtained with the square wave. The amplitude difference is probably due to the fact that with the square wave, the frequency difference sample is present for only half the time whereas with the 200ns sample it is present for about 99% of the time. The effective frequency characteristic of this sampling system is determined by the rate at which the voltage across the hold capacitor can follow the input signal. Thus it is probable that the frequency at which the output should be −3dB is about 15 MHz. In practice this frequency is somewhat lower because of the losses in other parts of the circuit. The suggestion by Mr. Birt that the value of the hold capacitors C_{12} and C_{17} should be increased to 180 pF will reduce this frequency to about 4 MHz and thus improve the noise performance.

While I agree with Mr. Birt that the 'quoted' maximum V_p of 8V for the BFW10 is a little worrying, I have never yet found any f.e.ts of this family with a higher V_p than 6V; normally it is between 2 and 4V.

D. E. O'N. WADDINGTON.

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

LONDON

4th. IERE/IEE—"Semiconductor probes for medical applications" by W. Abson at 18.00 at 9 Bedford Sq., W.C.1.

5th. IEE—Discussion on "Prediction of VHF/UHF service areas" at 17.30 at Savoy Pl., W.C.2.

5th. IERE—"An electronically controlled r.f. inductor giving a large tuning range" by M. W. Wheeler at 18.00 at 9 Bedford Sq., W.C.1.

6th. IEE—"The Ph.D. and its relevance to the needs of modern engineering" by Dr. C. Adamson at 17.30 at Savoy Pl., W.C.2.

7th. R. Instn.—"Telecommunications—full circle" by J. H. H. Merriman at 21.00 at 21 Albemarle St., W.1.

11th. IEE/I. Meas. Control—"Visual prosthesis—an implanted electrical aid for the sightless" by P. E. K. Donaldson at 17.30 at Savoy Pl., W.C.2.

11th. AES—"Modern developments in cassette recorders" by J. N. Eyres at 19.15 at Mechanical Engineering Dept., Imperial College, Exhibition Rd., S.W.7.

12th. IEE—"Advances in TV colour cameras" by A. V. Lord at 17.30 at Savoy Pl., W.C.2.

12th. IEE—"INSPEC—the IEE's international solution to the information problem" by D. H. Barlow at 17.30 at Savoy Pl., W.C.2.

12th. IERE—"Motorway and high speed road surveillance and control" by M. Brockman at 18.00 at 9 Bedford Sq., W.C.1.

24th. IEE—Discussion on "The teaching of electrical circuit theory" at 17.30 at Savoy Pl., W.C.2.

25th. IEE—"Printed resistors and their use in precision d.c. potentiometers" by V. S. Umantsev of U.S.S.R. at 17.30 at Savoy Pl., W.C.2.

25th. IEE/IERE—Colloquium on "R.F. measurements on solid-state active devices" at 9.30 at Savoy Pl., W.C.2.

26th. I. Navigation—"Port and terminal navigation and control problems in the 1980s" by Capt. H. J. Brandenburg at 17.00 at the Royal Institution of Naval Architects, 10 Upper Belgrave St., S.W.1.

CARDIFF

12th. SERT—"Television studio operation" by H. J. M. Lewis at 19.30 at Pontcanna Studios.

GLASGOW

12th. SERT—"TV signal distribution systems" by A. Schmiel at 19.30 at Macelland Galleries, Sauchiehall St.

MANCHESTER

6th. IERE—"High quality sound reproduction" by J. Harris at 19.15 at The Renold Building, U.M.I.S.T.

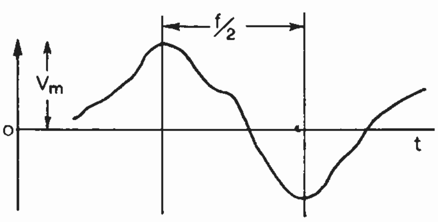
20th. SERT—"The Bush E.V.R. television replay system" by P. L. Booth at 19.30 at U.M.I.S.T.

Circuit Ideas

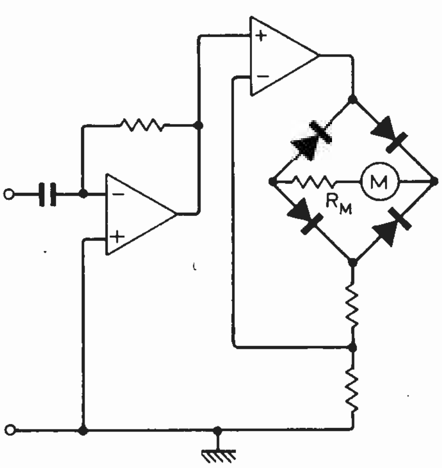
Waveform peak detector

For any waveform the average rate of change of voltage is proportional to V_m as shown. Thus if the voltage is differentiated and then averaged the resultant voltage is

$$\left.\frac{dv}{dt}\right|_{av.} = \frac{2V_m}{f/2} = 4V_m f \propto V_m$$



directly proportional to the peak value of the input voltage. A typical circuit is shown below. The action of the feedback in the second stage eliminates non-linearities

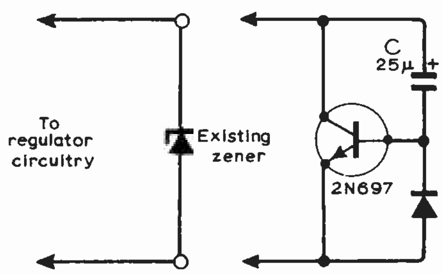


due to the diodes. A digital voltmeter could be used to monitor the drop across a resistance used in place of the analogue meter.

L. UNSWORTH,
Southport,
Lancs.

Power supply modification

The circuit is a simple modification to regulated power supplies making the voltage rise slowly at switch-on. This is desirable in audio amplifiers to avoid

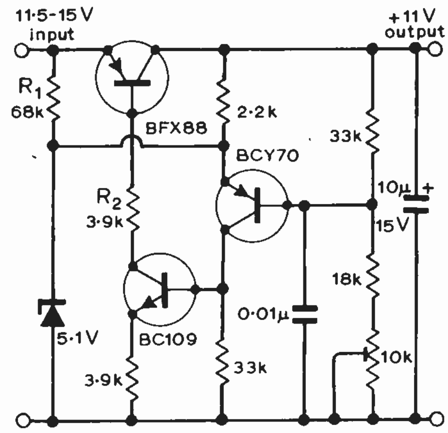


possible speaker damage. The slow run-up allows overload trip circuits to operate before excessive voltages are reached. The circuit has several virtues: an abnormally high capacitance is not needed; the run-up is fairly linear; and the diode discharges C at switch-off, thus, in the case of short-term power removal, the run-up is re-initiated. Being germanium (e.g. 1N480) the diode bypasses (by reverse leakage) any capacitor leakage.

P. LACEY,
Crediton,
Devon.

Battery supply regulator

The circuit is of the same type as that of P. Lacey (Circuit Ideas, November 1970). It has the same advantage that the difference between input voltage and regulated output can be small, making it ideal for battery regulation and has very good stabilization (of the order of 1:1000). Current limiting can be varied by choice of R_2, and the circuit has a re-entrant load characteristic. Putting a switch in series with R_1 gives an output which cuts



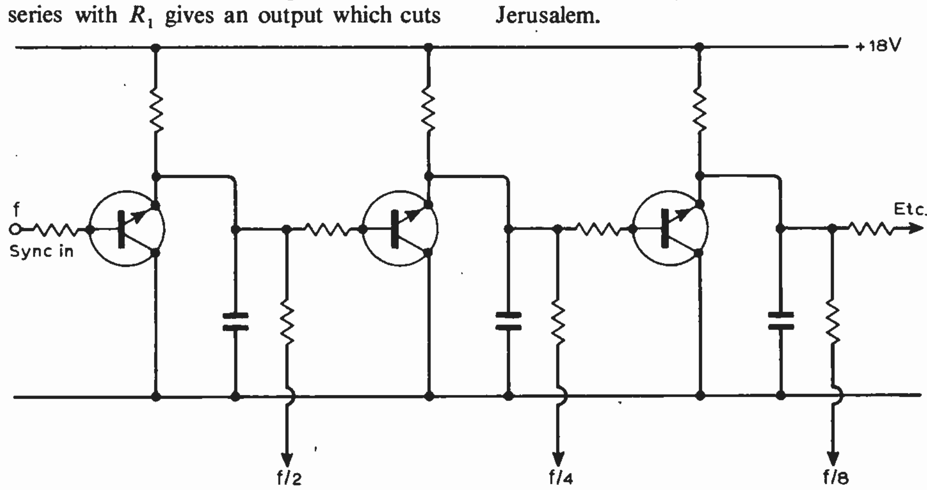
off after a short circuit and does not re-start until the switch is momentarily closed. I have used many circuits of this general type in equipment. They have superior stabilization and inferior output resistance compared with 'emitter follower' series regulators, but are less susceptible to the effects of short circuits and overloads.

T. R. E. OWEN,
Dept of Geodesy and Geophysics,
Cambridge University.

Negative resistance frequency divider

The free-running frequency of each of the relaxation oscillators in the figure below is determined by the value of the capacitor and the emitter resistor. To safeguard the device, the emitter resistor should not be less than about 1kΩ. If successive stages are set to free-run a little below the desired division frequency, reliable division can be achieved by judicious choice of sync resistor (higher for low frequencies and vice versa). Division by five or six per stage is possible. The output is a sawtooth, and frequency multiplication is also possible as the oscillators can be synchronized to harmonics of the preceding stages. Isolating resistors are necessary to avoid loading and consequent changes in frequency. Selection of transistors, which must be n-p-n silicon planar types, may be necessary. If this note should lead to an epidemic of electronic organs, the blame must go to J. A. H. Edwards (*Wireless World*, January 1970, p.12).

R. M. YOUNGSON,
Jerusalem.



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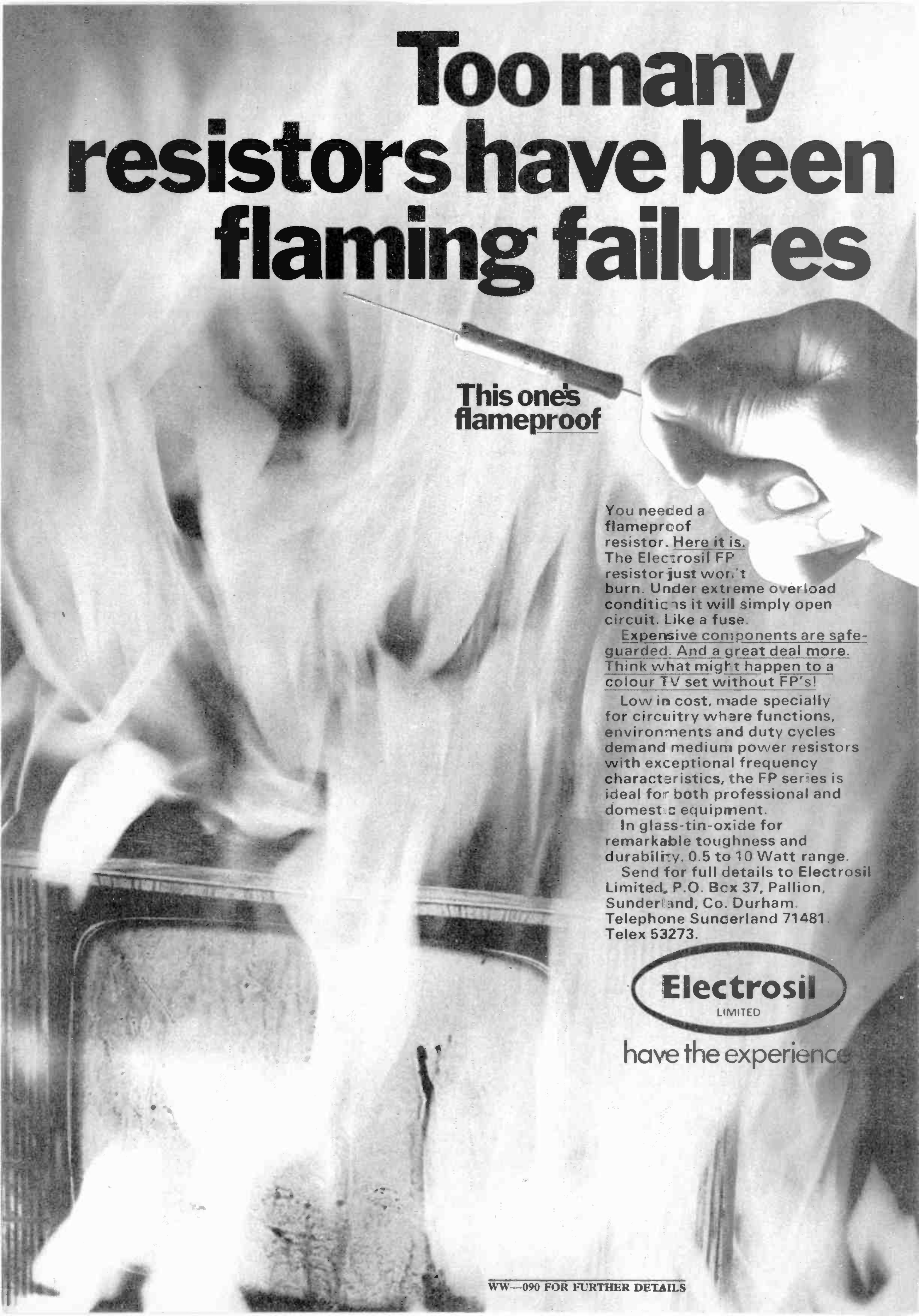


WW—090 FOR FURTHER DETAILS

Transients and Transcience

Sonex '71, London Airport, March 31-April 4

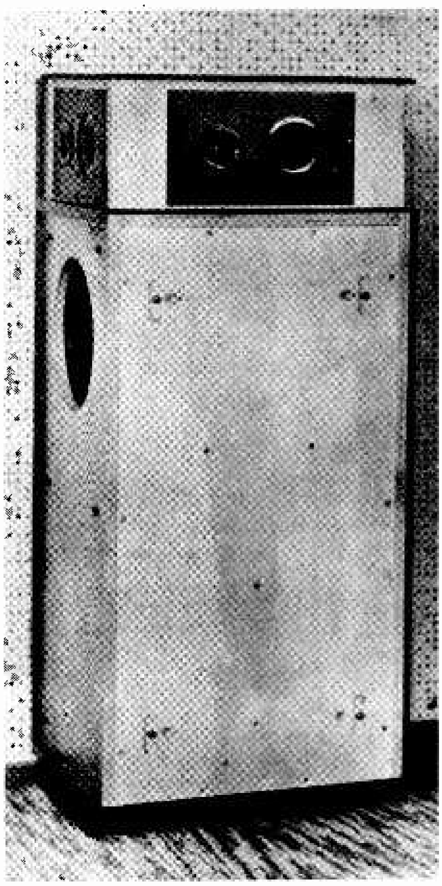
Visitors to this year's Sonex exhibition had the opportunity to listen to British equipment from nearly all the better audio manufacturers and to compare this with a fair representation of items manufactured outside the U.K. There was about twice as much British equipment as foreign. This is an excellent state of affairs—what poor equipment did get past the screening committee was simply out of place. The show seemed very well organized and relaxed, and to have surmounted any problems presented earlier by the breakdown of the postal service. There were two trade days and some reports of brisk business which, for the exhibitors, must be the justification of the effort.

Naturally, *our* interest in Sonex centres on the sound of the exhibits with respect to both engineering and demonstration techniques. In the report on Sonex 70* we made two main points. First that a particular item on display should be allowed to give a fair account of itself and second that music should be played but not 'used'. It is worth making one further observation. Specification sheets are often worse than useless. This can be turned round to say that certain engineering improvements are not worthwhile. For example there is still general confusion over the nature and significance of amplifier distortion. It is possible to prefer a class A amplifier with 5% distortion to a class B amplifier with 0.1%. On this matter it was interesting to watch visitors' reactions to a switch-over between the Phase 25 class A amplifier (costing £56 and delivering 12W per channel into 8Ω at about 0.02% harmonic distortion) and the Phase 44 class B amplifier (costing £42.50 and delivering 20W per channel into 8Ω at about 0.05% distortion), both made by Futuristic Aids. The manufacturers seemed quite happy to demonstrate the difference in sound—only the output stage distinguishes them electronically.

In relation to loudspeaker designs the published specifications can give very little idea of performance. To obtain clear mid-range and treble transient response a very light weight moving system (e.g. ribbon or electrostatic membrane) or a very efficient linear motor combined with a rigid diaphragm must be used. (A properly designed horn coupled to a non-too-linear drive unit can provide excellent quality over a fairly narrow band.) To produce clean bass from 70Hz down to 30Hz is a real challenge to any loudspeaker manufacturer. The ear is very sensitive to phase information from 1kHz downwards. A suitably designed efficient motor unit coupled to a rigid cone and fixed in a rigid and damped box baffle can produce very good results (the Acoustic Research AR3a is remarkable in this respect) but, space allowing, a horn loaded bass driver can provide almost the real thing, as can a very large array of units on a single baffle.

The multiple-array approach using wide range units can be very effective indeed. Not only is low frequency loading improved by a large total diaphragm area but distortion is reduced by the sharing of effort. A range of speakers based on this idea was demonstrated by Gabraphone (Modern Engineering & Technology Ltd, 4 Station Road, West Canterbury, Kent).

All this suggests that the manner of construction, i.e. the engineering philosophy, is at present the best guide to the likely performance of both amplifiers and speakers.



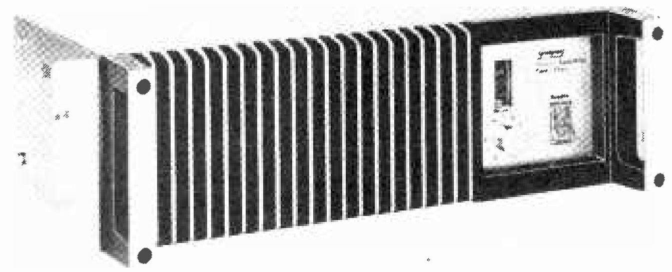
Radford's Studio 270 loudspeaker with front and side panels removed

Guidance needed

The quality of demonstrations seemed better this year than last although there are still a number of firms that need guidance. Perhaps British Audio Promotions could draw up a brief on effective demonstrations—with a note explaining that very loud noises make people feel ill. There were several excellent taped programmes but we believe that there should be personal contact between the visitor and a demonstrator. Decca had an automated room that seemed, significantly, always to be empty. We took our place and read the following: "we at Decca Special Products make our task of demonstrating the quality of equipment more difficult than it has to be for the very reason that we arrange a programme of music primarily for your enjoyment, and not, as perhaps some of the other exhibitors as a result of a search to find programme material which particularly enhances our products". Bowing to the Apollo speakers *we* left instantly.

In the Audio Fair report (December 1970) we argued that a pair of omni-directional speakers could not provide the correct sound pattern for true stereo. In the space available it was not possible to give a full acoustic explanation for this. It is with pleasure that we refer the reader to the article 'In all directions' by John Crabbe in the April '71 issue of *Hi-Fi News*. Apart from a mysterious reference to image shifts due to time differentials (omitted reference to Einstein?) the importance of suitably disposed constant pressure lobes, for proper stereo, is clearly brought out. How then are we to view Arthur Radford's latest creation, the Studio 270 (price about £130)? This speaker has a mid-range and treble unit at the top of the front and sides and a double acoustic line

* 'Cecilia—Saint or temple prostitute?' June 1970



Power amplifier type 744 from Grampian.

for the bass. The cabinet radiates equal energy in all directions throughout an included horizontal angle of 270° from 30Hz to 25kHz. Dispersion such as this is quite suitable for two-channel stereo provided the cabinets are correctly disposed. Radford's intention is that the listener should receive full transient information at all points in the stereo image. Also it is certainly true that the combined effect of two separately disposed sound sources is to qualitatively change the sound—a mono signal delivered by a correctly staged pair of speakers sounds less 'coloured' than the same signal heard from a single speaker placed centrally. Also, the difference between two-channel mono and stereo can be detected two rooms away.

These phenomena are also to some extent exploited in, or incidental to, the performance of Bowers and Wilkins' Model 70, the Lowther Auditorium Acousta, and our old friend the Quad electrostatic.

There were two other new speakers that deserve special comment. Cambridge Audio introduced the R40 as a junior version of the R50 using two Astec drivers designed by Jordan and an STC 4001G high frequency unit. Whilst having much of the 'cleanness' of the R50 the overall result can only be described as disturbing. In the Fane Fanfare we encounter the problems of crossing over at 1500Hz. The bass driver (in this case a 15in unit) is required to remain rigid, when it simply cannot, over the lower part of the mid band frequency range where the ear is acutely sensitive. Considering that the Fanfare is described as a 'monitor' and that the manufacturer is employing his newly designed model 700 high flux ribbon speaker which has 'un-surpassed transient response', making it 'the most faithful reproducer available today', the absence of a selected mid range unit starting at say 400Hz is almost beyond belief.

Amplifiers and tuners

Lowther have at last decided on which class A circuit to produce. Last year they were considering a simple emitter follower configuration using a load resistor but have now opted for a push-pull arrangement originally designed for germanium transistors by P. Tharma but suitably modified for silicon devices. They have also settled on a design for a u.h.f. television sound tuner with variable sensitivity, and a new v.h.f. tuner.

Since most expensive loudspeakers are greedy for watts Grampian's new range of amplifiers is of interest. Both the 50W and 100W versions are d.c. connected to the load (having a centre-tapped power supply) and employ 'dual slope protection' in the output stage allowing the amplifier to follow the shape of the s.o.a.r. curve for the power devices. The 100W version, type 744, supplies 20V r.m.s. across a 4 Ω load and 100V across 100 Ω. The amplifiers require 1V input for full output but are protected against transient inputs of up to 250V.

The PA50 amplifier and SC24 pre-amplifier from Radford have a very detailed specification. The PA50 (£85) boasts a distortion level of 0.01%, and the SC24 (£80) is run at a high rail voltage so that 200mV can be applied to the nominally 2.0mV magnetic cartridge input without overload.

To the cassette tape player/recorders listed in the Audio Fair review the Sonex show has added five new models. Incorporating the Dolby noise reduction system is the Rank Wharfedale DC9, which uses a Japanese made mechanism running at 1$\frac{7}{8}$in/sec and providing four tracks for stereo or mono recording or playback. It has "piano key" switches for controlling the mechanisms, two VU meters and recording level controls, and a 3-digit tape counter. The frequency response is ± 2dB from 50Hz to 12kHz and, with the Dolby system switched in, the signal/noise ratio is claimed to be better than 50dB. The other four new machines, not using the Dolby system, were shown by Brenell, Highgate Acoustics (maker, Luxor of Sweden), Philips and Shriro. The Brenell model, incorporating a Garrard mechanism, is unusual in that as well as the normal record/replay amplifiers it has two power amplifiers and two loudspeakers built in.

A Dolby noise reduction equipment which can be used between any tape recorder and any audio amplifier was shown by Highgate Acoustics under their trade name Alpha. It has two channels with level controls and meters, and the noise reduction characteristic is: 3dB at 600Hz, 6dB at 1200Hz, 9dB at 2400Hz and 10dB from 4kHz to 20kHz.

Although there is a general trend towards magnetic pickup cartridges, the less expensive ceramic piezo-electric types are still being produced and not only for cheap record players. A new design intended for high quality stereo record

Bell & Howell Design 1700 cassette player/ recorder (see Dec. 1970 issue).

JVC Nivico four-channel amplifier.

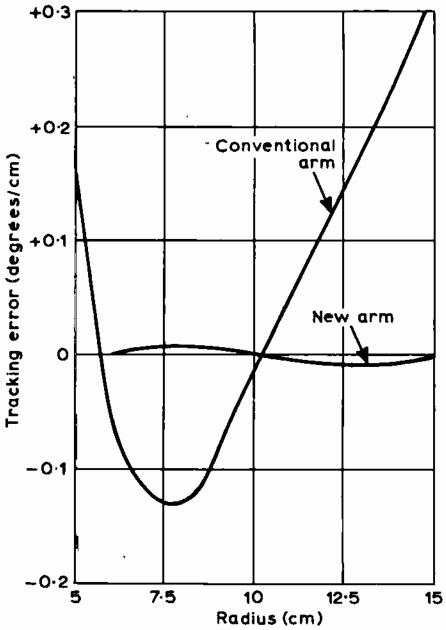
reproduction is the ACOS 104. Using a diamond stylus with a tip radius of 13-18 μm, it has a tip mass of 1.6-2.6mg and a static compliance of 20×10^{-6} cm/dyn (lateral) and 17×10^{-6} cm/dyn (vertical). Tracking weight is 2-5 grammes, and stereo separation is claimed to be at least 20dB at 1kHz. The cartridge can be used with magnetic-cartridge amplifier inputs with R.I.A.A. correction, or with high-impedance amplifier inputs.

A stereo f.m. tuner/amplifier just introduced by Goodmans, the Module 80, has an amplifier with a frequency response of $\pm$1.5dB from 30Hz to 20kHz and total harmonic distortion of less than 0.1% with a power output of 30W (per channel) continuous sinewave into 4Ω. The tuner, which uses f.e.ts in the r.f. amplifier, has a sensitivity of 1.5 μV for 26dB signal/noise ratio, pilot tone rejection of -36dB at 67kHz deviation, image rejection better than 54dB and i.f. rejection better than 90dB. Stereo cross-talk at 1kHz is -40dB. All the usual tuner/amplifier facilities and controls are provided, including a tuning indicator, a stereo broadcast indicator, a jack socket for stereo headphones, loudness compensation, and protection against short circuiting the amplifier's outputs.

One feature of the JVC Nivico four-channel amplifier, shown by Denham & Morley is its reasonable price, which is £110—not bad for four 10W (continuous sinewave power) integrated amplifiers, of harmonic distortion less than 0.08%, with separate VU meters. There are separate level controls for the four channels but common tone controls. Another feature is a facility, called a "sound field composer", which enables the user to create a four-channel stereo effect from two-channel sources. In this the amplifier outputs for the front two loudspeakers are produced in the normal way, while the outputs for the rear two speakers are produced as difference signals, L–R and R–L. Frequencies below 200Hz are directionless. A balanced tranformerless circuit enables the four amplifiers to be combined into two pairs for reproduction of conventional two-channel stereo.

Sinclair have replaced their IC-10 integrated circuit audio power amplifier by a new device with higher power output, the Super IC-12. This is claimed to give a power output of 6 watts continuous sinewave, a power gain of 90dB, to have a frequency response of $\pm$1dB from 5Hz to 100kHz, and to introduce less than 1% total harmonic distortion "(typically 0.1% at all output powers and all frequencies in the audio band". The input impedance is 250kΩ and the load impedance range is 3-15 ohms. Price, including a printed circuit board for mounting the device and external components required for particular applications, is £2.98.

How would you like a 10-watt, 8-ohm Rembrandt or, for that matter, any of the "world's artistic master pieces" with a choice of two power handling capacities? That in fact is what you can get with the



Tracking error of Garrard Zero-100 pickup arm compared with that of a conventional arm.

JVC Nivico "picture speakers". One model (10W), using a 5in drive unit, has a picture frame which is "hand made" in "real wood" and "antique finished". The other (5W) has a 5in drive unit and 2in tweeter and the picture frame is described as "vinyl sheet overlay plywood rose wood". Sound emerges from a space between the picture and the frame, and no doubt one advantage of this audio-visual combination is the complementary coloration of the two sources.

Metrosound were showing the latest Ortofon pickup arm, the AS212, which is an improved version of the maker's RS212 arm and with simpler styling. It has a built-in lowering device, an integral arm rest and magnetic bias compensation. The counterbalancing weight is in two integrated sections, one of which is rotated for balancing and the other rotated to give the required stylus tracking weight—indicated on a graduated scale. The arm has the same shape as the RS212 but we understand that it has a lower resonance frequency. Price is "about £29".

Because a pickup arm is a pivoted device and the pickup moves in an arc, the stylus and cartridge cannot always be correctly oriented in the record groove (corresponding to the cutter orientation) and this angular error, which can be up to 4 degrees, results in some distortion. In the Zero-100 turntable shown by Garrard the tracking error is reduced to a nominal 90 seconds of arc, say the makers, by pivoting the cartridge housing on the arm, at a point directly above the stylus tip, and continuously changing its orientation as the arm moves across the record so that the centre line of the housing is maintained at a tangent to the groove. This is done by a lever mechanism using a control rod parallel to the pickup arm. In a comparative demonstration using a frequency test record, the 2nd harmonic distortion on a 1000Hz band was shown to be better than 0.1% with the new arm, compared with 1.4% using a conventional arm at an equivalent position on the test record. The Zero-100 deck has an aluminium turntable, magnetic bias compensation, stylus force adjustment and fine speed control ($\pm$3%) and can be used as an auto-changer (up to six records) as well as for manual operation. Wow and flutter are claimed to be better than 0.1% r.m.s. The price is £55.

Garrard Zero-100 turntable.

A 4-speed auto-changer the BSR McDonald 210 measures 13¾in × 10¼in × 5½in and weighs 3¾lb. The square-section arm has a fixed balance weight, a cueing device, an automatic lock and an indication of stylus pressure. The type SC7M cartridge gives an output of 77mV at 1kHz.

A feature of AKG's latest headphones for stereo listening, type K180, is that the volume of the air space between the moving-coil transducers and the eardrums can be continuously varied by operating adjusting knobs on the earpieces. By this means the quality of the sound can be changed to give the listener the effect of sitting at different distances from the orchestra in a concert hall. Minimum air volume gives "brilliant presence of the sound . . . orchestra seat", medium volume "a spatial and neutral sound image . . . 15th row" while maximum volume gives "diffuse and soft sound . . . last row". The 'phones, which cost £32, are 600Ω impedance types and have a frequency range of 16Hz to 20kHz.

It has been discovered that when microphones are used on stages, or other situations where the sound has to be picked up at a distance, better results are obtained by placing the microphone as close to the floor as possible rather than on a high stand. This is because the path lengths for the direct and floor-reflected sound waves are almost the same and very little cancellation occurs, whereas if the microphone is on a high stand the path lengths differ considerably and the resulting wave cancellations can seriously affect the frequency response. To allow microphones to be mounted about ⅛in from the floor Shure have introduced a stand which is designed to isolate the microphone from floor vibrations. The microphone is hung in a rubber ring from the central boss of a thin-legged tripod which is about 5in high.

Digital TV Line Standards Converters

Painting by numbers

Electronic standards converters for changing 625-line television pictures into 405-line pictures have been used by the B.B.C. and I.T.A. at main transmitters for some years—their function being, of course, to provide a 405-line service from picture sources which are now almost all 625-line. These converters work on an analogue principle. During the 1970s the broadcasters will be gradually changing over to digital signal processing and distribution—all video information between the picture source and transmitter being represented by binary numbers on the p.c.m. principle. Meanwhile, the need for the 405-line service continues and in any case it will be carried on beyond the useful life of the present analogue standards converters. With this situation in mind both the B.B.C. and the I.T.A. have developed digital line standards converters. These, when eventually in operation, will be able to handle the digitally represented video information directly, and are expected to be more reliable and simpler to operate than are the analogue converters. *Wireless World* recently saw a demonstration of the B.B.C's experimental digital converter, developed at the Corporation's Research Department, Kingswood Warren, Surrey.

In a line standards converter, whether analogue or digital, two main processes are required. First, the input signals, which have been derived by scanning the scene according to a 625-line raster pattern, are modified by an 'interpolation' process. In this process 405 lines are derived from the incoming 625-line picture, in such a way that each derived line (still having a duration according to the 625-line/50-field standard) carries information corresponding to the scanning of the scene by a 405-line raster pattern. The process consists of combining the signals from two or more successive input lines in accordance with the relative positions of corresponding lines in the 625- and 405-line raster patterns, assuming the rasters to be superimposed. Secondly, the 405 lines provided by the interpolation process are individually adjusted in duration so as to occupy the correct time intervals demanded by the 405-line/50-field standard. This 'time-redistributing' process is effected by means of information stores. For this reason the whole system is described as a 'line-store converter'.

The B.B.C. digital converter (Fig. 1) samples the incoming 625-line/50-field signal at a rate of 11MHz. The magnitude of each sample is then represented by an 8-digit binary number; thus the input signal is quantized into 256 discrete levels. The process of interpolation is carried out using a digital store—an m.o.s. integrated circuit shift register—with a capacity corresponding to the information contained in one input line, together with high-speed binary 'arithmetic' which accepts two 8-bit numbers or 'words', multiples each by a suitable 3-bit number and adds the resulting products. These arithmetical operations are achieved with an unusual type of logic, devised by J. P. Chambers, involving clocked delays, and this is implemented by t.t.l. integrated circuits.

The second, time-redistributing, process is carried out using an assembly of stores—again m.o.s. shift registers—each having a capacity corresponding to one input line. Each wanted line from the interpolator is 'loaded' into one of the redistributing stores at a rate corresponding to 625-line scanning. Shortly after the store has been fully loaded it is 'emptied' at a rate corresponding to the 405-line scanning standard. By providing a suitable number of shift register stores and a suitable switching arrangement, it is possible to ensure that the stores can be loaded and emptied in sequence and that all the wanted lines are suitably processed in the correct order. Finally, ancillary circuits provide 405-line/50-field sync pulses in digital form which are added to the digital signals from the time-redistributing stores, and the combined digit stream is fed out.

For the purpose of the demonstration the output digit stream was fed into a digital-to-analogue converter (shown in Fig. 1) to produce a conventional 405-line video signal, and this was displayed on a monitor alongside the original 625-line picture on another monitor. No difference could be seen between the two pictures except very occasionally when the interpolator could not derive exactly the right information to present a particular optical pattern correctly in certain parts of the 405-line picture. It was explained that this was due to a limitation of the interpolation formula, which uses quantities (binary numbers) drawn from only two successive television lines. Future designs of digital converter would use a more advanced formula—and consequently more arithmetical operations—based on a greater number of successive lines, and this would reduce the interpolation errors.

The I.T.A. converter, which has not yet been demonstrated, is similar in principle to the B.B.C. one, we understand, but operates at the higher sampling rate of 13MHz. Although these line standards converters are not primarily intended for giving a colour television signal output, the I.T.A. state that their equipment, because of its higher sampling rate, could in fact handle the colour information in the chrominance signals as well. This would be necessary, for example, if the line converter were used as part of a complete colour television standards converter† giving field rate conversion as well—say for changing American colour pictures to European colour pictures.

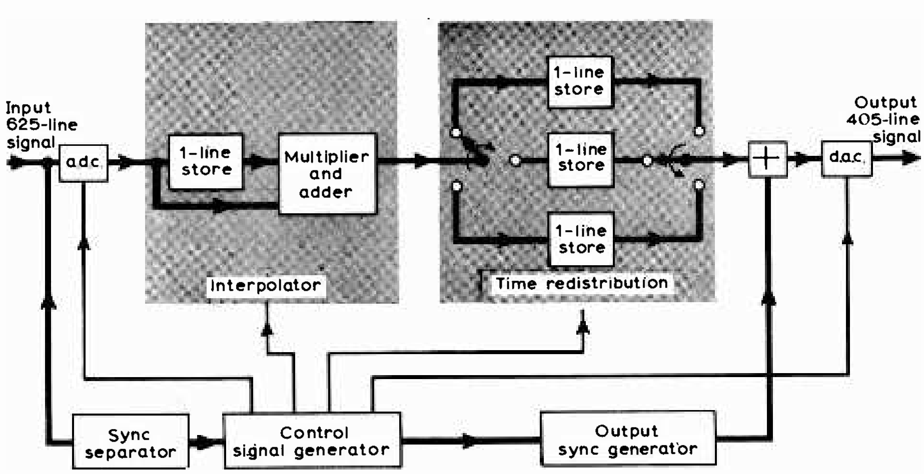


Fig. 1. Principle of the B.B.C. digital line store converter. The analogue-to-digital converter (a.d.c.) quantizes the input signal and translates the samples into binary numbers, as in p.c.m. If the input signal were already encoded, assuming a p.c.m. distribution system, this a.d.c. would not, of course, be necessary.

†"Colour TV Standards Converter", *Wireless World*, Oct. 1967.

Using Non-linear Loops

The theory applied

by Thomas Roddam

For the last couple of months I have been offering readers some thoughts on a topic which they well know to be relevant only to designers of large and complicated systems. Feedback, yes, but feedback with switches in the circuit, that is not for the ordinary man. Now I intend to show that it is for the ordinary man—and who is more ordinary than a man building a power unit?— and that even if you accept some approximations you can still emerge with an answer which enables you to choose sensible components to start messing about at the bench.

The first problem we shall discuss is the design of a switching regulator. In particular we shall take a series switching regulator. Anyone who would prefer to think of it in a slightly different way can call it a class-D d.c. amplifier. The purpose of the system is simple: we have a rough supply of $V_{in} \pm$ a lot and we want a supply of $V_{out} \pm$ a little. At low levels we can use a conventional class-A valve or transistor regulator, but this consumes a fair amount of power and we find that either economy or the cooling problem demand a better solution. Switching regulators, chopper regulators, are the answer. In theory they introduce no power loss at all, so that they combine economy with the avoidance of cooling problems.

A chopper, as its name indicates, chops. This means that there will be a smoothing circuit following the chopper. It is possible to drive the chopper at a fixed frequency and to vary the mark-space ratio to control the output. It is also possible to allow the system to drive itself. Fig. 1 is indicative of the general difference between the class-A, dissipative, regulator and the pure switching type of regulator. We must go more deeply into the circuit arrangements, but in doing this I am going to skip one question which crops up in most power supply problems. We always have to get a shift in d.c. levels at some point in the circuit. In the class-A system of Fig. 1(a), for example, we need a supply for the base of the pass transistor: if we take this from the unregulated input we find in a practical design that we must drop quite a fair voltage from collector to emitter, or get a wide range of base feed current. It is the detail of design here which is rather tedious if you want a solution which looks best. The theory of this kind of regulator chooses an arbitrary form here, and in this study of the chopper I shall assume that if necessary another d.c. supply is available to put biases where they are needed.

The circuit we are considering consists of three essential parts. There is the chopper itself, the averaging circuit and the circuit which drives the chopper. These are shown in Fig. 1(b). For practical purposes they will normally be something like the elements shown in Fig. 2. The series pass power transistor and the flywheel diode do the

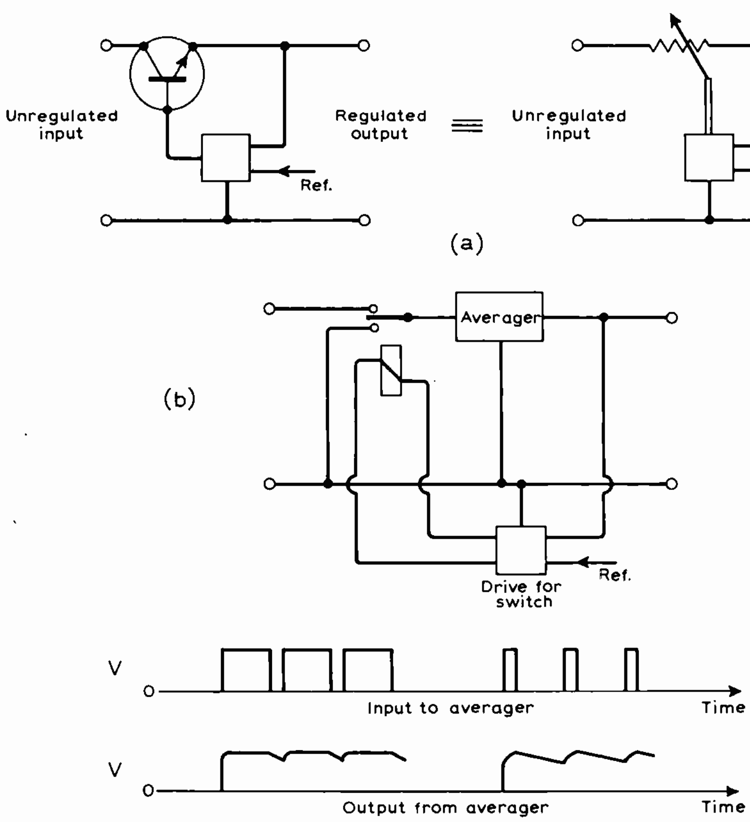


Fig. 1. Class A and chopper regulators: (a) class A regulator: (b) chopper regulator; (c) behaviour of a chopper regulator.

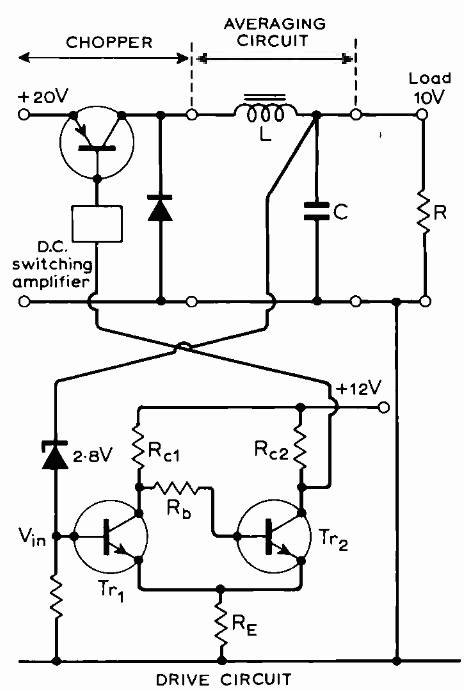


Fig. 2. Part-practical chopper regulator. $Tr_{1,2}$ BSX19. $R_{c1} = R_{c2} = R_B = 1k\Omega$. $R_b = 10k\Omega$. $V_{in\,off} = 6{\cdot}6V$. $V_{in\,on} = 7{\cdot}8V$.

actual chopping, and the interrupted current flows into the low-pass filter. A Schmitt trigger, the values of which are taken directly from Electronic Counting, p. 65 (Mullard), feeds through a d.c. switching amplifier, which hides a d.c. level problem, to the base of the pass transistor. For the Schmitt circuit shown, triggering is at 6·6 V and 7·8 V, so that a 2·8 V zener diode will put the mid-point of the zener band (7·2 V) up to 10 V at the positive terminal of C. The input voltage is taken as 20 V, and we expect to get an on-off ratio of 1:1. I fully realize that you have a 39·2 V source and you want to get 24·5 V, but this is my example and by using simple numbers we can look at the meaning instead of worrying about arithmetic. When I look at Rolls-Royce car advertisements it is not the odd tenpence on the price which worries me.

The nominal load of this regulator is to be 1 amp. At full load, then, $R = 10$ ohms. At this point I am in a state of total innocence about the order of magnitude to use for L and C. Later we shall show how we can work back, but now, guessing madly, I choose to make this a low-pass half-section with a design cut-off frequency of 1600Hz, so that $\omega_c = 10^4$. Immediately,

$$L = R/\omega_c = 1\text{mH}$$

$$C = 1/\omega_c R = 10\mu\text{F}.$$

These are plausible values, anyway, and 1mH at 1A, although it means a gapped core, can be got on a reasonable ferrite.

I propose to try the describing function method of analysis, and the first step is to study the characteristics of the linear part of the circuit. This is shown in Fig. 3, and it is extremely simple to find that

$$\frac{V_1}{V_2} = 1 + j\omega LG - \omega^2 LC, \text{ or}$$

$$1 + j\omega L/R - \omega^2 LC$$

It is usual to normalize this. First we introduce ω_0, given by

$$\omega_0^2 LC = 1.$$

This gives us

$$\frac{V_1}{V_2} = 1 - \left(\frac{\omega}{\omega_0}\right)^2 + j\frac{\omega}{\omega_0}\cdot\frac{1}{R}\cdot\frac{L}{C}$$

Now the servo designers take

$$\zeta = \frac{1}{2R}\sqrt{\frac{L}{C}}$$

so that $$\frac{V_1}{V_2} = 1 - \left(\frac{\omega}{\omega_0}\right)^2 + j2\zeta\left(\frac{\omega}{\omega_0}\right)$$

We can work out the values of

$$20 \log\left|\frac{V_2}{V_1}\right|$$

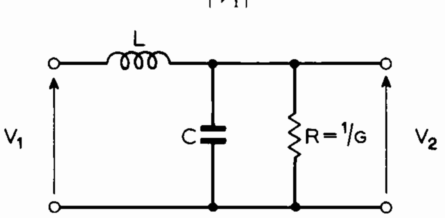


Fig. 3. The linear part of the circuits.

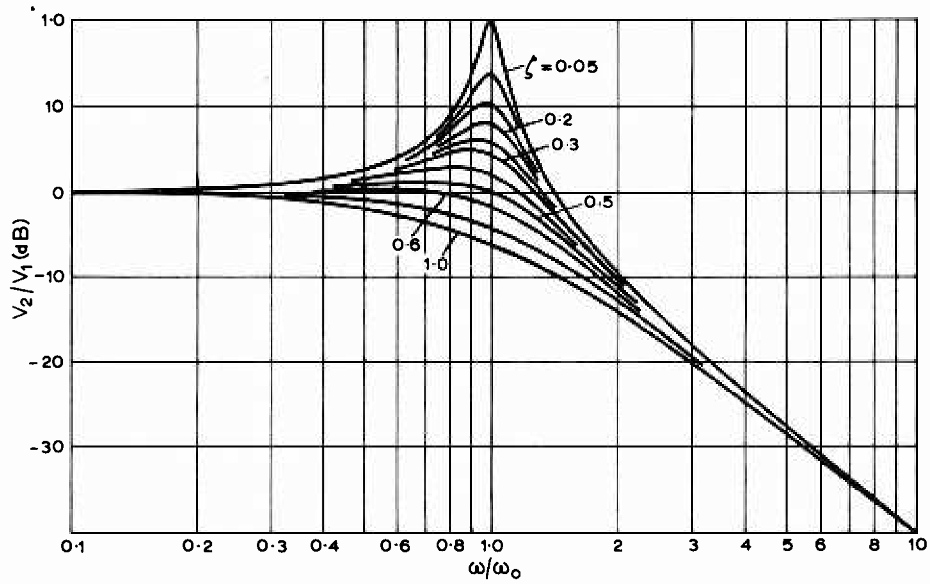


Fig. 4. Magnitude of V_2/V_1 versus frequency ratio ω/ω_0 for various values of $\zeta \leqslant 1$

$$\frac{V_2}{V_1} = \frac{1}{\left(1-\frac{\omega^2}{\omega_0^2}\right) + j2\zeta\frac{\omega}{\omega_0}}$$

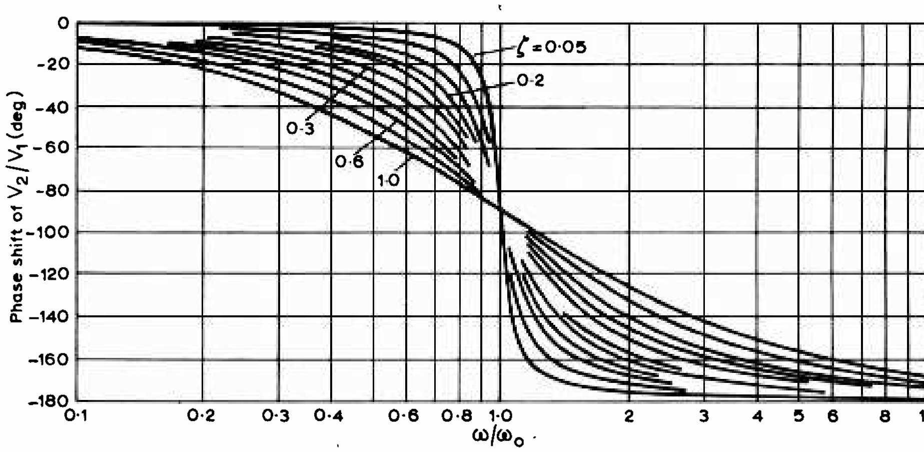


Fig. 5. Phase shift of V_2/V_1 versus frequency ratio ω/ω_0 for various values of $\zeta \leqslant 1$

$$\frac{V_2}{V_1} = \frac{1}{\left(1-\frac{\omega^2}{\omega_0^2}\right) = j2\zeta\frac{\omega}{\omega_0}}$$

and of the phase angle, which will give us the response of this network for various values of ζ. These are shown in Figs. 4 and 5. We now use a little intuition or common-sense or guesswork. The Schmitt trigger works on about $\pm 0{\cdot}5$ V and can easily be made more sensitive. The input to the network is ± 10 V from the 10 V centre level. We shall expect at least 20dB attenuation through the averager. The transmission curves of Fig. 4 are all pretty close to each other, and to the asymptote, for which

$$\left|\frac{V_1}{V_2}\right| = \left(\frac{\omega}{\omega_0}\right)^2.$$

The phase angle is given by

$$\tan\theta = \frac{2\zeta(\omega/\omega_0)}{1-(\omega/\omega_0)^2}$$

We expect to be in the region where $(\omega/\omega_0)^2 \gg 1$. Guessing, $(\omega/\omega_0)^2$ is about 10. Roughly, then

$$\tan\theta = -2\zeta/(\omega/\omega_0)$$

$$= -1/\omega CR.$$

In the region we are interested in studying,

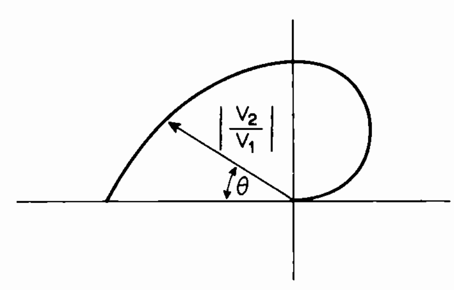


Fig. 6. Polar plot of the response of the LCR network.

we have

$$\sin\theta = (180-\theta)\cos\theta = -1, \text{ and so}$$

$$180° - \theta = 1/\omega CR.$$

This will be very useful in examining the effect of load changes.

I am far too lazy to draw in detail the Nyquist plot of this response. The general shape of it is shown in Fig. 6, and we can, with advantage, find which bit of this we need before we start working out the detail. We must therefore find the describing function of the switch and its control mechanism. The input-output diagram is shown in Fig. 7. I have assumed that this Schmitt is a bit more sensitive than the model, so that I have exactly 1 volt peak-to-peak hysteresis. If the input is less than this, the trigger circuit stays where it is and there is no output from the switch. As soon as the input a.c. signal to the Schmitt reaches $0{\cdot}5 \sin \omega t$, the triggering will take place at the tips of the sine wave, and we shall get a 10 V square wave out. As the input rises the triggering takes place earlier, in the way shown in Fig. 8, but as the output is not changed the gain is less. The sine wave component of the output is actually $(4/\pi)10$ volts, or 12·6 V. I propose to alter R_b in my Schmitt trigger again, to make it operate at $\pm 0{\cdot}63$ V—like the original, in fact, so that the maximum gain is just 20 times.

We can work out a few points very easily. For the 0·6 V input the gain is 20 and the angle 90°. The angle will come back to 60° when input $= 0{\cdot}6/\sin 60 = 0{\cdot}6/0{\cdot}866 \approx 0{\cdot}7$, giving a gain of 18 times. For 45°, the input is $0{\cdot}6/0{\cdot}7 = 0{\cdot}857$, giving a gain of about 15. For 30° the gain is 10. These results are sketched out in Fig. 9.

Let us begin by considering our system with its nominal 10-ohm load. We have

$$\left|\frac{V_1}{V_2}\right| = \left(\frac{\omega}{\omega_0}\right)^2$$

For the 10-ohm load

$$\zeta = \frac{1}{20}\sqrt{\frac{10^{-3}}{10^{-5}}} = \frac{1}{2}$$

It turns out to be easiest to take

$$\tan\theta = -2\zeta/(\omega/\omega_0)$$
$$\text{or } |\theta| = \omega_0/\omega$$

θ in radians.

$$\text{For } \frac{V_1}{V_2} = 25, \quad \frac{\omega}{\omega_0} = 5, \quad \theta = 11°$$

$$\frac{V_1}{V_2} = 16, \quad \frac{\omega}{\omega_0} = 4, \quad \theta = 14\tfrac{1}{2}°$$

$$\frac{V_1}{V_2} = 9, \quad \frac{\omega}{\omega_0} = 3, \quad \theta = 20°$$

$$\frac{V_1}{V_2} = 4, \quad \frac{\omega}{\omega_0} = 2, \quad \theta = 25\text{–}30°.$$

The approximations are falling apart here.

We are interested in finding the conditions which make the transmission round the loop pass through the point (1,0). The conventional way of doing this is to plot V_2/V_1, with ω as parameter, in the complex plane, and to plot $1/G(a)$, where $G(a)$ is the describing function, with (a), the signal amplitude as parameter, and to find the intersection of these curves. The usual way of drawing these two curves is as polar plots, like the one in Fig. 6. However, even with suitable graph paper it is not very satisfactory for this problem, because we are only going to work in a very limited range of angles and it's a terrible waste of paper. Working on scrap, setting out the angles is a bore and so I propose to plot the interesting region in rectangular co-ordinates, $|\mu\beta|$ and θ.

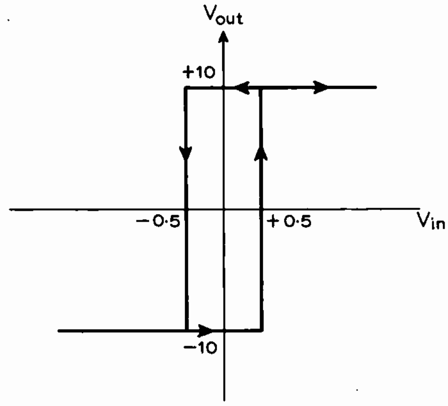


Fig. 7. The switch and Schmitt trigger. $V_{in} = 0$ corresponds to 7·2 V at the Schmitt input, or 10 V before the zener diode. $V_{out} = 0$ is the nominal + 10 V.

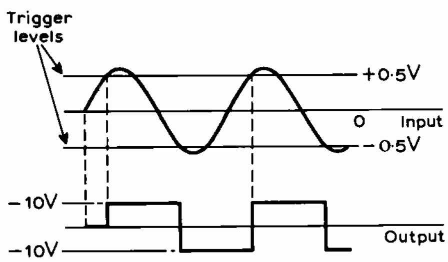


Fig. 8. The switching system.

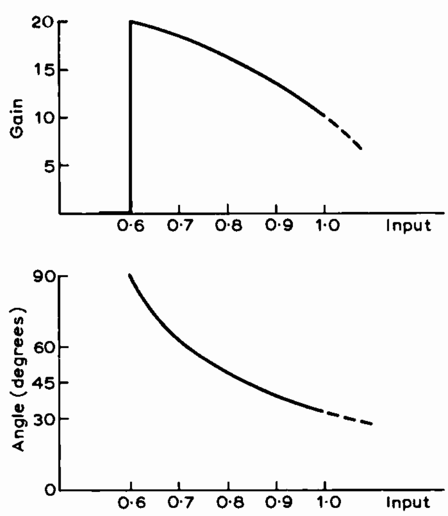


Fig. 9. Sketch of describing function.

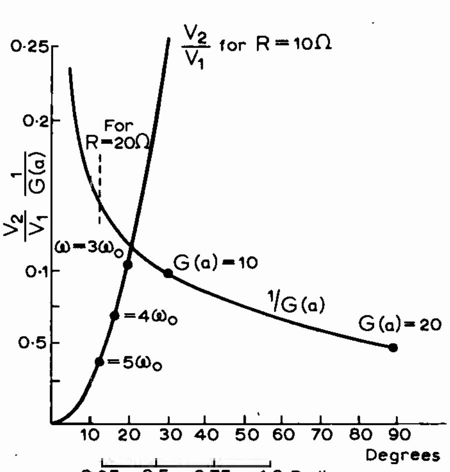


Fig. 10. Plots of LCR response and 1/(describing function).

For the LC network we have

$$\left|\frac{V_2}{V_1}\right| = \left(\frac{\omega_0}{\omega}\right)^2$$

$$\text{and} \quad |\theta| = \frac{\omega_0}{\omega}$$

Approximately, then, $|V_2/V_1| = |\theta|^2$, a parabola. I have plotted this in Fig. 10, and then gone on to transfer the data of Fig. 9 on to the same scale. I find I did not draw enough of Fig. 9, but the intersection tells me that the system will oscillate at just below $3\omega_0$, or something less than 5000Hz, and that the value of $G(a)$ will be, at a guess, 7 or 8. The ripple will be rather more than 1 volt.

This is not really good enough, but before we modify the design let us see what happens if we reduce the output current to half its nominal value by making $R = 20$ ohms. We saw that for LCR the amplitude does not vary much when we change R, at least not if we are working where we should be, but the angle is inversely proportional to R. It is very easy indeed to add the small bit of the (V_2/V_1) curve which shows the new intersection, at a rather larger amplitude and a lower frequency.

Naturally I would not have gone to all this trouble unless I could see some way of making the circuit work. If the value of R_b in the Schmitt trigger is increased the hysteresis gets smaller and smaller, and so the maximum value of $G(a)$ gets bigger and bigger. Using just the Mullard values we should be able to push $G(a)$ up to about 100 at the maximum, with a $\pm 0{\cdot}1$ volt hysteresis gap. Fig. 11 shows the essential region for this condition. It will be seen that the frequency has been pushed up to about 7000Hz and the ripple is down to about one-half volt r.m.s.

The actual chopper frequency is not, in theory, very significant because we can change L and C. In practice it matters, because if we choose to chop at 1MHz the transistor and the diode are going to have rather a hectic time and will cost a lot of money. It is a straightforward scaling problem. Taking this rough answer of 5–7kHz for 1mH, 10μF we can move up to 25kHz with 200μH, 2μF. The transistor switching losses will increase by a factor of 5, and the ripple will be about the same.

It is not possible to avoid having some ripple, because it is the ripple at the output which keeps the whole thing working. On the other hand it is very easy to smooth out this sort of high frequency ripple. Indeed it seems to me, although I have never seen this stated explicitly, that you must add an LC section after the Schmitt tap-off point. The reason is this: we have shown a resistive load, but the power supply user may have a large capacitance at his input, possibly because he would otherwise be sending signals back down the power line. Surge protection must provide a high input impedance at the switching frequency and will give high ripple attenuation.

Operation in an off-set mode requires the study of a describing function which includes a d.c. component. We can look for a rough and ready answer by using what we have already. Suppose that the input voltage is reduced to 11 volts. The chopper must then

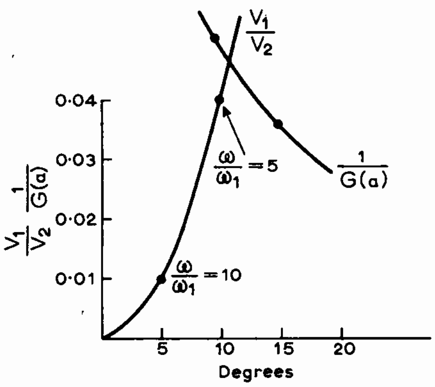


Fig. 11. Revised Fig. 10 with ±100mV hysteresis.

be on almost all the time, so we shall need a large amount of ripple, centred on a fairly low voltage. The regulation against changes of input voltage will only be a factor of about 10, even for small changes.

In a sense, we still have not got a very good voltage regulator. We can try passing the buck to the circuit designer. It is useful to draw the amplitude-phase diagram as a polar diagram, and this is sketched in Fig. 12. If we increase $G(a)$ we make $1/G(a)$ smaller. When we carry this process too far, we lose the trigger effect in our Schmitt trigger, and we have no phase shift due to hysteresis. The characteristic becomes that of a saturating system. In theory, however, this will not oscillate, though stray capacitance effects may produce enough extra phase shift in a practical circuit. We can design in this extra phase shift. As it is a passive system we will normally consider it in conjunction with the *LCR* system. A lead-lag network, shown in Fig. 13, will modify the (V_2/V_1) curve to the form shown in Fig. 13(b). As this crosses the $\theta = 0$ (i.e. full positive feedback) axis it is just a question of getting enough gain, even without hysteresis. From a practical point of view, however, the absence of hysteresis means a slow transition from on to off, and back again, with the increased switching losses. It will easily be seen, when Figs. 12 and 13 are compared, that this sort of characteristic can be made to cross the $1/G(a)$ line wherever we wish, and therefore we can make full use of the sensitivity of the switching control circuit.

An important feature of this class of circuit is the speed at which it makes its decisions. If it is operating at 10kHz, 10 milliseconds is, as it were, a lifetime. The

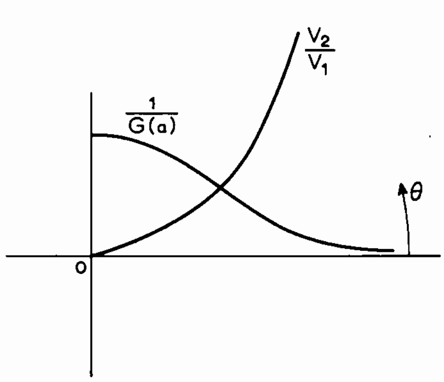


Fig. 12. The general form, as a polar plot, of the critical region.

ripple from rectified and roughly smoothed mains is just another input variation to be reduced by the regulator.

There is quite a lot more detailed design work to do before you arrive at a practical circuit. I suspect that usually this is done by the method of building a system and then modifying it to make it work. One modification with a theoretical basis is to adopt the following reasoning. We find that as we reduce the loading, (refer back to Fig. 10), we get a substantial change in characteristic. We can hardly tell the user that he must always draw 1 amp: sometimes he only wants 100mA. We become fairly independent of loading, however, once the loading is light. If we design for, say, 2 ohms load, with $L = 200\mu$H and $C = 50\mu$F we have the same cut-off frequency but the characteristic where we are studying it is not nearly so sensitive to load. Frequency and regulation remains more nearly constant.

One reason why I chose this switching regulator as my first example is that it lends itself very well to analysis by another method. This is the method called the phase plane method by some writers, but which I feel might well be called the situation trajectory method. We go right back to first principles, and having drawn the circuit in Fig. 14 we write down the circuit equations:

$$L\,dI/dt = V_1 - V_2$$
$$V_2 = Q/C$$
$$I = V_2/R + dQ/dt$$

From which:

$$\frac{dI}{dt} = \frac{V_1 - Q/C}{L}$$
$$\frac{dQ}{dt} = I - Q/CR$$

and
$$\frac{dI}{dQ} = \frac{CV_1 - Q}{CRI - Q}$$

This is the classic form, which corresponds to working with position and velocity in a servo system. It is easier to work with V_2.

$$\frac{dI}{dt} = \frac{1}{L}(V_1 - V_2)$$
$$\frac{dV_2}{dt} = \frac{1}{C}\left(I - \frac{V_2}{R}\right)$$

I have also found that it is easier, in this example anyway, to leave time in the two equations, instead of solving a differential equation and using tables.

For the practical circuit,

$$L = 1\text{mH} = 10^{-3}$$
$$C = 10\mu\text{F} = 10^{-5}$$
$$R = 10 \text{ ohms, at full load.}$$

The average state is $V_2 = 10$ volts, $I = 1A$ and $V_1 = 20$ volts or 0. Provided that I is always positive, so that the fly-wheel diode is always conducting if the transistor is off, we can measure everything from the average state, and aim for $V_2 = 0, I = 0, V_1 = \pm 10$ volts. Then with this new meaning for I and V_2

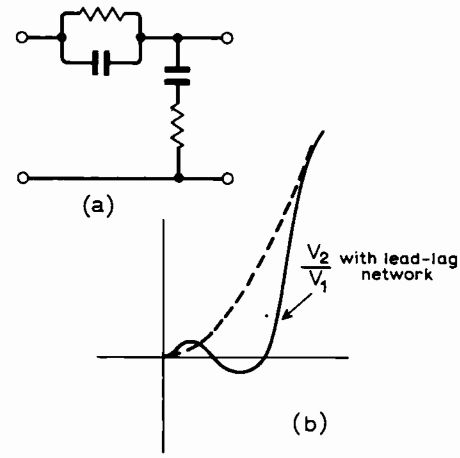


Fig. 13. Tailoring the characteristic: (a) lead-lag network; (b) effect on characteristic.

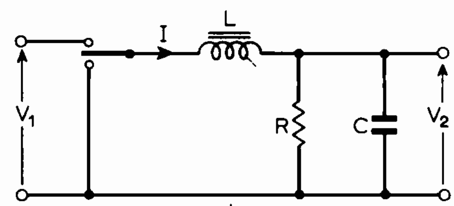


Fig. 14. The switching regulator again.

$$\frac{dI}{dt} = 10^3(\pm 10 - V_2)$$
$$\frac{dV_2}{dt} = 10^5\left(I - \frac{V_2}{R}\right), R = 10$$

A reasonable guess at a value of dt to give a smoothish curve is 10 microseconds. A smaller value would be better, but would involve much more work. Let us try, and write the elapsed time as $n10^{-5}$ seconds.

$$dI = (\pm 10 - V_2)/100|_n$$
$$dV_2 = (I - V_2/10)|_n$$

Initially, $I = 0$, $V_2 = 0$, and we take the + sign in the dI equation

	dI	dV_2	at end of time	I	V_2
$n = 1$	0·1	0		0·1	0
2	0·1	0·1		0·2	0·1
3	0·099	0·19		0·299	0·29
4	0·097	0·27		0·396	0·56
5	0·0944	0·34		0·49	0·9

We have gone too far. After $n = 4$ we have V_2 at a value which will trip the Schmitt trigger if the total hysteresis gap is ±0·5 volts. So now we take the minus sign and step 5 becomes:

5	−0·1056	0·34	0·29	0·9
6	−0·109	0·2	0·18	1·1
7	−0·11	0·07	0·07	1·8
8	−0·118	−0·11	−0·48	1·69
9	−0·117	−0·649	−0·6	1·04
10	−0·11	−0·7	−0·71	0·34

Doubling the size of the time steps

12	−0·207	−1·48	−0·92	−1·14

We should not have done that, so back to

11	−0·1034	−0·744	−0·81	−0·4

The switching point is going to be pretty soon after this, and I am going to take it as now, which means I take the plus sign again.

12A	+0·104	−0·77	−0·7	−1·17
13	+0·112	−0·58	−0·59	−1·75
14	+0·117	−0·41	−0·48	−2·16
15	0·12	−0·27	−0·36	−2·43
16	0·124	−0·12	−0·24	−2·55
17	0·125	+0·01	−0·12	−2·54

I confess to having looked for some graph paper to plot this out as Fig. 15. I confess also that I do not believe point number 6, but it does not matter: the system looks after itself, forgetting errors as we go round. With more energy one can draw several loops, and see how the system settles down to a steady movement round the loop. It looks as though each circuit will take some 200μs, giving a ripple frequency of 5000Hz, and that the ripple will be about 1·7 volts r.m.s. The frequency agrees fairly well with the answer we got by the describing function method, but the ripple comes out rather higher. Considering that I have deliberately worked very roughly I feel that the argument is quite reasonable. The reader may have wondered how I got the frequency: I simply noted that from one maximum of V_2 at $n = 7$ to the other, a maximum of $|V_2|$ at $-2{\cdot}55$, was 9–10 steps of 10μsec, so that right the way round will be about 20 steps.

Given enough energy we might work out another set of data of the same kind for, say, $R = 100$, which would leave the expression for dI unchanged but would alter the equation for dV_2 to contain a term $V_2/100$. We might then find that we should need to look at another switching condition, for if the negative value of I in this analysis exceeds the standing current the flywheel diode ceases to operate. There is then a section of the trajectory in which we have just the capacitor supplying the load, and we must work out the equation to cover this condition. At least, we must if we are prepared to work in this region. In practice we increase either the inductance or, by modifying the switch circuit, the frequency. We may have a separate oscillator.

The external oscillator is fed in to the circuit so that its voltage adds to the error voltage. To make the calculations simple I am going to feed in a triangular signal of $\pm 0{\cdot}2$ volts and 25 kHz frequency, shown in Fig. 16. Looking at Fig. 15, and doing some guessing, I propose to start calculating at the point where $I = 0{\cdot}1$, $V_2 = 0$ for $t = 0$, and to keep all the other values the same. In view of the fatigue which sets in as soon as I start on one of these long tables, I shall summarize the result in the form of Fig. 17. The ripple is down to less than 0·5 V r.m.s., and the frequency is up to 25kHz.

The serious reader is still left with a lot of plodding, for the whole pattern must be worked out for the lightly loaded situation as well. The analogue simulation is what a lot of you will do. Having first calculated by either of the techniques described, and at this stage the describing function method is the easiest, the sort of values you will use in the *LC* network, you construct your analogue system. The easiest thing here is often to build the unit itself. Then you use a signal generator as the supply of jitter. This technique has the great advantage that you can check the heating in the switching transistor, about which you normally know only typical switching times.

It should be possible to use the describing function method to take account of an external drive. This involves the consideration of a modulator effect in the control loop. Without going into any detail, there is no doubt that this is a pretty complicated procedure, especially as the injected oscillator waveform will probably not be a sine wave. I myself prefer the use of the sawtooth produced by a unijunction oscillator, because it is the cheapest way I know of getting a well-defined signal which is always either rising or falling. I do not like driving the Schmitt trigger from a sine wave, because the flat top produces uncertainty of triggering in the critical region.

The sampled data technique can be applied to the driven regulator. It is of special value in considering the slow variations in output caused by input or load changes. In Fig. 18 we see how the output voltage is tested almost regularly by the sawtooth, and the switch is then used to produce the pulse length modulated output train from the sampler. The *LC* network provides the hold function. A really formal solution along these lines is complex, because the sampling is not taken at the regular instants of the basic theory, but the exact epoch of either the leading edge or the trailing edge of the pulses depends on the deviation which is being measured. This 'picture' approach, however, does make it very easy to work out the loop gain at very low frequencies and thus to predict what we might call the Avo-to-Avo gain, the change in the d.c. output shown on a moving coil instrument for changes in working conditions.

The real crunch comes in the awkward problems. If you need to know exactly what happens after a load change the situation trajectory enables you to trace it in detail. If you simply want a self-switching circuit the describing function enables you to get the frequency in the right region from the beginning: I find this useful, because inductors take more procurement time than anything else. The *idea* of sampling data is useful because it provides a direct appraisal of the size of the oscillator drive, and the sensitivity of the switch.

In a later article I propose to examine another non-linear system which, if not carefully designed, can go very wrong in a very odd way.

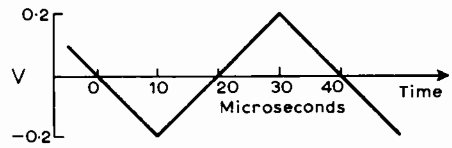


Fig. 16. Master oscillator voltage added to error.

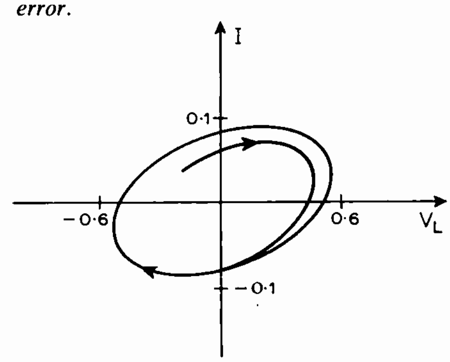


Fig. 17. Form of the solution for a driven switching regulator.

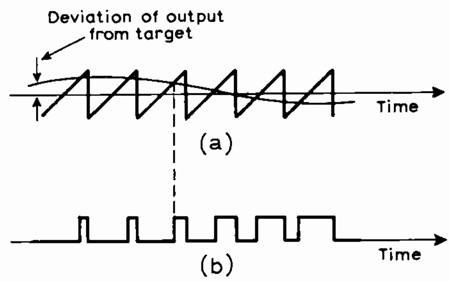


Fig. 18. Switching regulator as sampled data system: (a) sampler and pulse length modulator; (b) p.l.m. pulses into holder.

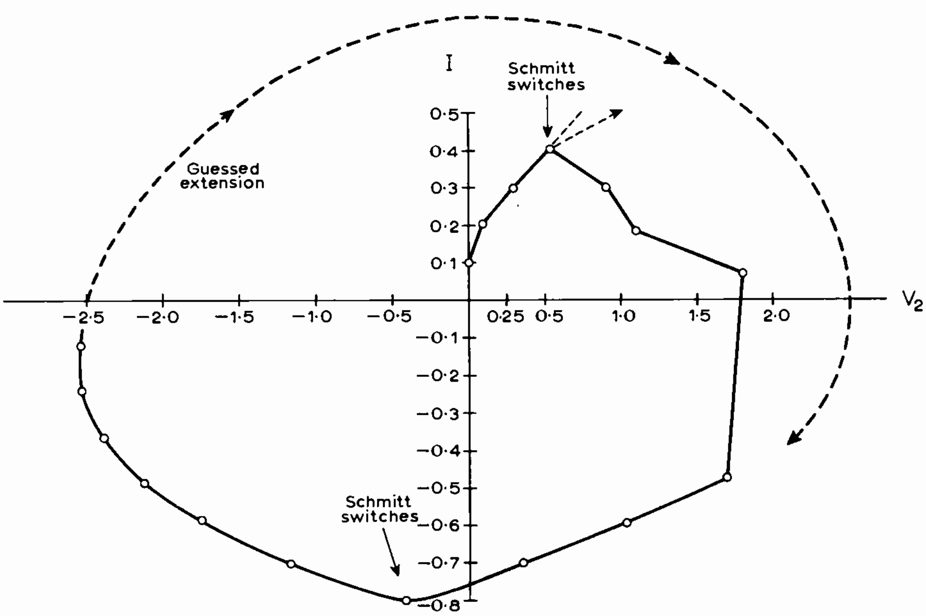


Fig. 15. Beginning of the trajectory.

Audio Festival in France

Among the most interesting events at the Festival du Son, Paris (5-9th March), was a public demonstration by O.R.T.F. (Office de Radio et Television Francaise). Arranged in two parts it was intended principally to gauge public reaction to various types of quadraphonic recording (O.R.T.F. dubbed the system 'la tetraphonie') but included some two-channel stereo sound accompanying television pictures.

Two-channel television sound has been transmitted on an experimental basis in Japan and Germany where each channel has carried a different language—the original and a translation of a foreign film sound track for example. However, O.R.T.F's recorded demonstration was concerned entirely with the ability to provide a stereophonic accompaniment to their black-and-white television picture. The main objection which seems aesthetic rather than technical—discounting the ludicrous contrast between a 58-cm television screen and a large stereo sound field—is the anomaly arising from movement of the camera. All the O.R.T.F. tapes were of an orchestra and the conventional camera techniques of zooming, panning or otherwise changing the viewing angle without a corresponding change in the aural perspective upset even a lay audience.

For experimental two-channel television sound transmissions O.R.T.F. have used the pilot-tone system transmitters of France Culture, bringing to mind the early days of stereo radio in Britain. Of course, in principle the pilot-tone system could be applied to television sound transmissions, but the French use a.m. and the O.R.T.F. engineers see little prospect of change, or of introducing f.m. sound on another frequency.

'La tetraphonie' turned out to be a series of recordings made with different microphone configurations and replayed through four loudspeakers, disposed in various ways around the room. Practically coincident cardioid microphones are used extensively for two-channel work by O.R.T.F., so it was surprising that, despite a claim to have employed all the obvious arrangements, a true tetraphonic format was not used. The five situations presented are illustrated. As one might expect (a) and (b) seemed to please most people, although (a) tended to produce obvious rear images if one was too near the rear speakers, while (e) was obviously 'left-right' and, despite the sense of ambience, thought less good than either (a) or (b). Arrangements (c) and (d) were thought not worthwhile by most listeners.

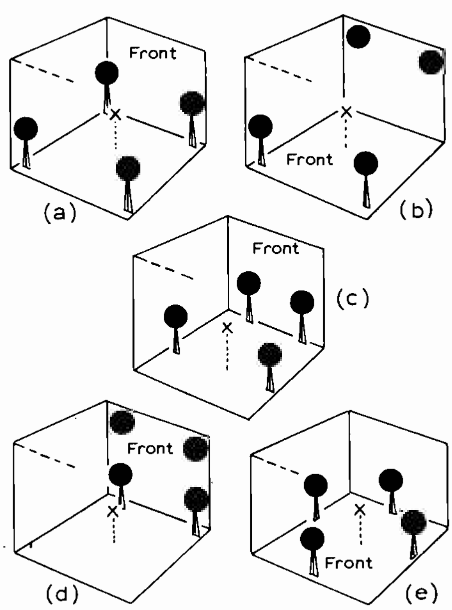
Notwithstanding the semblance of experimental conditions, including the issue of forms for gauging 'audience reaction', and the excellent presentation, several engineers present commented on the lack of experimental design and the absence of any provision for comparison between mono and two-channel stereo, not to mention between four channels and one of the four-channel simulation processes now available. Whatever the results of the tests, they will hardly repay the enthusiasm and efforts of those responsible.

One or two excellent pieces of equipment not at present available in the U.K. were noticed, and most impressive in terms of sound quality were the electrostatic headphones produced by Audiotec. This small French concern produces three excellent loudspeakers and a range of electronics as well as importing the wares of the Japanese Stax company. Having handled their electrostatic headphones—similar in design to those described by J. P. Wilson in *Wireless World* in December 1968—and concluding that they could do better, Audiotec produced their own giving the Stax product to another agent. A true push-pull design with transformer drive, the headset is claimed to have a response of 20Hz to 20kHz $\pm$3dB and a maximum sound output of 115dB. Heard in conjunction with the Stax capacitative pickup the quality was noticably smooth and musical—definitely one of the few acceptable noises in the show.

One interesting approach to turntable design was displayed by Link. Taking the decoupled suspension/belt-driven system devised many years ago by Acoustic Research, the designer has attempted to produce a more stable machine by inclining the suspension and adding damping, claiming the unit is then more stable to lateral and vertical shocks which represent the two most likely modes. The Link turntable also employs an unusual main bearing with a bronze bush and Teflon insert mounted in the platter, a fixed supporting member being rigidly attached to the floating plate. As the centre of gravity of the assembly is below the point of suspension any tendency for the platter to take up slack in the bearing by rocking as it rotates is said to be eliminated, improving the rumble performance of the equipment.

Two loudspeakers claimed to be 'servo controlled'. Few details were available of the American Harmon-Kardon Landmark 100 which purports to use motional-feedback, the literature available referring to a 'correcting signal' derived from the drive units, but giving no explanation of its origins. Whatever its merits as a design the resultant sound was truly horrible, perhaps due to the inept demonstration.

The Belgian Servosound is based on the idea (attributed by Prof. Korn, the designer, to Paul Voigt) of using the output impedance of a feedback amplifier to compensate for the acoustical deficiencies of the loudspeaker and its enclosure. Accordingly the loudspeakers are sold complete with 20 or 60-watt amplifiers in which the n.f.b. loop includes a component mysteriously labelled 'circuit cybernetique d'asservissement'. This turns out to be a bridge which includes compensation for the acoustical and electrical circuits of the drive unit and its enclosure *at low frequencies*, thus avoiding the problems associated with negative output impedances in the past. Professor Korn claimed this was the only way of obtaining properly controlled cone motion at low frequencies and that in his experiments 11dB of electrical damping could be produced compared with a maximum of 4dB using mechanical methods. R.F.J.



When O.R.T.F. used these arrangements for demonstrating four-channel recordings, most listeners preferred (a) and (b). Symbol X denotes ideal listening position, and 'front' the direction listener was facing. In recording, cardioid microphones occupied complementary positions, but in (a) were closer together than in (b).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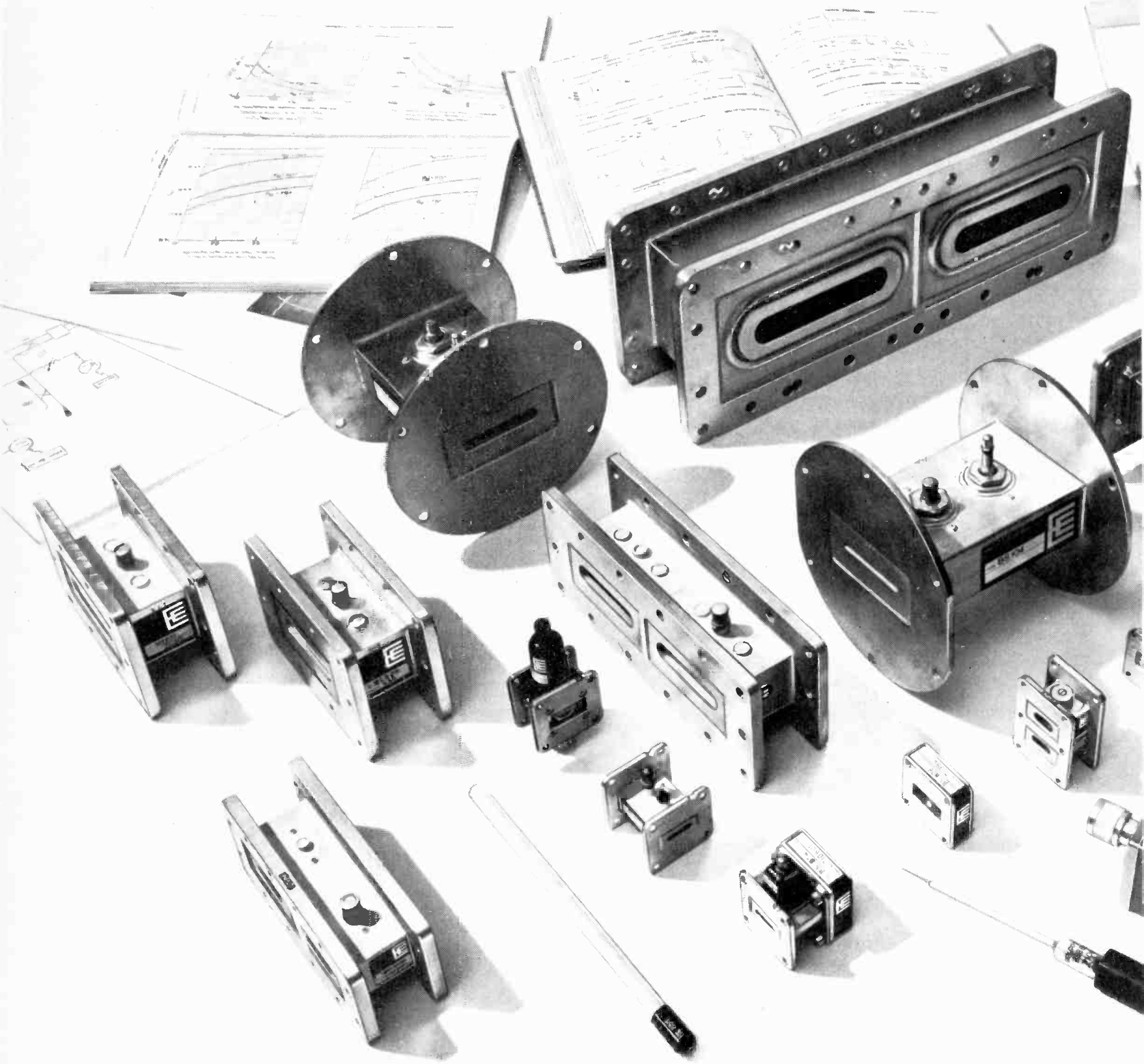

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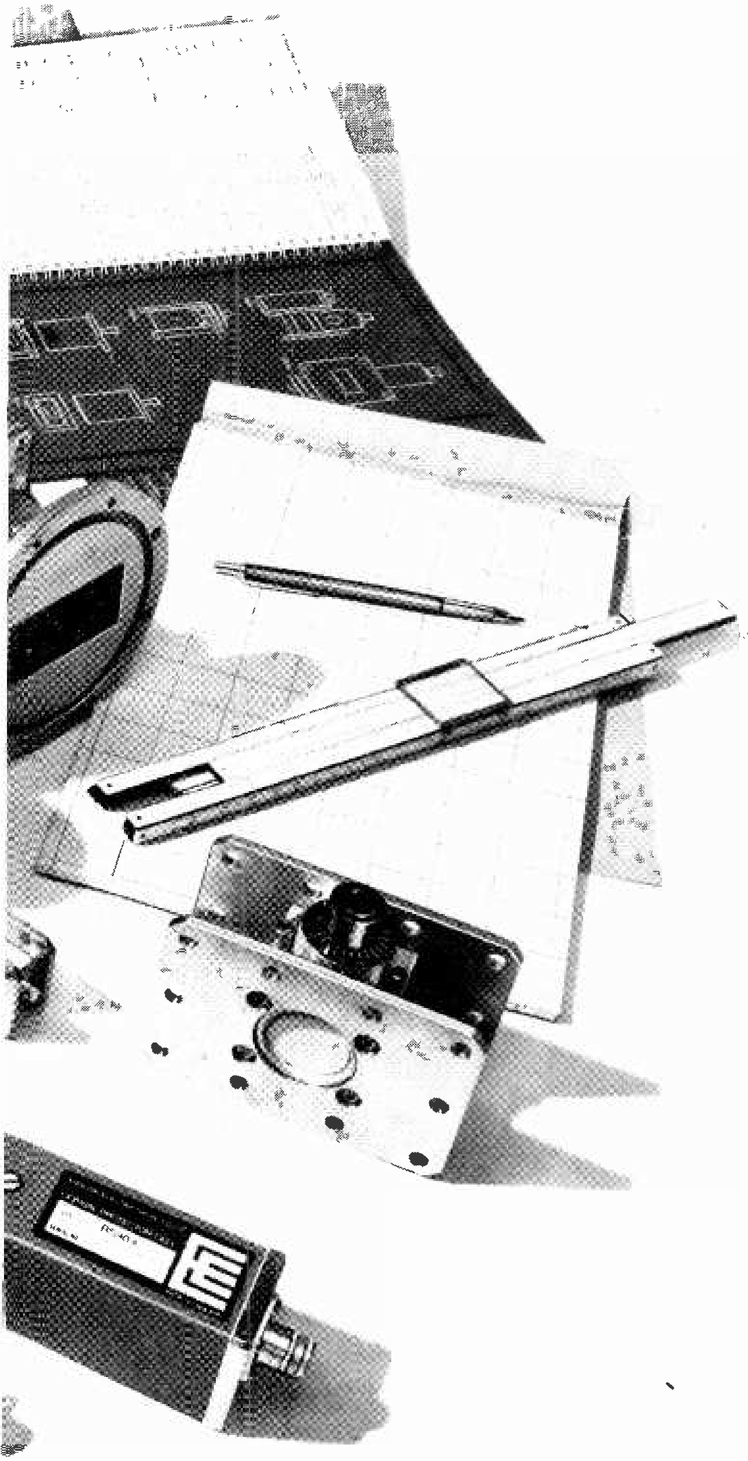

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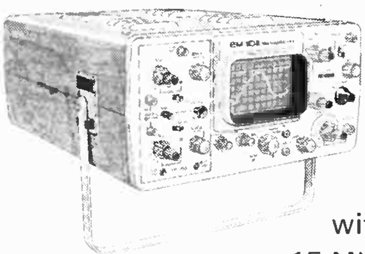

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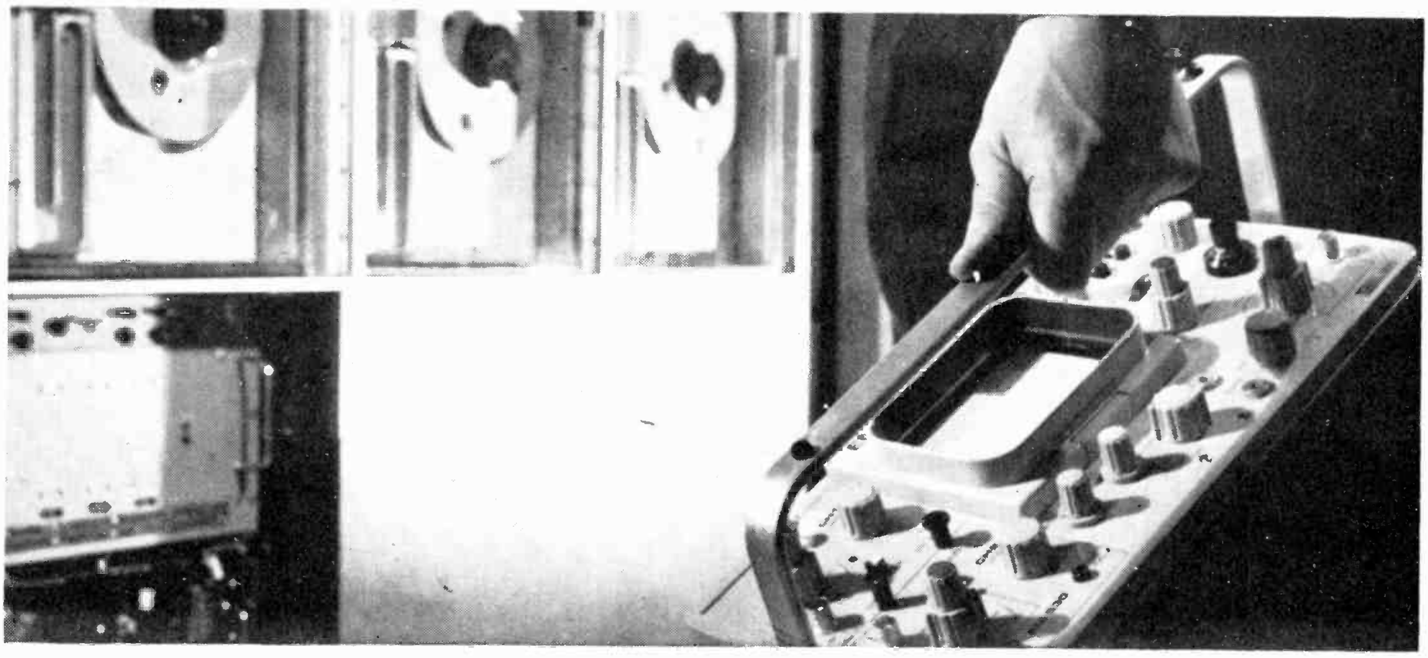

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2—Further details of high-performance design for home construction

by L. Nelson-Jones, F.I.E.R.E.

This sensitive f.m. tuner design, described in last month's issue, has a performance equal to the better examples of commercial tuners, but at a much lower cost. Full constructional details were given in Part 1 and this article discusses in detail some of the devices used—especially the dual-gate m.o.s.f.e.t., integrated circuit demodulator and ceramic i.f. filters—and concludes with alignment instructions.

The dual-gate m.o.s.f.e.t. is not to be confused with the type of junction f.e.t. which has two gate connections, usually one to the gate and the other to the substrate, as this has gates effectively in parallel. The dual-gate m.o.s.f.e.t. has gates effectively in series so that it can be likened to the multi-grid valve or a cascode stage and like these devices has the advantage of very low feedback capacitance from output to input. It has also the same advantages as single-gate m.o.s.f.e.t.s namely, good signal handling, low noise, and high input impedance. Fig. 9 shows the likeness of the dual-gate m.o.s.f.e.t. to a cascode stage, and its construction. The drain current of a dual-gate m.o.s.f.e.t. is a function of both gate potentials, and this enables gate 2 to be used for gain control in the case of r.f. amplifiers, or for injection of local oscillator voltages in the case of mixer stages. Type 40673 is very similar to the 3N140 but in addition has full protection of both gates by pairs of zener diodes between each gate and the source (and substrate) electrodes. These diodes are clearly of minute proportions—they add only a fraction of a picofarad to the gate capacitances. The breakdown of these diodes is around ±10 volts, so that normal signal levels do not cause conduction. But the diodes will conduct long before the gate breakdown voltages are reached, and, provided the resultant currents are adequately limited by the circuit values, no harm will result to the gates.

Apart from the obvious advantage of two controlling gates, the great advantage of the second gate is that it acts as a 'guard ring' between the drain, and gate 1. The result of this guard ring action is a typical drain-to-gate 1 capacitance of 0.02pF (with a maximum for the 40673 and 3N140 types of 0.03PF). This low value of feedback capacitance enables such a device to give up to 28dB of power gain at 100MHz, without need for neutralization, but in practice a gain of 20dB is a more realistic figure for an r.f. amplifier at this frequency. This ensures a high margin of stability, which together with the superior signal handling qualities of the m.o.s.f.e.t. make this a very easy device to use for r.f. amplification in an f.m. tuner.

Integrated circuit i.f. amplifiers

Integrated-circuit i.f. amplifiers have been available for some time now in various forms, from the simple differential pair and the cascode stage, up to relatively complex circuits such as that used in the receiver described (TAA661B). There are now a number of these more complex circuits available, nearly all of which use a product detector for demodulation. Examples of these are the Sprague ULN-2111, Plessey SL432A, and the SGS TAA661B. Fig. 10 shows the circuit of the TAA661B, together with the basic external connections.

Gain is provided by three stages, each of which is a non-saturating differential amplifier followed by an emitter follower.

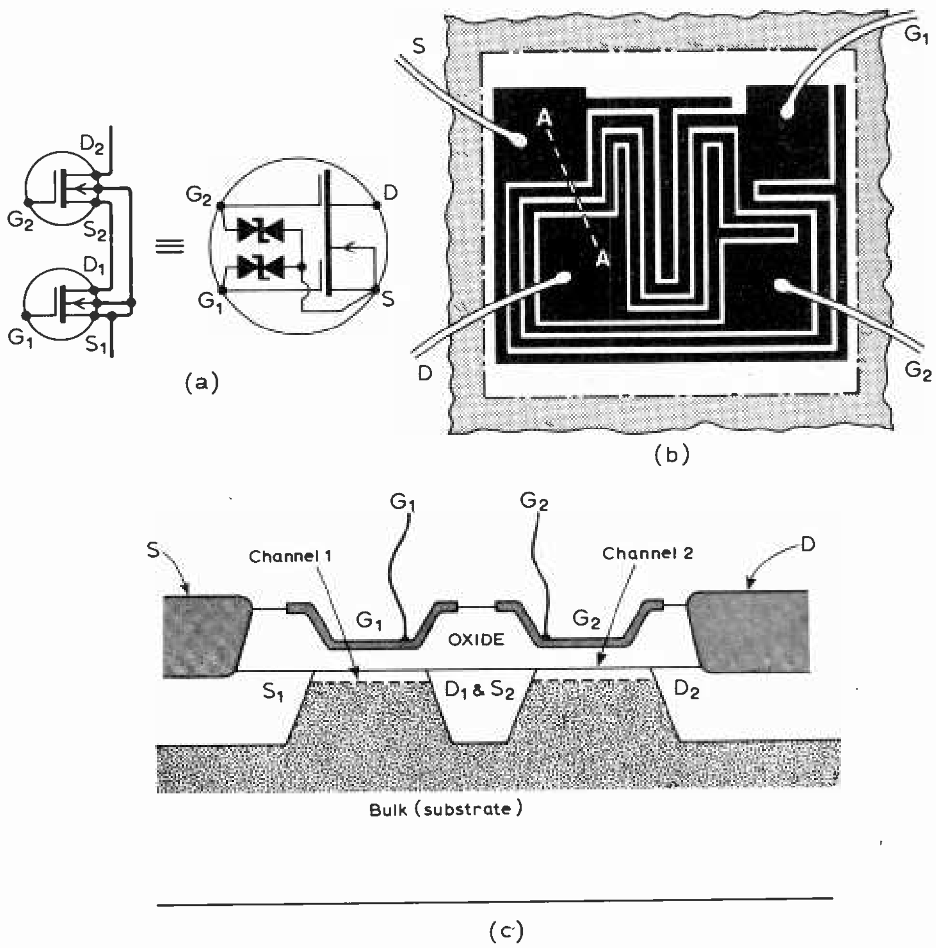


Fig. 9. Symbolic representation of dual-gate m.o.s.f.e.t. (a) showing similarity to cascode stage. Plan view (b) shows complete separation of gate 1 from drain-by-gate 2; (c) shows section across A-A. Bi-directional zener diodes conduct at around ±10V preventing gate breakdown (type 40673 only).

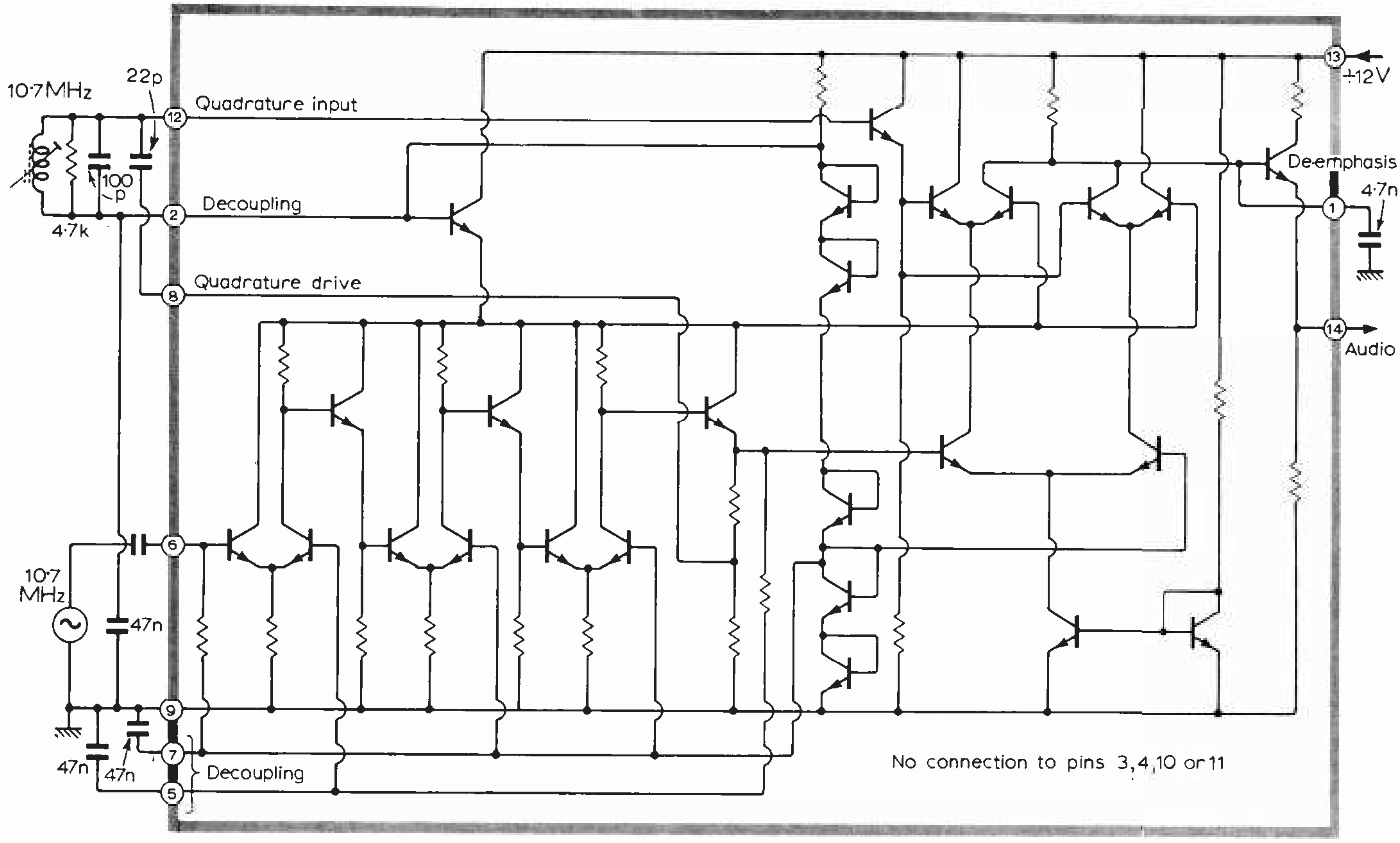


Fig. 10. Demodulation and i.f. amplification are performed in this single-chip integrated circuit (TAA661B). Phase-sensitive detector consists of 'tree' of differential pairs with constant-current tail (to right of bias chain), fed with a phase reference provided by tuned circuit and with signal to lower pair.

Overall d.c. feedback is applied so that the output level at the third emitter follower is kept equal to that of the base of the input transistor. This voltage is set at approximately 1.4 volts by the bias chain of five diodes which has two outputs, equal to two and five 'diode voltage drops'. The higher of these voltages is used to control the main supply line of the amplifier stages via an emitter follower. This supply line is therefore at approximately 2.8 volts—five 'diode drops' less the base-diode drop of the emitter follower.

The detector consists of a 'tree' of differential pairs with a constant-current source in the common 'tail' connection. This constant-current source is a 'current mirror' circuit where the constant current is equal to the current feeding the second transistor, strapped as a diode. The current mirror principle is based on the fact that two equal transistors with equal base-emitter voltages will also have equal collector currents. This principle may be extended so that two transistors of an integrated circuit having different areas (but otherwise similar) will have collector currents equal to their areas when used in such a circuit.

The detector acts as a phase-sensitive full-wave rectifier, with a phase reference provided by a tuned circuit driven from a tap on the load of the final emitter follower of the amplifier. The lower two transistors of the tree are driven by the signal from

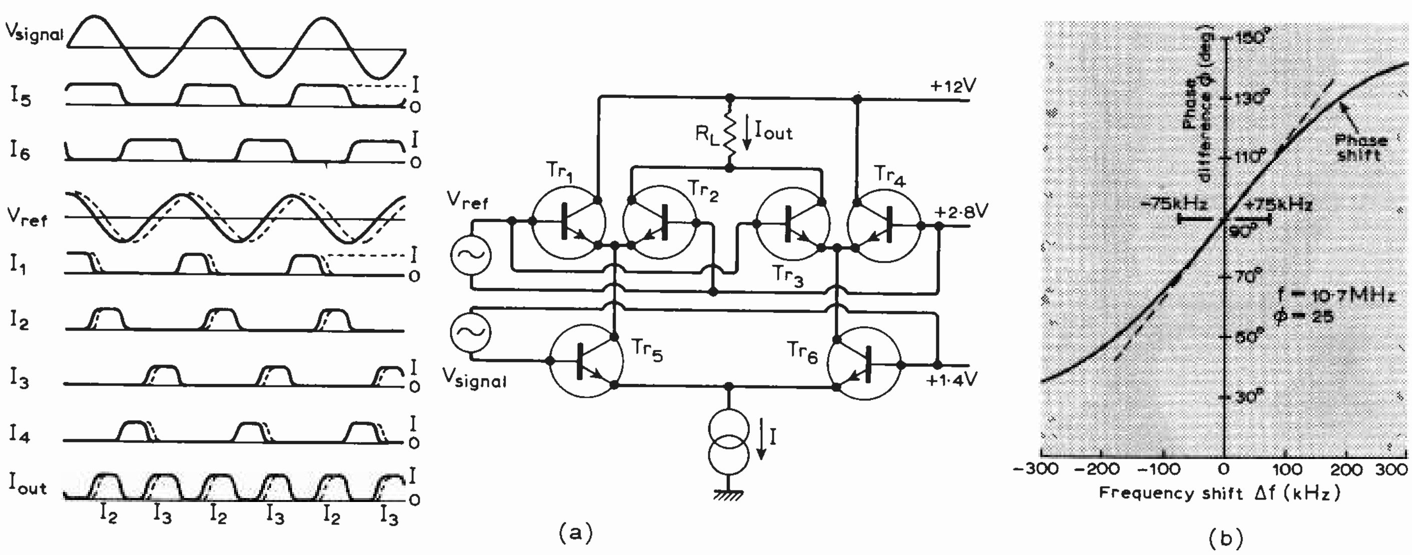


Fig. 11. At resonant frequency of tuned circuit—see Fig. 10—signal applied to lower differential pair is in quadrature with reference from tuned circuit fed to upper pairs, and current divided equally between each of the upper pairs (a). When signal frequency deviates, phase difference between the two signals increases or decreases (b), changing proportion of current through each half of both upper pairs.

the amplifier, and as the two bases of the pair are at equal d.c. potential—due to the overall 100% d.c. feedback over the amplifier—the collector currents of these two transistors become square waves at the carrier frequency, at all signal levels above the limiting threshold of the amplifier chain. The two upper pairs of transistors are fed by the reference voltage from the tuned circuit and like the lower pair the bases of both pairs are at equal d.c. potential.

One base of each pair is connected to the supply line of the amplifier, while the other is fed by an emitter follower, biased via the tuned circuit from the same potential as the base of the emitter follower controlling the supply line of the amplifier. The voltage across the tuned circuit is approximately 300mV peak-to-peak with full limiting so that these upper pairs of transistors are also fully switched at the reference frequency. At the resonant frequency of the reference circuit, the signal voltage applied to the lower pair of transistors is in quadrature with the signal from the tuned circuit to the upper pairs of transistors, due to the loose coupling of the tuned circuit via the 22-pF capacitor. Thus at resonance the current square wave through each half of the lower pair of transistors will divide equally between each of the upper pairs, because the two signals are in quadrature, and the transition of the reference waveform takes place midway through each half cycle of the current square wave supplied by the lower pair. Action is shown in Fig. 11a.

As the frequency departs from the centre frequency of the tuned circuit, the phase difference between the two signals decreases or increases, depending on the direction of the frequency shift, so that the proportion of the current passing through each half of each upper pair changes, Fig. 11b. The collectors of the upper pairs are connected so that the pair which have an increase in current for an increase in frequency are connected together, as are those having a decrease. One pair of collectors is connected to a load resistor, and the other pair direct to the 12-volt supply. The load resistor drops approximately 6.0 volts at the centre frequency so that the output level is typically +5.5 volts, at the emitter of the emitter-follower output stage.

De-emphasis is arranged by a capacitor connected to the base of the emitter follower. Alternatively a separate de-emphasis network can be connected to the output in the usual way, with a much smaller value of capacitor connected to pin 1. A capacitor connected to this pin is still essential to preserve overall stability by by-passing the r.f. voltages present at this point. A similar reduction is necessary if the output is applied to a stereo decoder. A value of 150pF is suitable in either case.

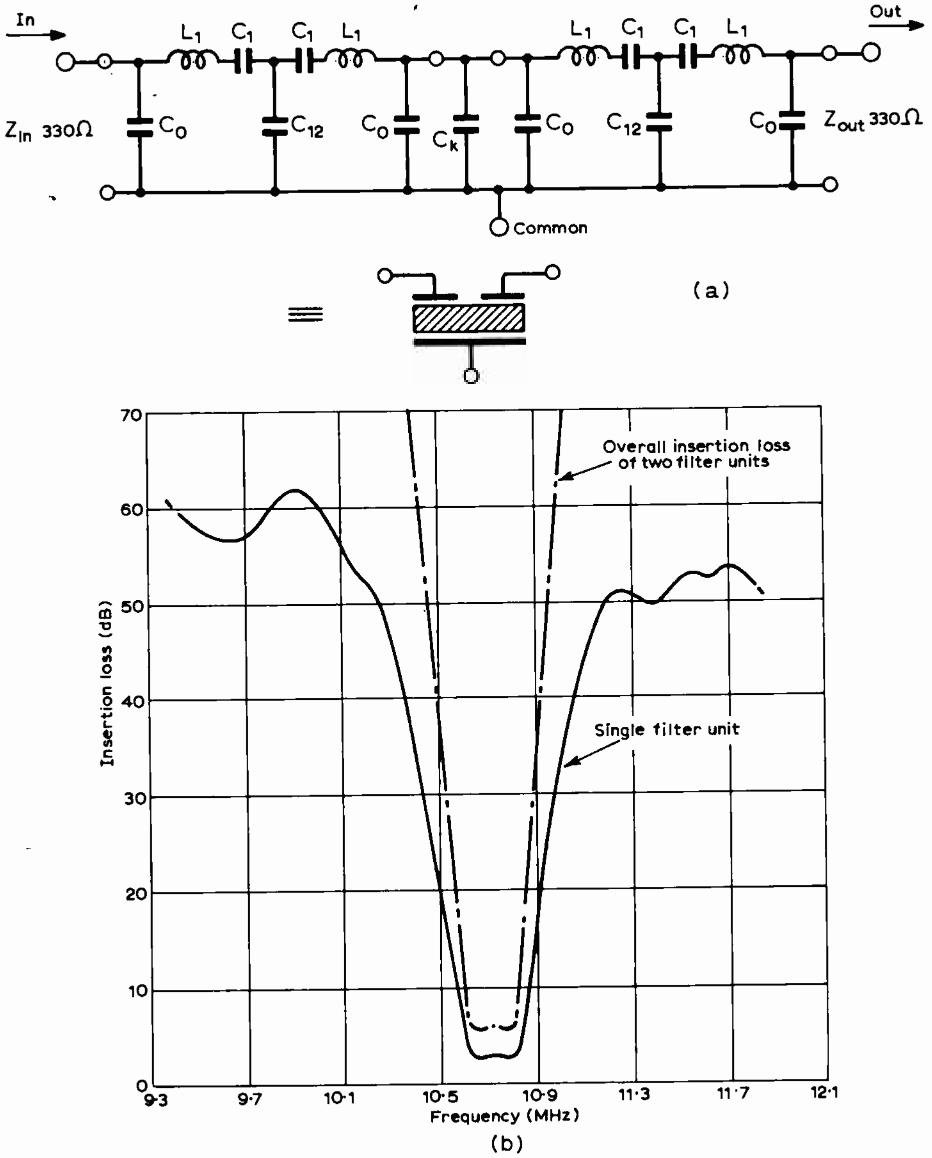


Fig. 12. Ceramic resonrtor used is equivalent to two 2-pole filters coupled by capacitor C_k (a) and has selectivity shown at (b). Two cascaded filters give a bandwidth of 220kHz at 3dB down and 560kHz at 60 dB down.

Ceramic i.f. resonators

There are a number of ceramic resonators on the market and they take different physical forms. Some are similar to the type of filter common in communications receivers where high degrees of selectivity are required, and these have tuned circuits at input and output with one or more resonators between. Others use only ceramic resonators, with perhaps coupling capacitors, and have a family resemblance to the type of crystal filter used in v.h.f. communications receivers for high degrees of i.f. selectivity at 10.7MHz. The type of filter used in the tuner consists only of a single ceramic resonator which by the layout of its electrodes performs the function of a multi-section filter with a bandpass characteristic.

Such filters are now also being made in quartz for v.h.f. communications receivers and can equal the performance of much more complex multi-element filters, despite their relative simplicity. This excellence of performance is true also of the ceramic type, where the device used has a performance slightly better than a multi-element device of otherwise similar characteristics, both in respect of selectivity and passband loss. Due to its greater simplicity it is also much cheaper, and smaller.

The equivalent circuit of the filter (Vernitron FM-4) is of two 2-pole filters coupled by an additional capacitor *Ck* as shown in Fig. 12. Physically all the elements are on a single ceramic substrate. The overall response is equivalent to two critically-coupled bandpass circuits in cascade. Figure 12b shows the typical selectivity of such a single unit (solid curve) consisting of a single substrate multi-pole filter with the equivalent circuit of Fig. 12a. The broken curve shows the result of using two such complete resonator units (with a suitable buffer stage between) to obtain higher selectivity. The resultant performance is more than adequate for f.m. broadcast reception, with 3-dB bandwidth of typically 220kHz and 60dB bandwidth of around 560kHz. Ripple in the pass-band is quoted as not exceeding 1dB (2dB for two stages).

Measurements confirm these figures for typical pairs of filter units in a practical amplifier. These resonators cannot be coupled directly to one another in normal use or the balance of the response curves will be upset, resulting in a highly asymmetric response—the use of driving or load impedances noticeably different from the 330-ohm design impedance will upset the degree of coupling in individual sections. This relatively low impedance of 330 ohms is perhaps one of the drawbacks of this type of ceramic resonator, although most such filters have impedances in the same region. In practice, however, the reduction in gain due to the use of such low-impedance loads in the amplifier chain is not too serious, especially as an additional low-gain buffer stage between the filter sections is needed to avoid interaction of the filters.

The most serious loss of gain from this low load impedance would occur in the mixer stage, where with a typical dual-gate f.e.t. stage as described, the voltage gain of the mixer would be reduced to a little below unity with such a load. In the tuner design the mixer is therefore modified to use a tuned load with a grounded-base buffer stage feeding a 330-ohm resistive load to which the first filter is connected. This ensures a true 330-ohm source for the filter, and results in an overall mixer gain of 24dB. The mixer load circuit is designed to work at only a moderate Q so that the tuning of this circuit is not highly critical.

Due to production tolerances the ceramic resonators are graded into frequency bands and appropriately colour coded to indicate their exact frequency tolerance. For the type used there are five groups covering a total spread of 150kHz (at 37.5-kHz intervals) around 10.7MHz. In a receiver using two such filters, both must be of the same colour group to achieve a satisfactory result. (Details of these groupings were given in the parts list.)

Variable-capacitance diodes

In the past few years some improvements have been made in the parameters of variable-capacitance diodes for tuning. These improvements have given diodes a higher Q and a wider variation in capacitance for a given voltage change. Many tuners now use such diodes exclusively for tuning the r.f. circuits, and they are becoming common in u.h.f. television tuners. The great advantage of these diodes for tuning is that the r.f. circuitry can be made very compact, thus minimizing pick-up and easing screening problems, and making circuit location independent of dial mechanism location. The main disadvantage, so far as the average constructor is concerned, is that both availability and price are at a disadvantage compared with a normal tuning capacitor at the present time.

Another common use of these diodes is a.f.c., and here the requirements are not nearly so severe as only a small variation of capacitance is required. Availability of diodes for this purpose with a smaller change of capacitance with voltage is fairly good and prices are moderate. Such a device is the Texas TIV307, whose capacitance versus voltage curve is shown in Fig. 13 (as measured by the author on three samples). This device could also be used for tuning purposes—it has just adequate capacitance variation without

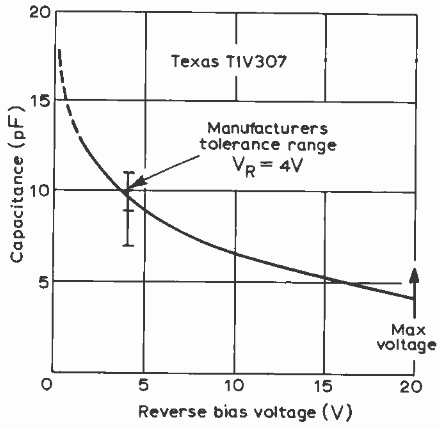


Fig. 13. Capacitance-voltage characteristic for a.f.c. diode.

using too high or too low a control voltage. Too low a control voltage is undesirable, especially in the oscillator stage, where harmonic generation and conduction of the diode become a problem at low bias voltage. Too high a voltage can be a problem either because the diode will not withstand it, or because the voltage is simply not available.

The smallest capacitance swing is in the oscillator circuit (from 87.5 + 10.7 = 98.2 to 108 + 10.7 = 118.7MHz) which has a frequency ratio f_{max}/f_{min} of 1.22, and a capacitance ratio of 1.22^2 :1 or 1.46 : 1. The r.f. circuits need a capacitance swing of $(108/87.5)^2 = 1.53:1$. A swing of from 2.5 to 7 volts would give such a change if the only capacitance were the diode. But there will always be 10-15pF of general circuit capacitance, so that a diode change from 10 to 20pF at least is necessary (or just over 2:1 variation in the diode). With some care in circuit layout and a change in L/C ratio the TIV307 could just give this swing (or its companion with higher capacitance TIV308–12pF at −4 volts), especially if a higher supply voltage than the 12 volts used in the design were available. It is the author's intention at a later date to design a diode-tuned receiver, but in the present design a normal tuning capacitor is used mainly on the grounds of cost and the difficulty of obtaining diodes in suitably matched triplets.

Alignment of tuned circuits

The tuned circuits must be aligned in reverse order, that is starting at L_5 and working back to L_1. By far the easiest way of aligning the i.f. section is to use a wobbulator centred on 10.7MHz and having a sweep frequency of 50Hz, with a peak-to-peak deviation of 1 to 2MHz. Fig. 14 shows the response of a correctly aligned i.f. amplifier and demodulator: The y-axis is the output of the tuner (1 volt/division) and the x-axis is the modulation voltage (75kHz/division). The display shown is for a moderate input, but is well into limiting. Apply the wobbulator input to L_2 via a capacitor at about 1mV level from 80 ohms. The core of L_4 is easily set for maximum gain by looking at the noise amplitude at either side of the display. As the core is moved the noise is first greatest on one side and then at the other as the resonant frequency of L_4 moves across the band. Set the core to mid-way between the positions giving maximum noise on either side.

If a wobbulator is not available then at least a signal generator must be used. Connect as for the wobbulator above to L_2 via a capacitor and apply a level of around 1mV from 80 ohms. Connect a centre-zero meter of around ± 3V full scale between the output and the a.f.c. reference lead (preferably better than 10kohm/volt sensitivity). Rock the tuning of the signal generator back and forth around 10.7MHz while adjusting the core of L_5 until the positive peak excursion is equal to the negative peak excursion—Fig. 14. If the signal generator calibration is fine enough the tuning of L_5 is finally set for best linearity, plotting output voltage against frequency. If the core of L_5 is far from the correct setting, the output may be a totally positive or totally negative excursion, with no S-shape.

If a centre-zero meter is not available the 10-volt range of a multi-meter may be used connected between the output and earth. When the signal generator is far off tune the reading of the output level should be around 5.5volts (supply at 12 volts). This is equivalent to the zero centre reading using the centre-zero instrument as above. The tuning of L_5 is now set for equal deflections about 5.5 volts.

To set L_4 the signal generator is set slightly to one side of the centre frequency and the level dropped until the meter indication begins to change (i.e. drops below limiting level). Adjust L_4 to make good this change (i.e. to increase signal strength) reducing the signal generator level to keep the i.f. stages below limiting level. Continue the process until no further improvement can be made. Alternatively, the core of L_4 may be tuned for maximum noise output with no signal generator connected or with the generator switched off.

While aligning the i.f. section it is a help to have the oscillator out of action to

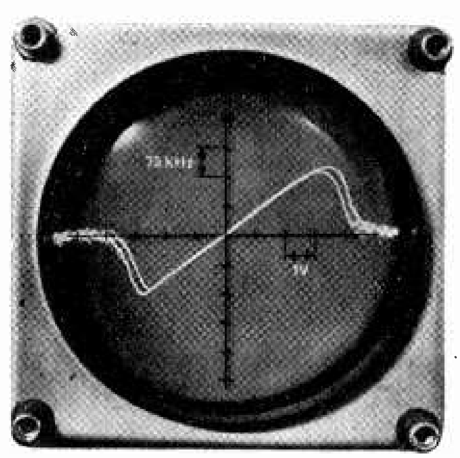


Fig. 14. Response of correctly aligned i.f. amplifier and demodulator. L_4 is set for maximum gain midway between positions giving maximum noise, either side of the display.

prevent spurious responses from i.f. harmonics. This is most easily achieved by shorting out L_3 with a single crocodile clip across the ends of the coil to connect together the end turns.

It is not sufficient to set the output level to 5.5. volts (or zero with respect to the a.f.c. reference) with an input of 10.7MHz when tuning L_5 for two reasons. First the majority of signal generators, even of very high quality, are not accurate enough to ensure a symmetrical S-shaped characteristic, and, secondly, the ceramic resonators are not necessarily peaked at 10.7MHz. If the frequency of the generator is known to within about 10kHz or better and is set to the i.f. indicated by the ceramic resonators colour code (see parts list), then L_5 may be set initially in this way. But the symmetry of the S-shaped characteristic of the detector should still be checked after setting L_4, and any slight correction made as appropriate to the core position of L_5.

Align the r.f. section in the usual way for superheterodyne receivers—set the oscillator so that the correct span of input frequencies is covered, and then adjust the r.f. circuits to track correctly.

To adjust the oscillator set the tuning capacitor to maximum capacitance and the signal generator to 87.5MHz. Adjust the variable capacitor next to the oscillator coil to receive the 87.5-MHz signal. Set the tuning capacitor to minimum capacitance and the signal generator to 108MHz. Now adjust the trimmer capacitance again noting which way this adjustment is to tune in the 108-MHz signal. (With this type of capacitor, maximum capacitance is with the silvering on the top disc towards the centre connecting pin of the capacitors three pins, and minimum is 180° from this position i.e. farthest from the middle pin.)

If the capacitance setting needs reducing at 108MHz then increase the value of L_3 by squeezing the coil to bring the turns closer together. Re-adjust the capacitor to bring the receiver back to tune at 108MHz and return to 87.5MHz and maximum capacitance of the tuning capacitor. If the trimming capacitor now needs decreasing in capacitance then the coil inductance has been increased too much.

An alternative method, possibly quicker, is to set the 108-MHz end using only the trimmer capacitor and then find to what frequency the low-end is tuned, without altering the trimmer capacitor. If this is below 87.5MHz, reduce the inductance by opening out the turns; if it is above 87.5MHz, close up the turns. Set the frequency and tuning again to 108MHz and reset the trimming capacitor. Return to the low end and again check the frequency the receiver is set to; continue this process until on reaching the low end the receiver is set to exactly 87.5MHz.

Having set the span of the oscillator, the two r.f. coils and their trimmer capacitors need adjusting to complete the alignment. This is possibly the most difficult part of the alignment procedure because of the high sensitivity of the receiver. Perhaps the simplest method is to dispense with the signal generator altogether at this point and to tune for maximum noise, with the signal generator switched off but still connected. Tracking of the r.f. coils may be set in a similar way to the oscillator coil.

Set the tuning capacitor to minimum capacitance, and tune for maximum noise using the trimmers. Set the tuning capacitor to maximum capacitance and, in the manner used for the oscillator, check whether the trimmer capacitance needs increasing or decreasing to tune for maximum noise at the low-frequency end of the dial. If the capacitance needs increasing, squeeze the coil turns closer together; if the trimmer needs decreasing in capacitance then open out the coil turns slightly. Return to the minimum value of the tuning capacitance and repeat the process from the beginning, and continue to do so until both r.f. coils need no change of tuning of the trimmer on going from one end of the dial to the other.

Further reading

The publications listed may interest those wishing to pursue various design aspects.

"MOS field-effect transistors", RCA product guide MOS160A

Data sheets on devices 40673, 3N140, 3N141, 40603, 40604 (RCA)

Data sheets on devices CA3028A, 3028B, 3053 (RCA)

"Understanding and using the dual-gate m.o.s.f.e.t." RCA application report ST-3529

"Application of dual-gate m.o.s. field-effect transistors in practical radio receivers," RCA application report ST-3486

"Integrated-circuit frequency modulation i.f. amplifiers", RCA application report ICAN-5380

"Integrated circuits for f.m. broadcast receivers", RCA application report ICAN-5269

"Use of 10.7MHz ceramic coupled-mode filters in linear i.c. i.f. strips", Vermitron application report

Data sheet on ceramic filter FM-4, bulletin 94033 (Vernitron)

Data sheet on TAA661B (SGS)

Addresses

RCA (GB) Ltd, Lincoln Way, Windmill Road, Sunbury-on-Thames, Middx

SGS Ltd, Aylesbury, Bucks

Vernitron Ltd, Thornhill, Southampton SO9 1QX, Hants

Correction

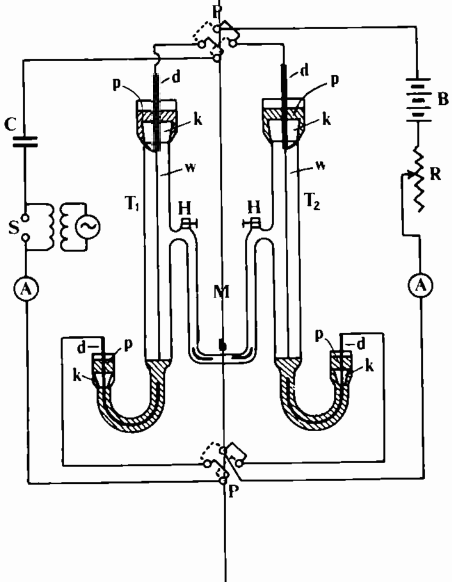
In the parts list for the tuner–published in the April issue–47-nF capacitors (10 needed) were accidentally omitted. These can be similar types to the 1-nF capacitors. In Fig. 4 a link should be added to the top left corner of L_5, between the earth area at the perimeter and the earth area under L_5. Inductor L_5 should be 10 turns–Fig. 6c. Finally, in the caption to Fig. 2, pin 2 should, of course, read pin 1.

Sixty Years Ago

May 1911. *The Marconigraph*, the original title of *Wireless World*, opened its second issue with a word of thanks to the press and the public on the reception accorded to issue No.1. The writer of a short note on the journal's content was extraordinarily prophetic when he wrote 'The other short articles and notes of recent happening in the Wireless World will no doubt prove of interest to all'.

The major technical article in the issue "A note on the Experimental Measurement of the High-frequency Resistance of Wires" was written by Dr J. A. Fleming. In essence the technique consisted of obtaining two samples of the wire and passing an a.c. current down one and a d.c. current down the other. The d.c. current was adjusted until the amount of heat produced in each wire was equal. It was then possible to calculate the r.f. resistance of the wire. The original drawing is reproduced on this page. The wires (w) are suspended in mercury (k) in air-tight glass tubes (T_1, T_2). The temperature changes affect the mercury levels and therefore the air pressure in each tube. The air bubble in paraffin oil (b) indicates the pressure difference.

This was all before the days of oscillators and the method of generating the a.c. waveform is of interest. This is how Fleming described it: 'The greatest practical difficulty is to secure a sufficiently steady high-frequency current. This was generated by employing a motor-driven alternator to give current to a large high-tension transformer raising the potential of an alternating current having a frequency of 50 to a potential of 10,000 or 20,000 volts. This voltage was used to charge one or more Leyden jars, which were discharged across a spark-gap, an air-blast on the gap being used to steady the discharge. The frequency of the oscillations so created was measured in each case by a cymometer, and the mean-square value of the current by one of the Author's hot-wire thermo-electric ammeters'.



London Component Show

Exhibitors at Olympia, May 18-21

Although held in alternate years, with very different titles, the London Electronic Component Show and the Instruments, Electronics & Automation Exhibition are very similar and the participants largely the same. This year it is the turn of the Component Show which opens at Olympia on 18th May for four days. It will be open each day from 10.00 to 18.00 and admission is 25p (overseas visitors free).

Below we list the manufacturers and suppliers who are participating. Many of the overseas manufacturers listed are being represented by their agents whose names are given in parentheses. Some others, as with the French and Spanish, are participating in collective displays. In addition to the manufacturers listed below several banks, publishers (including our own IPC Electrical-Electronic Press), the Minpostel and other organizations providing services to the electronics industry are exhibiting.

The Electronic Components Board is organizing a conference on the theme "Forward into the '70s" which is to be held at the Royal Garden Hotel during the period of the Show.

AB Electronic Components
AEG-Telefunken (Britimpex)
AMP
A.P.R. (Guest Intl.)
Accumulatorenfabrik Sonnenschein (Bauch)
Adams & Westlake Co.,
Advance Electronics
Advance Filmcap
Aladdin Components
Aladdin Electronics
Alden Metal Products
Alma Components
Alston Capacitors
Altoflex
American Embassy
Amphenol
Arcolectric Switches
Arena
Arrow Electric Switches
Artek Systems (Tranchant Electronics)
Ashburton Resistance Co.
Associated Automation
Astralux Dynamics
Ates Electronics
Atomichron Inc. (Claude Lyons)
Audax,
Aumann K. G. (Cole)
Avo

BICC-Burndy
B. & R. Relays
B.V.C. Electronic Dev.
Bakelite Xylonite
Beckman Instruments
Beclere Company
Belling & Lee
Benedict & Jager (B & R Relays)
Benney Electronics
Berec International
Bertan Associates Inc. (Claude Lyons)
Besson & Partner
Biomation Inc. (Data Labs)
Birch-Stolec
Bissett Berman Corp. (G. E. Electronics)
Bobifil Talleres Tarraso (Kolectric)
Bofors A. B. (Guest Intl)
Bogen, Wolfgang (Cole)
Bonnella, D. H., & Son
Borguno—Jorge Borguno Clua
Bourns-Trimpot
Bowthorpe Electric,
Brandauer & Co.
Britimpex
British Brown-Boveri
British Insulated Callender's Cables
British Physical Labs.
British Standards Inst.
Brookdeal Electronics
Bulgin & Company
Burgess Micro Switch Co.
Burr-Brown Research Corp. (Fluke)

C.B.M. Electronic Components
C.C.L.
C.G.S. Resistance Co.
Cadmium Nickel Batteries
Callins International
Cambion Electronic Products
Carlingswitch
Carr Fastener Co.
Cathodeon Crystals
Celdis
Centralab
Chamberlain & Hookham
Channel Electrical Equipment
Ciba-Geigy (UK)
Cintra Inc. (Fluke)
Circuit Integration
Clare Electronics
Clarke, H., & Company
Clarke-Hess Communications Research Corp. (Claude Lyons)
Cliff Plastic Products (Guest)
Coil Winding Equipment Company,
Cole Electronics
Colvern
Computing Techniques
Comway Electronics
Concordia Electric Wire & Cable Co.
Connollys
Control Data Corp. (Claude Lyons)
Cosmocord
Counting Instruments
Crompton Parkinson
Crouzet
Culton Control Systems
Culton Instruments

Darby Industries
Data Laboratories
Data Precision
Davall & Sons
Daven McGraw Edison (Ultra Elec. Components)
Davis-Relays
Davu Wire & Cables
Daystrom Industrial Products
Deac
Develco Inc. (Claude Lyons)
Dial Engineering Co.
Diamond H Controls
Digital Equipment Co.
Djevahirdjian SA (Cole)
Dubilier Condenser Co.
Dunlop Co.
Durrwachter-Doduco K.G. (J.M. Harding)

ECC Corp. (Claude Lyons)
EFCO,
E.M.A. (Culton Controls)
EMI Electronics
EMI Electron Tube Division,
EMI-Varian
Eagle International,
Edicron
Efco-Frankel
Egen Electric
Elcomatic
Electrautom
Electrical Remote Control Co.
Electricole
Electro Acoustic Industries
Electro Mechanisms
Electrographic
Electrosil
Electroustic
Electrothermal Engineering
Elektronska Industria (Guest Intl)
Elgenco Inc. (Claude Lyons)
Emihus Microcomponents
Engineering Enterprises
English Electric Valve Co.
Enthoven Solders
Erg Industrial Corp.
Erie Electronics
Erma
Etri
Euro Electronic Inst. (Livingston)
Euro Electronic Rent
Ever Ready Company
Evans, Frederick W.
Evershed & Vignoles

FKS Communications (Claude Lyons)
F. R. Electronics
FABRI-TEK Computer Components
Fagor Electrotecnica S.C.I.
Fairchild Semiconductor
Farnell Instruments
Ferranti
Filhol
Floform Parts
Fluke International Corp.
Forbes, Neil D.
Formica
Foxall & Sons
Frequency Electronics Inc. (Claude Lyons)

GDS (Sales)
G.E. Electronics
G.E.C. Electronic Tube Co.
G.E.C. Semiconductors
G.K.N. Screws & Fasteners
G.K.N. Shardlow Metrology
Gardners Transformers
General Instrument Microelectronics
Globe Union/Centralab (Ultra Electronics)
Goodacre & Davenport Semiconductors
Goodmans Loudspeakers
Gordos Corp. (B & R Relays)
Gore & Associates
Greenpar Engineering
Gresham Instrumatic
Gresham Lion Electronics
Gresham Recording Heads
Gresham Transformers
Gruner, W. (G. E. Electronics)
Guest International
Guidline Instruments (Claude Lyons)

H.C.D. Research
Haddon & Stokes
Hallam, Sleigh & Cheston
Harding, J. M., Worthing
Harwin Engineers S.A.
Hatfield Instruments
Hawthorn Baker
Hayden Laboratories
Heath-Gloucester
Hellermann Electric
Hesto-Henkels-Stocko
Highland Electronics
Hinchley Engineering Co.
Hirschmann, Richard (Electroustic)
Hivac
Howells Radio
Huber, J. J.
Hunt Capacitors
Huntec
Hysol Sterling

IRC (Dubilier)
ITT Cannon Electric
ITT Components Group Europe
ITT Electronic Services
Imhof-Bedco
Imperial Chemical Industries
Imperial Metal Industries
Impex Electrical
Inersa, S.A.
Infin S.A.S.—Prodotti Neohm (Dubilier)
Insulating Components & Materials
Integrated Photomatrix
Intercontinental Radio
International Light Inc. (Claude Lyons)
Intersil (Tranchant Electronics)
Iskra Kranj (Guest Intl)

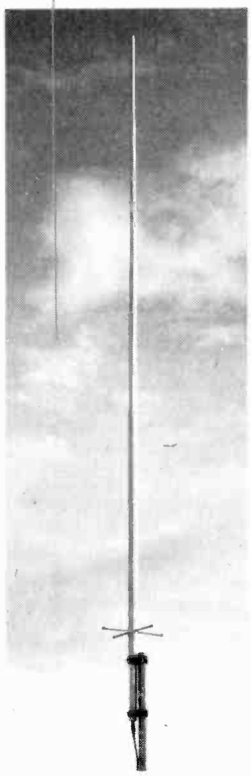
J Beam Engineering
Jackson Brothers
Jeanrenaud
Jermyn Industries
Joseph Electronics

K.S.M. Electronics
Kabel-und Metallwerke (Hayden)
Kemo
Kenton Laboratories
Klippon Electricals
Knowles Electronics
Kolectric
Kovo (Edicron)
Kristall-Verarbeitung (Cole)
Kulite Semi-Conductor Products (Electro-Mechanisms)
Kumag A. G. (Cole)

L.C.R. Components
Labhire
Labservice
Lee Green Precision Industries
Lemosa
Levell Electronics
Lewis Spring Company
Licon Electronics
Linton & Hirst
Lion Mechanical Products
Lipa & Isostat
Livingston Hire
Lloyd Instruments
Lock, A. M. & Co.
Londex
Lucas, Joseph

One of two new instruments from Heath. The 15MHz frequency counter, type IB-101.

Pulse generator, model 728, introduced by AMF Venner. Frequency range d.c. to 30MHz; repetition frequency between 0.2Hz and 25MHz.



Latest v.h.f./u.h.f. colinear aerial from J Beam Engineering in 15-ft glass fibre shroud.

Lyons, Claude
Lyons Instruments

M.B. Metals
M.C.P. Electronics
M-O Valve Co.
McMurdo Instrument Co.
Magnetic Devices
Magnetic & Electrical Alloys
Mallory Batteries
Mann Components
Mansol
Marconi Communication Systems
Markovits, I.
Marquardt, J. & J. (G.E. Electronics)
Mas S.p.A. (G.E. Electronics)
May Precision Components
Mechanics for Electronics (Techmation)
Menzel & Brandau (Collinson-Goodwell)
Metway Electrical Industries
Microsystems International
Midland Engineering & Machine Co.
Millivac Instruments (Claude Lyons)
Milton Ross Co.
Morgan Crucible Co.
Morganite Resistors
Motorola Semiconductors
Mullard
Multicore Solders

N.S.F.
National Semiconductor
Newport Instruments
Nore Electric Co.

Officine Galileo (Techmation)
Oliver Pell Control
Olivera—Justo Olivera Lacruz
Omegna—Talleres
Optimation Inc. (Fluke)
Ostby & Barton Co.
Oxley Developments Co.

Palmer Aero Products
Palmer, G. A. Stanley
Park Royal Porcelain Co.
Parmeko
Pedoka
Penny & Giles
Permacel
Permanoid
Perp—Industrial
Pickering Electronics
Piher
Pistor & Kronert
Plasmoulds
Plastronics
Plessey Co.
Portescap
Power Development
Precious Metal Depositors
Precision Electronic Components (Techmation)
Precision Relays
Preh Elektrofeinmechanische Werke (G.E. Electronics)
Pressac
Printed Motors
Pye Switches
Pye TMC

Quickdraw Co.

R.M.T. (Kolectric)
Radiall Microwave Components
Radiatron
Rafi Electronic (Cole)
Rathdown Industries
Raytheon Co.
Redpoint
Reliance Controls
Rendar Instruments
Research Instruments
Resistances
Reutlinger & Soehne (Cole)
Rifa, AB (Techmation)
Rilton Electronics
Rockland Systems Corp. (Claude Lyons)
Rola Celestion
Roselson—Acustica Electronica
Rosenthal Technical Components
Rosenthal Technische Werke
Ross, Courtney & Co.
Royal Worcester Industrial Ceramics
Ruf Ohg. Wilhelm (Electroustic)
Ruff, H. (Cole)
Russenberger S.A. (Guest Intl)

SECME
SFIM (Electro Mechanisms)
SGS
S.T.P. Electronics
S.T.P. Engineering
Sakae Tsushin Kogyo Co. (Electro Mechanisms)
SASCO
Schaevitz Engineering (Electro Mechanisms)
Salford Electrical Instruments
Saunders-Roe Developments
Scottish Instruments
Sealectro
SEFRAM (Electro Mechanisms)
Semicomps
Semiconductor Specialists
Sfernice
Siemens AG (B. & R. Relays)
Siemens
Sifam Electrical Instrument Co.
Signetics International Corp.
Silec Semiconductors (Electroustics)
Simmonds Relays
Sintered Glass-to-Metal Seal Co.
Smiths Industries
Solderstat
Sorensen Lighted Controls
Souriau Lectropon
South London Electrical Equipment Co.
Southern Transformer Products
Special Products Distributors
Spinner GmbH. (Hayden Labs.)
Sprague Electric
Stability Capacitors
Standard Pneumatic Motor Co.
Steatite Insulations
Steatite & Porcelain Products
Stemag-Steatit-Magnesia (Cole)
Straumann, Reinhard (Claude Lyons)
Suflex
Suhner Electronics
Surrey Steel Components
Symonds, R. H.

Tagra
Tape Recorder Spares
Tau-tron Inc. (Claude Lyons)
Te Re Co. (Permanoid)
Techmashexport of U.S.S.R.
Techmation
Technograph
Technograph & Telegraph
Tectonic
Tektronix U.K.
Tektronix Datatek N.V.
Telcon-Magnetic Cores
Telcon Metals
Teledyne Philbrick Nexus
Telequipment
Temco
Terminal Insulators
Thomson, C.S.F.
Thorn Bendix
Thorn Electrical Industries
Thorn Radio Valves & Tubes
Tokyo Sokki Kenkyujo Co. (Electro Mechanisms)
3M Company
Tranchant Electronics
Tranchant Electronique S.A.
Transistor AG
Transitron Electronic
Tucker, Geo. Eyelet Co.
Tufnol
Tyco Bytrex Division (Electro Mechanisms)

Ultra Electronics Components
Union Carbide
United Detector Technology (Techmation)
United Trade Press
Unitrode Corp. (G.E. Electronics)

Varelco
VARTA Batteries
Venner Electronics
Vero Electronics
Videon S.A. (Cole)
Vision Engineering
Vitality Bulbs
Vitramon Europe
Vitrohm (Dubilier)

Wandleside Warren Wire Co.
Washington, George
Waycom
Waycom Semiconductors
Wayne Kerr Laboratories
Wego Condenser Co.
Weller Electric
Welwyn Electric
West Hyde Developments
Westinghouse Brake & Signal Co.
Weyrad
Whiteley Electrical
Wickmann Werke (G.E. Electronics)
Wingrove & Rogers
Wire Products & Machine Design
Woden Automation
Woden Transformer Co.

Z & I Aero Services

Electronic Building Bricks

11. Adding quantities and numbers

by James Franklin

Arithmetical addition is a familiar process in everyday life and work, and it is quite common in electronics too. Most obviously it is needed in electronic computers—addition of numbers in a digital computer or addition of quantities in an analogue computer. Less obviously, it is needed in electronic communications systems for combining one or more signals into a single signal. The electrical signal which enters your television set from the aerial could be plotted as a single graph—a quantity varying with time—but it is in fact the result of adding, in the transmitter, several component signals bearing different types of information.

We have already distinguished between analogue and digital methods of representing information (Part 4) and this distinction must be continued in the operations performed on the information.

For analogue addition in electronics we can use any of several electrical variables, the most common ones being charge, voltage and current. A method of adding charges (quantities of electrons) can be seen in the principle of charge storage described in Part 6. Transfer a quantity of electrons from one source and another quantity from a second source into the same charge store, and the total quantity of electrons is the arithmetical addition of the two charges.

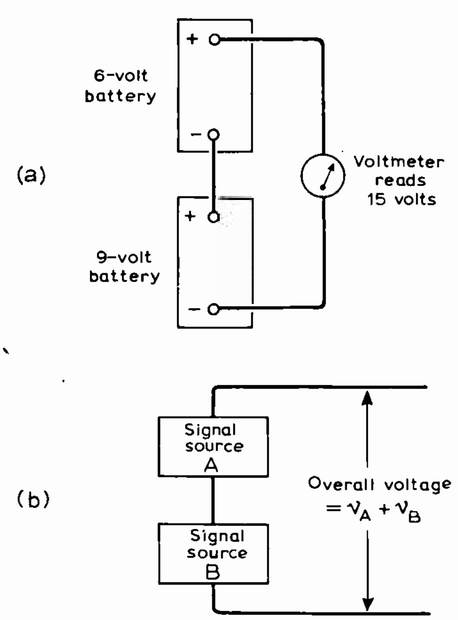


Fig. 1. Way of connecting two batteries (a) so that their voltages are arithmetically added; and (b) the same principle applied to the addition of two voltages which are varying with time.

Adding voltages is familiar to anyone who has put three 1.5-volt cells into a torch to make a 4.5-volt battery, or has noticed that a 12-volt car battery is made up of six 2-volt cells. The principle, which is called *series* connection, is illustrated in Fig. 1(a). But what about voltages which are varying and representing information—how do we add them? The basic principle is the same: the two sources of voltage, the signal sources, are connected in series, as shown schematically in Fig. 1(b) and at any instant the addition of the voltages is the overall voltage measured across the pair. This process is illustrated by the graphs in Fig. 2. The voltage variation with time of source A is plotted in one graph (v_A) and the voltage variation of source B in another (v_B). If the two voltages are added at successive instants of time the total voltage varying with time is as plotted in the top graph ($v_A + v_B$).

Adding currents is achieved by arranging the separate electron flow paths from a number of signal sources to merge into a common path in which the total current can be measured. This is illustrated in Fig. 3 and is known as *parallel* connection. (The letter i introduced here is the generalized symbol for current.) The addition of the three currents at any instant of time is the current measured in the common path. It is easy to understand why this is so if one remembers that current is electron flow rate—coulombs per second (Part 3). Suppose that the three currents in Fig. 3 had steady values of 2, 3 and 7 coulombs per second (amperes). Over a period of one second there would move through the common path a total quantity of electrons (charge) of $2+3+7$ coulombs, that is 12 coulombs. Thus the total flow rate in this common path would be 12 coulombs per second, or 12 amperes. This is for steady currents, but the same principle of addition applies when i_A, i_B and i_C are all varying with time independently.

If we want to add numbers represented in electrical form we have to use the principle of digital adding (see above). This can be achieved in several ways. For example, if we feed six pulses into an electronic counter, then eight pulses, the counter will register fourteen—it will have performed the addition $6+8=14$. The method most widely used, however, is based on binary notation and arithmetic. As explained in Part 6, binary numbers, normally written using the two symbols '1' and '0', can be represented electrically by 'on' and 'off' states of electronic switches. For electronic binary addition, shown schematically in Fig. 4, the information about these states is conveyed from rows of electronic switches (called registers) to a binary adder; and this presents the sum as a line of 'on' and 'off' states in a further row of electronic switches (register).

In Fig. 4 the binary states representing each number are presented to the adder simultaneously. In another method of binary adding the states are fed in serially and the sum states are also produced serially. In fact the inputs and the output of the adder are all signals, in the form of trains and pulses.

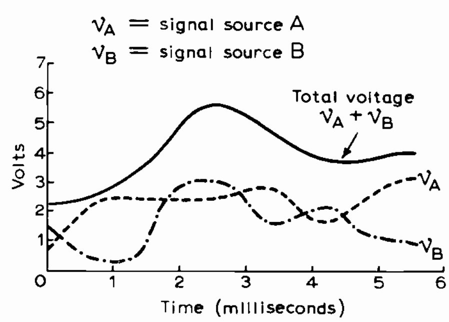


Fig. 2. Graphical illustration of what happens in Fig. 1(b) over a period of time. At any instant the voltages plotted in the lower two graphs add up to the voltage in the upper graph.

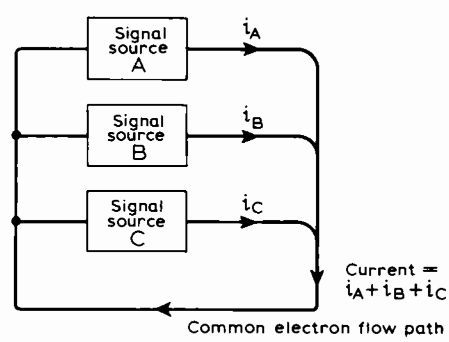


Fig. 3. Principle of adding currents from signal sources by causing them to pass through a common path.

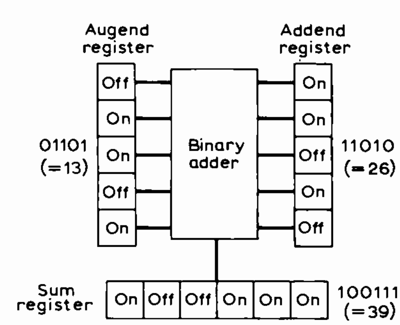
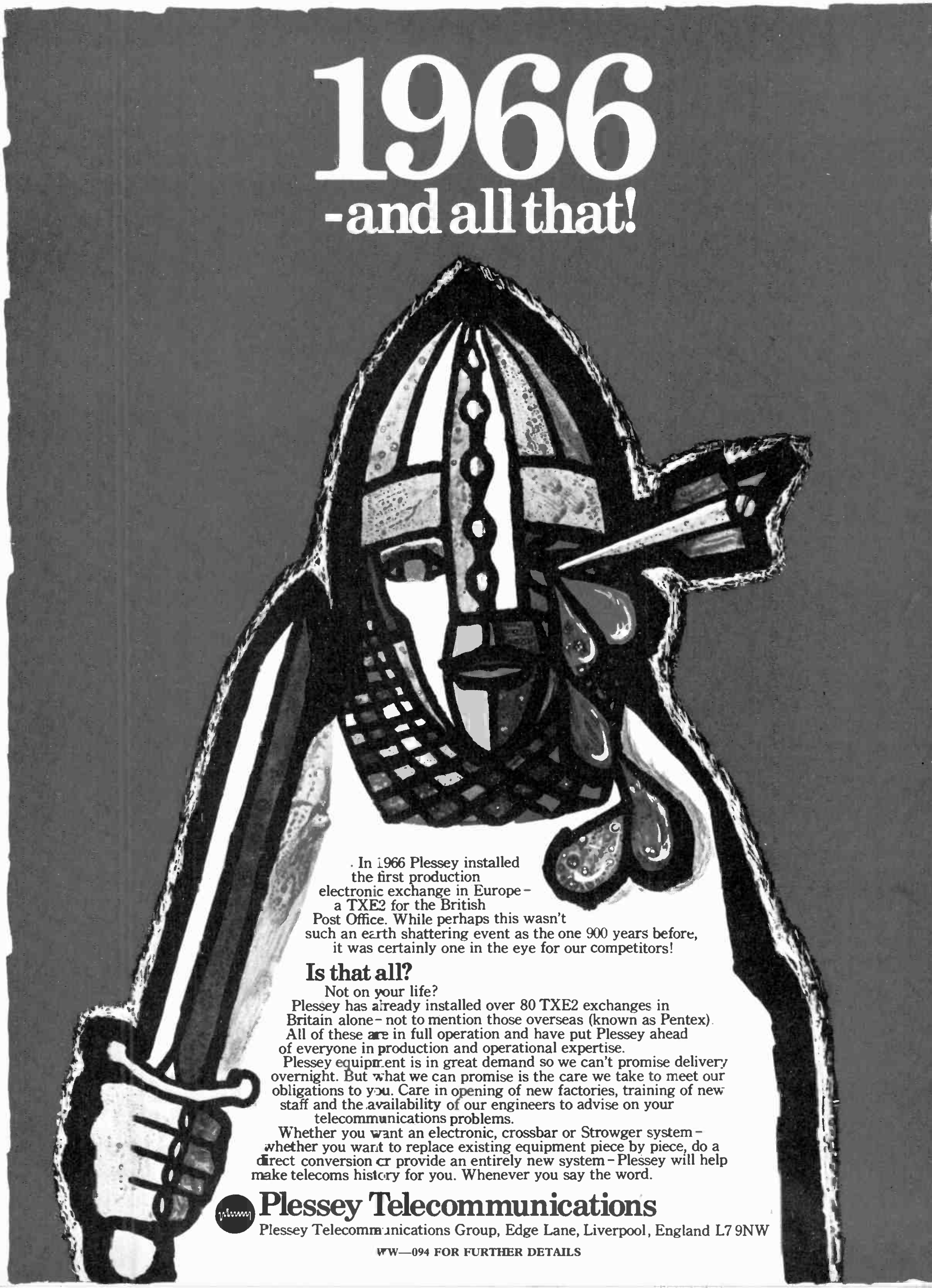


Fig. 4. Digital addition using binary notation and arithmetic. Numbers are represented by 'on' and 'off' states of electronic switches.


1966
-and all that!
In 1966 Plessey installed the first production electronic exchange in Europe – a TXE2 for the British Post Office. While perhaps this wasn't such an earth shattering event as the one 900 years before, it was certainly one in the eye for our competitors!
Is that all?
Not on your life?
Plessey has already installed over 80 TXE2 exchanges in Britain alone – not to mention those overseas (known as Pentex). All of these are in full operation and have put Plessey ahead of everyone in production and operational expertise.
Plessey equipment is in great demand so we can't promise delivery overnight. But what we can promise is the care we take to meet our obligations to you. Care in opening of new factories, training of new staff and the availability of our engineers to advise on your telecommunications problems.
Whether you want an electronic, crossbar or Strowger system – whether you want to replace existing equipment piece by piece, do a direct conversion or provide an entirely new system – Plessey will help make telecoms history for you. Whenever you say the word.
plessey
Plessey Telecommunications
Plessey Telecommunications Group, Edge Lane, Liverpool, England L7 9NW
WW—094 FOR FURTHER DETAILS

Elements of Linear Microcircuits

8: Wideband amplifiers

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

Whatever branch of electronics you work in, you will probably one day find a need for a linear amplifier with a flat frequency response perhaps from d.c. to r.f., or even v.h.f. Such an amplifier goes variously, and sometimes loosely, under the names 'wideband', 'video', 'broadband', 'base-band' or 'linear pulse'. In this article we will use the term wideband to cover all variants.

Wideband amplifiers are mostly used to amplify broad frequency spectrum signals (as in oscilloscope *Y* deflection amplifiers), but can also be used to amplify a narrow spectrum that may move about in centre frequency or be of uncertain frequency. In the days of valves you could, without too much trouble, design amplifiers up to about 10MHz bandwidth, leaning heavily on classic texts like Millman and Taub 'Pulse and Digital Techniques' (McGraw-Hill). With the arrival of transistors, the readily achievable bandwidth was pushed out to 100MHz along the lines indicated by the author in 'Elements of Transistor Pulse Circuits' (Iliffe).

By the 1970s the electronic equipment designer could choose from a wide range of complete wideband amplifiers self-contained in small metal or plastic containers about the size of a half new penny which is 17mm in diameter.

*Newmarket Transistors Ltd.

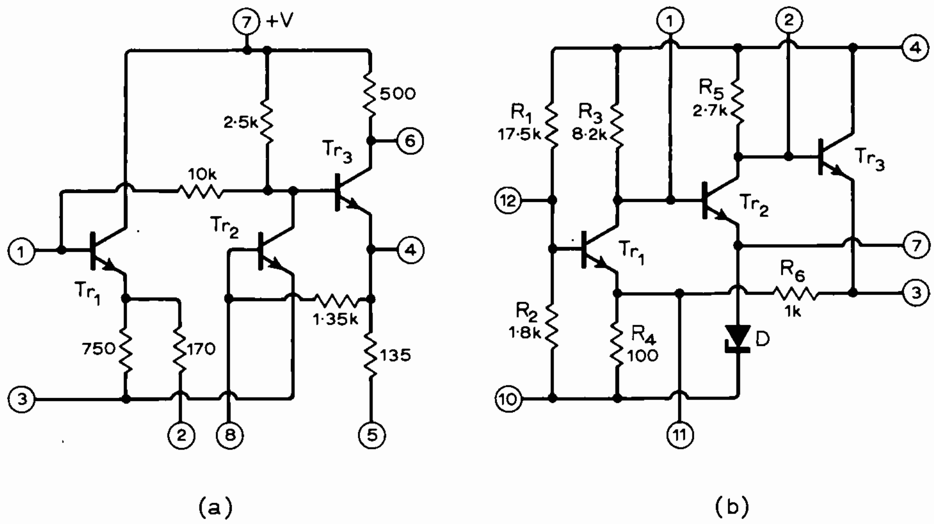


Fig. 2. Three-transistor wideband amplifier microcircuits; (a) Sprague ULN2103; (b) Sylvania SA20.

The main requirements of a wideband amplifier are good linearity (i.e. low harmonic distortion), gain stability, and uniform phase shift (i.e. low phase distortion). Wideband linear i.c. amplifiers meet these requirements well, because the transistors diffused into the silicon chip have frequency cut-offs between 300 and 1000MHz so that in the passband of the broadband amplifier, usually less than 100MHz, they are working at what is a relatively low frequency. As a result there is little differential phase shift across the transistor. Also, in a small silicon chip, no troubles can arise from parasitics in the interconnecting leads as happens in discrete component amplifiers. Finally, thermal compensating elements diffused into the chip make gain stability a minor problem. A survey of wideband amplifier microcircuits at the beginning of 1971 revealed 150 types commercially available.

Circuitry

The Ferranti ZLA10 with the circuit of Fig. 1(a) is a 12V two-transistor d.c. coupled feedback pair with a mid-band current gain of 26dB (×20). The 3dB bandwidth is d.c. to 120MHz, and output resistance is not more than 400Ω. Feedback (d.c.) is applied from terminal seven to terminal six. The ZLA10 is packaged in an eight-lead TO-5 can.

The same sort of d.c. coupled feedback pair is used in the Plessey SL201 of Fig. 1(b) with the additions of an emitter resistor R_3 in the input transistor, the splitting of the output transistor emitter resistor R_7, R_8,

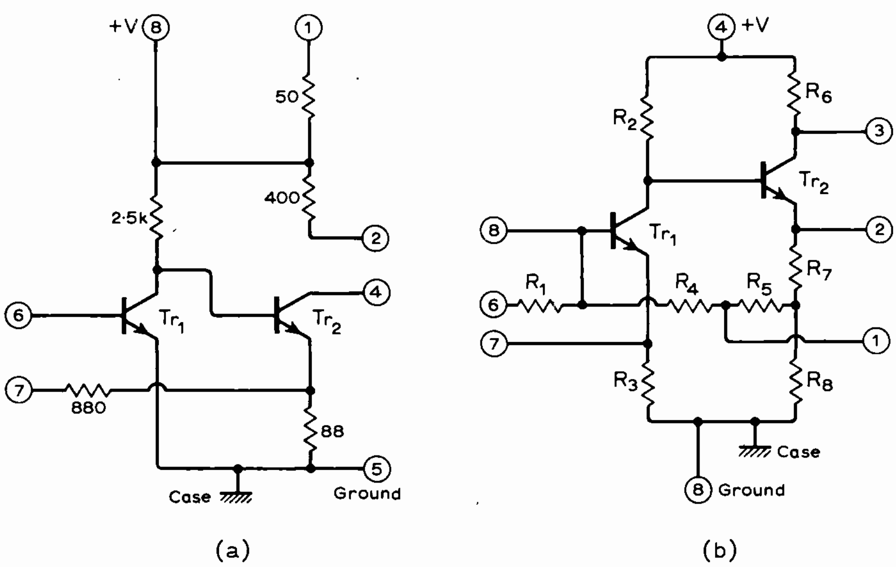


Fig. 1. Examples of two-transistor wideband amplifier microcircuits; (a) Ferranti ZLA10; (b) Plessey SL201.

and extra leadout pins one, seven and six for versatility. Designed for a 9V rail it draws 15mA supply current. With a mid-band 9dB voltage gain, it has a bandwidth of d.c. to 10MHz. It is housed in an eight-lead TO-5 package with the case connected to the negative supply terminal.

An extra transistor adds little extra cost or production difficulty in an i.c. One illustrative example is the Sprague ULN2103 of Fig. 2(a). This is a d.c.-feedback pair Tr_2, Tr_3, with an added input emitter follower Tr_1. Taking 10mA from a 12V supply, the ULN2103 has a mid-band gain of 30dB from d.c. out to a 50MHz 3dB down, an input resistance of 1.2kΩ, an output resistance of 750Ω, all in an eight-lead dual-in-line package.

Another way of using three transistors in a wideband amplifier i.c. is the Sylvania SA20 of Fig.2(b). Basically it is a d.c.-coupled feedback triplet with the overall gain set by the ratio of R_6 to R_4. Typically it can be set up to provide 20dB gain to 100MHz (−3dB) while drawing 24mA from a 24V supply, and providing 12V peak-to-peak into a 1.2kΩ load.

An example of the use of four transistors in a wideband microcircuit is the Signetics SE501 with the circuit of Fig.3(a). This has multi-access points that enable it to be connected as a wideband amplifier with four different gains and with bandwidths up to 50MHz without requiring the use of any external discrete components except the necessary input and output coupling capacitors.

The SE501 circuit is a d.c. coupled feedback pair Tr_1, Tr_2, with an emitter follower Tr_3 for isolation. A second isolated emitter follower stage Tr_4 is available and may be connected to increase the drive at the cost of increased power consumption. Taking 3.5mA (7.5mA with the second emitter follower used) from a 6V supply, the SE501 has an open loop gain of 46dB (×200) and bandwidth of 3MHz to 16dB (×6) and 55MHz bandwidth depending on how it is connected.

Four-transistor wideband i.cs tend to be higher gain or more versatile versions of two- and three-transistor circuits. However the Beckman Instruments 823 of Fig.3(b) is an interesting departure. With ±30V power supply and an idling current of only 10mA, this thick film hybrid, unity-gain, output buffer amplifier has a 3dB bandwidth from d.c. to 4MHz, with an input resistance greater than 1kΩ and an output resistance less than 10Ω. It can provide a 52V peak-to-peak output swing with a rise time of less than 0.1μs.

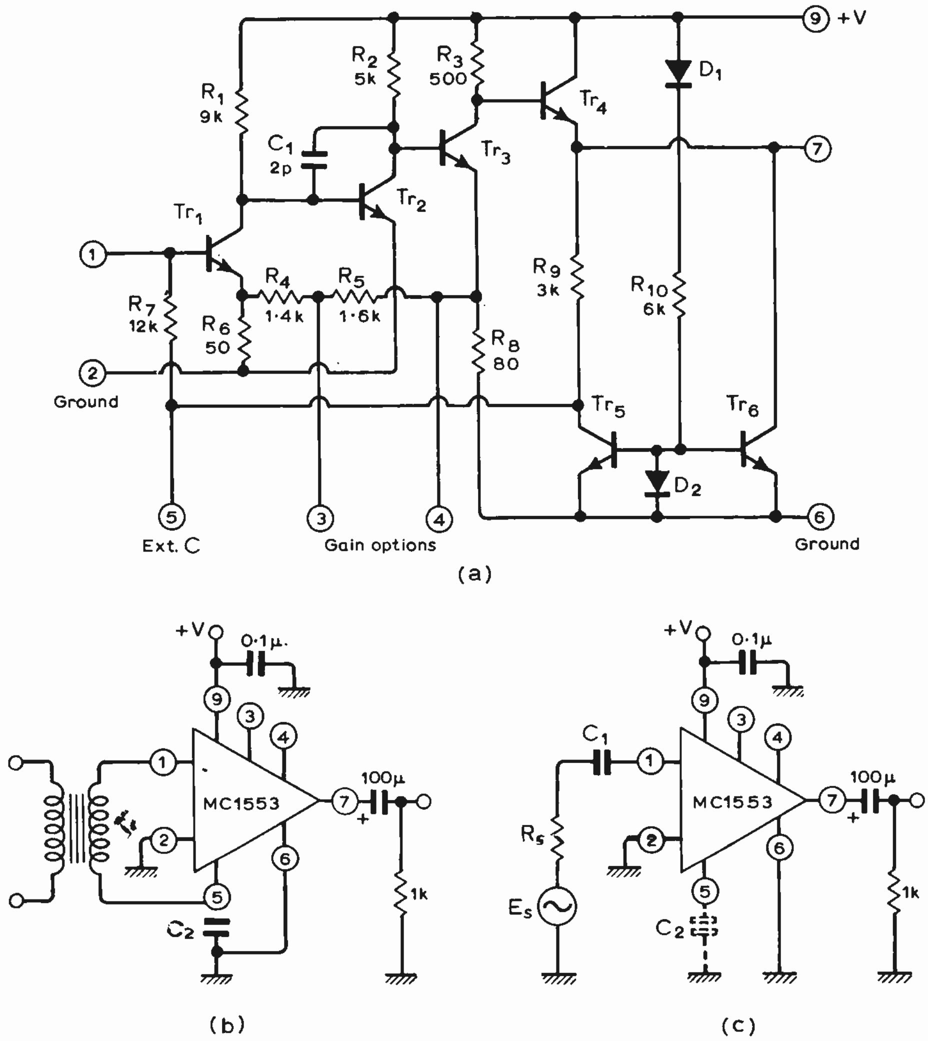


Fig. 4. A six-transistor wideband amplifier microcircuit; Motorola MC1553; (a) circuit diagram; (b) transformer input arrangement; (c) capacitor input arrangement.

As wideband amplifier microcircuits employ more and more transistors they tend to lose the versatility of the simpler versions discussed earlier. However, even the six-transistor Motorola MC1553 of Fig.4(a) has a variety of uses.

Basically the 1553 is a d.c.-coupled feedback triplet Tr_1, Tr_2, Tr_3, with an output emitter-follower buffer Tr_4. Transistor Tr_5 is incorporated in a d.c. feedback loop to establish and stabilize the output operating point. A current-source transistor Tr_6 is used to set symmetrical positive and negative load current excursions regardless of power supply voltage, temperature or load resistance.

A second feedback loop for a.c. operation consists of resistors R_5, R_4 and R_6. This enables gains from 50 to 400 to be obtained by varying the amount of feedback, by changing external interconnection and by taking the output at various points of the circuit. Bandwidth of course falls as the gain is increased by reducing feedback.

Fig.4(b) and 4(c) show the MC1553 circuit connections for transformer and capacitor inputs, the 'dotted' capacitor

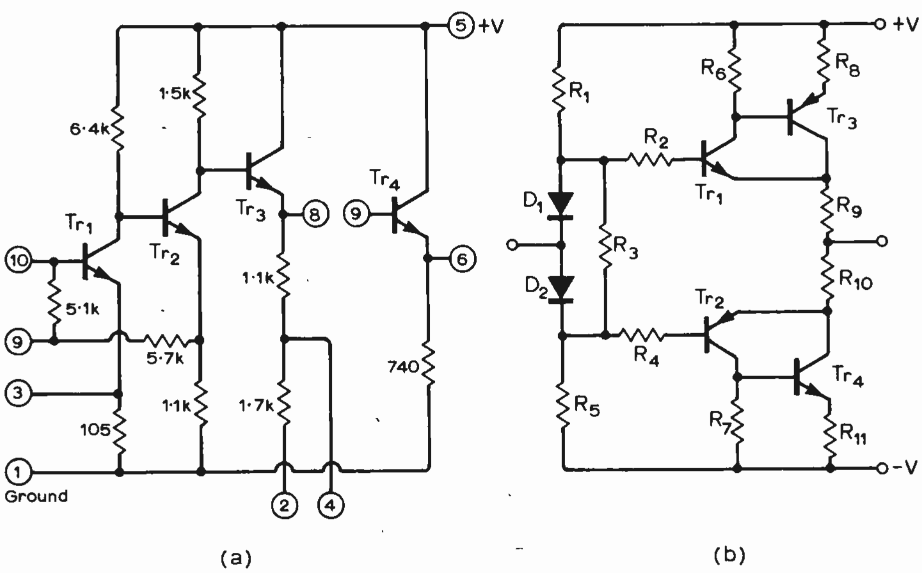


Fig. 3. Four-transistor wideband amplifier microcircuits; (a) Signetics SE501; (b) Beckman Instruments 823.

C_2 in 4(c) is included when the source resistance R_s is more than 500Ω (up to 5kΩ). Typical gain options are ×400 (20MHz bandwidth) leaving terminals three and four disconnected; ×200 (25 MHz) connecting three to four. The low 3dB cut off frequency is set by C_1 and C_2. For practical capacitor values, it can be down around 10 to 100kHz.

The RCA CA3001, using a seven transistor circuit with a mid-band gain of 16dB and a 3dB bandwidth of 16MHz, draws only 10mA from a ±6V (or single 12V) supply. Fig.5 shows a typical application of the CA3001 in a cascaded three stage amplifier which gives a mid-band gain of 65dB, with 3dB response limits of 10kHz and 10MHz. The need for external interstage coupling capacitors can be avoided by using output terminals twelve and seven to bring into operation internal capacitors, but this severely restricts the low-frequency end of the bandpass.

The Fairchild 702 was probably the most widely used wideband i.c. microcircuit in the second half of the 1960s. It was very similar in circuitry with its nine transistors to some of the op-amps whose circuits were given earlier in this series. With simple compensation the 702 can give a stable 40dB gain flat from d.c. to over 5MHz for 3dB down, and it can be arranged to give a usable gain up to 30MHz.

The Fairchild μA733 is an example of the extended bandwidths now attainable. It is a two-stage differential amplifier with both differential input and output available. Internal series-feedback is used to obtain wide bandwidth, low phase distortion and gain stability. Emitter follower outputs enable the device to drive capacitive loads, and all stages are current-source biased to obtain high-power supply and common mode rejection ratios.

External connections make it possible to obtain fixed gains of 400, 100, and 10, and in addition provision is made for having the gain adjustable between 10 and 400 by selecting an external resistor. At a voltage gain of 100 the 3dB bandwidth is 90MHz.

As yet there is very little standardization and, if you want to use some of the wealth of devices, you cannot avoid studying the individual products in detail. To help you at least to know where to look, a selected directory of wideband amplifier microcircuit manufacturers, whose products circulate in the United Kingdom, is appended in Table 1.

TABLE 1

Directory of wideband amplifier microcircuits

Manufacturer	Type Number
Analogue Devices	901, 903
Beckman Instruments	821, 822, 823, 866
C.T.S. Microelectronics	CTS861
D.D.C.	VA21, VA22, VA23, VA24, CD23
Engineering Electronics	G106
Ferranti	ZLA10, ZLA15
Fairchild Semiconductors	μA702, μA712, μA719, μA733, μA751
Intronics	A501, A502
Mitsubishi	M5113, M5134
Motorola	MC1410, MC1445, MC1510, MC1545, MC1552, MC1553, MC1590, MFC4010P
Philco Ford	PA7600, PL7600, PA7605, PA7606, PA7712, PA7713, PD7712, PL7712
Plessey	SL201, SL521, SL571
R.C.A.	CA3001, CA3011, CA3012, CA3020, CA3021, CA3022 CA3023, CA3034, CA3035, CA3040
Raytheon	RC733, RM733
Sescosem	SFC2510
Siemens	TAA721, TAA722
Signetics	SE501, NE501, N5733, S5733
Silicon General	SG733, SG1401, SG1402, SG2401, SG2402, SG3401, SG3402
Sprague	ULN2103
Sylvania	SA20, SA21
Teledyne	CMC6020, CMC6021
Texas	SN2600, SN2610, SN5510, SN5511, SN7501, SN7511
Westinghouse	WC1146, WM1146

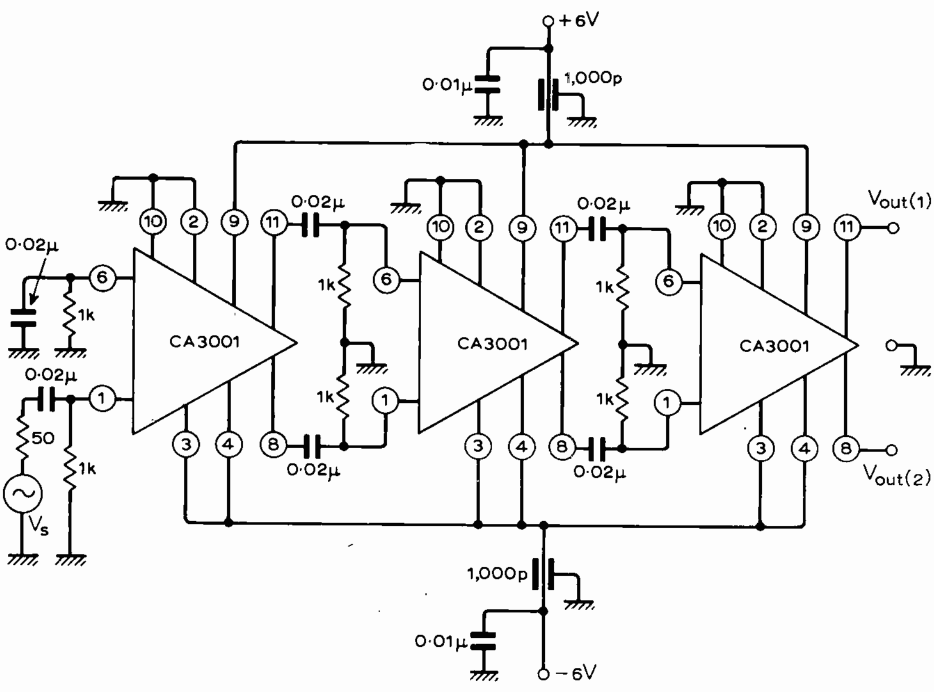
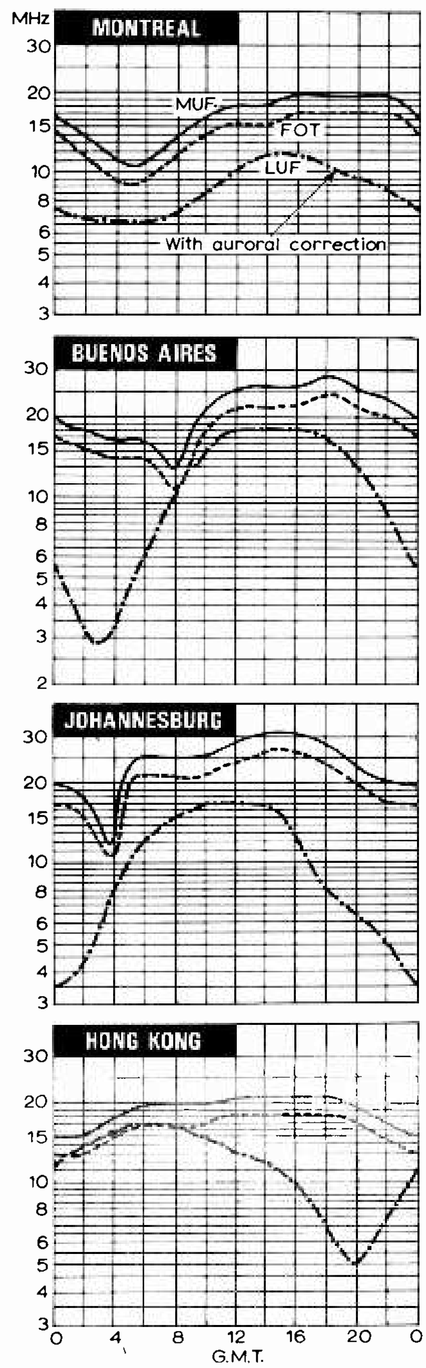


Fig. 5. Seven-transistor wideband amplifier microcircuit, RA C3001; typical arrangement in three-stage cascaded amplifier.

H.F. Predictions—

The ionospheric index used for these predictions is 90. Seasonal changes are most apparent on routes within the northern hemisphere. The MUFs are about 20MHz and vary little during most of the 24 hours. Daylight MUFs on the trans-equatorial paths continue above 25MHz and amateur 10-metre band openings should be possible.

Unlike MUF, the lowest usable frequency (LUF) is closely dependent upon such system factors as transmitter power, aerial gain, and type of service. The LUFs drawn here were prepared by Cable & Wireless and are for commercial telegraphy using directional aerials and high-power transmitters. Those for the amateur service would be considerably higher, especially during daylight. Generally the proximity of optimum traffic frequency (FOT) and LUF is a measure of the difficulty of communication.



Memory for Karnaugh Map Display

*by Brian Crank**

This 32-bit store is intended for use with the Karnaugh map display unit which was described last month. It enables the user to store two Karnaugh maps either of which can be displayed or altered at will and replaces the external logic that is normally used with the unit.

When the thought occurred that a memory could easily be made to partner the Karnaugh map display unit the question had to be asked what is the point when a pencil and paper would do just as well? Two points in favour are that the student using the unit can find his own way round the map without the aid of an instructor and the unit is more likely to arouse the student's interest than a pencil and paper.

In use, the memory is connected to the Karnaugh map display unit and information is fed in on switches and push-buttons. Two complete maps can be stored in this way.

The basic building block used in the memory is the t.t.l. integrated circuit type SN7481 which consists of sixteen flip-flops arranged in a four-by-four matrix as shown in Fig.1. There are four Y address lines and four X address lines which are used to put in, and retrieve information from, the flip-flops.

The top left-hand flip-flop is the only one common to both the Y_1 and X_1 address lines and if both these lines are UP (at logical 1 or +4.5V) this flip-flop is 'addressed'. Every other flip-flop in the store can be individually addressed using one particular combination of X and Y address lines.

Each flip-flop has two-states (0 and 1) and the state of *only the addressed flip-flop* appears at the output of the store. So by manipulation of the X and Y drive lines it is possible to examine the state of each flip-flop in turn. Two outputs are provided from the i.c. one being the inverse of the other. When a flip-flop is addressed its content appears at the output of the store but the state of the flip-flop itself is in no way changed.

So much for getting information out of the store, now how about putting it in in the first place?

There are two inputs, write 1 (W_1) and write 0 (W_0). If the W_1 input is at 1 then the flip-flop which is addressed will have a 1 written into it or if the W_0 input is at 1 the addressed flip-flop will have a 0 written into it.

The circuit of the complete memory unit is given in Fig.2, where it will be seen that two sixteen-bit stores are used. Each store can hold a complete Karnaugh map and each flip-flop in a particular store holds information for one square of the Karnaugh map (either an 0 or a 1).

The store X and Y address lines are driven by the logic outputs of the Karnaugh map display unit via NOR gates. Now if the output of the display unit is $\bar{A}\,\bar{B}\,\bar{C}\,\bar{D}$ both inputs to the top left-hand NOR gate will be DOWN (0V) and the Y_1 address line of store 1 will be UP (as will be the Y_1 line of store two via a separate NOR gate). In addition the X_1 lines of both stores will be UP and therefore the top left-hand flip-flop in each store will be addressed. The content of this flip-flop in the store selected by S_2 will be fed to the input of the display unit and will appear on the c.r.t. screen in the top left-hand square of the Karnaugh map which represents $\bar{A}\,\bar{B}\,\bar{C}\,\bar{D}$.

Going back to basic logic theory a NOR gate with the inputs A and B will have an output:

$$\overline{A + B}=\bar{A}\,\bar{B}$$

As the clock generator drives the counter in the display unit and changes the inputs to the memory each flip-flop in both of the stores is addressed in turn and the content of each flip-flop in the selected store (S_2) appears on the c.r.t. screen in the corresponding place on the Karnaugh map.

Writing the maps into the stores is very simple. Say it is wished to write a 1 into the square representing $ABCD$ on the map held in store 1. Store 1 is selected on S_1; switches $S_{3 \text{ to } 6}$ are set to $ABCD$ and the W_1 button is pressed. A 1 will be written into the square $ABCD$ on the relevant map.

The logic outputs of the display units are applied to the switches $S_{3 \text{ to } 6}$ and in turn are connected to a four-input NAND gate. The output of this gate can be connected by the W_0, W_1 push-buttons to one of

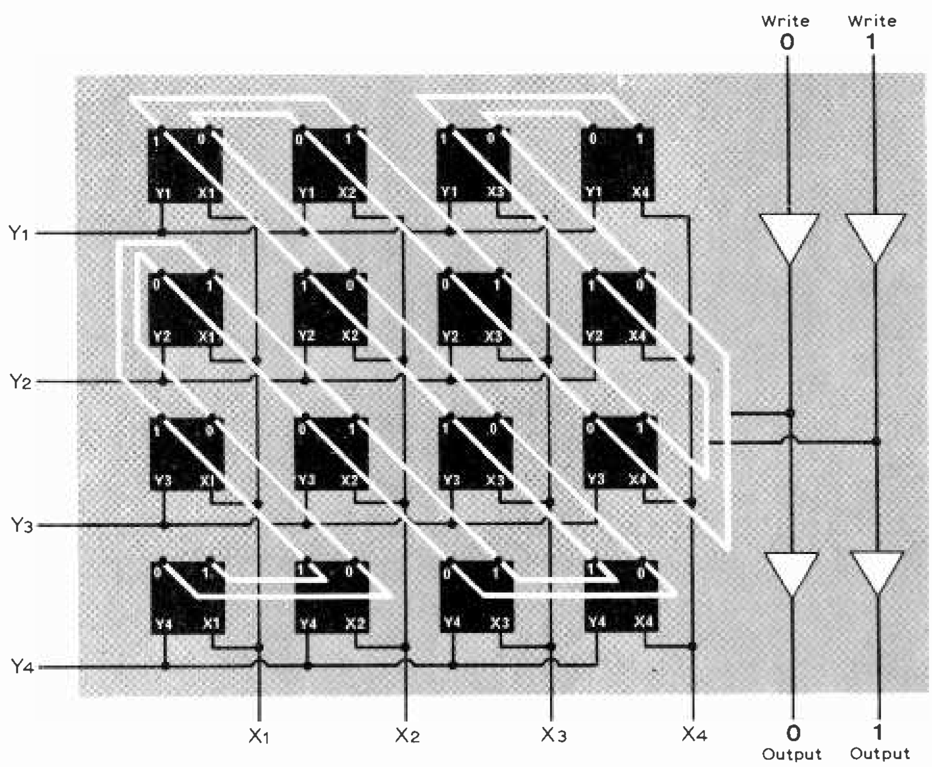


Fig. 1. The internal arrangement of the SN7481 integrated circuit 16-bit store which forms the basis of this unit. The inputs A, B, C, D, etc., are provided by the Karnaugh map display unit.

* Deputy Editor, *Wireless World.*

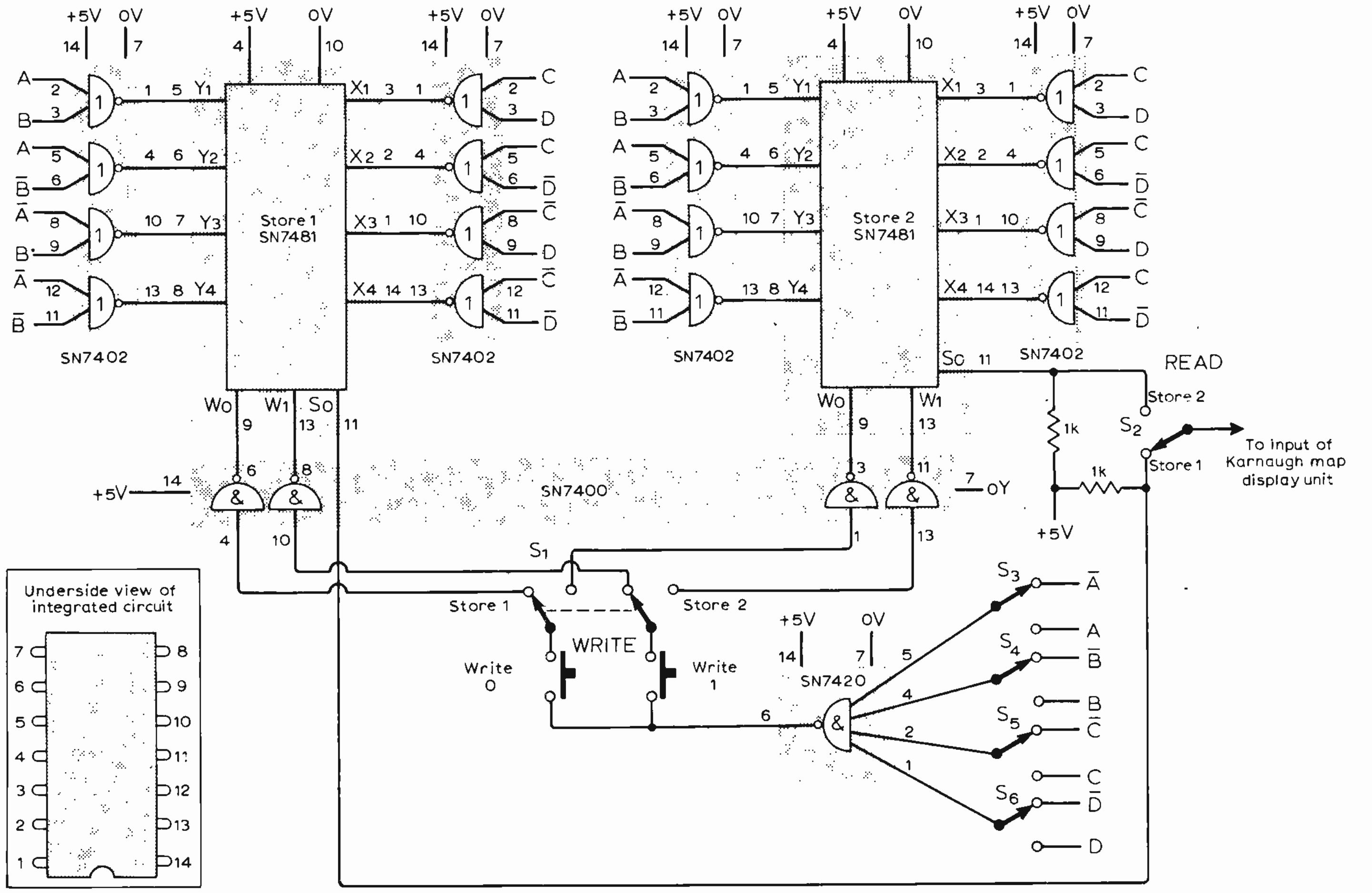


Fig. 2. The circuit of the memory unit.

the four NAND gates (used only as inverters) which are connected to the $W_0$and W_1 inputs of the stores.

In our example above with the switches in the positions described the following sequence occurs. When the output of the display unit reaches $ABCD$ the spot on the c.r.t. face will be in the square of the Karnaugh map representing $ABCD$ and the flip-flop in both stores corresponding to $ABCD$ will be addressed. All inputs to the four-input NAND gate will be UP so its output will go DOWN. This DOWN is passed via the closed W_1 push-button and S_1 to the inverter connected to the W_1 input of store 1. The output of this inverter will go UP and a 1 will be written into the flip-flop corresponding to $ABCD$ in store 1 and a 1 will appear on the screen of the c.r.t. in the $ABCD$ position provided that store 1 is selected on S_2. If the W_0 button had been pressed a 0 would have been written.

Note it is possible to display the contents of one store while amending the contents of the second store. The two resistors are required because the store outputs do not have internal loads.

If dual storage is not required a single Karnaugh map can be stored in one SN7481. The circuit alterations are simple, omit one SN7481, two SN7402, one 1kΩ resistor, S_1 and S_2. Use only half of the SN7400.

Correction: Because of the polarity of the scan waveforms the logic outputs D and $\bar{D}$ (Fig. 10 last month) should be reversed otherwise the map will appear reversed in the X direction.

Shopping list

SN7481, 16-bit store	× 2
SN7400, quad 2-input NAND gate	× 1
SN7402, quad 2-input NOR gate	× 4
SN7420, dual 4-input NAND gate	× 1
1kΩ, 0.25W, 10%	× 2
Switches single-pole change-over	× 5
Switch double-pole change-over	× 1
Lektrokit board LK141	× 1

Modifications to the display unit

I am indebted to A. W. Critchley of the TV Development Department of E.M.I. Electronics Ltd who has suggested some modifications which simplify the Karnaugh map display unit still further. The two unused exclusive-OR gates can be employed to replace the transistors in the multivibrator circuit (Tr_2 and Tr_3). The circuit of Fig. 3 shows how.

The clamping circuit consisting of $D_{1\text{ to }6}$, $R_{24\text{ to }27}$ and C_8 can be replaced with four resistors. The ladder networks are connected directly to the outputs of the counter and a 1kΩ resistor is connected between each counter output and +5V. These resistors remove the step in the counter output waveform (see Fig. 4). This modification increases the output from the ladder networks so it may be found necessary to reduce the value of the deflection amplifier feedback resistors R_{33} and R_{37} to avoid distortion.

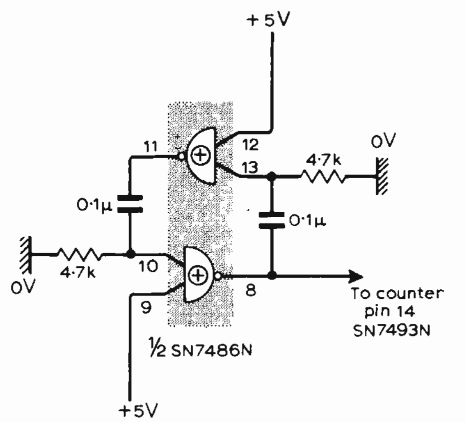


Fig. 3. The two unused exclusive-OR gates can be used as a multivibrator.

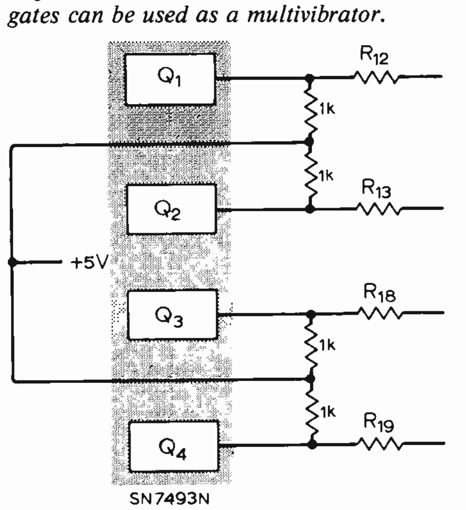


Fig. 4. The clamping network can be replaced by four resistors as shown.

Personalities

John Bardeen, M.S., Ph.D., professor of electrical engineering and physics in the University of Illinois at Urbana, who in 1956 shared with **William Shockley** and **Walter Brattain** the Nobel Prize in Physics for the trio's discovery of the transistor effect, has been awarded the Medal of Honour of the I.E.E.E. The citation reads: 'For his profound contributions to the understanding of the conductivity of solids, to the invention of the transistor, and to the microscopic theory of superconductivity'. Dr. Bardeen, born in Madison, Wisconsin, in 1908, graduated in electrical engineering at the University of Wisconsin in 1928 and received his doctorate in mathematical physics from Princeton University in 1936. He was a postdoctoral fellow at Harvard University, assistant professor of physics at the University of Minnesota, a physicist at the U. S. Naval Ordnance laboratory during the war years, and from 1945 to 1951 a research physicist at the Bell Telephone Laboratories. He has been professor of electrical engineering and physics at the University of Illinois since 1951.

Group Captain Eric R. Madger, O.B.E., has joined Raytheon Overseas Ltd as manager for international systems sales in the London office. He joined the Royal Air Force in 1939 and served in radio and electronics specialities throughout World War II. Following the war he worked in the Radar Research Establishment at Malvern; as an electronics officer in the Far East; and at the Air Ministry as a squadron leader responsible for new electronic systems. From 1960 to 1962 Group Captain Madger, then a wing commander, served in the United States at Strategic Air Command Headquarters. Upon his return to England, he commanded the R.A.F's Radio Introduction Unit. He was at one time with the Ministry of Defence where he was responsible for all aspects of integrated national air defence and air traffic control systems, and later Group Captain Electrical Engineering in the Signals Command HQ.

Gp. Captain E. R. Madger

The M-O Valve Company has announced a re-organization of production responsibilities at its Hammersmith factory. **L. E. Algar,** is appointed manager of the receiving valve and transmitting valve departments, and also becomes deputy general manager; **R. E. Brittain,** is manager of the reed department; **K. G. Cook,** manager of the gasfilled valve and surge arrester departments; **R. G. Robertshaw** manager of microwave departments; and **A. B. MacFarlane** manager of the cathode-ray tube department. Each product group manager is responsible for all aspects of production and development in his respective area.

Dr. E. R. Skelt has been appointed chief engineer of the research and development activities of Marriott Magnetics Ltd, of Penryn, Cornwall. Dr Skelt was previously leading a research team in thin film devices and techniques at G.E.C. English Electric.

Among the recipients of awards to be presented by the Institute of Physics and the Physical Society at its annual dinner on May 4th are the following:
J. A. Ratcliffe, C.B., C.B.E., F.R.S., formerly director of radio and space research in the Science Research Council, receives the Guthrie medal and prize 'for his contributions to radio physics and to the physics of the upper atmosphere'. Mr. Ratcliffe, who is 68, graduated at Sidney Sussex College, Cambridge, and apart from the war years when he was at the Telecommunications Research Establishment, he remained at the University as a reader in physics until 1960. He then became director of the Radio Research Station of the D.S.I.R. (now the Science Research Council). **F. E. Jones,** M.B.E., D.Sc., managing director of Mullard Ltd, receives the Glazebrook medal and prize 'for his applications of semiconductor physics and for management in a physics based industry. Dr. Jones, who is a graduate of King's College, London, was at T.R.E., Malvern, from 1940 to 1952 (at one time as head of experimental physics research). For four years from 1952 he was deputy director of the Royal Aircraft Establishment, Farnborough. The Bragg medal and prize of the I.P.P.S. goes to **G. R. Noakes,** M.A.(Oxon), formerly science master at Uppingham School, 'for his contribution to the development of new approaches to the teaching of physics particularly through the medium of textbooks'. Mr. Noakes was a regular contributor, under the pseudonym 'Quantum', to our sister journal *Electronic & Radio Engineer* (no longer published).

R. J. Clayton, C.B.E., M.A., F.Inst.P., F.I.E.E., technical director of the General Electric Company, has been appointed a visiting professor at Imperial College, London. Mr. Clayton will be associated with the Electrical Engineering Department and will be concerned with developments intended to strengthen the links between the department and industry.

R. J. Clayton

Malcolm Hearn, B.Sc., product manager of Data Systems Group of Racal, which he joined seven years ago, has become sales manager of Racal-Milgo. After gaining his degree at Imperial College in 1956, Mr. Hearn completed a graduate apprenticeship with the B.B.C. and then served a three-year short-service commission in the R.A.F. His initial sales experience was gained in the Radio Division of Standard Telephones & Cables.

R. C. Strand, M.I.E.E., Grad. Inst.P., who has been with Roband Electronics five years, is appointed chief engineer. He has been in charge of the Roband design group manufacturing special-to-customer power supplies. He will now be responsible for co-ordinating the activities of the oscilloscope, digital instruments and power supply groups.

F. Delissen has been appointed divisional manager of the Production Division of Painton & Co. Ltd (now part of the Plessey Components Group), responsible for the manufacture of components for both the Connector and Resistor Divisions. Prior to this, Mr. Delissen was general services manager for the Swindon Region of the Plessey Components Group and divisional manager, Actona Engineering Division.

W. R. R. Haines, managing director of the Plessey Electronics Group, has become president of the Electronic Engineering Association for 1971 in succession to **Percy Allaway** (E.M.I.). Mr. Haines joined Decca Radar Ltd in 1953 and after a number of varied appointments became the first general manager of Plessey Radar Ltd in 1965, at the time when Plessey acquired part of Decca Radar's interests.

OBITUARY

Philip Hylton Spagnoletti, O.B.E., B.A., M.I.E.E., who had been associated with Standard Telephones and Cables since 1929, latterly as business development consultant, died on 14th March. Born in 1906, he graduated in natural sciences at Trinity College, Cambridge, in 1928. After several years' service overseas on radiotelephone installations Mr. Spagnoletti returned to the U.K. in 1937 and started up the airborne radio division of S.T.C. and was responsible for the work on radio altimeters and several other important communications and navigational devices used during the war. In 1945 he became chief engineer of Kolster-Brandes Ltd, an S.T.C. company making radio and television sets. He became general manager in 1947. At the same time he was responsible for Brimar valves. He was awarded the O.B.E. in 1955 for "valuable assistance to the Postmaster General in television and hearing aids". From 1957 to 1965 Mr. Spagnoletti was group executive in charge of components activities in S.T.C.

World of Amateur Radio

British amateur callsigns

During March, the first of the new G4-three-letter (G4AAA onwards) callsigns were issued by Minpostel. This event brings to a close a 25-year period during which all new British calls were in the G3AAA to G3ZZZ series (the same series is used regardless of the 'country' prefix such as GM, GI etc). Since the vast majority of calls are issued in strict alphabetical sequence, the call denotes the approximate date of issue. Through the courtesy of Minpostel's Radio Regulatory Division, the following list, indicating the date at which each sequence began to be issued, has been prepared: it is believed to be the first complete and officially checked list ever to be published, and thus of considerable interest to all amateurs and listeners:

call	issue started	call	issue started
G3A—	July, 1946	G3N—	September, 1958
G3B—	November, 1946	G3O—	February, 1960
G3C—	June, 1947	G3P—	June, 1961
G3D—	December, 1947	G3Q—	not used
G3E—	July, 1948	G3R—	May, 1962
G3F—	December, 1948	G3S—	May, 1963
G3G—	October, 1949	G3T—	March, 1964
G3H—	October, 1950	G3U—	March, 1965
G3I—	December, 1951	G3V—	February, 1966
G3J—	September, 1952	G3W—	February, 1967
G3K—	October, 1954	G3X—	November, 1967
G3L—	June, 1956	G3Y—	November, 1968
G3M—	October, 1957	G3Z—	December, 1969

Class B (v.h.f./u.h.f. 'phone only) licences have been issued as follows:

G8A—	June, 1964
G8B—	June, 1967
G8C—	September, 1968
G8D—	September, 1969
G8E—	September, 1970

In addition, G6-three-letter calls have been issued since 1964 for amateur television; G5-three-letter calls since 1966 to foreign amateurs for use in the U.K.

The earlier two-letter and G2-three-letter calls stem from pre-war licensing—the following estimated dates have not been checked by Minpostel. Many of the earliest G2, G5 and G6 calls were issued and re-issued many times, and the number of original holders is fairly low:

G2—	From 1920 to 1939
G3—	during 1937 and 1938
G4—	during 1938 and 1939
G5—	from 1921 to 1939
G6—	from 1921 to 1939
G8—	during 1936 and 1937

The 2-three-letter calls were originally issued before World War II as 'artificial aerial' licences without permission to radiate, but were re-issued to same amateurs from 1946 onwards as radiating licences with G prefix. At various times G7 and G9 licences have been issued for special purposes and to firms.

On the bands

With the expectation of a continuous decline in sunspot numbers until autumn 1975, interest is growing in the lower-frequency bands. The lively 'W1BB 160-metre DX Bulletin' is reporting such achievements as the first-ever contact between Europe (West German station DL9KRA) and Japan (JA3AA), and good signals this season in transatlantic tests from British, Scottish and Czech stations. K8YUA/KL7 in Alaska has heard British stations G3RCE/A, G3RKJ and G3ZDY. What must be one of the few beam aerials on 'Top Band' is the array used by K5TFG consisting of two dipole elements 50ft high and spaced 53ft 10in apart. And on 3.5 MHz, the early months of the year produced exceptional openings from Europe into the Far East and to the West Coast of America via the long path. The March B.E.R.U. contest brought numbers of familiar calls on the bands, but conditions were only fair, and there was a noticeable lack of African participation this year. On the other hand, the A.R.R L. DX contests saw the usual fantastic scores being piled up, often at rates of around a-contact-a-minute for considerable spells. And those engineers who think of v.h.f. as being for 'local' operation except in abnormal propagation conditions, might ponder the series of almost 200 contacts on 144.41 MHz, without a miss, between G6CW, Nottingham, and PAoPCD, Delft, Netherlands, using s.s.b.

Changes in U.S. band-planning?

Considerable concern and alarm is being expressed by amateurs in many countries at a recent F.C.C. "Notice of proposed rule making" (Docket 19162). The new rules, if adopted, will change the U.S. sub-allocations in all h.f. bands from 3.5 MHz to 28 MHz. The changes proposed include extending the frequencies allotted to 'phone operation (for example, 14150 to 14350 kHz instead of 14200 to 14350 kHz), to reduce c.w. sections allotted to 'extra class' licences from 25 kHz to 10 kHz, and to introduce a novice sub-band (c.w.) between 28150 and 28250 kHz. Many amateurs believe that these proposals will destroy the present balance between frequency allocations for the U.S.A. and the rest of the world, in view of the high powers and elaborate aerials used by large numbers of American amateurs, and will also upset existing I.A.R.U. voluntary band-planning. The effects would be especially severe in countries near the United States, where it has long been the practice to operate 'phone in segments below the U.S. 'phone allocations. But the general effect would be felt throughout the world in a general squeezing of the c.w.-only segments of the bands.

The F.C.C. action is perplexing in view of the recent decision of the A.R.R.L. not to press for additional 'phone allocations in the h.f. bands. There is a feeling that the new proposals will be opposed by many organizations, who can submit comment to F.C.C. until June 1st. The F.C.C. has shown in the past that where there is strong opposition such proposals may be dropped, modified or deferred.

In Brief

A new Canadian v.h.f. beacon station, VE2BYG, using 250 watts e.r.p. on 50.065 MHz and located 250 miles north-west of Montreal is expected to remain in operation for six months.... As the result of 17 successful prosecutions by the British Post Office for unlicensed operation during a recent two-month period, fines totalling £580, plus £235 costs, were imposed, with forfeiture of equipment in 14 cases.... A special British call, GB2ITU, is expected to be heard during this year's 'World Telecommunication Day' on May 17.... An amateur station, GB3CLR, will be a feature of the open-day of Battersea Adult Education Institute, London S.W.11, on April 24. ... Franz Turek, DL7FT, is expecting to be operating from rarely heard Albania during June 16 to 30, using the call ZA2RPS.... Early dates in the 1971 mobile rally season include: May 2, the Spalding rally at Surfleet (talk-in stations G3VPR/P and G3XBS/P); and May 30, Maidstone Y.M.C.A. Amateur Radio Society at 'Y' Sportscentre, Melrose Close, Maidstone. Talk-in station GB3YSC on 1.8, 3.5, 70 and 144 MHz. Details from A. S. Walter, G3WXL, 31 Lansdowne Avenue, Maidstone, Kent.... This year's reunion of the British Radio Amateur Old Timers' Association is on May 7.... Convention of the Northern Amateur Radio Societies on May 9.... The R.S.G.B. has formed a committee to plan for its Diamond Jubilee year 1973.

PAT HAWKER, G3VA

New Products

Multi-mode i.f. amplifier/detector i.c.

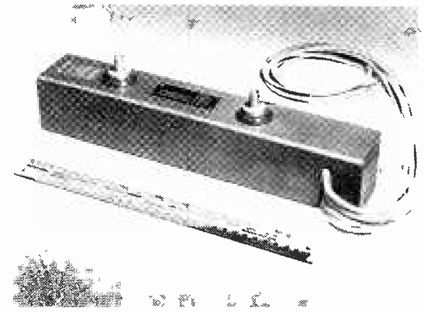
The National Semiconductor LM173 series integrated circuit is designed for f.m. and both double- and single-sideband amplitude modulated i.f. amplifier and detector applications. It contains over 100 transistors giving two amplifier sections, a gain-controlled stage, a balanced f.m. or s.s.b. detector, and an active a.m./s.s.b. peak detector. It can be used in three main modes—an a.m. i.f. strip with an a.g.c. range of 70dB; an f.m. i.f. strip with balanced quadrature detector (with external tuned circuit); and an s.s.b. i.f. strip with audio-operated a.g.c., double balanced detector and automatic mixer balancing. Cost is $4.85 for LM373 (TO-5, 0—70°C type). This circuit follows two earlier 'sub-systems'—an a.g.c./squelch amplifier and an a.m./a.g.c. i.f. amplifier. National Semiconductor Corpn., 2900 Semiconductor Drive, Santa Clara, California 95051, U.S.A.
WW 310 for further details

Radiotelephones for maritime use

Single-sideband m.f. and h.f. radiotelephones are announced by Kelvin Hughes, marking their entry into the maritime communications market. The radiotelephones, together with a new a.m. receiver, appear at an opportune time—from 1st Jan. 1972 all new h.f. equipment installed aboard ships must be single sideband (1st Jan. 1973 for m.f. radiotelephones). The inshore type (Falkland, illustrated) covers 1.6 to 3.8MHz in 11 transmit and 15 receive channels at either 50 or 120 watts peak envelope power. The other set—called Pentland—is intended for large vessels and is in two duplex versions. The Alpha is an m.f. set with 18 transmit and 30 receive channels and with a peak envelope power of 400 watts—the maximum allowed. The other version—the Bravo—is designed for the ocean-going vessels which need to transmit and receive over long distances at any time of day or night. Consequently this has an additional 23 transmit and receive channels on the h.f. band from 4.0 to 22MHz. Valve output stages are used in these sets to give protection against misuse. In the 400-watt sets parallel output valves give the required power and in the low-power sets a cascode valve-transistor circuit is used, with the advantage that output valves do not need to be matched. A low-cost d.s.b. receiver is made to complement these sets for receiving weather broadcasts and for direction finding. The equipment, designed in collaboration with Racal, is made by Kelvin Hughes, a division of Smiths Industries, at New North Road, Hainault, Ilford, Essex.
WW302 for further details

High-power c.w. travelling-wave tubes

E.E.V. have developed three new high-power c.w. travelling-wave tubes. The tubes are the N1065, which produces a minimum output power of 35W over the frequency band 10.5GHz to 12.4GHz, the N1075, with a minimum output power of 100W from 8GHz to 12GHz, and the N1077, giving 100W minimum from 5GHz to 12GHz. Saturated gain is 36dB for N1065 and 30dB for N1075 and N1077. All are of metal/ceramic construction. Periodic permanent magnetic focusing of the electron beam is employed. The focusing system forms an integral part of the tube, and a particular feature of its design is the measures taken to achieve a very high



degree of alignment between the electron gun, the helix structure and the magnetic field—to minimize helix interception under full r.f. conditions. English Electric Valve Co. Ltd, Chelmsford, Essex.
WW328 for further details

Portable dual-channel 18MHz oscilloscope

A robust dual-channel portable 18MHz oscilloscope, TF2204, has recently been added to the Marconi Instruments range. Mains, 24V battery and special military versions are available. Features include automatic triggering, high sensitivity (20mV/cm at 18MHz or 2mV/cm at 5MHz), and the inclusion of signal delay. Stable triggering is obtained over the full

bandwidth of the vertical deflection system. The instruments also have a channel-selective internal triggering. The display is bright and the 100 × 80mm screen has an internal graticule to minimize parallax errors. The 'scope measures 250mm high × 250mm wide × 350mm deep and weighs 11.5kg. The budgetary f.o.b. U.K. price of the mains version is £360. Marconi Instruments Ltd, St. Albans, Herts.
WW325 for further details

L.S.I. digital circuits

Plessey announce a new range of digital circuits, the SB220 series, suitable for digital control and metering applications. Used collectively, the circuits SB220, 221 and 222 provide frequency-to-digital

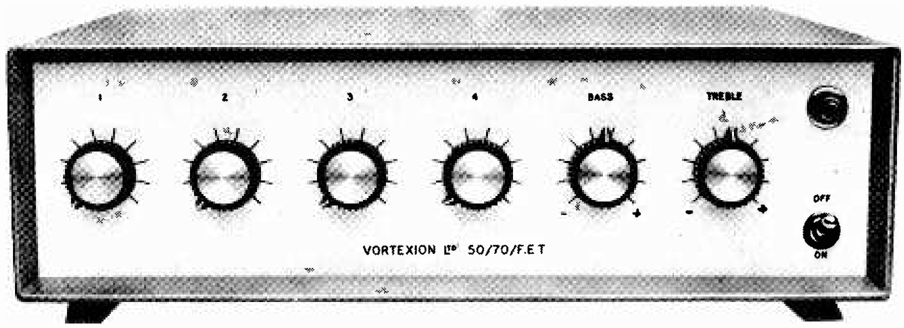
Continued on page 261

WW—096 FOR FURTHER DETAILS

Vortexion

This is a high fidelity amplifier (0.3% intermodulation distortion) using the circuit of our 100% reliable—100 Watt Amplifier (no failures to date) with its elaborate protection against short and overload, etc. To this is allied our latest development of F.E.T. Mixer amplifier, again fully protected against overload and completely free from radio breakthrough. The mixer is arranged for 2-30/60Ω balanced line microphones, 1-HiZ gram input and 1-auxiliary input followed by bass and treble controls. 100 volt balanced line output or 5/15Ω and 100 volt line.

THE VORTEXION 50/70 WATT ALL SILICON AMPLIFIER WITH BUILT-IN 4-WAY MIXER USING F.E.T.s.



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

THE 100 WATT MIXER AMPLIFIER with specification as above is here combined with a 4 channel F.E.T. mixer, 2-30/60Ω balanced microphone inputs, 1-HiZ gram input and 1-auxiliary input with tone controls and mounted in a standard robust stove enamelled steel case. A stabilised voltage supply feeds the tone controls and pre amps, compensating for a mains voltage drop of over 25% and the output transistor biasing compensates for a wide range of voltage and temperature. Also available in rack panel form.

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

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

20/30 WATT MIXER AMPLIFIER. High fidelity all silicon model with F.E.T. input stages to reduce intermodulation distortion to a fraction of normal transistor input circuits. The response is level 20 to 20,000 cps within 2 dB and over 30 times damping factor. At 20 watts output there is less than 0.2% intermodulation even over the microphone stage at full gain with the treble and bass controls set level. Standard model 1-low mic. balanced and 1 auxiliary input.

ELECTRONIC MIXERS. Various types of mixers available. 3-channel with accuracy within 1 dB Peak Programme Meter. 4-6-8-10 and 12-way mixers. Twin 2, 3, 4 and 5 channel stereo. Built-in screened supplies. Balanced line mic. input. Outputs: 0.5 V at 20K or alternative 1 mW at 600 ohms, balanced, unbalanced or floating.

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

WW—097 FOR FURTHER DETAILS

conversion with inputs up to 1MHz. Digital output is available either in natural binary or gray-coded binary for non-ambiguous asynchronous access, thus being randomly accessible. The SB220 circuit is a 5-bit reversible gray-code counter which cannot overflow, can be infinitely cascaded, and can provide 5-bit natural binary code outputs. SB221 is a 5-bit binary rate multiplier allowing the multiplication of a basic frequency by any prescribed number up to the capacity of the multipliers (which can be infinitely cascaded). The multiplication ratio can be controlled by the natural binary outputs of the SB220 to provide effectively a binary to frequency converter. The multiplier uses gray code. The SB222 circuit provides a number of functions in one package; frequency comparison, phase locking and digital filtering. All three circuits are available in 24-lead d.i.l. ceramic packages, are designed to work over the temperature range 0° to 70°C and can interface directly with conventional i.c. logic. Plessey Microelectronics, Cheney Manor, Swindon, Wilts.
WW 314 for further details

V.H.F. aircraft receiver

Monitor model 15WB/SS from Park Air Electronics includes, in addition to full coverage of the aeronautical v.h.f. a.m. band 118 to 136MHz on a continuous tuning scale, six spot frequencies using crystal-controlled oscillator modules. Each oscillator is fitted to a plug-in printed circuit card and is delivered pre-aligned for fitting when frequency changes are required. Cost of the new equipment packed for export is £145 and availability is eight weeks from date of order. Park Air Electronics Ltd, Red Lion Square, Stamford, Lincs.
WW306 for further details

Coaxial magnetron

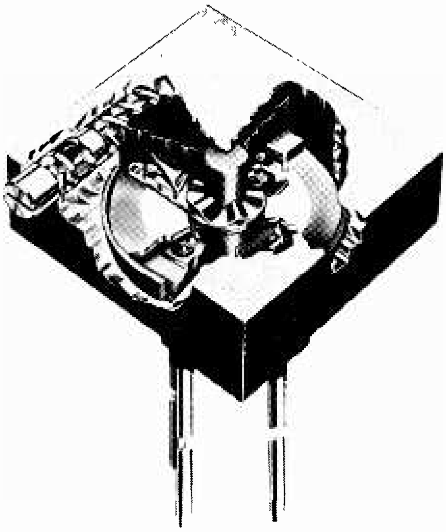
A fixed frequency c.e.m. coaxial magnetron, the SFD 305, is now available from EMI-Varian. Characteristics are as follows:

frequency, fixed ± 0.030GHz .. 9.345GHz
peak power output (min) 28kW
heater, standby
  voltage 12.6V
  current (max) 1.3A
  warm-up time (min) 120s
pulling factor, 1.5:1 v.s.w.r (max) . 6MHz
pushing factor (max) 300kHz/A
weight (max) 272g
cooling .... forced air

EMI-Varian Ltd, Hayes, Middx.
WW 326 for further details

Welded cermet trimmer

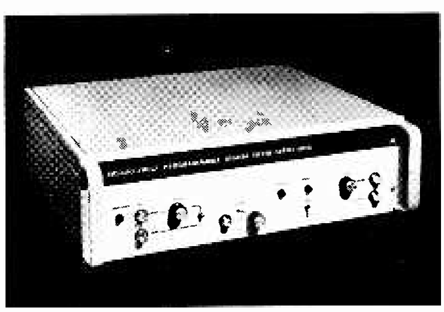
A 9mm square miniature cermet trimmer type 3755GB, in a diallyl phthalate case with gold strap welded terminations, is available from Amphenol. Resistance values range from 100Ω to 1MΩ. Power



rating is 1W at 70°C (zero at 150°C) and the operating temperature range is −55° to + 150°C. The trimmer is protected against vibration, humidity and salt spray. Dielectric strength is 900V r.m.s. at room conditions, 350V r.m.s. at 80,000ft. The wiper is shock and vibration proof, with a self-locking leadscrew and ratcheting clutch, and has a carbon tipped metal contact. Amphenol Ltd., Thanet Way, Whitstable, Kent.
WW 313 for further details

Digital filters

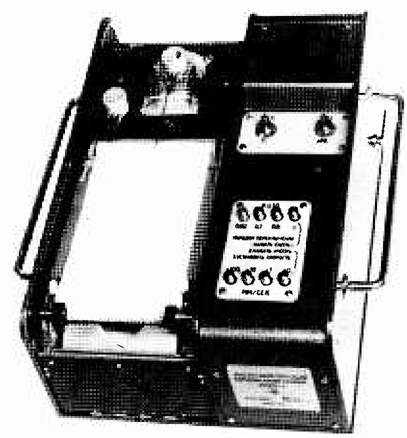
A range of programmable digital filters from Rockland Systems Corporation of New York, is now available in the U.K. through Lyons Instruments. Since all digital filters are composed of four basic components—adders, multipliers, shift-register delays, and memory—a modular approach has been adopted. The basic components are usually combined into second-order building blocks (two poles and/or two zeros) and these blocks are then combined or multiplexed to realise any number of filters of any desired order. Programmability is achieved by employing a read/write coefficient memory; fixed filter characteristics may be obtained with a read-only memory. Standard arithmetic accuracies are 16-24 bits at sampling rates up 500kHz at 16 bits (8MHz bit rate). A-to-d and d-to-a conversion accuracies, where required, are limited to those commercially available (8-12 bits). Where the full 500kHz sampling rate is unnecessary, each filter may be multiplexed among several inputs, or on one input to effect higher-order filtering, or both. Up to 50 second-order filters at 10kHz sampling



rate, or 500 at 1kHz sampling rate, are then available per instrument. To take an example, the Rockland model 4124/4125, is a programmable tenth-order recursive digital filter, which can realise arbitrary 'all-pole' designs such as Butterworth, Bessel or Chebyshev low-pass, high-pass, or band-pass filters. Lyons Instruments Ltd, Hoddesdon, Herts.
WW321 for further details

Strip chart recorders

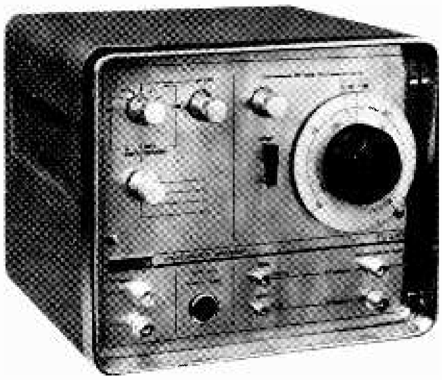
More Russian-made instruments are available from Z & I Aero Services. Designed for recording momentary values of currents and voltages are strip chart recorders H320-1 (single channel) and H320-3 (three channels). Movements are moving-coil types with a natural frequency of oscillation of 5Hz (representing maximum frequency) and a sensitivity of 8mA f.s.d. (80mm). A lightweight syphon pen is attached to the moving-coil frame and a



large ink well mounted coaxially with the frame. Error on d.c. is 2.5% rising to 10% at maximum frequency. One of nine chart speeds can be selected from 1.2 to 3000mm/min. Internal impedance is 210 ohms. Prices are £55 (single channel) and £90 (three channels). A ten-channel event recorder, type H30, is also available in which the ink syphons are connected to rotary relays in each channel. Current consumption is 120mA per pen. Price £52. Z & I Aero Services Ltd, 44a Westbourne Grove, London W.2.
WW 318 for further details

Modulation analyser

Depth of modulation in a.m. transmitters or deviation in f.m. transmitters can be measured with analyser type TG-2700 made by Green ECE Ltd. Designed for narrow-band transmitters in mobile or portable v.h.f. and u.h.f. radiotelephones, the most sensitive deviation range is 3kHz. The instrument is compatible with transmitter output analyser type TG-2400 for power and envelope display. For f.m. measurement, frequency coverage extends from 30 to 480MHz, with deviation range from 3 to 100kHz. Deviation due to residual noise is 32dB below 3kHz; accuracy for both f.m. and a.m. is ±5%; and sensitivity



at r.f. is 2mV into 60 ohms. Made by Green E.C.E. Ltd of 5 Thorold Road, London N22 4YE, it is marketed by Echometrix Ltd, 113 The Broadway, Leigh-on-Sea, Essex, for £225.
WW320 for further details

High-current switching transistors

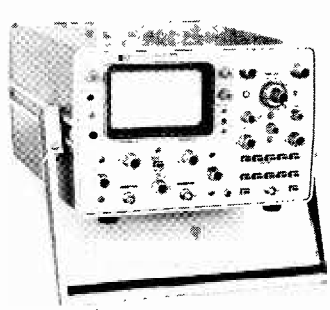
Three new high-speed, high-current, switching transistors are available from Mullard. Types BDY90, 91 and 92 are n-p-n silicon planar devices and have a transition frequency of typically 70MHz. The transistors are TO-3 encapsulated, and the continuous power dissipation rating is 40W. However, under pulsed conditions with a duty cycle of 0.1 and a pulse duration of 0.1ms, each can dissipate 250W. The saturation voltage is less than 1.5V. The specification includes:

	'90	'91	'92	
V_{CBO}	120	100	80	V
V_{CEO}	100	80	60	V
I_{CM}	15	15	15	A
P_{tot} (T_{mb} = 75°C)	40	40	40	W

Mullard Ltd, Mullard House, Torrington Place, London WC1E 7HD.
WW303 for further details

Battery-powered oscilloscope

Hewlett-Packard model 1701A dual-channel 'scope has a frequency range of d.c. to 35MHz, a 60 × 100mm display and delayed sweep. Consuming 18W it runs for up to 6 hours on its own battery and can also be powered by 115 or 230V a.c. mains or by any external d.c. source between 11.5 and 36V. Each vertical channel has a rise time of less than 10ns. Input impedance is 1MΩ/27pF (10MΩ/14pF with ×10 resistive divider probes supplied). Calibrated deflection ranges from 10mV/div to 5V/div. Either channel's signal can be displayed by itself, or both can be displayed on alternate sweeps or during the same sweep if chopped. The two inputs may be added or subtracted. Sweeps lock on to signals up to 35MHz that deflect the trace by 0.5cm. On slightly larger signals (> 100mV) sweeps trigger stably on signals up to 75MHz. Hewlett-Packard Ltd, 224 Bath Road, Slough, Bucks. SL1 4DS.
WW 317 for further details



Portable variable transformers

A range of portable Regulac variable transformers is being produced by Claude Lyons. Models with 240V input and 0-270V output have a range of current ratings between 1 and 13.5A. Also available are four 120V input/135V output types rated between 2.25 and 15A. The variable transformer is mounted in a robust case with carrying handle, input cable, mains switch and output fuse, and can be supplied with either a socket outlet or insulated terminals. A voltmeter or ammeter, or both, can be fitted if required. Claude Lyons Ltd, Valley Works, Hoddesdon, Herts.
WW 315 for further details

Indicator tubes

Indicator tubes types ZM1263, ZM1265 and ZM1175C, from Mullard, operate with a supply voltage of 170V. Each is 19 × 47.5mm. The ZM1263 is a side-viewing tube that contains symbols for alternating (~), plus (+), minus (−) and a fourth symbol, consisting of a spiral of two and a quarter turns for 'equipment failed' or anything else that has no conventional symbol. It is intended for use in digital voltmeters and similar instruments. The ZM1265, another side-viewing tube, is intended for use as an 'up, down, left or right' indicator in the control panels of milling machines and other machine tools. It displays an arrow pointing in one of the four directions. The ZM1175C is a pinned version of the numerical indicator tube type ZM1175. The pins are formed by cropping the flying leads so that the tube can be plugged into a holder. Mullard Ltd., Mullard House, Torrington Place, London WC1E 7HD.
WW309 for further details

High-speed memory

A new, read-write, random-access m.o.s. memory available from Mullard has maximum access time of 250ns and cycle time of 750ns. Type FEQ101, the memory contains sixteen words of four bits and an address decoder on the same silicon chip. A common bit line used for the corresponding bit in each word serves as the data input/output sense line. A buffer in each bit isolates it from the bit line while it is being read, and reading is non-destructive as it is accomplished by sensing the output current of the buffer stage. A chip-select input on the FEQ101 enables several of the integrated circuits to be connected to form memories with capacities much greater than 64 bits. The specification includes:

gate supply voltage	−20 V
drain supply voltage	−10 V
nominal input levels	−27 V
minimum sense current	0.7 mA
maximum stand-by dissipation	2.0 mW/bit
operating temperature range	0 to +75°C
encapsulation	16 lead plastic dual-in-line

Mullard Ltd, Mullard House, Torrington Place, London WC1E 7HD.
WW307 for further details

Plug-in resistors

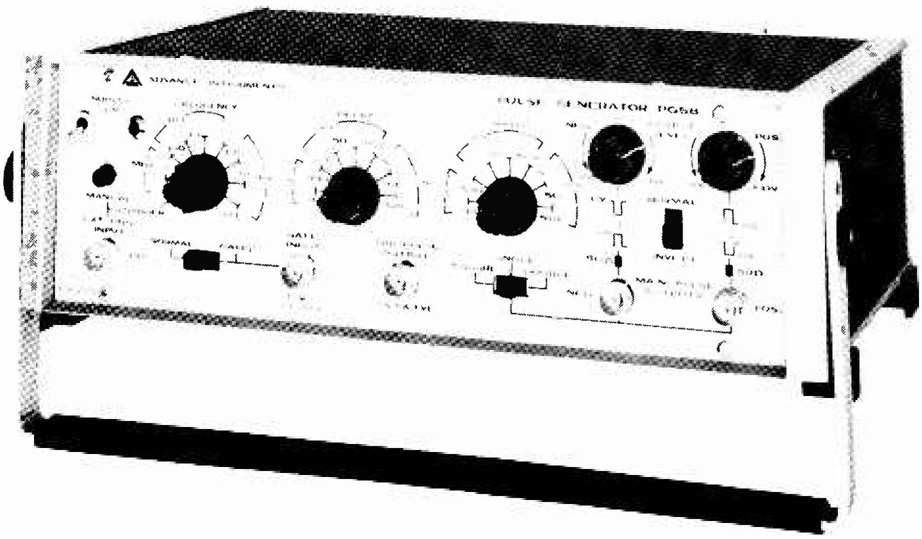
Tin oxide resistors with plug-in terminations have been developed by Erie. The resistors—rated at 0.3W at 70°C ambient temperature—are available from 10Ω to 300kΩ with ±2 and ±5% tolerances.

voltage rating	250V
temperature coeff.	400 p.p.m. above 220Ω 500 p.p.m. below 220Ω
load life stability	±3% at 0.3W
noise	< 1μV/V
price	£0.65 per 100 (5% tolerance)

Erie Electronics Ltd, South Denes, Great Yarmouth, Norfolk.
WW 311 for further details

Pulse generator

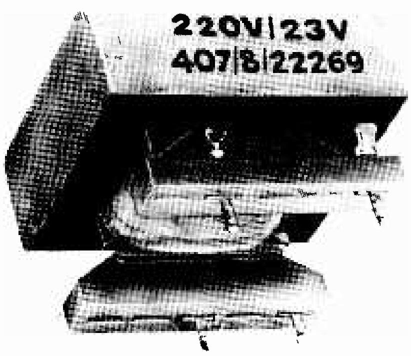
A new pulse generator, the PG58 from Advance Electronics, provides repetition frequencies from 0.1Hz to 5MHz, pulse widths and delays from 100ns to 500ms, single pulse and double pulse, or square waves, from simultaneously available positive and negative outputs. Maximum



output is 10V into an open circuit (5V into 50Ω) from each output. The PG58 may be externally triggered or synchronously gated and a manual trigger facility is provided. There is output protection against voltage feed-in of ± 15V. Advance Electronics Ltd, Raynham Road, Bishops Stortford, Herts.
WW 316 for further details

Miniature transformer

A miniature laminated transformer is available from Plessey. Designed for use with printed circuits, power output approaches 1.5W. Input voltage is 220V, 50Hz. Up to ten pins can be used for input and output connections, and the terminal



strips are 20mm apart—the assembly measures 30 × 25 × 25mm. Bobbins are made from glass-filled nylon. The working temperature range is 40 to 120°C. Industrial & Electronic Components Division, Plessey Components Group, Vicarage Lane, Ilford, Essex.
WW305 for further details

M.O.S. large scale i.cs

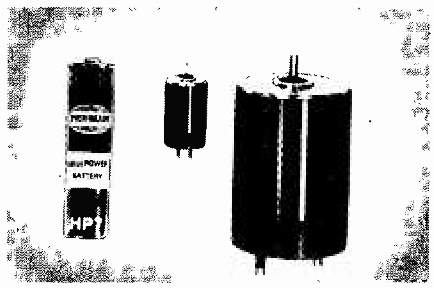
Thorp Electronic Components are distributing a range of components from UNISEM (a subsidiary of Aircraft International of America) which includes random access memories, read-only memories and character generators. The designs interface directly with worst-case d.t.l. and t.t.l. levels without the need for pull-up or pull-down resistors and will operate over the full −55° to +125°C military specification range. 'Commercial' types operate from −25° to +70°C. The UA3524, a fully-decoded 1024 word × 1 bit r.a.m. has a maximum access time at 70°C of 250ns and a cycle time of 400ns together with a refresh time of only 16 cycles. It is fully specified from −25° to +70°C. A military version, UA2524, is also available, specified from −55° to +125°C. Thorp Electronic Components Ltd, Victoria House, 63-66 Foregate Street, Worcester.
WW308 for further details

F.E.T. switch/drivers

A new range of junction f.e.t. switch/drivers for use with ± 15V supplies includes twin-channel s.p.s.t. and d.p.s.t. devices. Others are available for double-throw applications. The devices allow the coupling of low-level logic to high-voltage input circuits, and maximum on-resistances of 15 to 100Ω are available. DG151A and DG161A will handle analogue signals of ± 7.5V at frequencies greater than 1MHz; DG151B and DG161B are suitable for ± 5.5V. They are available in TO-86 flatpack or TO-116 package. Siliconix Ltd, Saunders Way, Sketty, Swansea, SA2 8BA.
WW 312 for further details

Efficient d.c. motors

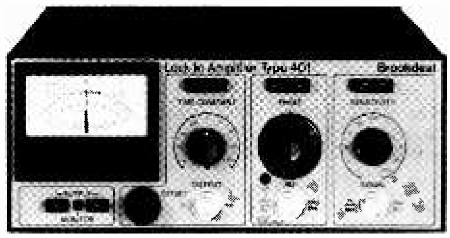
Trident Engineering produce a range of permanent magnet d.c. motors, designated Maxon, rated from 0.25W to 20W, and



with starting torque up to 1,200g cm. The motors have ironless rotors allowing efficiency up to 90%, low inertia, and a high power-to-volume ratio. There are nine frame sizes—from 12mm to 32mm diameter. Operation is from 1, 3, 6, 12, or 24V supplies. Operating temperature range is −20° to +65°C. The commutator has up to 13 segments for smooth output. Trident Engineering Ltd, Shute End, Wokingham, Berks, RG11 1BH.
WW322 for further details

Battery-operated lock-in amplifier

A signal recovery instrument which can be operated from batteries, if required, is the lock-in amplifier Type 401, introduced by Brookdeal Electronics. Capable of recovering repetitive signals of down to 100dB below the noise level, it has a sensitivity which may be varied from 1μV to 100mV and a frequency range of 1Hz to 50kHz. The input dynamic range is 100dB. In the reference channel, phase shifts of 90° and 180° can be introduced by operating push buttons, while a calibrated variable control gives a further 0-100° adjustment. The instrument is claimed to have automatic circuitry which enables it to measure signals without



unnecessary setting up procedures and keeps it operating correctly during lengthy experiments. For supply power the 401 can have one of three interchangeable plug-in power packs: a battery pack using three PP9 dry batteries; an a.c. mains power unit; or a dual-purpose unit which allows operation from either a.c. mains or internal rechargeable batteries. Brookdeal Electronics Ltd., Market Street, Bracknell, Berks.
WW301 for further details

D.I.L. pulse transformer

Bourns (Trimpot) have introduced Model 4252-1005 miniature d.i.l. pulse transformer—a 16-pin unit with high insulation resistance, fast rise and fall time, clean pulse performance, and low coupling capacitance. The specification includes:

operating temperature range	0° to 70°C
pulse inductance (± 10%, 0° to 70°C)	150μH
leakage inductance	1.0μH
coupling capacitance	5pF
pulse width	400ns

Bourns (Trimpot) Ltd, Hodford House, 17/27 High Street, Hounslow, Middx.
WW324 for further details

Literature Received

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

ACTIVE DEVICES

GEC Semiconductors Ltd, Witham, Essex, have sent us the following literature:

Data sheet for silicon gate transistors M11/12/14-02; gate threshold voltage 1 to 2V; BV_{SDS} = -25V; C_{gd} = 0.3 to 0.5pF WW401

Bipolar, m.o.s., hybrid, integrated circuit product guide WW402

Integrated circuit price list WW403

'MOSFET product guide', publication No.MOS-160C, contains data on single, dual and dual-gate m.o.s.f.e.ts. An index of application notes is included. RCA Ltd, Lincoln Way, Windmill Rd, Sunbury-on-Thames, Middlesex WW441

Thorp Electronic Components Ltd, Victoria House, 63-66 Foregate St, Worcester, the U.K. distributors for United Aircraft's (U.S.A.) Unisem components, have available the following literature:

'Hybrid microcircuits' describes the facilities available at the Electronic Components Division of United Aircraft for the assembly and design of thin and thick film, single or multi-layer, hybrid microcircuits WW404

'LSI memory devices', m.o.s., data sheet WW405

'H22-08, -10, -12 D/A converters'. Digital-to-analogue converters for 8-, 10- or 12-bits with $\pm$0.5 l.s.b. accuracy WW406

James Scott (Electronic Engineering) Ltd, Cartyne Industrial Estate, Glasgow E.2, U.K. distributors for E & M Laboratories (U.S.A.), have available an E & M catalogue devoted to 'Microwave devices and ferrite components' WW407

Bulletin EN2020 from International Rectifier (Great Britain) Ltd, Hurst Green, Oxted, Surrey, is a data sheet for a new range of 70A silicon power diodes which are intended for maximum reverse repetitive voltages from 100 to 1,200 .... WW408

'Professional cathode ray tubes' is the title of a new publication from the M-O Valve Co. Ltd, Brook Green Works, Hammersmith, London W.6. WW442

PASSIVE COMPONENTS

Electrosil Ltd, Pallion, Sunderland, Co. Durham, have produced a wall chart/leaflet giving data on their range of glass capacitors. Rated between -55 and $+125$°C some of these capacitors are available for up to 6kV working WW409

A large number of transformers with a wide range of voltage outputs and current ratings intended mainly for transistor equipment power supplies are described in the publication 'Transistor power supply transformers' from Gardners Transformers Ltd, Christchurch, Hampshire WW443

Intended for use in recording studios a range of jack socket assemblies, which can be supplied in rows of 20 sockets for 19-inch panel mounting, is described in a leaflet 'Audio jackfields'. D. N. Jones Electronics Ltd, Vapery Lane, Pirbright, Woking, Surrey WW444

Data is given on valves, TV picture tubes and deflection components, microwave components, vacuum capacitors, cathode-ray tubes, photoelectric devices, X-ray tubes, semiconductors and other electronic components as well as applications information (in German) in AEG-Telefunken's 'Taschenbuch-1971'. Allgemeine Elektricitats-Gesellschaft, AEG-Telefunken, Fachbereich Rohren, Vertrieb, 7900 Ulm, Soflinger Strasse 100, West Germany WW445

APPLICATION NOTES

'Using a dual-polarity, tracking, voltage regulator' is the self-explanatory title of an application note from Silicon General Inc., 7382 Bolsa Avenue, Westminster, California 92683, U.S.A. ... WW410

'Design of fixed and programmable counters using the RCA CD4018 COS/MOS presettable divide-by-n counter', application note No. ICAN-6498, describes the design of a counter which will divide by 3 to 999. RCA Ltd, Sunbury-on-Thames, Middlesex WW411

'FEQ101 64-bit read-write random access memory' is a publication which describes the FEQ101 memory i.c. which is organized as 16-words of 4-bits each. It shows how larger storage capacities may be obtained with the device. Mullard Technical Information Service, Industrial Electronics Division, Mullard Ltd, Mullard House, Torrington Place, London WC1E 7HD WW412

Hewlett Packard Ltd, 224 Bath Rd, Slough, Bucks, have produced application notes which describe some uses for their 3721A correlator:

4, 'Correlation measures wind force' ... WW413

5, 'Measurement of nuclear reactor criticality' WW414

6, 'Correlation measures supersonic turbulence' WW415

'Micronotes', Vol.8, No.1, published by Microwave Associates Inc, Cradock Rd, Luton, Beds, LU4 0JQ, deals with the question of pulse priming magnetrons to achieve pulse-to-pulse coherence WW416

EQUIPMENT

Aveley Electric Ltd, Arisdale Avenue, South Ockendon, Essex RM15 5SR, have sent us the following literature:

Data sheet, Rohde & Schwarz, OMTF, 0-50MHz precision oscilloscope WW417

Brochure, North Atlantic 8525 angle position indicator for resolver/synchro-to-digital conversion WW418

Data sheet, Narda model 9500, 1 to 12.4GHz sweep generator WW419

Dawe Instruments Ltd, Concord Rd, Western Avenue, London W.3, have published a booklet called 'Stroboscopes' WW421

Electronic Instruments, power supplies, industrial control and logic tutor kits are the areas covered by the Farnell Instruments Ltd (Sandbeck Way, Wetherby, Yorkshire LS22 4DH) short-form catalogue WW422

A transistor controlled relay unit is described in data sheet CD/7 from LTH Electronics Ltd, Eltelec Works, Chaul End Lane, Luton, Beds ... WW423

Delays from 1ns to 999.999μs with accuracies up to 100ps are available with the programmable digital delay generator model 7040 which is described in a leaflet from Berkeley Nucleonics Corp., 1198 Tenth St, Berkeley, California 94710, U.S.A. WW424

We have received a catalogue from Loewe Opta GmbH, West Berlin, Kronach, West Germany, which describes, in German, their range of TV and radio receivers, audio equipment, tape recorders, domestic video recorders, and electronic photoflash equipment WW425

Limrose Electronics, Lymm, Cheshire, inform us that they have revised the instruction booklet for Compukit-1. Copies cost 40p each.

Zoom Television Ltd, The Bury, Church St., Chesham, Bucks, have developed a pulse counter, called the Edi-cue, which is for precise editing of video tape on helical scan recorders and is described in a leaflet WW426

A multi-purpose industrial radio control system is briefly described in a leaflet from Ariel Electronics, 100 Colne Rd, Twickenham, Middlesex .. WW427

The publication 'Danavox headsets' describes a variety of headsets including one with a built-in inductive loop receiver. Danavox (Gt. Britain) Ltd, Bagshot Rd, Sunninghill, Berks. WW428

Y-Tronics is the name of a series of units manufactured by the White Electrical Instrument Co. Ltd, Spring Lane North, Malvern Link, Worcestershire, designed to be used in conjunction with the Nuffield-A-level electronics course. They are described in a booklet WW430

Also available from the same company is a leaflet describing a variety of moving-iron and moving-coil meters WW431

Intended for industrial training and similar applications a random access slide projector (ES2500) is described in a leaflet from Electrosonic Ltd, 47 Old Woolwich Rd., London S.E.10 .... WW432

Electromagnets, spectrum analyzers, analogue and hybrid computers and a wide range of electronic test instrumentation are included in the 152-page catalogue of Systron Donner Ltd, St. Mary's Rd, Sydenham Industrial Estate, Leamington Spa, Warwickshire WW433

A leaflet is available which describes the type-62 racking system, intended for transmission equipment, manufactured by Pye TMC Ltd, Transmission Division, Sevenoaks Way, St. Mary's Cray, Orpington, BR5 3AD, Kent WW441

Heathkit (Gloucester) Ltd, Gloucester, GL2 6EE, have sent us a copy of their latest catalogue giving details of a wide range of equipment which can be obtained 'ready-made' or in kit form WW434

Resistance boxes are the subject of two leaflets from the Croydon Precision Instruments Company, Hampton Rd, Croydon CR9 2RU. They can be supplied in 1, 4, 5 or 6 decades from 10 $\times$ 0.0001Ω to 10 $\times$ 1MΩ. High dissipation models are available WW435

The short-form catalogue of Green Electronic and Communication Equipment Ltd, 5-15 Thorold Rd, London N22 4YE, includes a transmitter output analyzer, a modulation analyzer, a synthesized digital signal generator and other items ... WW437

Manufactured in Germany by Howaldtswerke-Deutsche Werfk a range of cable measuring equipment including fault location sets, burn-out and impulse test sets, fault search equipment, etc is described in a brochure from Echometrix Ltd, 113/115 The Broadway, Leigh-on-Sea, Essex . WW438

Also available from the same company is a price list for the wide range of test equipment manufactured by Nordmende WW439

GENERAL INFORMATION

The Institution of Production Engineers, 10 Chesterfield St, London W1X 8DE, has published a booklet 'Quality—its creation and control in the seventies' which is available price 75p.

The latest issue of the journal *Non-Ionizing Radiation* carries several articles discussing the hazards, and effects on the human body, of radiation in the m.f., h.f. and microwave bands. Kendervic Ltd, P.O. Box 13, Guildford, Surrey WW440

A booklet, published jointly by the B.B.C. and the I.T.A., and available from the engineering information departments of either for 50p, called 'Specification for television standards for 625-line system-I transmissions' should be of value to all engaged in television design work.

logarithmic amplifiers

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- ☆ High gain operational amplifier and log function in a single encapsulation.
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- ☆ Output current ± 2 mA.
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- ☆ Operating range 1n A—1mA
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WW—099 FOR FURTHER DETAILS

Low Noise FET RF Amplifiers
Frequency: As specified in the range 1 to 250 MHz.
Bandwidth: As specified up to 10% of signal frequency @ —1 dB.
Gain: 40 dB. @ 50 MHz. 30 dB @ 150 MHz.
Gain control: 20 dB. manual or external AGC.
Noise Factor: 1·5 dB. @ 150 MHz. 2·5 dB. @ 250 MHz.
Impedance: 52 or 75 ohms or as specified.
Connectors: BNC, N, SO239, L604, or as specified.
Power: 12v. @ 12 ma. DC. Negative earth.
Size: $4\frac{1}{2}'' \times 2\frac{1}{2}'' \times 1\frac{1}{4}''$. Diecast case.
Weight: 12 oz.
Price: £30.

Low Noise Broadband RF Amplifiers
Frequency: As specified in the range DC to 150 MHz.
Bandwidth: As specified from 10% to 20% of signal frequency @ —1 dB.
Gain: 70 dB. @ 30 MHz. 50 dB. @ 100 MHz.
Gain control: 60 dB. manual or external AGC.
Noise Factor: 1·5 dB.
Power: 12v. @ 22 ma. DC. Negative earth.
Price: £50.
Impedance, Connectors, Size, and Weight as above.

Wideband RF Amplifiers
Frequency: DC to 100 MHz. @ —3 dB.
Gain: 45 dB.
Gain control: 120 dB. manual or external AGC.
Noise Factor: 6 dB.
Power: 12v. @ 30 ma. DC. Negative earth.
Price: £50.
Impedance, Connectors, Size, and Weight as above.

Low Noise Crystal Controlled FET Frequency Converters
Input frequency: As specified in the range 1 to 250 MHz.
Output frequency: As specified in the range 100 KHz. to 250 MHz.
Price: £50.
Other details as FET RF Amplifiers.

The four basic units above are also available with up to 6 outputs with separate gain controls, integrated high-pass, low-pass, or spot frequency filters, as matched pairs for interferometers, or modified for particular applications. We also manufacture AM, FM, and SSB receivers with phase lock loops and integrated circuits, linear amplifiers, repeaters, and frequency multipliers.

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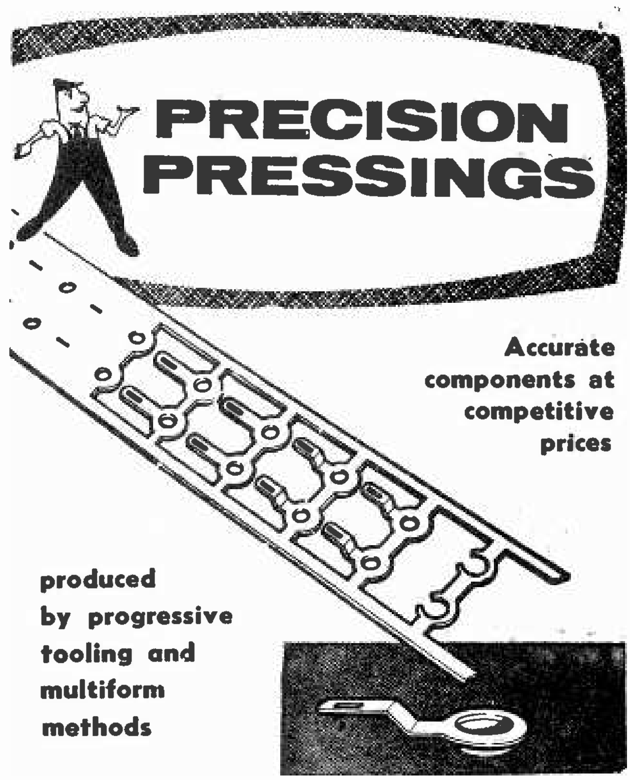

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Sinclair Project 60

Z.30 & Z.50 power amplifiers

The Z.30 and Z.50 are of advanced design using silicon epitaxial planar transistors to achieve unsurpassed standards of performance. Total harmonic distortion is an incredibly low 0.02% at full output and all lower outputs. Whether you use Z.30 or Z.50 amplifiers in your Project 60 system will depend on personal preference, but they are the same size and may be used with other units in the Project 60 range equally well.

SPECIFICATIONS ***(Z50 units are interchangeable with Z.30s in all applications).***
Power Outputs
Z.30 15 watts R.M.S. into 8 ohms using 35 volts: 20 watts R.M.S. into 3 ohms using 30 volts.
Z.50 40 watts R.M S. into 3 ohms using 40 volts: 30 watts R.M.S. into 8 ohms, using 50 volts.
Frequency response: 30 to 300,000 Hz ±1dB.
Distortion: 0.02% into 8 ohms.
Signal to noise ratio: better than 70dB unweighted.
Input sensitivity: 250mV into 100 Kohms.
For speakers from 3 to 15 ohms impedance.
Size $3\frac{1}{2}$ x $2\frac{1}{4}$ x $\frac{1}{2}$ in.

Z.30
Built tested and guaranteed with circuits and instructions manual **£4.48**

Z.50
Built, tested and guaranteed with circuits and instructions manual. **£5.48**

Power Supply Units

Designed specially for use with the Project 60 system of your choice.
Illustration shows PZ.5 to left and PZ.8 (for use with Z.50s) to the right. Use PZ.5 for normal Z.30 assemblies and PZ.6 where a stablised supply is essential.

PZ-5 *30 volts unstabilised* **£4.98**
PZ-6 *35 volts stabilised* **£7.98**
PZ-8 *45 volts stabilised (less mains transformer)* **£7.98**
PZ-8 *mains transformer* **£5.98**

Guarantee

If within 3 months of purchasing Project 60 modules directly from us, you are dissatisfied with them, we will refund your money at once. Each module is guaranteed to work perfectly and should any defect arise in normal use we will service it at once and without any cost to you whatsoever provided that it is returned to us within 2 years of the purchase date. There will be a small charge for service thereafter. No charge for postage by surface mail. Air-mail charged at cost.

Stereo 60 pre-amp/control unit

Designed for the Project 60 range but suitable for use with any high quality power amplifier. Again silicon epitaxial planar transistors are used throughout, achieving a really high signal-to-noise ratio and excellent tracking between channels. Input selection is by means of push buttons and accurate equalisation is provided for all the usual inputs.

SPECIFICATIONS
Input sensitivities: Radio–up to 3mV. Mag. p.u. 3mV: correct to R.I.A.A. curve ± 1dB: 20 to 25,000 Hz. Ceramic p.u.–up to 3mV: Aux–up to 3mV.
Output: 250mV
Signal-to-noise ratio: better than 70dB.
Channel matching: within 1dB.
Tone controls: TREBLE + 15 to —15dB at 10KHz: BASS + 15 to—15dB at 100Hz.
Front panel: brushed aluminium with black knobs and controls.
Size: $8\frac{1}{4}$ x $1\frac{1}{4}$ x 4 ins.

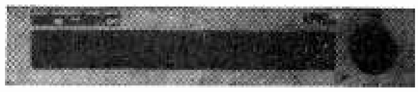
Built, tested and guaranteed. **£9.98**

Active Filter Unit

For use between Stereo 60 unit and two Z.30s or Z.50s, and is easily mounted. It is unique in that the cut-off frequencies are continuously variable, and as attenuation in the rejected band is rapid (12dB/octave), there is less loss of the wanted signal than has previously been possible. Amplitude and phase distortion are negligible. The A.F.U. is suitable for use with any other amplifier system. Two stages of filtering are incorporated–rumble (high pass) and scratch (low pass). Supply voltage – 15 to 35V. Current – 3mA. H.F. cut-off (–3dB) variable from 28kHz to 5kHz. L.F cut-off (–3dB) variable from 25Hz to 100Hz. Distortion at 1kHz (35V. supply) 0.02% at rated output.

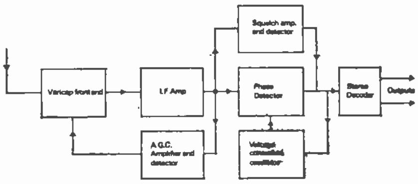
Built, tested and guaranteed **£5.98**

Stereo FM Tuner



first in the world to use the phase lock loop principle
Before production of this tuner, the phase lock loop principle was used for receiving signals from space craft because of its vastly improved signal to noise ratio over other systems. Now, for the first time, the principle has been applied to an FM tuner with fantastically good results. Other original features include varicap diode tuning, printed circuit coils, an I.C. in the specially designed stereo decoder and squelch circuit for silent tuning between stations. Sensitivity is such that good reception becomes possible in difficult areas. Foreign stations can be tuned in suitable conditions and often a few inches of wire are enough for an aerial. In terms of a high fidelity this tuner has a lower level of distortion than any other tuner we know. Stereo broadcasts are received automatically as the tuning control is rotated, a panel indicator lighting up as the stereo signal is tuned in. This tuner can also be used to advantage with any other high fidelity system.

SPECIFICATIONS:
Number of transistors: 16 plus 20 in I.C.
Tuning range: 87.5 to 108 MHz
Capture ratio: 1.5dB
Sensitivity: 2μV for 30dB quieting: 7μV for full limiting.
Squelch level: 20μV.
A.F.C. range: ±200 KHz
Signal to noise ratio: >65dB
Audio frequency response: 10Hz—15KHz (±1dB)
Total harmonic distortion: 0.15% for 30% modulation
Stereo decoder operating level: 2μV
Pilot tone suppression: 30dB
Cross talk: 40dB
I.F. frequency: 10.7 MHz
Output voltage: 2 x 150mV R.M.S.
Aerial impedance: 75 Ohms
Indicators: Mains on: Stereo on; tuning indicator
Operating voltage: 25-30 VDC
Size: 3.6 x 1.6 x 8.15 inches: 91.5 x 40 x 207 mm



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Sinclair IC10/Q16/Micromatic

IC10

The world's most advanced high fidelity amplifier

This is the world's first monolithic integrated circuit high fidelity power amplifier and pre-amplifier. The circuit itself is a chip of silicon only a twentieth of an inch square by one hundredth of an inch thick, having 5 watts RMS output (10 watts peak). It contains 13 transistors (including two power types), 2 diodes, 1 zener diode and 18 resistors, and is encapsulated in a solid plastic package which holds the metal heat sink and connecting pins. This exciting device is more rugged and has considerable performance advantages, including complete freedom from thermal runaway and a very low level of distortion. The IC10 is primarily intended as a full performance high fidelity power and pre-amplifier, for which application it only requires the addition of such components as tone and volume controls and a battery or mains power supply. It may also be used in other applications including car radios, electronic organs, servo amplifiers (it is dc coupled throughout) etc.

Circuit Description

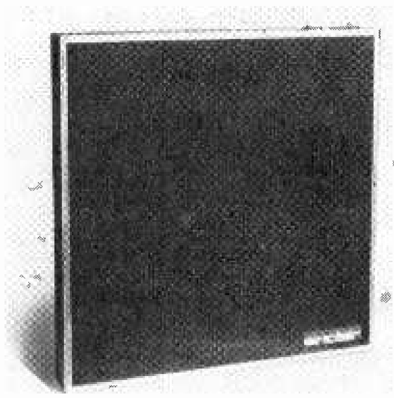
The first three transistors are used in the pre-amp and the remaining 10 in the power amplifier. Class AB output is used with closely controlled quiescent current which is independent of temperature. There is generous negative feedback round both sections and the amplifier is completely free from crossover distortion at all supply voltages, making battery operation eminently satisfactory.

Each IC10 is sold with a comprehensive manual giving circuit and wiring diagrams for a large number of applications in addition to high fidelity. These include oscillators, etc. The pre-amp section can be used as an RF or IF, amplifier without any additional transistors.

Specifications:

Output: 10 watts peak, 5 watts RMS continuous.
Frequency response: 5Hz to 100kHz 1 ± dB.
Total harmonic distortion: Less than 1% at full output.
Load impedance: 3 to 15 ohms.
Power gain: 110 dB (100,000,000,000 times) total.
Supply voltage: 8 to 18 volts. (A Sinclair power unit, PZ.7 is available for mains operation).
Size: 1 x 0.4 x 0.2 in. plus heat sink and tags.
Sensitivity 5 mV.
Input impedance: Adjustable externally up to 2.5 Mohms.
Price (with manual) **£2.98** post free.

Q16



High fidelity loudspeaker

The Q16 employs the well proven acoustic principles specially developed by Sinclair in which a special driver assembly is meticulously matched to the characteristics of the uniquely designed cabinet. In reviewing this exclusive Sinclair design, technical journals have justly compared the Q16 with much more expensive loudspeakers. Its shape enables the Q16 to be positioned and matched to its environment to much better effect than is the case with conventionally styled enclosures. A solid teak surround with a special all-over cellular foam front is used as much for appearance as its ability to pass all audio frequencies.

This elegantly designed shelf mounting speaker brings genuine high fidelity within reach of every music lover.

Specifications:

Construction: Special sealed seamless sound or pressure chamber with internal baffle.
Loading: up to 14 watts TMS.
Input impedance: 8 ohms.
Frequency response: From 60 to 16,000 Hz, confirmed by independently plotted B and K curve.
Driver unit: Special high compliance unit having massive ceramic magnet of 11,000 gauss, aluminium speech coil and a special cone suspension for excellent transient response.
Size and styling: 9¾ in square on face x 4¾ in. deep with neat pedestal base. Black all-over cellular foam front with natural solid teak surround.
Price £8.98.

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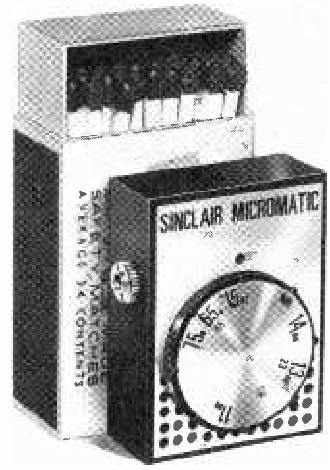

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Considerably smaller than an ordinary box of matches, this is a multi-stage AM receiver brilliantly designed to provide remarkable standards of selectivity, power and quality for its size. Powerful AGC counteracts fading from distant stations; bandspread at higher frequencies makes reception of Radio 1 easy. The plug-in magnetic earpiece provided matches the Micromatic's output to give wonderful standards of reproduction. Everything including the special ferrite rod aerial and batteries is contained within the minute and attractively designed case. Whether you build a Micromatic kit or buy this amazing receiver ready built and tested, you will find it as easy to take with you as your wrist watch, and dependable under the severest listening conditions.

Specifications:

Size: 36 x 33 x 13 mm (1⁴/₅ x 1³/₁₀ x ½ in.)
Weight: including batteries, 28.4 gm (1 oz.).
Case: Black plastic with anodised aluminium front panel and spun aluminium dial.
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This book provides in one volume practical information on modern techniques in measuring electrical quantities and describes the instruments and various methods which may be used. SI units are used throughout the text which contains much data which will be of great value to the practical engineer as well as the examination student.

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P. Tharma

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Measuring Oscilloscopes

Edited by J. F. Golding

The text has been prepared by Staff Engineers of Marconi Instruments Limited. Throughout, emphasis has been laid on methods and principles rather than detailed descriptions of circuits which may be rendered obsolete as new devices are produced. The book provides a comprehensive guide to the principles of operation and applications of the modern oscilloscope, and will be of value to students, technicians and all who have occasion to use this instrument.

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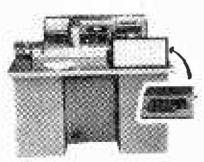

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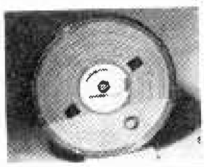

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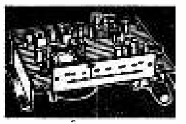

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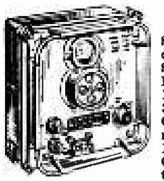

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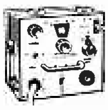

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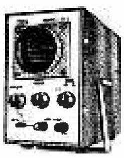

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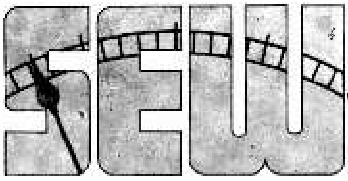

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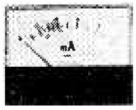
NEW "SEW" DESIGNS!

CLEAR PLASTIC METERS



TYPE SW. 100
100 x 80 mm.

		20V. D.C.	£2·97½
50µA	£3·47½	50V. D.C.	£2·97½
50-0-50µA	£3·37½	300V. D.C.	£2·97½
100µA	£3·37½	1 amp. D.C.	£2·97½
100-0-100µA	£3·25	5 amp. D.C.	£2·97½
500µA	£3·12½	300V. A.C.	£2·97½
1mA	£2·97½	VU Meter	£3·75

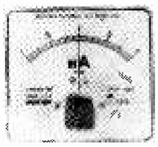
BAKELITE PANEL METERS

TYPE S-80
80 mm.
square fronts

50µA	£3·12½	50V. D.C.	£2·47½
50-0-50µA	£2·97½	300V. D.C.	£2·47½
100µA	£2·97½	1 amp. D.C.	£2·47½
100-0-100µA	£2·87½	5 amp. D.C.	£2·47½
500µA	£2·62½	300V. A.C.	£2·62½
1mA	£2·47½	VU Meter	£3·37½
20V. D.C.	£2·47½		

"SEW" CLEAR PLASTIC METERS

Type MR.85P. 4¼in. × 4¼in. fronts.



		10mA	£2·60
		50mA	£2·60
		100mA	£2·60
		500mA	£2·60
		1 amp.	£2·60
		5 amp.	£2·60
		15 amp.	£2·60
		30 amp.	£2·60
		20V. D.C.	£2·60
		50V. D.C.	£2·60
		150V. D.C.	£2·60
50µA	£3·60	300V. D.C.	£2·60
50-0-50µA	£3·10	15V. A.C.	£2·60
100µA	£3·10	300V. A.C.	£2·60
100-0-100µA	£3·10	S Meter 1mA	£2·87½
200µA	£2·87½	VU Meter	£3·60
500µA	£2·75	1 amp. A.C.*	£2·60
500-0-500µA	£2·60	5 amp. A.C.*	£2·60
1mA	£2·60	10 amp. A.C.*	£2·60
1-0-1mA	£2·60	20 amp. A.C.*	£2·60
5mA	£2·60	30 amp. A.C.*	£2·60

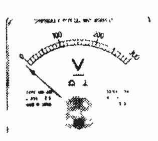
Type MR.52P. 2½in. square fronts.

50µA	£3·10	10V. D.C.	£2·00
50-0-50µA	£2·60	20V. D.C.	£2·00
100µA	£2·60	50V. D.C.	£2·00
100-0-100µA	£2·37½	300V. D.C.	£2·00
500µA	£2·25	15V. A.C.	£2·00
1mA	£2·00	300V. A.C.	£2·00
5mA	£2·00	S Meter 1mA	£2·10
10mA	£2·00	VU Meter	£3·10
50mA	£2·00	1 amp. A.C.*	£2·00
100mA	£2·00	5 amp. A.C.*	£2·00
500mA	£2·00	10 amp. A.C.*	£2·00
1 amp.	£2·00	20 amp. A.C.*	£2·00
5 amp.	£2·00	30 amp. A.C.*	£2·00

Type MR.65P. 3½in. × 3¼in. fronts

50µA	£3·37½	10V. D.C.	£2·10
50-0-50µA	£2·75	20V. D.C.	£2·10
100µA	£2·75	50V. D.C.	£2·10
100-0-100µA	£2·60	150V. D.C.	£2·10
200µA	£2·60	100V. D.C.	£2·10
500µA	£2·37½	15V. A.C.	£2·10
500-0-500µA	£2·10	50V. A.C.	£2·10
1mA	£2·10	150V. A.C.	£2·10
5mA	£2·10	300V. A.C.	£2·10
10mA	£2·10	500V. A.C.	£2·10
50mA	£2·10	S Meter 1mA	£2·37½
100mA	£2·10	VU Meter	£3·37½
500mA	£2·10	50mA A.C.‡	£2·10
1 amp.	£2·10	100mA A.C.*	£2·10
5 amp.	£2·10	200mA A.C.*	£2·10
10 amp.	£2·10	500mA A.C.*	£2·10
15 amp.	£2·10	1 amp. A.C.*	£2·10
20 amp.	£2·10	5 amp. A.C.*	£2·10
30 amp.	£2·10	10 amp. A.C.*	£2·10
50 amp.	£2·37½	20 amp. A.C.*	£2·10
5V. D.C.	£2·10	30 amp. A.C.*	£2·10

Type MR.38P. 1 21/32in. square fronts.



		200mA	£1·37½
		300mA	£1·37½
		500mA	£1·37½
		750mA	£1·37½
		1 amp.	£1·37½
		2 amp.	£1·37½
		5 amp.	£1·37½
		10 amp.	£1·37½
50µA	£2·00	3V. D.C.	£1·37½
50-0-50µA	£1·87½	10V. D.C.	£1·37½
100µA	£1·87½	15V. D.C.	£1·37½
100-0-100µA	£1·75	20V. D.C.	£1·37½
200µA	£1·75	100V. D.C.	£1·37½
500µA	£1·50	150V. D.C.	£1·37½
500-0-500µA	£1·37½	300V. D.C.	£1·37½
1mA	£1·37½	500V. D.C.	£1·37½
1-0-1mA	£1·37½	750V. D.C.	£1·37½
2mA	£1·37½	15V. A.C.	£1·37½
5mA	£1·37½	50V. A.C.	£1·37½
10mA	£1·37½	150V. A.C.	£1·37½
20mA	£1·37½	300V. A.C.	£1·37½
50mA	£1·37½	500V. A.C.	£1·37½
100mA	£1·37½	S Meter 1mA	£1·60
150mA	£1·37½	VU Meter	£2·10

Type MR.45P. 2in. square fronts.

50µA	£2·25	5 amp.	£1·50
50-0-50µA	£2·10	10V. D.C.	£1·50
100µA	£2·10	20V. D.C.	£1·50
100-0-100µA	£1·87½	50V. D.C.	£1·50
200µA	£1·87½	300V. D.C.	£1·50
500µA	£1·60	15V. A.C.	£1·50
500-0-500µA	£1·50	300V. A.C.	£1·50
1mA	£1·50	S Meter 1mA	£1·87½
5mA	£1·50	VU Meter	£2·25
10mA	£1·50	1 amp. A.C.‡	£1·50
50mA	£1·50	5 amp. A.C.‡	£1·50
100mA	£1·50	10 amp. A.C.‡	£1·50
500mA	£1·50	20 amp. A.C.‡	£1·50
1 amp.	£1·50	30 amp. A.C.‡	£1·50

"SEW" BAKELITE PANEL METERS

Type MR.65. 3½in. square fronts.

		500mA	£1·75
		1 amp.	£1·75
		5 amp.	£1·75
		15 amp.	£1·75
		30 amp.	£1·75
		50 amp.	£1·75
		5V. D.C.	£1·75
		10V. D.C.	£1·75
		26V. D.C.	£1·75
		50V. D.C.	£1·75
		150V. D.C.	£1·75
		300V. D.C.	£1·75
25µA	£3·50	30V. A.C.*	£1·75
50µA	£2·37½	50V. A.C.*	£1·75
50-0-50µA	£2·25	150V. A.C.*	£1·75
100µA	£2·25	300V. A.C.*	£1·75
100-0-100µA	£2·25	500mA A.C.*	£1·75
500µA	£2·10	1 amp. A.C.*	£1·75
1mA	£1·75	5 amp. A.C.*	£1·75
1-0-1mA	£1·75	10 amp. A.C.*	£1·75
5mA	£1·75	20 amp. A.C.*	£1·75
10mA	£1·75	30 amp. A.C.*	£1·75
50mA	£1·75	50 amp. A.C.*	£1·75
100mA	£1·75	VU Meter	£3·10

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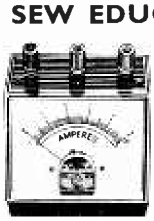


Type ED 107

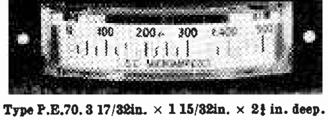
Size overall 100mm × 90mm × 108mm

A new range of high quality moving coil instruments ideal for school experiments and other bench applications. 3in. mirror scale. The meter movement is easily accessible to demonstrate internal working.

Available in the following ranges:—

50µA	£4·50	20V d.c.	£3·97
100µA	£4·25	50V d.c.	£3·97
1mA	£3·97	300V d.c.	£3·97
50-0-50µA	£4·25	Dual range	
1-0-1mA	£3·97	500mA/5A d.c.	£4·25
1A d.c.	£3·97	5V/50V d.c.	£4·25
5A d.c.	£3·97	Triple range	
10V d.c.	£3·97	1mA/10mA/100mA	£4·62

EDGWISE METERS



Type P.E.70. 3 17/32in. × 1 15/32in. × 2½ in. deep.

50µA	£3·00	500µA	£2·60
50-0-50µA	£2·87½	1mA	£2·37½
100µA	£2·87½	300V. A.C.	£2·37½
100-0-100µA	£2·75	VU Meter	£3·25
200µA	£2·75		

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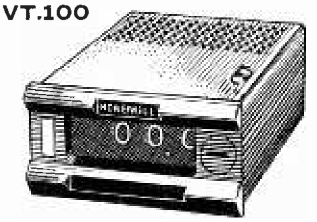
HONEYWELL DIGITAL VOLTMETER VT.100



Can be panel or bench mounted. Basic meter measures 1 volt D.C. but can be used to measure a wide range of AC and DC volt, current and ohms with optional plug in cards.

Specification:
Accuracy: ± 0·2, ± 1 digit.
Resolution: 1mV.
Number of digits: 3 plus fourth overrange digit.
Overrange: 100% (up to 1·999)
Input impedance: 1000 Meg ohm.
Measuring cycle: 1 per second.
Adjustment: Automatic zeroing, full scale adjustment against an internal reference voltage.
Overload: to 100v. D.C.
Input: Fully floating (3 poles).
Input power: 110-230v. A.C. 50/60 cycles.
Overall size: 5⅝in. × 2 13/16in. × 8 3/16in.

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230 VOLT A.C. 50 CYCLES RELAYS

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100 Kc/s to 1,000 Mc/s. A.C. 10 mV to 3v. D.C. 10 mV. to 3v. Current 0.01 uA to 0.3 mA. Resistance 1 ohm to 10 megohm. £125.

TTIS. TRANSISTOR TESTER
Full range of facilities for testing PNP or NPN transistors in or out of circuit. £37·50.
Carriage 50p. per item.

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2N698	42p
2N706	10p
2N706A	12p
2N708	15p
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2N918	37p
2N929	22p
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2N4291	15p
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28103	37p
28104	37p
40250	50p
40361	55p
40362	60p
AC107	37p
AC126	25p
AC127	25p
AC128	25p
AC154	15p
AC176	25p
AC187	30p
AC188	30p
ACY17	30p
ACY18	25p
ACY19	25p
ACY20	22p
ACY21	22p
ACY22	17p
ACY28	17p
ACY40	15p
AD140	50p
AD149	50p
AD161	37p

AD162	37p
AF114	25p
AF115	25p
AF116	25p
AF117	25p
AF118	62p
AF119	20p
AF124	25p
AF126	17p
AF127	17p
AF139	30p
AF178	47p
AF180	52p
AF181	42p
AF186	40p
AF239	42p
ASY26	25p
ASY27	32p
ASY28	25p
ASZ17	42p
AUY10	97p
BAY31	7p
BC107	12p
BC108	12p
BC109	12p
BC113	25p
BC116	40p
BC125	55p
BC126	55p
BC147	17p
BC148	12p
BC149	20p
BC167	15p
BC172	17p
BC177	25p
BC186	25p
BC182L	10p
BC184L	12p
BC212L	12p
BCY30	25p
BCY31	30p
BCY32	50p
BCY33	25p
BCY34	30p
BCY38	40p
BCY42	15p
BCY43	20p
BCY71	30p
BCY72	15p
BCZ11	40p
BD121	65p
BD123	80p
BD124	80p
BF115	25p
BF117	47p
BF167	25p
BF173	30p
BF180	37p
BF181	37p
BF182	32p
BF184	25p
BF185	25p
BF194	17p
BF915	15p
BF200	37p
BF224	30p
BF225	30p
BF244	47p
BFX12	22p
BFX13	25p
BFX29	30p
BFX30	32p
BFX44	37p
BFX85	40p
BFX86	32p
BFX87	32p
BFX88	25p
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OA90	10p
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OA95	7p
OA200	7p
OA202	10p
OA210	17p
OC19	37p
OC20	97p
OC22	50p
OC23	60p
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OC74	30p
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OC76	25p
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OC78	20p
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OC81D	20p
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6H6	20p
6J4	50p
6J5	20p
6J5GT	30p
6J6	20p
6J7	45p
6K8G	35p
6L6GT	45p
6LD20	40p
6Q7	40p
6SA7	40p
6SG7	35p
6SJ7	40p
6SK7	35p
6SL7	35p
6SN7	35p
6SQ7	40p
6U4	60p
6V6G	25p
6V6GT	32p
6X4	30p
6X5G	30p
6X5GT	27p
10C2	50p
10F1	90p
10P13	55p
10P14	£1·10
12AT6	30p
12AT7	30p
12AU7	30p
12AX7	30p
12AV6	33p
12BA6	35p
12BE6	35p
12BH7	40p
19AQ5	35p
20D1	45p
20F2	75p
20L1	£1·10
20P1	50p
20P3	60p
20P4	£1·10
20P5	£1·20
25L6	45p
25Z4	30p
25Z5	42p
25Z6	65p
30C15	80p
30C17	85p
30C18	75p
30F5	85p
30FL1	70p
30FL12	92p

30FL14	75p
30L15	85p
30L17	80p
30P12	80p
30P19	80p
30PL1	70p
30PL13	93p
30PL14	90p
35L6	50p
35W4	30p
35Z4	30p
35Z5	40p
50B5	45p
50C5	40p
80	50p
85A2	40p
807	50p
1625	50p
5763	70p
6146	£1·50
AZ31	50p
CY31	35p
DAF91	25p
DAF96	42p
DF91	25p
DF96	42p
DK91	35p
DK92	50p
DK96	42p
DL92	35p
DL94	45p
DL96	42p
DM70	32p
DY86	33p
DY87	35p
E88CC	65p
E180F	95p
EABC80	35p
EAF42	35p
EB91	20p
EBC41	55p
EBC81	30p
EBF80	40p
EBF83	40p
EBF89	32p
EBL21	60p
EC86	60p
EC88	60p
ECC40	60p
ECC84	30p
ECC85	60p
ECC88	40p
ECF80	35p
ECF82	35p
ECF86	65p
ECH21	57p
ECH35	60p
ECH42	70p
ECH81	30p
ECH83	40p
ECL80	40p
ECL82	35p
ECL83	65p
ECL86	40p
EF37A	60p
EF39	40p
EF40	50p
EF41	65p
EF42	70p
EF80	25p
EF85	35p
EF86	30p
EF89	28p
EF91	33p
EF92	40p
EF183	30p
EF184	35p
EH90	40p
EL34	50p
EL33	£1·25
EL41	55p
EL42	58p
EL81	55p
EL84	25p
EL85	43p
EL91	32p
EL95	35p
EM80	40p
EM81	50p
EM84	35p
EM85	£1·00
EM87	43p

EY51	40p
EY86	40p
EY87	42p
EZ140	45p
EZ41	45p
EZ80	25p
EZ81	28p
GZ32	48p
GZ34	60p
KT66	£1·70
KT88	£1·75
MU14	60p
PABC80	40p
PC86	60p
PC88	60p
PC97	45p
PC900	48p
PCC84	40p
PCC85	40p
PCC88	55p
PCC89	50p
PCC189	55p
PCF80	30p
PCF82	34p
PCF84	50p
PCF86	60p
PCF800	80p
PCF801	50p
PCF802	50p
PCF805	75p
PCF806	70p
PCF808	75p
PCL82	35p
PCL83	65p
PCL84	45p
PCL85	40p
PCL86	45p
PFL200	70p
PL36	55p
PL81	50p
PL82	45p
PL83	45p
PL84	40p
PL500	75p
PL504	80p
PY32	55p
PY33	63p
PY80	35p
PY81	30p
PY82	30p
PY83	38p
PY88	40p
PY800	50p
PY801	50p
U25	75p
U26	75p
U50	32p
U52	33p
U191	75p
U281	40p
U282	40p
U301	40p
U801	£1·00
UABC80	35p
UAF42	55p
UBC41	50p
UBC81	40p
UBF80	40p
UBF89	35p
UCC84	49p
UCC85	40p
UCF80	55p
UCH21	60p
UCH42	70p
UCH81	35p
UCL82	35p
UCL83	60p
UF41	60p
UF80	35p
UF85	40p
UF89	35p
UL41	65p
UL84	30p
UY41	45p
UY85	30p
VR105/30	38p
VR150/30	35p

ZENER DIODES

400mw. (3.3 to 33v)	1.5 watt (2.4 to 200v)	10 watt (3.9 to 100v)
15p	20p	25p

THYRISTORS

PIV	50	100	200	300	350	400
1A	25p	27p	37p	40p	—	47p
3A	30p	37p	40p	45p	—	50p
5A	—	55p	65p	—	—	75p
7A	—	55p	65p	70p	—	97p

TRIACS

8C41A	8C41B	8C41D
100PIV 6A	6A 200PIV	400 PIV 6A
97p	£1.10	£1·37

INTEGRATED CIRCUITS

L900	40p	CA3005	£1·17	FJH221	25p
L914	40p	CA3011	74p	FJH231	25p
L923	60p	CA3052	£1·65	FJH241	25p
IC-10	£2·50	FCH131	50p	FJH251	25p
SL403	£2·25	FCH161	50p	FJJ121	60p
MC1303	£2·62	FJH141	25p	FJJ131	60p
MC1304	£2·75	FJH171	25p	FJJ211	£1·25
PA246	£2·45	FJH181	25p	FJY101	25p

HI-FI EQUIPMENT

SAVE UP TO 33⅓% OR MORE

SEND S.A.E. FOR DISCOUNT PRICE LISTS AND PACKAGE OFFERS!

GARRARD

Full current range offered brand new and guaranteed at fantastic savings

40 MK 11 Stereo	£8·40	SL65B	£14·97
		SL72B	£26·97
2025 T/C Stereo	£9·87	AP76	£20·97
		SL75B	£30·75
3000 Stereo	£10·50	SL95B	£40·97
SP25 Mk III	£11·75	401	£29·97

Carriage 37½p extra each item.

TEAK BASES AND PERSPEX COVERS

1. For SP25, SL65, SL55, 3000, 2025T/C, 2025 1000, £3·97½.
2. For AP75, SL75, SL95, £5·97½.
3. For SP25 etc. to operate with lid in place £5·97½. Carriage 37½p extra each type.

B.S.R. McDONALD

MP60 £11·95 610 £15·95
510 £12·95 310 £10·95
Carriage 37½p extra each item

TEAK BASE AND PERSPEX COVER for above BSR range £3·97½. Carriage 37½p.

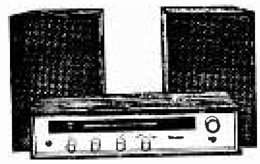
TPDI SERIES with plinth and cover and ready wired.
MP60 £19·50 610 £22·97
510 £20·97
Carriage 50p extra each item.

SPECIAL OFFERS

Garrard SP25 Mk III fitted Goldring G800 cartridge and wooden plinth with perspex cover, ready wired. Total list price £35. OUR PRICE £22.50 Carr. 50p.

GOLDRING GL69/2 fitted Goldring G800 cartridge complete with de luxe base and cover. Total list price £50.80 OUR PRICE £39. Carr. £1

TELETON SPECIAL OFFER!



CR10T AM/FM STEREO TUNER AMPLIFIER WITH MATCHING PAIR SA1003 SPEAKER SYSTEMS Output 4 watts per channel. Excellent reception AFC, built-in MPX. Cer/XTAL Input. Total List £50·25. OUR PRICE £29·95. Carr. 62½p.
Also available with Garrard 2025T/C Record Changer, Plinth, cover and stereo cartridge. Ready wired. £45. Carr. £1.

AMERICAN RECORDING TAPES

First grade quality American tapes. Brand new and guaranteed. Discounts for quantities. Postage 10p Over £3 post paid.

3in. 225ft. L.P. Acetate	17½p
3¼in. 600ft. T.P. Mylar	50p
5in. 600ft. Std. plastic	42½p
6in. 900ft. L.P. acetate	50p
5in. 1,200ft. D.P. Mylar	75p
5¾in. 1,200ft. L.P. acetate	62½p
5¾in. 1,200ft. L.P. Mylar	80p
5¾in. 1,800ft. D.P. Mylar	£1·12½
5¾in. 2,400ft. T.P. Mylar	£1·97½
7in. 1,200ft. Std. acetate	62½p
7in. 1,800ft. L.P. acetate	75p
7in. 1,800ft. L.P. Mylar	£1·00
7in. 2,400ft. D.P. Mylar	£1·25
7in. 3,600ft. T.P. Mylar	£2·25

TAPE CASSETTES

Top quality in plastic library boxes.
C60—60 min. 42½p; 3 for £1·22½
C90—90 min. 62½p; 3 for £1·80
C120—120 min. 75p; 3 for £2·17½
Casette Head Cleaner 56p All Post Extra.

ECHO HS-606 STEREO HEADPHONES

Wonderfully comfortable. Lightweight adjustable vinyl headband, 6ft. cable and stereo jack plug, 25-17,000 cps., 8 Ω imp. £3·37½. P.P. 12½p.

HOSIDEN DH-08S DE-LUXE STEREO HEADPHONES

Features unique mechanical 2 way units and fitted adjustable levelcontrols. 8 ohm impedance. 20-20,000cps. Complete with spring lead & stereo jack plug. £7·97½. P. & P. 12½p.

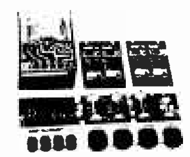
GOLDRING CARTRIDGES!

G850	£5·12½
G800	£7·50
G800E	£11·97½
G800 Super E	£16·80

P. & P. 12½p any type.

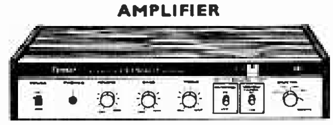
SINCLAIR EQUIPMENT

Project 60. Package Offers



2 × Z30 amplifier, stereo 60 pre-amp, PZ5 power supply. £19. Carr. 37½p. Or with PZ6 power supply, £21. Carr. 37½p. 2 × Z50 amplifier. stereo 60 pre-amp, PZ8 power supply. £21·50. Carr. 37½p. Transformer 4 PZ8, £2·97½ extra. Add to any of the above £4·87½ for active filter unit and £16 for a pair of Q16 speakers. PROJECT 60 FM TUNER £20·97½. Carr. 37½p. All other Sinclair products in stock; 2,000 amplifier £23. Carr. 37½p. 3,000 Amplifier £36. Carr. 37½p. Neoteric amplifier £46. Carr. 37½p.

TELETON SAQ-206 STEREO AMPLIFIER



Latest exciting release. Brand new model, beautifully styled with walnut case. 6 + 6 watts r.m.s. Switched inputs for mag, xtal, aux, tape. Incorporates volume, bass, treble and sliding balance control, scratch filter and loudness control. Rec. List £29·00. Our Price £19·97. Carr. 37p. Suggested system. SAQ 206 amplifier, SP25 III, plinth and cover, G800 cartridge, pair DJ 3 way speakers. Total Rec. List £81. Our Price £59·50. Carr. £1·50.

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Our latest edition giving full details of a comprehensive range of HI-FI EQUIPMENT COMPONENTS, TEST EQUIPMENT and COMMUNICATIONS EQUIPMENT. FREE DISCOUNT COUPONS VALUE 50p. 248 pages, fully illustrated and detailing thousands of items at bargain prices.

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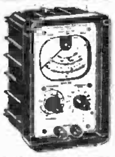
◄— See previous page • G. W. SMITH & Co. (RADIO) LTD • Also see opposite page —►

RUSSIAN C1-16 DOUBLE BEAM OSCILLOSCOPE

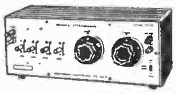
5 mc/s Pass Band. Separate Y1 and Y2 amplifiers. Rectangular 5 in. × 4 in. C.R.T. Calibrated triggered sweep from .2 μ/sec. to 100 milli-sec. per cm. Free running time base 50 c/s-1 mc/s. Built-in time base calibrator and amplitude calibrator. Supplied complete with all accessories and instruction manual. £87 Carr. paid.



MARCONI CT44 TF956 AF ABSORPTION WATTMETER

1 μ/watt to 6 watts. £20. Carr. £1.

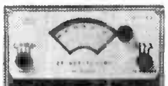
TE111 DECADE RESISTANCE ATTENUATOR



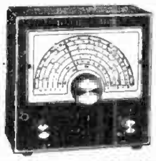
Variable range 0-111 db. Connections. Unbalanced T and Bridge T. Impedance 600 ohms. Range (0.1 db × 10) + (1 db × 10) + 10 + 20 + 30 + 40 db. Frequency: DC to 200 KHZ (—3db). Accuracy: 0.05 db. + indication db × 0.01. Maximum input less than 4 watts (50 volts). Built in 600 Ω load resistance with internal/external switch. Brand new £27·50 P. & P. 25p.

BELCO AF-5A SOLID STATE SINE SQUARE WAVE C.R. OSCILLATOR

Sine 18-200,000 Hz; Square 18-50,000 Hz. Output max. +10 dB (10 K ohms). Operation internal batteries. Attractive 2-tone case 7½ in. × 5in. × 2in. Price £17·50 Carr. 17½p.



TE-16A TRANSISTORISED SIGNAL GENERATOR



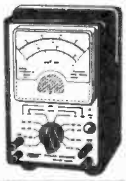
5 Ranges 400 kHz-30 mHz. An inexpensive instrument for the handyman. Operates on 9 v. battery. Wide easy to read scale. 800 kHz modulation. 5½ in. × 5½ in. × 3½ in. Complete with instructions and leads. £7·97½ P. & P. 20p.

BELCO DA-20 SOLID STATE DECADE AUDIO OSCILLATOR

New high-quality portable instrument Sine 1 Hz to 100 KHz. Square 20 Hz to 20 KHz. Output max. +10 db (10 K ohms). Operation 220/240 v. A.C. Size 215 mm × 150 mm × 120 mm.

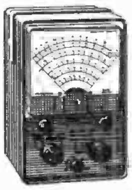
Price £27·50 Carr. 25p.

T.E.40 HIGH SENSITIVITY A.C. VOLTMETER



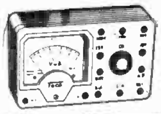
10 meg. input 10 ranges: .01/.03/.1/.3/1/3/10/30/100/300 v. R.M.S. 4 cps.-1.2 Mc/s. Decibels −40 to +50 dB. Supplied brand new complete with leads and instructions. Operation 230 v. A.C. £17·50 Carr. 25p.

TE-65 VALVE VOLTMETER



High quality instrument with 28 ranges. D.C. volts 1.5-1,500 v. A.C. volts 1.5-1,500 v. Resistance up to 1,000 megohms. 220/240v. A.C. operation. Complete with probe and instructions £17·50. P. & P. 30p. Additional Probes available; R.F. £1·75 H.V. £2·12½.

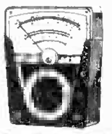
MULTIMETERS for EVERY purpose!



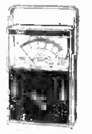
TECH PT-34. 1,000 O.P.V. 0/10/50/250/500/1,000V. a.c. and d.c. 0/1/100/500 mA. d.c. 0/100 K. £1·97½ P. & P. 12½p.

MODEL TE-200 20,000 O.P.V. Mirror scale, overload protection. 0/5/25/125/1,000 V.D.C. 0/10/50/250/1,000 V.A.C. 0/50 μA/250 MA. 0/60K/6 meg. + 20 to + 62 db. £3·75 P. & P. 15p

MODEL TE-80. 20,000 O.P.V. 0/10/50/100/500/1,000 v. A.C. 0/5/25/50/250/500/1,000 v. D.C. 0-503A. 5/50/500mA. 0/6K/60K/600K/6 meg. £4·37½ P. & P. 15p

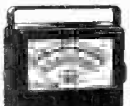


MODEL TE-70. 30,000 O.P.V. 0/3/15/60/300/600/1,200 v. D.C. 0/6/30/120/600/1,200 v. A.C. 0/30μA/3/30/300mA. 0/16K/160K/1.6M/16 Meg. £5·50 P. & P. 15p



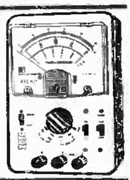
TMK MODEL TW-50K 46 ranges, mirror scale. 50K /Volt D.C. 5K /Volt A.C. D.C. Volts: .125, .25, 1.25, 2.5, 5, 10, 25, 50, 125, 250, 500, 1000V. A.C. Volts: 1.5, 3, 5, 10, 25, 50, 125, 250, 500, 1000V. D.C. Current: 25, 50μA, 2.5, 5, 25, 50, 250, 500mA, 5, 10 amp. Resistance 10K, 100K, 1 MEG, 10 MEG. Decibels: -20 to +81.5 dB. £8·87½ P. & P. 17½p

TE-900 20,000 Ω/VOLT GIANT MULTIMETER. Mirror scale and overload protection. 6 in. full view meter. 2 colour scale. 0/2.5/10/250/1,000/5,000 v. A.C. 0/25/12.5/10/50/250/1,000/5,000 v. D.C. 0/50μA/0/10/100/500mA/10 amp. D.C. 0/2K/200K/20 MEG. OHM. £15 P. & P. 25p



MODEL 5025 57 Ranges, Giant 5½ in. Meter, Polarity Reverse Switch. Sensitivity: 50K /Volt D.C. 5K /Volt A.C. D.C. Volts: .125, .25, 1.25, 5, 10, 25, 50, 125, 250, 500, 1,000V. 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, 10 MEG. Decibels: —20 to +85 dB £12·50 P. & P. 17½p.

FTC-401 TRANSISTOR TESTER

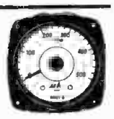


Full capabilities for measuring A, B and ICO. NPN or PNP. Equally adaptable for checking diodes. Supplied complete with instructions, battery and leads. £6·97½. P. & P. 15p.

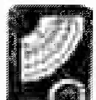
AVO CT471A MULTIMETER

Battery operated, fully transistorised. Sensitivity 100 MΩ/v. Measures A.C./D.C. voltages 12mV. to 1,200 V A.C./D.C. current 12μA. to 1.2 Amp. Resistance 12 ohm to 120 mΩ H.F., V.H.F., U.H.F. voltage with multiplier 4V. to 400V. up to 50 Mc/s., 40 mV. to 4V. up to 1,000 Mc/s. Offered in perfect condition. £55 each. Carr. 50p.

270° WIDE ANGLE 1mA METERS



MW1-6 60mm. square £3·97½
MW1-8 80mm. square £4·97½
P. & P. extra



HONOR TE.10A. 20 kΩ/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. £3·47½. P. & P. 15p.

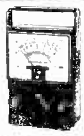
MODEL TE-300 30,000 O.P.V. Mirror scale, overload protection 0/.6/3/15/60/300/1,200 V.D.C. 0/6/30/120/600/1,200 V.A.C. 0/30μA/6mA/6 OmA/300mA/600mA. 0/8K/80K/800K/8 meg. -20 to + 63 db. £5·97½. P. & P. 15p.

MODEL TE-12. 20,000 O.P.V. 0/0.6/6/30/120/600/1,200/3,000/6,000 v. D.C. 0/6/30/120/600/1,200 v. A.C. 0/60μA/6/60/600 mA. 0/6K/600K/6Meg./60 Meg.Ω. 50 PF. .2 MFD. £5·97½. P. & P. 17½p.

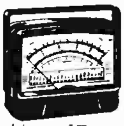
MODEL 500 30,000 O.P.V. with overload protection, mirror scale. 0/.5/2.5/10/25/100/250/500/1,000 v. D.C. 0/2.5/10/25/100/250/500/1,000 v. A.C. 0/50μA/5/50/500 mA. 12 amp. D.C. 0/60/K/6 meg/60 meg Ω. £8·87½. Post paid.

MODEL TE-90 50,000 O.P.V. Mirror scale, overload protection. 0/3/12/60/300/600/1,200 v. D.C. 0/6/30/120/300/1,200 v. D.C. .03/6/60/600 MA. D.C. 16K/160K/1.6/16 MEG. —20 to +63 dB. £7·50. P. & P. 15p.

TMK MODEL TW-20CB FEATURES RESETTABLE OVERLOAD BUTTON. Sensitivity: 20K Ω/Volt D.C. 5K Ω/Volt A.C. D.C. Volts: 0-0.5, 2.5, 10, 50, 250, 1,000V. A.C. Volts: 0-2.5, 10, 50, 250, 1,000V. D.C. Currents: 0-0.05, 0.5, 5, 50, 500mA. - 10 amp. Resistance: 0-5K, 50K, 0-500K. 5 MEG. Decibels: -20 to + 52db. £11·50. P. & P. 17½p.



MODEL AS-100D. 100K Ω/Volt 5 in., mirror scale. Built-in meter protection 0/3/12/60/120/300/600 1,200 v. D.C. 0/6/30/120/300/600 v. A.C. 0/10μA/6/60/300MA/12 Amp. 0/2K/200K/2M/200M. -20 to + 17 dB. £12·50. P. & P. 17½p.



TMK LAB TESTER 100,000 O.P.V. 6½ in. Scale Buzzer Short Circuit Check. Sensitivity: 100,000 OPV D.C. 5 /Volt A.C. D.C. Volts: .5, 2.5, 10, 50, 250, 1,000V. A.C. Volts: 3, 10, 50, 250, 500, 1,000V. D.C. Current: 10, 100μA, 10, 100, 500mA, 2.5, 10 amp. Resistance: 1K, 10K, 100K, 10MEG, 100MEG. Decibels: —10 to +49 db. Plastic Case with carrying handle. Size 7½ × 6½ × 3½. £18·90. P. & P. 25p.

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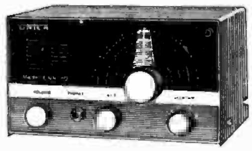
50 K Ω/Volt. Mirror scale D.C. volts: 0.6/3/12/30/300/600. A.C. volts: 3/30/300/600. D.C. current: 20μA/6/60/600mA. Resistance: 10K/100K/1 Meg. Decibels: —20 to + 57 dB. £7·50. P. & P. 15p.



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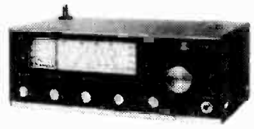

UR-1A SOLID STATE COMMUNICATION RECEIVER

4 Bands covering 550kc/s - 30mc/s. FET, S Meter, Variable BFO for SSB, Built in Speaker. Bandspread, Sensitivity Control. 220/240v AC or 12v DC. 12½" × 4½" × 7". Brand new with instructions. £25. Carr. 37½p.

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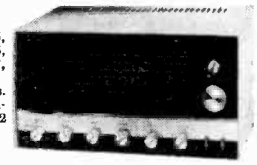
LAFAYETTE HA 800 SOLID STATE AMATEUR COMMUNICATION RECEIVER



3.5 - 4, 7 - 7.3, 14 - 14.35, 21 - 21.45, 28 - 29.7, 50 - 54 mc/s. Dual conversion, 2 mech. filters, product detector, variable BFO, S Meter, 100kc/s calibrator. 220/240v AC or 12v DC. 15" × 9½" × 8½". 18 lb. Brand new with instructions. £57·50. Carr. Paid. (100kc/s Crystal £1·97½p extra).

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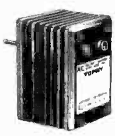

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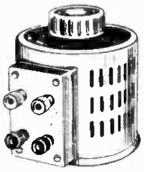

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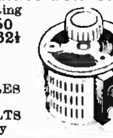

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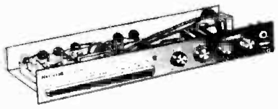
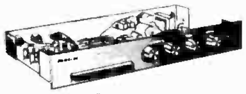

IC STEREO


FET 154


FET9/4

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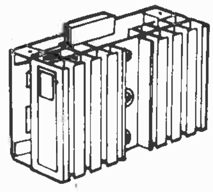

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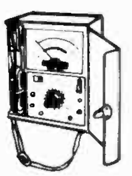

AF105 50k/volt multi-meter (illus.). **Price £8·50** p.p. 20p Leather case **£1·42**

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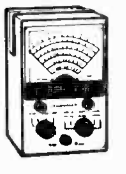

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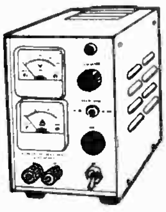

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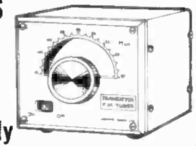

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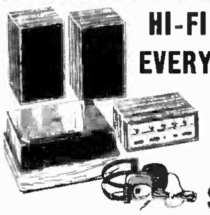

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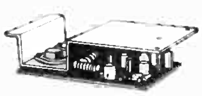
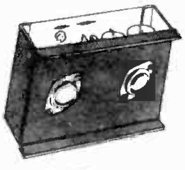
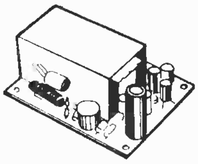
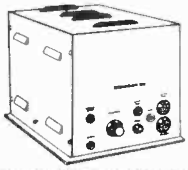

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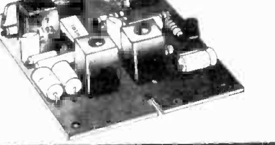

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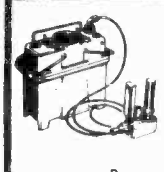

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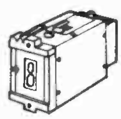

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2N696	0·20
2N697	0·20
2N698	0·25
2N699	0·62½
2N706	0·12½
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2N708	0·15
2N709	0·62½
2N718	0·25
2N718A	0·30
2N726	0·30
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2N1304	0·22½
2N1305	0·22½
2N1306	0·25
2N1307	0·25
2N1308	0·30
2N1309	0·30
2N1507	0·17½
2N1613	0·25
2N1631	0·35
2N1632	0·30
2N1637	0·30
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2N2221	0·25
2N2222	0·30
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2N2540	0·22½
2N2613	0·35
2N2614	0·30
2N2646	0·52½
2N2696	0·32½
2N2711	0·25
2N2712	0·25
2N2713	0·27½
2N2714	0·30
2N2865	0·62½
2N2904	0·30
2N2904A	0·32½
2N2905	0·37½
2N2905A	0·40
2N2906	0·25
2N2906A	0·27½
2N2907	0·30
2N2923	0·15
2N2924	0·15
2N2925	0·15
2N2926	
Green	0·14
Yellow	0·12½
Orange	0·12½
2N3011	0·30
2N3014	0·32½
2N3053	0·25
2N3054	0·50
2N3055	0·75
2N3133	0·30
2N3134	0·30
2N3135	0·25
2N3136	0·25
2N3340	0·97½
2N3349	1·30
2N3390	0·25
2N3391	0·20
2N3391A	0·30
2N3392	0·17½

2N3393	0·15
2N3394	0·15
2N3402	0·22½
2N3403	0·22½
2N3404	0·32½
2N3405	0·45
2N3414	0·22½
2N3415	0·22½
2N3416	0·37½
2N3417	0·37½
2N3439	1·30
2N3440	0·97½
2N3570	1·25
2N3572	0·97½
2N3605	0·27½
2N3606	0·27½
2N3607	0·22½
2N3702	0·12½
2N3703	0·12½
2N3704	0·17½
2N3705	0·15
2N3706	0·12½
2N3707	0·15
2N3708	0·09
2N3709	0·10
2N3710	0·11
2N3711	0·12
2N3713	1·87½
2N3714	2·00
2N3715	2·22½
2N3716	2·90
2N3773	2·40
2N3791	2·75
2N3819	0·35
2N3823	0·97½
2N3854	0·27½
2N2754A	0·27½
2N3855	0·27½
2N3855A	0·30
2N3856	0·30
2N3856A	0·35
2N3858	0·25
2N3858A	0·30
2N3859	0·27½
2N3859A	0·32½
2N3860	0·30
2N3866	1·50
2N3877	0·40
2N3877A	0·40
2N3900	0·37½
2N3900A	0·40
2N3901	0·97½
2N3903	0·35
2N3904	0·35
2N3905	0·37½
2N3906	0·37½
2N4058	0·17
2N4059	0·10½
2N4060	0·12½
2N4061	0·12½
2N4062	0·12½
2N4244	0·47½
2N4245	0·42½
2N4254	0·42½
2N4255	0·42½
2N4284	0·17½
2N4285	0·17½
2N4286	0·17½
2N4287	0·17½
2N4288	0·17½
2N4289	0·17½
2N4290	0·17½
2N4291	0·17½
2N4292	0·12½
2N4303	0·47½
2N5027	0·52½
2N5028	0·57½
2N5029	0·47½
2N5030	0·42½
2N5172	0·12½
2N5174	0·52½
2N5175	0·52½
2N5176	0·45
2N5232A	0·30
2N5245	0·45
2N5246	0·42½
2N5249	0·67½
2N5265	3·25
2N5266	2·75
2N5267	2·62½
2N5305	0·37½
2N5306	0·40
2N5307	0·37½
2N5308	0·37½
2N5309	0·62½
2N5310	0·42½
2N5354	0·27½
2N5355	0·27½
2N5356	0·32½
2N5365	0·47½
2N5366	0·32½
2N5367	0·57½
2N5457	0·37½
2S005	0·75
2S020	2·00
2S102	0·50
2S103	0·25
2S104	0·25
2S501	0·32½
2S502	0·35
2S503	0·27½
3N83	0·40

3N128	0·70
3N140	0·77½
3N141	0·72½
3N142	0·55
3N143	0·67½
3N152	0·87½
R.C.A.	0·52½
40050	0·55
40250	0·87½
40251	0·32½
40309	0·32½
40310	0·45
40311	0·35
40312	0·47½
40314	0·37½
40315	0·37½
40316	0·47½
40317	0·37½
40319	0·55
40320	0·47½
40323	0·32½
40324	0·47½
40326	0·37½
40329	0·30
40344	0·27½
40347	0·57½
40348	0·52½
40360	0·42½
40361	0·47½
40362	0·57½
40370	0·32½
40406	0·57½
40407	0·40
40408	0·52½
40409	0·55
40410	0·62½
40412	0·50
40467A	0·57½
40468A	0·35
40528	0·72½
40600	0·57½
40603	0·50
AC107	0·30
AC126	0·20
AC127	0·25
AC128	0·20
AC154	0·22½
AC176	0·25
AC187	0·62½
AC188	0·37½
ACY17	0·27½
ACY18	0·25
ACY19	0·25
ACY20	0·25
ACY21	0·25
ACY22	0·20
ACY28	0·20
ACY40	0·20
ACY41	0·25
ACY44	0·40
AD140	0·52½
AD149	0·57½
AD150	0·62½
AD161	0·37½
AD162	0·37½
AF106	0·42½
AF114	0·25
AF115	0·25
AF116	0·25
AF117	0·25
AF118	0·62½
AF119	0·20
AF124	0·22½
AF125	0·20
AF126	0·20
AF127	0·17½
AF139	0·37½
AF178	0·42½
AF179	0·72½
AF180	0·52½
AF181	0·42½
AD239	0·42½
AF279	0·47½
AF280	0·62½
AF211	0·32½
ASY26	0·25
ASY27	0·37½
ASY28	0·37½
ASY29	0·27½
ASY26	0·25
ASY50	0·25
ASY51	0·32½
ASY52	0·25
ASY54	0·25
ASY62	0·25
ASY63	0·17½
ASY72	0·25
ASY83	0·25
ASY86	0·32½
ASZ21	0·42½
AU103	1·50
BC107	0·12½
BC108	0·12½
BC109	0·12½
BC113	0·20
BC114	0·25
BC115	0·27½
BC116	0·27½
BC116A	0·27½
BC118	0·32½
BC121	0·20

BC122	0·20
BC125	0·35
BC126	0·35
BC140	0·37½
BC147	0·17½
BC148	0·12½
BC149	0·17½
BC152	0·17½
BC157	0·20
BC158	0·17½
BC159	0·20
BC160	0·62½
BC167	0·15
BC168B	0·14
BC168C	0·15
BC169B	0·14
BC169C	0·15
BC170	0·12½
BC171	0·15
BC172	0·15
BC175	0·22½
BC182	0·12½
BC183	0·12½
BC184	0·15
BC182L	0·10
BC183L	0·10
BC184L	0·15
BC212L	0·12½
BCY10	0·27½
BCY12	0·27½
BCY30	0·27½
BCY31	0·30
BCY32	0·50
BCY33	0·25
BCY34	0·30
BCY38	0·40
BCY39	0·60
BCY40	0·50
BCY42	0·15
BCY43	0·15
BCY54	0·32½
BCY58	0·22½
BCY59	0·22½
BCY60	0·97½
BCY70	0·20
BCY71	0·42½
BCY72	0·17½
BCZ10	0·27½
BCZ11	0·42½
BD116	1·12½
BD121	0·65
BD123	0·82½
BD124	0·82½
BD131	0·75
BD132	0·85
BDY10	1·37½
BDY11	1·62½
BDY17	1·50
BDY18	1·75
BDY19	1·97½
BDY20	1·12½
BDY38	0·97½
BDY60	1·25
BDY61	1·25
BDY62	1·00
BF115	0·25
BF117	0·47½
BF163	0·37½
BF167	0·25½
BF173	0·32½
BF177	0·30
BF178	0·30
BF179	0·30
BF180	0·35½
BF181	0·32½
BF184	0·25
BF185	0·42½
BE194	0·17½
BF195	0·20
BF196	0·42½
BF197	0·42½
BF198	0·42½
BF200	0·52½
BF224	0·20
BF225	0·20
BF237	0·22½
BF238	0·22½
BF244	0·32½
BFW61	0·47½
BFX12	0·22½
BFX13	0·22½
BFX29	0·30
BFX30	0·30
BFX43	0·37½
BFX44	0·37½
BFX51	0·20
BFX68	0·67½
BFX84	0·25
BFX85	0·32½
BFX86	0·25
BFX87	0·27½
BFX88	0·25
BFX89	0·62½
BFX93A	0·70
BFY10	0·32½
BFY11	0·42½
BFY17	0·22½
BFY18	0·32½
BFY19	0·32½
BFY20	1·60
BFY21	0·42½
BFY24	0·45

BFY25	0·25
BFY26	0·20
BFY29	0·50
BFY30	0·50
BFY41	0·50
BFY43	0·62½
BFY50	0·22½
BFY51	0·22½
BFY52	0·22½
BFY53	0·17½
BFY56A	0·57½
BFY75	0·30
BFY76	0·42½
BFY77	0·57½
BFY90	0·67½
BFW58	0·27½
BFW59	0·25
BFW60	0·25
BPX25	1·85
BPX29	1·80
BPY10	1·45
BRY29	0·47½
BSX19	0·17½
BSX20	0·17½
BSX21	0·37½
BSX26	0·45½
BSX27	0·47½
BSX28	0·32½
BSX60	0·82½
BSX61	0·62½
BSX76	0·22½
BSX77	0·27½
BSX78	0·27½
BSY10	0·27½
BSY11	0·27½
BSY24	0·15
BSY25	0·15
BSY26	0·17½
BSY27	0·17½
BSY28	0·17½
BSY29	0·17½
BSY32	0·25
BSY36	0·25
BSY37	0·25
BSY38	0·22½
BSY39	0·22½
BSY40	0·32½
BSY51	0·32½
BSY52	0·32½
BSY53	0·37½
BSY54	0·40
BSY56	0·90
BSY78	0·47½
BSY79	0·45
BSY82	0·52½
BSY90	0·57½
BSY95A	0·12½
BSW41	0·42½
BSW70	0·27½
C111	0·75
C424	0·27½
C425	0·55
C426	0·40
C428	0·37½
C744	0·30
D16P1	0·37½
D16P2	0·40
D16P3	0·37½
D16P4	0·40
GET102	0·30
GET113	0·20
GET114	0·20
GET118	0·20
GET119	0·20
GET120	0·52½
GET873	0·12½
GET880	0·30
GET887	0·20
GET889	0·22½
GET890	0·22½
GET896	0·22½
GET897	0·22½
GET898	0·22½
MJ400	1·07½
MJ420	1·12½
MJ421	1·12½
MJ430	1·02½
MJ440	0·95
MJ480	0·97½
MJ481	1·25
MJ490	1·00
MJ491	1·37½
MJ1800	2·17½
MJE340	0·62½
MJE520	0·87½
MJE521	0·87½
MPF102	0·42½
MPF103	0·37½
MPF104	0·37½
MPF105	0·37½
MPS3638	0·32½
NKT0013	0·47½
NKT124	0·42½
NKT125	0·27½
NKT126	0·27½
NKT128	0·27½
NKT135	0·27½
NKT137	0·32½
NKT210	0·30
NKT211	0·30
NKT212	0·30
NKT213	0·30

NKT214	0·22½
NKT215	0·22½
NKT216	0·37½
NKT217	0·42½
NKT219	0·30
NKT223	0·27½
NKT224	0·25
NKT225	0·22½
NKT229	0·30
NKT237	0·35
NKT238	0·25
NKT240	0·27½
NKT241	0·27½
NKT242	0·20
NKT243	0·62½
NKT244	0·17½
NKT245	0·20
NKT261	0·20
NKT262	0·30
NKT264	0·20
NKT271	0·20
NKT272	0·20
NKT274	0·20
NKT275	0·20
NKT281	0·27½
NKT401	0·87½
NKT402	0·90
NKT403	0·75
NKT404	0·62½
NKT405	0·75
NKT406	0·62½
NKT451	0·62½
NKT452	0·62½
NKT453	0·47½
NKT603F	0·32½
NKT613F	0·32½
NKT674F	0·30
NKT677F	0·30
NKT713	0·20
NKT717	0·42½
NKT734	0·27½
NKT736	0·35
NKT773	0·25
NKT781	0·30
NKT10339	0·32½
NKT10419	0·30
NKT10439	0·37½
NKT10519	0·32½
NKT20329	0·47½
NKT20339	0·37½
NKT80111	0·77½
NKT80112	0·97½
NKT80113	1·12½
NKT80211	0·92½
NKT80212	0·92½
NKT80213	0·92½
NKT80214	0·92½
NKT80215	0·92½
NKT80216	0·92½
OC20	0·75
OC22	0·50
OC23	0·60
OC24	0·60
OC25	0·50
OC26	0·27½
OC28	0·62½
OC29	0·62½
OC35	0·50
OC36	0·62½
OC41	0·22½
OC42	0·25
OC44	0·20
OC45	0·12½
OC46	0·15
OC70	0·15
OC71	0·12½
OC72	0·12½
OC74	0·32½
OC75	0·22½
OC76	0·22½
OC77	0·30
OC81	0·20
OC81D	0·22½
OC83	0·25
OC84	0·25
OC139	0·32½
OC140	0·32½
OC170	0·30
OC171	0·30
OC200	0·40
OC201	0·60
OC202	0·75
OC203	0·42½
OC204	0·42½
OC205	0·90
OC207	0·75
OCP71	0·42½
ORP12	0·62½
ORP61	0·50½
P346A	0·22½
TIS34	0·62½
TIS43	0·40½
TIS44	0·12½
TIS45	0·12½
TIS46	0·12½
TIS47	0·12½
TIS48	0·12½
TIS49	0·12½
TIS50	0·17½
TIS51	0·12½
TIS52	0·12½
TIS53	0·22½

PANEL METERS
38 Series—FACE SIZE 42 × 42 mm. All prices for 1-9 pieces. All meters D.C. £

50	Microamp	1·87½	5	,,	1·25
100	,,	1·75	10	,,	1·25
200	,,	1·62½	50	,,	1·25
500	,,	1·37½	100	,,	1·25
50-0-50	,,	1·75	500	,,	1·25
100-0-100	,,	1·62½	1	Amp	1·25
500-0-500	,,	1·25	5	,,	1·25
1	Milliamp	1·25	10	Volts	1·25
			20	,,	1·25
			50	,,	1·25
			300	,,	1·25
			500	,,	1·25

SPEAKERS (3 ohm) £

10" × 6"	1·87½	3"	0·62½
9" × 4"	1·27½	5"	0·72½
8" × 5"	1·27½	8" Ceramic	2·37½
7" × 4"	0·97½	12" Ceramic	1·97½
5" × 3"	0·62½	*Post and packing*	0·15

PRESETS Carbon Miniature and Sub miniature. Vertical and Horizontal. 0·1 watt, 0·2 watt, all at 0·06 each. 0·3 watt 0·075.

CARBON POTENTIOMETERS £
Log. and Lin. Less switch .. .. 0·16
Log. and Lin. With switch .. .. 0·25
Wire-wound Pots (3 watts) .. .. 0·37½
Twin-Ganged Stereo Pots. (Log. and Lin.) Less Switch 0·40

HEAT SINKS £
4·8" × 4" × 1" Finned for Two TO-3 Trans. .. 0·47½
4·8" × 2" × 1" Finned for One TO-3 Trans. .. 0·32½
For SO-1 0·025 For TO-5 0·05 Finned
For TO-18 0·05 Finned For TO-1 0·05 Finned

ZENER DIODES £
400 mW (from 3·3v to 33v) .. .. 0·17½
1 Watt (from 2·4v to 200v) .. .. 0·37½
10 Watt (from 3·9v to 100v) .. .. 0·30
20 Watt BZY93 Series (from 7·5v to 75v) .. 0·52½

Antex 15W. Soldering Iron .. .. 1·62½
D.G. 30 W. Soldering Irons .. .. 0·97½

POSTAGE AND PACKING CHARGES
U.K. .. .. 0·12½
EUROPE .. .. 0·25 (minimum)
COMMONWEALTH (AIR) .. .. .. 0·65 (minimum)

SILICON RECTIFIERS

PIV	50	100	200	400	600	800	1000	1200	1400
	£	£	£	£	£	£	£	£	£
1A	0·10	0·12½	0·15	0·16	0·17½	0·19	0·20	—	—
3A	0·15	—	—	0·22½	—	0·30	—	—	—
6A	—	—	0·25	0·30	0·32½	0·35	0·50	—	—
10A	—	0·52½	0·57½	0·65	0·77½	0·87½	0·97½	1·25	1·60
17A	—	0·57½	0·62½	0·77½	0·90	0·97½	1·20	1·57½	1·87½
35A	—	1·37½	1·60	1·97½	2·37½	2·70	3·10	3·50	4·50

1 amp and 3 amp are plastic encapsulation.

DIODES AND RECTIFIERS

IN914	0·07½	AAZ17	0·12½	BAY38	0·25	OA5	0·17½
IN916	0·07½	BA100	0·15	BY100	0·17½	OA10	0·22½
IN4007	0·22½	BA102	0·22½	BY103	0·22½	OA9	0·10
IS44	0·10	BA110	0·32½	BY122	0·37½	OA47	0·07½
IS113	0·15	BA115	0·07½	BY124	0·15	OA70	0·07½
IS120	0·15	BA141	0·32½	BY126	0·15	OA73	0·10
IS121	0·17½	BA142	0·32½	BY127	0·17½	OA79	0·09
IS130	0·12½	BA144	0·12½	BY164	0·57½	OA81	0·07½
IS131	0·12½	BA145	0·20	BYX10	0·22½	OA85	0·07½
IS132	0·15	BA154	0·12½	BYZ10	0·35	OA90	0·07½
IS940	0·07½	BAX13	0·12½	BYZ11	0·32½	OA91	0·07½
AA119	0·10	BAX16	0·12½	BYZ12	0·30	OA95	0·07½
AA129	0·10	BAY18	0·17½	BYZ13	0·25	OA200	0·10
AAZ13	0·10	BAY31	0·07½	FST3/4	0·22½	OA202	0·10
AAZ15	0·12½						

MAINS TRANSFORMERS £
1 amp Charger. Sec. 0-3-5-9-18v .. .. 0·97½
2 amp Charger. Sec. 0-3-5-9-18v .. .. 1·27½
1 amp (Douglas) MT103 Sec. tappings from 6v to 50v .. 1·62½
2 amp (Douglas) MT104 Sec. tappings from 6v to 50v .. 2·12½
Post and packing 0·22½.
5 amp (Douglas) MT107 Sec. tappings from 6v to 50v .. 5·50
Post and packing 0·37½.
Various other Transformers ranging from ½A to 5A in stock.

TRIACS £

SC35D	1·12½	SC51D	1·95
SC36D	1·00	40430	0·97½
SC40D	1·50	40486	0·95
SC41D	1·20	40528	0·72½
SC45D	1·62½	40430	1·30
SC46D	1·42½	40432	1·37½
SC50D	2·05	40512	1·45

Economy Range Triacs
TC4/10 (Pressfit) 4 amp 100 PIV .. .. .. 0·65
TC4/20 (Pressfit) 4 amp 200 PIV .. .. .. 0·75
TC4/40 (Pressfit) 4 amp 400 PIV .. .. .. 0·87½
ST2 DIAC .. .. 0·16

INTEGRATED CIRCUITS
SEE OUR ADVERTISEMENT ON OPPOSITE PAGE.
SHOWING NEW I.C.s AT NEW LOW PRICES.

THYRISTORS

PIV	50	100	200	300	400
1A	0·25	0·27½	0·37½	0·40	0·47½
4A	—	0·47½	0·55	0·57½	0·77½
5A	—	0·55	0·65	—	0·75
7A	—	0·55	0·65	—	0·97½

TIC47 0·6 amp. 200 PIV 0·55.
Also 12 amp 100 PIV 0·75; 2N3525 at £1·12½.

VEROBOARD

	·15 Matrix	·1 Matrix
2½" × 3¾"	0·17½	0·20
2½" × 5"	0·21	0·24
3¾" × 3¾"	0·21	0·24
3¾" × 5"	0·27½	0·27½
2½" × 17"	0·62½	—
3¾" × 17"	0·80	1·07½
5" × 17"	—	1·32½
3¾" × 17" (Plain)	—	0·57½
5" × 17" (Plain)	0·85	—
2½" × 17" (Plain)	0·47½	—

Vero Pins (Bag of 50) £0·25. (Bag of 100) £0·40.
Vero Cutter £0·45. Pin Insertion Tools (·1 and ·15 matrix) at £0·55.

RESISTORS
Carbon Film
¼ watt 5% .. .. 0·01½ 1 watt 10% .. .. 0·02½
½ watt 5% .. .. 0·02
2 watt 10% .. .. 0·06 ½ watt 5% .. .. 0·01
1 watt M/oxide .. 0·09

Wire Wound £
2½ watt 5% (up to 270 ohms only) .. .. 0·07½
5 watt 5% (up to 8·2k ohms only) .. .. 0·10
10 watt 5% (up to 25k ohms only) .. .. 0·12½

CAPACITORS. Polyester, ceramics, Polystyrene, silver mica, tantalum, trimmers etc.
Electrolytics

MFD.	V.	£	MFD.	V.	£	MFD.	V.	£
1	18	0·07½	25	50	0·07½	400	16	0·14
1·6	25	0·07½	32	40	0·07½	500	6	0·12½
2	350	0·10	32	450	0·27½	500	25	0·19
2·5	16	0·07½	40	16	0·07½	500	50	0·24
4	10	0·07½	50	12	0·07½	640	16	0·17½
4	40	0·07½	50	25	0·07½	1000	16	0·25
4	350	0·11	50	50	0·10	1000	25	0·25
5	18	0·07½	64	25	0·07½	1000	50	0·37½
5	50	0·07½	80	16	0·07½	2000	25	0·42½
6·4	6·4	0·07½	80	25	0·07½	2000	50	0·62½
8	40	0·07½	100	6·4	0·07½	2500	12	0·25
8	450	0·15	100	12	0·07½	2500	25	0·47½
10	12	0·07½	100	25	0·10	2500	50	0·67½
10	25	0·07½	100	50	0·12½	2500	64	0·77½
12·5	25	0·07½	125	10	0·07½	3000	25	0·52½
16	10	0·07½	200	10	0·07½	4000	100	2·37½
16	15	0·07½	250	25	0·14	4500	64	2·25
16	450	0·16	250	50	0·19	5000	25	0·62½
25	6·4	0·07½	320	10	0·07½	5000	50	0·97½
25	10	0·07½						
25	25	0·07½						

THERMISTORS (MULLARD)

R53 (STC) 1·27½	VA1010 0·12½	VA1039 0·15	VA1077 0·20
K151 (Siemens) 1K 0·12½	VA1015 0·19	VA1040 0·12½	VA1091 0·22½
VA1005 0·15	VA1033 0·12½	VA1053 0·12½	VA1096 0·20
	VA1034 0·12½	VA1066 0·19	VA1097 0·20
	VA1037 0·12½	VA1074 0·12½	VA3705 0·87½
	VA1038 0·12½	VA1075 0·22½	

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"Parvalux" Reversible 100 RPM Geared Motor. Type S.D.14, 230/250v. A.C. 22 lb./in. 3/8" spindle. 1st class condition. £7·50 each. P. & P. 50p. Also limited number only as above. **Brand New. £12·50** each P. & P. 50p.

ELECTRO CONTROL (CHICAGO). Shaded pole 240v. 50 Hz, 110 rpm, 16 lb./in. **£2·25.** P. & P. 25p. 200 rpm 10 lb./in. **£2·50.** P. & P. 25p.

MYCALEX. Open frame, shaded pole motors. 240v. 50 Hz, 7 rpm. 28 lb./in. 80 rpm. 12 lb./in. **£2·25** each. P. & P. 25p.

SMITHS SYNCHRONOUS MOTORS. 12 r.p.h. 240v., 50 Hz, 2 watts. **88p** each. P. & P. 25p.

"CROUZET" TYPE 965. 115/240v. 50Hz. 47/68 Watts. 50 rpm. Stoutly constructed. Size: 2 11/16" dia. × 3 1/4" long plus spindle 1"×1/4" dia. Anti-clock. **£2·75.** P. & P. 25p.

ELECTROLYTIC CAPACITORS MULLARD. 900μF 100v. heavy ripple screw terminals 1 5/16" dia.×3 1/2", **70p** eac., **£6·00** per doz. 1,600μF 64v. 1 3/8" dia. × 3" **38p** ea., **£3·50** per doz. 10,000μF 10v. 1 3/8" dia. × 3". **38p** ea., **£3·50** per doz. 1,250μF 25v. 1" dia. × 2". **50p** ea., **£4·50** per doz.

HUNTS 1,000μF 50v. 1 3/8" dia. × 2", **25p** ea., 10,000μF 6v. 1 3/8" dia. × 2", **30p** ea., **£3·00** per doz. 16μF 350v. 7/16" × 1 1/2" wire ends, **£2·00** per doz. 1,000μF 50v. 1" dia. × 3", **30p** ea., **£3·00** per doz. 32-32μF 275v. 1" dia. × 2", **38p** ea. 100μF 100v. 1" dia. × 2", **25p** ea.

ERIE. Ceramicon capacitor. Type CHV411P. 500 P.F. 30KV Size 1·5" dia. × 1·44" long. **50p** ea. Carriage paid.

"TANSITOR" (U.S.A.) TANTALUM WET SINTERED ANODE POLARISED CAPACITORS. DC size: 1 1/4" long × 3/8" dia. 200μF. 25v. DC size: 3/4" long × 3/8" dia. 180μF. 25v. DC size: 3/4" long × 3/8" dia. 150μF. 30v. DC size: 3/8" long × 1/8" dia. 2·5μF. 300v. DC size: 3/8" long × 3/32" dia. One wire each end. Also few only, Tansistor "MICRO-MODULE" capacitors 0·2 mfd. 15v. wire-ended, size: 3/16" dia. (disc). **T.A.G. and Union Carbide** 15 mfd. 10v. All types **£1·25** per doz. (mixed or as required). Carriage paid.

VINKOR POT CORE ASS. TYPE LA.2103. Normal price £1·48. Our price **75p** each. Special quote for quantity.

AMPEX. Dynamic stick microphone, high impedance, low noise. Offered well below makers price at **£6·50.** P. & P. 25p.

Special offer of AMPEX professional tape heads, mu-metal shrouded. (Designed for model AG20). Full track record, or playback, **£4·50.** Erase head **£2·50.** Set of 3 with mounting bracket and cover **£10·50.** Half track record or playback only, **£4·50** each or **£8·00** per pair with bracket and cover. Carriage paid.

SYLVANIA CIRCUIT BREAKERS gas filled providing a fast thermal response between 80° and 180°C. 10 amp. at 240v. continuous. Fault currents of 28 amps. at 120v. or 13 amp. at 240v. silver contacts. Supplied in any of the following opening temperatures: 90, 95, 100, 115, 120, 125, 130, 135, 140, 145, 150, 160, 170, 175. 3 for **£1·00. £3·50** per dozen.

"TEDDINGTON" CONTROLS THERMOSTAT TYPE TBB.—Adjustable between 75° and 120°C. Circuit cuts in again at 3° below cut-out setting. 42" capillary and sensor probe. The thermostat actuates a 15 amp. 250v. c/o switch. A second single pole on/off switch is incorporated in the adjustment mechanism. **88p.** Carriage Paid.

Painton Rotary Switch. Type 72 (to P.O. spec. RC1416). 3 pole, 3 position, 2 bank. Offered at less than half normal price at **£1·63.** Carriage Paid.

"GOYEN" PRESSURE SWITCH. Incorporating differential adjustment between 2" and 12" water gauge (a max. of approx. 1/2 p.s.i.). A single pole change-over switch rated 15 amps. 250v. is actuated. Air inlet tube 3/16". On Projection 11/16". Overall size: dia. 3 1/4", depth 2" plus 3/16" (air tube). **£1·25.** Carriage Paid.

THORN KEY SWITCH. 3 change-over. Neat action, either locking or spring-return, as required determined by reversing fixing plate. Attractive plastic prestle. Available red, green, grey, cream. **60p** each. Carriage paid.

HONEYWELL (USA) Sub-miniature 2 bank panel mounting micro-switch, positive toggle action giving 2 change-overs. Size: 7/16" × 7/16" × 3/8". **63p** each. Carriage paid.

"HONEYWELL" V3 Series. Flush microswitch 10 amp. c/o. The side panel is insulated. End plate size: 2" × 3/8". **£1·50** per doz. Carriage Paid.

OMRON MICROSWITCH. Type VV—15—1A. Single c/o 10 amp. at 250v. 1 1/4"×3/8"×3/8". **£1.50** per dozen.

MARCONI SANDERS Micro-wave switch. Type No. 6442. Maker's list price £75. Our price **£7·50**

OXLEY P.T.F.E. BARB TERMINALS. Stand off 11/32" or 1/2". **£2·75** box of 100.

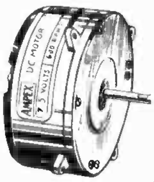
HARWIN. Tapped (6 Ba) high voltage "stand off" insulators, length 3/4", tapped (8 Ba) 3/4" long. **£2·00** per 100. Carriage Paid.

K.L.G. SEALED TERMINALS. Type TLS1 AA, overall length 11/16", box of 100, **£1·00** Type TLS1 BB, overall length, 1", box of 100, **£1·50** Carriage Paid.

THORN QUICK ACTION SWITCH Type S800. Current rating 16 amps. Nom. Contacts Hard Silver. Operating speed 1mm/Sec. Max. 28,000 dps. per hour. Service life 10 million Ops. Min. Weight 40 gr. **75p.** Carriage Paid.

All items new and unused unless otherwise stated.

MOTORS



AMPEX 7.5v. D.C. MOTOR. This is an ultra-precision tape motor designed for use in the AMPEX model AG20 portable recorder. Torque 450GM/CM. Stall load at 500ma. Draws 60ma on run. 600 rpm ± 5% speed adjustment, internal AF/RF suppression. 1/8" dia. × 1" spindle, motor 3" dia. × 1 5/8". Original cost £16·50. **Our price £4·25.** P. & P. 25p. Large quantity available (special quotations). Mu-metal enclosure available **75p** each.

NEW HYSTERESIS MOTORS BY WALTER JONES. Type 14050/12, 240v. 50 c/s 1500 rpm cont. rating, output 2.0 oz./in. Size: 3 1/2" × 2 1/2" × 2 1/2". Spindle 1" × 3/16". Weight 3 lb. Maker's price in region of £22·50 Our price **£6·50** each. Carriage Paid.

VACTRIC PRECISION D.C. MOTOR. Type XO7P19. 10v. D.C. 0.66 amp. 8000 rpm. 30 gm/cm. Size 7. Original makers packing. Limited supply. **£3·50** Carriage Paid.

MYCALEX MAINS. Shaded pole, 1425 rpm. 3/16" spindle. 2 for **£1·25.** Carriage Paid.

MAINS INDUCTION MOTOR. Open frame, 3/16" spindle, weight 3/4 lb. Powerful. **88p** each. P. & P. 12p

E.M.I. PROFESSIONAL TAPE MOTOR. 110/240 v. 50 Hz. 3000 rpm, reversible, silent running. 4 1/2" dia. × 4 1/2" long. Spindle 3/16" × 2". Weight 6 lbs. **£3·50** each or **£6·00** per pair. P. & P. 50p each.

PRECISION AND SERVO POTENTIOMETERS

PRECISION LINE (USA). Size 15. 300Ω ± 5% LIN. Continuous track plat. wipers set at 180°. **£2·25** each. Carriage Paid.

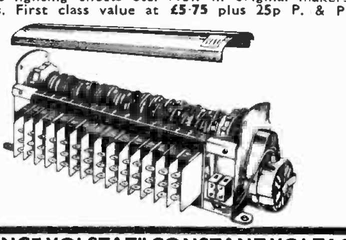
PENNY & GILES. Size 15. 500Ω. Type Q26201-72/1. Continuous track. **£2·50** each. Carriage Paid.

BECKMAN. Type AS.506, 10 turn. Tol. ±1%. LIN Tol. ±·07%. 40k. Long spindle. **£2·00** each. Carriage Paid.

S.T.C. Type B330 CT. 2500Ω. 2 1/2" dia. × 1 1/2". Completely copped encased. **£1·25** each. Carriage paid.

PROGRAMME TIMER BY HONEYWELL

A bank of 15 micro-switches are each independently operated by 15 pairs of cams which in turn are individually adjustable to give switching periods of zero to 12 seconds with infinitely variable combinations. A mains synchronous motor drives the cam shaft at 1 rev. per 12 seconds (5 R.P.M.). Designed originally for vending machines at a cost of **£15·00** plus. Many applications where continuous sequence programmes are required, such as lighting effects etc. New in original makers cartons. First class value at **£5·75** plus 25p P. & P.



"ADVANCE VOLSTAT" CONSTANT VOLTAGE TRANSFORMER. Input 190 to 260v. Output 230 R.M.S. at 100 Watts. Supplied with matching capacitor. **£2·00** plus 25p P. & P.

CRYSTAL OVENS G.E.C. Type QC940. 6/12v., AC/DC, 75°C. Takes 2 1/2" min. crystals. Similar to above 12v. only by **SNELGROVE** (Toronto), **£1·50** each, P. & P. 15p.

BERCO. Rotary rheostat. Type L25. 100 Ω. 25 watt. 1 1/2" dia. 1/4" spindle. **50p** each. 13p Carriage.

PAINTON BOURNS TRIMPOTS. 1k, 2k, 2.5k, 5k, 10k, 20k, 50k, 500k. Other Trimmer pots in stock. RIL 10k. MORGANITE 1k. MEC 200 Ω (tubular) 50 Ω. Any 3 for **£1·10** carr. paid.

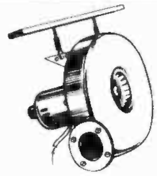
"TEXAS" Unmarked, Tested, TO5 Geranium general-purpose transistors. 24 for **£1·00** P. & P. 13p. Large quantity available.

CINEMA ENGINEERING Precision "Standard" Wire Wound Resistors. Extremely high stability over very wide temperature range. 1/6 Watt 0·25% 30K, 75K **30p** ea. 1/3 Watt 0·05% 9K, 10·02K, 50K, 200K, **60p** ea. 0·1% 100K, 250K, 625K, **60p** ea. 0·25% 477K, **60p** ea. 0·5% 500K, **60p** ea. 1% 500Ω, 850Ω, 3,770Ω, 3K, 4K, 5K, 10K, 15K, 50K, 90K, 375K, 450K, **60p** ea. 1/2 Watt 0·05% 200Ω, **60p** ea. 0·1% 9·65K, 14·6K, 15·33K, 500K, 800K, 1 meg., **60p** ea. 0·5% 81K, 2·2 meg, **60p** ea. 0·1% 20K, 1·35 meg, 1·5 meg, 2 meg, 3·3 meg, **60p** ea. 1 Watt 0·05% 0·24959K. **£1·00** ea. 0·1% 3·24K 1 meg, 3 meg, 4 meg, 3·75 meg, **£1·00** ea. 1% 2·4 meg, 2·5 meg, 3·6 meg, **£1·00** ea. 2 Watt 0·05% 5 meg, **£1·50** ea 0·1% 5·714 meg, 10 meg, **£1·50** ea. ±0·1% 2 meg, 2KM, **£1·50** ea. 0·5% 5·9 meg, 10 meg, **£1·50** ea. 1% 2K, 5K, 5 meg, 10 meg, **£1·50** ea.

RIL Type 2 ±0·01% 6·666K **£1·00** each.
RIL Type 9 ±1% 560Ω **13p** each.
ALMA ±0·05% 50K **75p** each.
ALMA ±0·1% 141·46K **50p** each.
SHALLCROSS ±0·5% 3400Ω **30p** each.

ELECTRO-THERMAL PRECISTOR ±0·1% 2·4K Price **50p.**

Brand New "DISCUS" Centrifugal Blower by Watkins & Watson. 240v. 50 Hz. Powered by A.E.I. continuous rating 2850 rpm motor. Cowl diameter 10". Outlet flange 2" I.D. Coupling flange supplied. These superb precision units are ideally suited for **Organ construction.** Offered at approx. half makers price **£12·50.** Carriage £1·50.



"DECCO" MAINS SOLENOID.—Compact and very powerful. 16 lb. pull. 3/8" travel which can be increased to 1" by removing captive-end-plate. Overall size 2"×2 1/4"×2 3/4" high. **£1·50.** P. & P. 25p.

WEBBER MAINS SOLENOID. Robust and strong. On this item the plunger travel is 1 1/2". Performance: 6 lb. pull at 1 1/2"; 8 lb. at 1"; 10 lb. at 1/2". The non-captive plunger has a fixing eye to take up to 3/16" bolt. Size: 2 1/4" high × 2" × 2". **£1·25** plus 25p P. & P.

SPECIAL OFFER

MAINS SOLENOID BY MAGNETIC DEVICES LTD. A beautifully constructed solenoid at half normal price. A two-sided bracket is incorporated for vertical or horizontal mounting. Size: 2" × 1 1/2" × 1 1/4". Pull is approx. 2 lb., plunger travel 1 1/2". Fixing eye takes up to 1/4" bolt. Plunger non-captive. New in original makers boxes. **75p** each, plus 25p P. & P. Large number available, special price for quantity.

RELAYS

Perspex enclosed, plug in, with base. Size 1 1/2" × 1 3/4" × 3/4" MQ 308 600Ω 24v. 4 c/o. **60p** ea., **£5·00** per doz. MQ 508 10,000Ω 100v. 4 c/o. **50p** ea., **£4·50** per doz.

"ISKRA" 240 V.A.C. 3 c/o. 6 amp contacts. Size approx.: 1 1/2" × 1 1/4" × 1". **88p.**

"OMRON" OCTAL BASE. A.C. mains. 2 × 15 amp. C/O contacts. Perspex enclosed. **88p.**

A.E. Perspex enclosed, plug in, 50Ω 6v. 2 c/o. **63p** ea. 470Ω 12v. 4 c/o. **73p** ea. 2,780Ω 48v. 4 c/o. **73p** ea. 1,260Ω 48v. 6 c/o. **83p** ea.

CLARE. Sealed relay. Type RP3716G4. **£1·25** ea.

CLARE ELLIOTT. Sub-min 675Ω 24v. Type WJ 2 c/o. Similar to above. 340Ω 17·6v. **75p** ea.

MAGNETIC DEVICES. Sub-min 24v. 2 c/o, 3/4" × 5/8" + 13/16". **75p** ea.

BOURNE. Trimpot sub-miniature relay 18v. 1,000Ω 1 amp. 1 c/o encapsulated 3/8" × 3/32" × 3/16" high. **£1.25** ea.

SIEMENS. High speed type 89L. 1,700Ω + 1,700Ω, **63p** ea.

"B. & R." 3 c/o. 10 amp. contacts (silver) operates on 2 volts D.C. Draws approx. 1 amp. Size: 2" × 1 1/2" × 1 5/8". **£1·00.**

DIAMOND "H" sealed relay. Type BR115CIT-IC 26v. 150Ω 4 c/o encapsulated in heavy brass case glass sealed terminals. Robust. **75p** ea.

SCHRACK. Octal base 24v. 2 HD c/o. Perspex enclosed, **63p.**

E.R.G. 1,000Ω 6v. DC. 1 make encapsulated reed type. Size: 3/8" × 7/16" × 1 3/8". 4 for **£1·00.**

SANGAMO WESTON. Moving coil relay 315Ω 310μa, complete with base. **75p** ea.

S.T.C. Midget sealed relay. Type 4190EC. 12v., 40mA 170Ω. Single HD make. **53p** ea.

F.I.R.E. Plug in relay, 115v., coil 50/60 c.p.s., 3 heavy duty silver change-over contacts. Very robust. **63p** ea.

LATCH-MASTER. Miniature relay 6, 12, 24v. DC. One make one break 5 amp contacts. Once current is applied relay remains latched until input polarity is reversed. 5/8" dia. × 7/8". Please state vertical or horizontal mount and voltage. Original cost £8·00, now offered at **£1·63** ea.

G.E.C. Sealed relay. Type M 1492. 24v. 670Ω. New condition but ex-equipment. **£1·00** ea.

HELLERMANN DEUTSCH. Type L26F18. Latching relay. Latch coil 200Ω 26v. DC. Reset 375Ω 6 change-over switching. A truly superb relay. Measuring only 1 5/8" × 1" dia. **£3·75** ea. Limited stock. All carriage paid.

SCHRACK Rotary Selector Relay RT304. 48v. coil (280 ohm). 48 positions, 4 sweep arms (4 pole 12 way). There are 2 secondary switches: (1) one c.o. H/duty contact set which changes over and back with each step; (2) two H/duty change-overs which change over on each 12th step and return on the following pulse. Size: 3 1/4"×1 3/4"×4 1/4" high. Also as above but 110v. (1,290 ohm coil). All new and in original maker's packing. **£3·25.** Carriage paid.

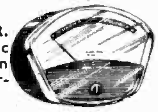
MAINS 6 DIGIT COUNTER BY E.N.M. LTD. Non-reset. Size: mounting plate 2" × 1 3/8". Unit size: 2 1/4" high × 1 13/16" × 1 3/16". **£1·38.**

TIME ELAPSED REGISTER. 24v. D.C. Has a 5 digit readout plus dial reading 1 hour (60 1 min. div.) metering. Total of 99,999 hrs. Non-reset sealed unit, chrome bezel, through panel mounting. Size 2 3/16" dia. × 3 5/16" overall. **£3·25.** Carriage paid.

DEAC. RECHARGEABLE PERMA-SEAL Nickel-Cadmium Batteries Type 900B. 1·22v. at 900 mA (10-hr. rate). Size 90 mm. × 13·5 mm. Weight 40 gr. Unused **63p** ea. P. & P. 12p.

METERS

ERNEST TURNER 800μa METER. 160Ω movement, 2" case, eliptic plastic front. Green-Red-Green uncalibrated scale **£1·50** each. Carriage Paid.



MINIATURE B.P.L. 500-0-500 MICRO-AMMETER. 13/16" dia. scale. Through panel mounting. Hermetically sealed. **£1·63.** Carriage paid.

"TAYLOR" AMMETER 0-1 amp. Modern design 3 1/2" × 3 1/4". Plastic front. Calibrated 50 × 20 ma Divs. **£2·50** plus 25p P. & P.

"ATLAS" SUB-MINIATURE LAMPS (Capped). —Ratings 5v. 60ma. ·35 ±25% Lumens. Life Expectancy 60,000 hours or at 6v. 70 ma. ·75±25% Lumens, 5,000 hours. Size: 9·1 × 3·1 mm. **£1·50** per doz. **£5·00** box of 50..

We welcome orders from established companies, educational depts., etc. (To cover invoicing costs minimum £2·50, please.) A discount of 10% may be deducted from all orders of £20·00 or over.

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ORGAN DIVIDER BOARDS, built to high industrial/computer standards. 5 octave set **£15**, complete with connection data and oscillator details.

COPPER LAMINATE PRINTED CIRCUIT BOARD
$8\frac{1}{2} \times 5\frac{1}{2} \times 1/16$ in. **12½p** sheet, 5 for **50p**
$11 \times 6\frac{1}{2} \times 1/16$ in. **15p** sheet, 4 for **50p**
$11 \times 9 \times 1/16$ in. **20p** sheet, 3 for **50p**
Offcut pack (smallest 4×2 in.) **50p** 300 sq. in.

RADIATION MONITORING EQUIPMENT. Portable and bench models (brand new) S.a.e. literature.

KLYSTRON POWER SUPPLY (Solartron AS562). **£40.** Carr. **£2·50.**

KLYSTRON POWER SUPPLY (Elliott PKU1). **£100**

120 AMP. AUTO TRANSFORMERS. 190-270v. 50 c/s (tapped every 5 volts). **£50** ea. (Carr. by arrangement.)

801A SIGNAL GENERATOR. 10-300 mc/s in 4 bands. Ext. 50 c/s-10 Kc/s. Output 200 m/v **£50** ea. P.P. £1·25.

SPEAKERS
"E.M.I." 19×14 in. 50 watts. 8 ohm (14A/600A.) Four tweeters mounted across main axis. Separate "X-over" unit balances both bass and h.f. sections. 20 Hz. to 20,000 Hz. Bass unit flux 16,500 gss. A truly magnificent system. **£25.** P.P. £1·50.
E.M.I. 13×8 in. with two tweeters and cross-over. 8 or 15 ohm **£3·75.** P.P. 25p.
"E.M.I." 13×8 in. Bass Unit. 10 watts 3-8-15 ohm models. **£2·50** each. P.P. 25p.
"E.M.I." 6½ in. Rd. 10 watt woofers. 8 ohm. **£1·50** ea. P.P. 12½p.
"FANE" 12 in. 20 watt. 15 ohm. (122/10A.) With integral tweeter. **£6** ea. P.P. 37½p.
SPEAKER SYSTEM ($20 \times 10 \times 10$ in.) Made to Spec. from ¾ in. board. Finished in black leathercloth. 13×8 in. speaker with twin tweeters complete with "X-over" 50 Hz. to 20,000 Hz. **£7·50.** P.P. 50p.

EXTRACTOR FANS/BLOWERS
"AIRMAX" 7½ in. FAN. In aluminium diecast housing (9 in.). 240v. Brand new. **£4·50.** P.P. 50p.
"PLANNAIR" 5½ in. FAN. (Type 5 PL 121-122.) Diecast housing. 240v. Brand new. **£6.** P.P. 50p.
"SOLARTRON" TANGENTIAL BLOWERS. Overall size $16 \times 5\frac{3}{4} \times 3\frac{1}{4}$ in. Air outlet $12 \times 1\frac{1}{2}$ in. 240v. Brand new. **£2·50.** P.P. 37½p.
BULK COMPONENT OFFER. Resistors/capacitors. All types and values. All *new* modern components. Over 500 pieces, **£2.** (Trial order 100 pieces **50p.**) We are confident you will re-order.

HIGH SPEED MAGNETIC COUNTERS ($4 \times 1 \times 1$ in.) 4 digit. 24/48v. (state which), **32½p** ea. P.P. 5p.
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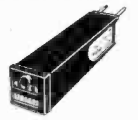

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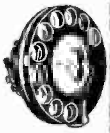

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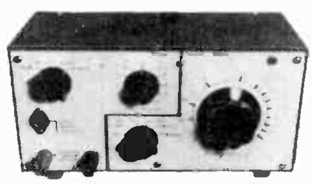
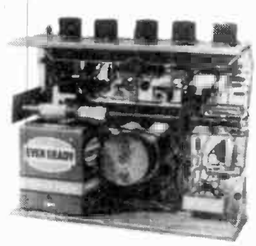
NEW SERIES...
SERVICING
An Introduction to Fault Finding

Starting from scratch, this comprehensive guide takes *Practical Wireless* readers through from basic principles to the more advanced aspects such as alignment of f.m. superhets and fault finding on hi-fi systems. The authors are G. J. King and H. W. Hellyer, who have written previous popular series on servicing. Be sure you do not miss the start of this important new series in the May issue, out now.



HI FI SIGNAL GENERATOR

The high standards of modern audio amplifiers have made many older audio signal generators obsolete. Starting in the May issue of *Practical Wireless*, the circuit and complete building instructions are given for this laboratory quality signal generator. Distortion at 1kHz is a mere 0·01% and output ranges run from 15Hz to 150kHz ± 1dB, though an additional range goes up to 1·5MHz.



'STATION FOCUS' SIX

The performance of the average superhet receiver depends largely upon the proper alignment of tuned circuits. In the medium and long-wave receiver described in the May *Practical Wireless*, separate panel controls are included for the correct alignment of the critical circuits. The prototype shown above has been built on a clear perspex panel.

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BP 02 = 7402	Quadruple 2-input Positive NOR Gates	23p	20p	15p
BP 03 = 7403	Quadruple 2-input Positive NAND Gates (with Open-Collector Output)	23p	20p	15p
BP 04 = 7404	Hex Inverters	23p	20p	15p
BP 10 = 7410	Triple 3-input Positive NAND Gates	23p	20p	15p
BP 13 = 7413	Dual 4-input Schmitt Trigger	35p	32p	29p
BP 20 = 7420	Dual 4-input Positive NAND Gates	23p	20p	15p
BP 30 = 7430	8-input Positive NAND Gates	23p	20p	15p
BP 40 = 7440	Dual 4-input Positive NAND Buffers	23p	20p	15p
BP 41 = 7441	BCD to decimal nixie driver	87p	77p	67p
BP 42 = 7442	BCD to decimal decoder (4-10 lines, 1 of 10)	87p	77p	67p
BP 47 = 7447	BCD-Seven-Segment Decoder/Drivers (15-V Outputs)	£1·40	£1·30	£1·20
BP 50 = 7450	Expandable dual 2-input AND-OR-INVERT	23p	20p	15p
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BP 53 = 7453	Quad 2-input Expandable AND-OR-INVERT	23p	20p	15p
BP 54 = 7454	4-wide 2-input AND-OR-INVERT Gates	23p	20p	15p
BP 60 = 7460	Dual 4-input Expander	23p	20p	15p
BP 70 = 7470	Single-phase J-K Flip-Flop	35p	32p	29p
BP 72 = 7472	Master-slave J-K Flip-Flop	35p	32p	29p
BP 73 = 7473	Dual Master slave J-K Flip-Flop	43p	40p	37p
BP 74 = 7474	Dual 0 type Flip-Flop	43p	40p	37p
BP 75 = 7475	Quad latch	47p	45p	43p
BP 76 = 7476	Dual J-K with pre-set and clear	47p	45p	43p
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BP 83 = 7483	Quad Full Adder	87p	77p	67p
BP 86 = 7486	Quad 2 input Exclusive OR Gates	80p	70p	60p
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BP 91 = 7491	8-bit Shift Registers	£1·21	£1·00	87p
BP 92 = 7492	Divide-by-Twelve Counters	87p	77p	67p
BP 93 = 7493	4-bit Binary Counters	87p	77p	67p
BP 94 = 7494	Dual entry 4-bit shift register	87p	77p	67p
BP 95 = 7495	4-bit up-down shift register	87p	77p	67p
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BP100 = 74100	8-bit Bistable Latches	£1·75	£1·65	£1·55
BP118 = 74118	Hex Set-Reset Latches	£1·30	£1·20	£1·00
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BP141 = 74141	BCD-to-Decimal Decoder/Driver	87p	77p	67p
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Devices may be mixed to qualify for quantity price. Larger quantities—prices on application. (TTL 74 Series only.)

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PAK No.		PAK No.		PAK No.	
UIC00 = 12 × 7400N	50p	UIC42 = 5 × 7450N	50p	UIC80 = 5 × 7480N	50p
UIC01 = 12 × 7401N	50p	UIC50 = 12 × 7450N	50p	UIC82 = 5 × 7482N	50p
UIC02 = 12 × 7402N	50p	UIC51 = 12 × 7451N	50p	UIC83 = 5 × 7483N	50p
UIC03 = 12 × 7403N	50p	UIC60 = 12 × 7460N	50p	UIC86 = 5 × 7486N	50p
UIC04 = 12 × 7404N	50p	UIC70 = 8 × 7470N	50p	UIC90 = 5 × 7490N	50p
UIC05 = 12 × 7495N	50p	UIC72 = 8 × 7472N	50p	UIC92 = 5 × 7492N	50p
UIC10 = 12 × 7410N	50p	UIC73 = 8 × 7473N	50p	UIC93 = 5 × 7493N	50p
UIC20 = 12 × 7420N	50p	UIC74 = 8 × 7474N	50p	UIC94 = 5 × 7494N	50p
UIC40 = 12 × 7440N	50p	UIC75 = 8 × 7475N	50p	UIC95 = 5 × 7495N	50p
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UICX1 = 25 × Asst'd 74's £1·50

Packs cannot be split but 20 assorted pieces (our mix) is available as PAK UICX1. Every PAK carries our BI-PAK Satisfaction or money back GUARANTEE.

DTL 930 SERIES

Type No.	Function	Price 1-24	25-99	100 up
BP930	Expandable dual 4-input NAND	23p	20p	15p
BP932	Expandable dual 4-input NAND buffer	25p	23p	20p
BP933	Dual 4-input expander	25p	23p	20p
BP935	Expandable Hex Inverter	25p	23p	20p
BP936	Hex Inverter	25p	23p	20p
BP944	Dual 4-input NAND expandable buffer without pull-up	25p	23p	20p
BP945	Master-slave JK or RS	35p	32p	29p
BP946	Quad, 2-input NAND	23p	20p	15p
BP948	Master-slave JK or RS	35p	32p	29p
BP951	Monostable	90p	85p	80p
BP962	Triple 3-input NAND	23p	20p	15p
BP9093	Dual Master-slave JK with separate clock	80p	75p	70p
BP9094	Dual Master-slave JK with separate clock	80p	75p	70p
BP9097	Dual Master-slave JK with Common Clock	80p	75p	70p
BP9099	Dual Master-slave JK Common Clock	80p	75p	70p

Devices may be mixed to qualify for quantity price. Larger quantity prices on application. (DTL 930 Series only.)

DTL (Diode Transistor Logic) INTEGRATED CIRCUITS manufacturers "Fall outs"—out of spec devices including functional units and part functional but classed as out of spec from the manufacturers very rigid specifications. Ideal for learning about I.C's and experimental work.

Pak No.		Pak No.	
UIC930 = 12 × μA 930	50p	UIC948 = 8 × μA 948	50p
UIC932 = 12 × μA 932	50p	UIC951 = 5 × μA 951	50p
UIC933 = 12 × μA 933	50p	UIC961 = 12 × μA 961	50p
UIC935 = 12 × μA 935	50p	UIC9093 = 5 × μA 9093	50p
UIC936 = 12 × μA 936	50p	UIC9094 = 5 × μA 9094	50p
UIC944 = 12 × μA 944	50p	UIC9097 = 5 × μA 9097	50p
UIC945 = 8 × μA 945	50p	UIC9099 = 5 × μA 9099	50p
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BP701C—SL701C	TO-5	8	OP Amp.	63p	50p	45p
BP702C—SL702C	TO-5	8	OP Amp Direct O/P	63p	50p	45p
BP702—72702	D.I.L.	14	G.P. O.P. Amp (Wide Band)	53p	45p	40p
BP709—72709	D.I.L.	14	High Gain OP Amp...	53p	45p	40p
BP709P—μA709C	TO-5	8	High Gain OP Amp...	53p	45p	40p
BP741—72741	D.I.L.	14	High Gain OP. Amp (Protected	75p	60p	50p
μA703C—μA703C	TP-5	6	R.F.—IF Amp	43p	35p	27p
TAA263	TO-72	4	A.F. Amp	70p	60p	55p
TAAA293	TO-74	10	G.P. Amp	90p	75p	70p

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Q13	3	AF 117 type trans.	50p
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Q17	3	NPN 1 ST141 & 2 ST140	50p
Q18	4	Madt's 2 MAT 100 & 2 MAT 120	50p
Q19	3	Madt's 2 MAT 101 & 1 MAT 121	50p
Q20	4	OC 44 Germ. trans. A.F.	50p
Q21	3	AC 127 NPN Germ. trans.	50p
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Q24	8	OA 81 diodes	50p
Q25	6	IN914 Sil. diodes 75PIV 75mA	50p
Q26	8	OA95 Germ. diodes sub-min. IN69	50p
Q27	2	10A 600PIV Sil. Rects. 1S425R	50p
Q28	2	Sil. power rects. BYZ 13	50p
Q29	4	Sil. trans. 2 × 2N696, 1 × 2N697, 1 × 2N698	50p
Q30	7	Sil. switch trans. 2N706 NPN	50p
Q31	6	Sil. switch trans. 2N708 NPN	50p
Q32	3	PNP Sil. trans. 2 × 2N1131, 1 × 2N1132	50p
Q33	3	Sil. NPN trans. 2N1711	50p
Q34	7	Sil. NPN trans. 2N2369, 500MHZ	50p
Q35	3	Sil. PNP TO-5 2 × 2N2904 & 1 × 2N295	50p
Q36	7	2N3646 TO-18 plastic 300MHZ NPN	50p
Q37	3	2N3053 NPN Sil. trans.	50p
Q38	7	PNP trans. 4 × 2N3703, 3 × 2N3702	50p
Q39	7	NPN trans. 4 × 2N3704, 3 × 2N3705	50p
Q40	7	NPN amp. 4 × 2N3707, 3 × 2N3708	50p
Q41	3	Plastic NPN TO-18 2N3904	50p
Q42	6	NPN trans. 2N5172	50p
Q43	7	BC 107 NPN trans.	50p
Q44	7	NPN trans. 4 × BC108, 3 × BC109	50p
Q45	3	BC 113 NPN TO-18 trans.	50p
Q46	3	BC 115 NPN TO-5 trans.	50p
Q47	6	NPN high gain 3 × BC167, 3 × BC168	50p
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Q49	4	NPN trans. 2 × BFY51, 2 × BFY52	50p
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U4	40	Germanium Transistors like OC81, AC128	50p
U5	60	200mA Sub-min. Sil. Diodes	50p
U6	30	Silicon Planar Transistors NPN sim. BSY95A, 2N706	50p
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U8	50	Sil. Planar Diodes 250mA OA/200/202	50p
U9	20	Mixed Volts 1 watt Zener Diodes	50p
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U14	150	Mixed Silicon and Germanium Diodes	50p
U15	25	NPN Silicon Planar Transistors TO-5 sim. 2N697	50p
U16	10	3-amp Silicon Rectifiers Stud Type up to 1,000 PIV	50p
U17	30	Germanium PNP AF Transistors TO-5 like ACY17-22	50p
U18	8	6-Amp Silicon Rectifiers BYZ13 Type up to 600 PIV	50p
U19	25	Silicon NPN Transistors like BC108	50p
U20	12	1·5 amp Silicon Rectifiers Top-Hat up to 1,000 PIV	50p
U21	30	AF Germanium alloy Transistors 2G300 Ser. & OC71	50p
U23	30	Madt's like MAT Series PNP Transistors	50p
U24	20	Germanium 1-amp Rectifiers GJM up to 300 PIV	50p
U25	25	300 Mc/s NPN Silicon Transistors 2N708, BSY27	50p
U26	30	Fast Switching Silicon Diodes like 1N914 Micro-min.	50p
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U31	20	Sil. Planar NPN trans. low noise Amp 2N3707	50p
U32	25	Zener diodes 400mW D07 case mixed Volts, 3-18	50p
U33	15	Plastic case 1 amp Silicon Rectifiers 1N4000 series	50p
U34	30	Sil. PNP alloy trans. TO-5 BCY26, 28302/4	50p
U35	25	Sil. Planar trans. PNP TO-18 2N2906	50p
U36	25	Sil. Planar NPN trans. TO-5 BFY50/51/52	50p
U37	30	Sil. alloy trans. SO-2 PNP, OC200 28322	50p
U38	20	Fast Switching Sil. trans. NPN 400 Mc/s 2N3011	50p
U39	30	RF Germ. PNP trans. 2N1303/5 TO-5	50p
U40	10	Dual trans. 6 lead TO-5 2N2060	50p
U41	25	RF Germ. trans. TO-1 OC45 NKT72	50p
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U43	25	Sil. trans. Plastic TO-18 AF BC113-114	50p
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Code Nos. mentioned above are given as a guide to the type of device in the Pak. The devices themselves are normally unmarked.

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400	43p	47p	67p	75p	93p	£1·75
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200	5p	9p	6p	14p	20p	24p	£1
400	6p	13p	7p	20p	27p	37p	£1·25
600	7p	16p	10p	23p	34p	45p	£1·85
800	10p	17p	13p	25p	37p	55p	£2
1000	11p	25p	15p	30p	46p	63p	£2·50
1200	—	33p	—	33p	57p	75p	—

2A POTTED BRIDGE RECTIFIERS 200V. 50p

SIL. G.P. DIODES

300mW	30	50p
40PIV (Min.)	100	£1·50
Sub-Min.	500	£5
Full Tested	1000	£9

Ideal for Organ Builders.

TRIACS.

VBOM	2A TO5	6A TO66	10A TO48
100	50p	63p	£1
200	70p	90p	£1·25
400	90p	£1	£1·60

VBOM—Blocking voltage in either direction.

EX-EQUIPMENT MULLARD AF 117 TRANSISTORS
Large can 4 lead Type. Leads cut short but still usable. Real value at 15 for 50p.

PRINTED CIRCUITS EX-COMPUTER
Packed with semiconductors and components. 10 boards give a guaranteed 30 trans. and 30 diodes.
Our price 10 boards 50p + 10p p. & p.
100 boards £3 + 30p p. & p.

SILICON DIAC
For use with Triacs
BR100 37p each

UNIJUNCTIONS
UT46. Eqvt. 2N2646 Eqvt. T1843. BEN3000 27p each. 25-99 25p. 100 UP 20p

GERM. POWER TRANS.

Type	Price each
OC20	50p
OC22	30p
OC23	33p
OC25	25p
OC26	25p
OC28	40p
OC29	40p
OC35	33p
OC36	40p
AD140	40p
AD142	40p
AD149	43p

DUAL-IN-LINE LOW PROFILE SOCKETS
14 AND 16 Lead Sockets for use with Dual-in-Line Integrated Circuits.

Order No.	Price each 1-24	25-99	100 up
TS014 14 pin type	33p	27p	25p
TS01 616 pin type	43p	37p	34p

NPN SILICON PLANAR
BC107/8/9 10p each, 50-99 9p. 100 up 8p each, 1,000 off, 7p each. Fully tested and coded TO-18 case.

CADMIUM CELLS
ORP12 43p
ORP60, ORP61 40p ea.

FET'S
2N3819 .... 40p
2N3820 ...... £1
MPF105 .... 43p

SILICON HIGH VOLTAGE RECTIFIERS
10-Amp 3-K.V. (3000 P.I.V.) Stud Type with Flying Leads, 80p each.

★ GIRO No. 388-7006 ★

PHOTO TRANS
OCP71 Type 43p

BY130 ....20p ea
400 Piv 500 mA Sil Rects.

AD161 *NPN*
AD162 *PNP*
MATCHED COMPLEMENTARY PAIRS OF GERM. POWER TRANSISTORS OUR LOWEST PRICE OF 63p *PER PAIR*

AF239 PNP GERM. SIEMENS VHF TRANSISTORS. RF MIXER - OSC. UP TO 900 MHZ. USE as REPLACEMENT FOR AF139-AF186 & 100's OF OTHER USES IN VHF. OUR SPECIAL LOW PRICE: 1-24 37p each, 25-99 34p each 100+ 30p each.

2N3055 115 WATT SIL. POWER. NPN.
OUR PRICE 63p EACH

FULL RANGE OF ZENER DIODES
VOLTAGE RANGE 2-33V
400mV (DO-7 Case) 13p ea. 1·5W (Top-Hat) 17p ea. 10W (SO-10 Stud) 25p ea. All fully tested 5% tol. and marked. State voltage required.

BRAND NEW TEXAS GERM. TRANSISTORS
Coded and Guaranteed

Pak No.			EQVT.
T1	8	2G371A	OC71
T2	8	2G374	OC72
T3	8	2G3744A	OC81D
T4	8	2G381A	OC81
T5	8	2G382T	OC82
T6	8	2G344A	OC44
T7	8	2G345A	OC45
T8	8	2G378	OC78
T9	8	2G399A	2N1302
T10	8	2G417	AF117

All 50p each pack.

2N2060 NPN SIL. DUAL TRANS. CODE D1699 OUR PRICE 25p each

120VCB NIXIE DRIVER TRANSISTOR
Sim. BSX21 and C407, 2N1893 FULLY TESTED AND CODED ND120, 1-24 17p each. TO-5 NPM 25 up 15p each.

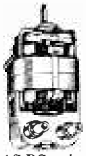
Please send all orders direct to our warehouse and despatch department.

Postage and packing add 7p. Overseas add extra for Airmail. Minimum order 50p. Cash with order please. **BY RETURN POSTAL SERVICE**

BI-PAK SEMICONDUCTORS
P.O. BOX 6, WARE, HERTS.

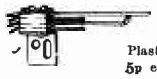
KING OF THE PAKS BI-PAK GUARANTEE SATISFACTION OR MONEY BACK

MULTI-SPEED MOTOR



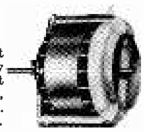
Replacement in many well-known food mixers. Six speeds are available 500, 850 and 1,100 r.p.m. from either or both of the nylon sockets (where the beaters of the food mixers normally go) and 8,000, 12,000 & 15,500 r.p.m. (ideal polishing speeds) from the main drive shaft. This drive shaft is ¼in. diameter and approximately 1in. long. A further point about this motor is that being 230/240v. AC-DC series wound its speed may be further controlled with the use of our Thyrister controller. This is a very powerful and useful motor size approx. 2in. dia. × 5in. long, mains 230/240v. Price **88p** plus 23p postage and insurance. 12 or more post free.

Double Leaf Contact

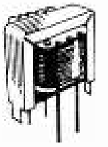


Very slight pressure closes both contacts. **6p** each. **60p** doz. Plastic push-rod suitable for operating, **5p** each, **45p** doz.

PAPST MOTORS



Est. 1/20th h.p. Made for 110-120 volt working, but two of these work ideally together off our standard 240 volt mains. A really beautiful motor, extremely quiet running and reversible. **£1·50** each. Postage one 23p, two 33p.



MIDGET OUTPUT TRANSFORMER

Ratio 140 : 1. Size approx. 1in. × ⅝in. × ⅝in., primary impedance 450Ω. Connection by flying leads **23p** each. **£2·40** doz.

MIDGET OUTPUT TRANSFORMER

Ratio 80 : 1. Size approx. 1⅛in. × 1in. × ⅝in. Primary impedance 132Ω. Printed circuit board connection **28p** each. **£3** doz.

CHART RECORDER MOTOR

Small (2in. diameter approx.) instrument motor with fixing flange and spindle (¼in. long, ⅛in. diameter); integral gearbox gives 1 rev. per 24 hours. **£1**.

IGNITION (E.H.T.) TRANSFORMER

Made by Parmeko Ltd. Primary 240v, 50 c.p.s. Secondary 5Kv at 23mA. Size approx. 4½in. × 3½in. × 2½in. thick. Price **£1·50** + 23p.

FLUORESCENT CONTROL KITS

Each kit comprises seven items—Choke, 2 tube ends, starter, starter holder and 2 tube clips, with wiring instructions. Suitable for normal fluorescent tubes or the new "Grolux" tubes for fish tanks and indoor plants. Chokes are super-silent, mostly resin filled. Kit A—15-20 w. **£1**. Kit B—30-40 w. **£1**. Kit C—80 w. **£1·20**. Kit E—65 w. **£1·20**. Kit F for 8ft. 125 w. tube **£1·75**. Kit MF1 is for 6in., 9in. and 12in. miniature tubes. **£1**. Kit MF2 for 21in. 13 w. miniature tube, **£1**. Postage on Kits A and B 23p for one or two kits then 23p for each two kits ordered. Kits C, D and E 23p on first kit then 18p for each kit ordered. Kit F 33p then 23p for each kit ordered. Kit MF1 18p on first kit then 18p on each two kits ordered.

3 DIGIT COUNTER

For Tape Recorder or other application, resettable by depressing button. Price **28p**.

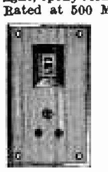
ISOLATION SWITCH

20 Amp D.P. 250 Volts. Ideal to control Water Heater or any other appliance. Neon indicator shows when current is on. **23p**; **£2·40** 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 ⅛in. thick. Rated at 500 MW. wire ended. **43p**. Suit most circuits.

5A 3-PIN SWITCHED SOCKETS



An excellent opportunity to make that bench dis board you have needed or to stock up for future jobs. This month we offer 6 British made (Hicraft) bakelite flush mounting shuttered switch sockets for only **50p** plus 18p post and insurance. (20 boxes post free.)

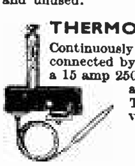
MOTOR WITH GEARBOX

Very powerful 7 r.p.m., operates from standard A.C. mains. **£1·50**, plus 18p P. & P.

TRANSDUCER

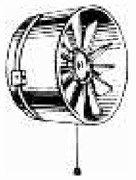
Made by Acos, reference No. I.D.1001. For measuring vibration, etc., to be used in conjunction with "G" Meter. Regular price £5. Our price **£2·50**. Brand new and unused.

THERMOSTAT



Continuously variable 30°-90°C Has sensor bulb connected by 33in. of flexible tubing. On operation a 15 amp 250 volt switch is opened and in addition a plunger moves through approx. ⅛in. This could be used to open valve on ventilator etc. **£1·50** plus 23p p. & ins.

EXTRACTOR FAN



Cleans the air at the rate of 10,000 cubic ft. 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, 5¼" casing with 5¼" fan blades. Suitable wherever it is necessary to move air fast. Kit comprises motor, fan blades, sheet steel casing, pull switch, mains connector, and fixing brackets. **£2** plus 36p post and ins.

MAINS TRANSISTOR POWER PACK

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 **83p**, plus 18p postage.

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 and on/off switch with neon warning light. Supplied complete with 7 feet of heavy cable. Wired up ready to work, **£2** less plug; **£2·25** with fitted 13 amp plug; **£2·40** with fitted 15 amp plug, plus 23p P. & I.

STANDARD WAFER SWITCHES

Standard size 1¼ wafer—silver-plated 5-amp contact, standard ¼" spindle 2" long—with locking washer and nut.

No. of Poles	2 way	3 way	4 way	5 way	6 way	8 way	9 way	10 way	12 way
1 pole	33p	33p	33p	33p	33p	33p	33p	33p	33p
2 poles	33p	33p	33p	33p	33p	33p	33p	55p	55p
3 poles	33p	33p	33p	33p	55p	55p	55p	75p	75p
4 poles	33p	33p	33p	55p	55p	55p	55p	95p	95p
5 poles	33p	33p	55p	55p	75p	75p	75p	£1·15	£1·15
6 poles	33p	55p	55p	55p	75p	75p	75p	£1·35	£1·35
7 poles	55p	55p	55p	75p	95p	95p	95p	£1·55	£1·55
8 poles	55p	55p	55p	75p	95p	95p	95p	£1·75	£1·75
9 poles	55p	55p	75p	75p	£1·15	£1·15	£1·15	£1·95	£1·95
10 poles	55p	55p	75p	95p	£1·15	£1·15	£1·15	£2·15	£2·15
11 poles	55p	75p	75p	95p	£1·35	£1·35	£1·35	£2·35	£2·35
12 poles	55p	75p	75p	95p	£1·35	£1·35	£1·35	£2·55	£2·55

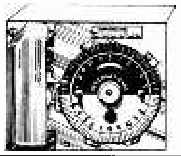
MOTORISED SWITCH FOR ANIMATED SIGNS, ETC.

This is a motorised programmer switch, mains operated, with six 15 amp changeover contacts operated by triggers on a rotating drum. Six triggers will put switches up and another six triggers will put switches down. Thus simple on/off operation or changeovers are possible. The triggers can be exactly set to any position around the drum which is rotated by a one-rev. per hour motor. A beautifully made precision switch which probably cost in excess of £20. Limited quantity only **£7·75** each, plus 23p post and insurance. Similar programmer by Honeywell but 15 × 10 amp. switches operated by 5 rpm motor. **£5·75** plus 23p post and insurance.

HONEYWELL PROGRAMMER

This is a drum type timing device, the drum being calibrated in equal divisions for switch purposes with trips which are infinitely adjustable for position. They are also arranged to allow 2 operations per switch per rotation. There are 15 changeover micro switches each of 10 amp type operated by the trips thus 15 circuits may be changed per revolution. Drive motor is mains operated 5 revs. per min. Some of the many uses of this timer are Machinery control, Boiler firing, Dispensing and Vending machines, Display lighting animated signs, Signalling etc. Price from Makers probably over £10 each. Special snip price **£5·75** plus 25p post and ins. Don't miss this terrific bargain.

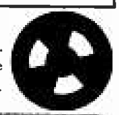
THIS MONTH'S SNIP



ELECTRIC TIME SWITCH

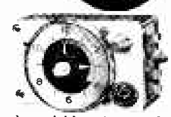
Made by Smiths these are A.C. mains operated. NOT CLOCKWORK. Ideal for mounting on rack or shelf or can be built into box with 13A socket. 2 completely adjustable time periods per 24 hours, 5 amp changeover contacts will switch circuit on or off during these periods. **£2·50**. post and ins. 23p. Additional time contacts **50p** pair.

COMPUTER TAPES



2,400ft. of the best magnetic tape money can buy. Made by E.M.I., 1in. wide, almost unbreakable and on a 10½in. metal computer spool. Users have claimed successful results with video as well as sound recordings. **£1** plus 33p post. Cassette to hold spool **50p** extra.

20 AMP ELECTRICAL PROGRAMMER



Learn in your sleep! Have Radio playing and kettle boiling as you awake—switch-on lights to ward off intruders—have warm house to come home to. All these and many other things you can do if you invest in an Electrical Programmer. Made by the famous Smiths Instrument Company. This is essentially a 230/240 volt mains operated Clock and a 20 amp Switch, the switch-off time of which can be delayed up to 12 hours (continuously variable not stepped). Similarly the switch-on time can be delayed. This is a beautiful unit, size 5¾ × 3¾ × 2¼in. deep. Metal encased, glass fronted with chrome surround. Offered at **£2·40** plus 23p postage and insurance.

INTEGRATED CIRCUITS

A parcel of integrated circuits made by the famous Plessey Company. A once in a lifetime offer of Micro-electronic devices well below cost of manufacture. The parcel contains 5 ICs all new and perfect, first grade device definitely not sub-standard or seconds. The ICs are all single silicon chip General Purpose Amplifiers. Regular price of which is well over £1 each. Full circuit details of the ICs are included and in addition you will receive a list of 50 different ICs available at bargain prices **25p** upwards with circuits and technical data of each. Complete parcel only **£1** post paid or List and all technical data.

4 AMP VARIAC CONTROLLERS

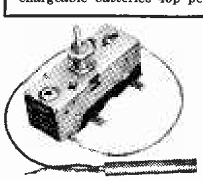
With this you can vary the voltage applied to your circuit from zero to 270 volts without generating undue heat. One obvious application therefore is to dim lighting. Ex equipment but little used—as good as new offered at approx. half price—**£5** plus 63p post and ins.

BARGAIN OF THE YEAR

MICROSONIC RADIOS

7 transistor Key chain Radio in very pretty case, size 2⅞ × 2⅛ × 1⅛ in.—complete with soft leather zipped bag. Specification: Circuit: 7 transistor superheterodyne Frequency range: 530 to 1600 Kc/s. Sensitivity: 5 mv/m. Intermediate frequency: 465 Kc/s, or 455 Kc/s. Power output: 40mW. Antenna: ferrite rod. Loudspeaker: Permanent magnet type. In transit from the East, these sets suffered slight corrosion as the batteries were left in, but when this corrosion is cleared away they should work perfectly—offered without guarantee except that they are new, **£1·25** plus 13p post and insurance. Less batteries. Six for **£7**. post free. Rechargeable batteries 43p per pair.

THERMOSTAT WITH PROBE



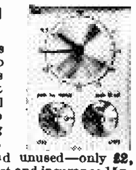
This has a sensor attached to a 15A switch by a 14in. length of flexible capillary tubing—control range is 20deg.F. to 450deg.F. so it is suitable to control soil heating and liquid heating especially when in buckets or portable vessels as the sensor can be raised out and lowered into the vessel. This 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 **63p** each.

PROTECT VALUABLE DEVICES

FROM THERMAL RUNAWAY OR OVERHEATING

Thyristors, rectifiers, transistors, etc., which use heatsinks can easily be protected. Simply make the contact thermostat part of the heat-sink. Motors and equipment generally, can also be adequately protected by having thermostats in strategic spots on the casing. Our contact thermostat has a calibrated dial for setting between 90deg. to 190deg.F. or with the dial removed range setting is between 80 to 800deg. F. Price **50p**.

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 **£2**, less than the value of the clock alone—post and insurance 15p.

UNDER-FLOOR HEATING CABLE

200ft. lengths, suitable for dissipating 1,000 watts at 80 volts. Join three in series to make a 240-volt mains-operated element of 3kW. Price **£1** per length, 23p post on any quantity.

3-CORE LEADS

Heavy duty 23/36, average length 5ft. **50p** per dozen lengths, plus 23p post and ins.

CONSTRUCTORS' PARCEL

1. Plessey miniature 2-gang tuning condenser with built-in trimmers and wave gang switch. 2. Ferrite slab aerial with coils to suit the above tuning condenser. 3. Circuit diagram giving all component values for 6-transistor circuit covering full medium wave and the long wave band around Radio 2. The three items for only **40p** which is half of the price of the tuning condenser alone.

MAINS RELAY

200/250v. with 3 10 amp contacts. This is a very well made relay which being very small only 1⅛ × 1 × ⅞in. approx., will fit into confined spaces. **63p** each. **£6·75** per dozen.

HEARING AID AMPLIFIERS

3 transistors and associated condensors and resistors on a little printed circuit board, the whole thing only about half as big as an Oxo cube. If you are making miniature equipment then these may well be just what you are looking for. **£1·75** each.

LARGE PANEL MOUNTING MOVING COIL METERS

Size 5in. × 4in. Centre zero 200-0-200 micro amp, made by Sangamo Weston. Regular price probably £8. Our price **£3**. Ditto but 100-0-100 **£4**.

A.C. AMMETER

0-5 amps., flush mounting, moving iron. Ex-equipment but guaranteed perfect **£1·50**.

CIRCUIT BOARDS

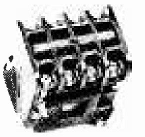
Heavy copper on 3/32 paxolin sheet, ideal for making power packs, etc., as sheet is very strong and thick enough to allow copper to be cut away with hacksaw blade. 5in. × 5in. **8p** each. 15in. × 5in. **23p** each.

SUB-MINIATURE MOVING COIL MICROPHONE

as used in behind the ear deaf aids

Acts also as earphone size only ⅜in. × ⅜in. × ⅛in. Regular price probably £3 or more. Our price **£1**. Note these are ex-equipment but if not in perfect working order they will be exchanged.

MAINS OPERATED CONTACTOR

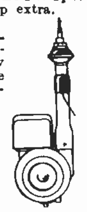


220/240v. 50 cycle solenoid with laminated core so very silent in operation. Closes 4 circuits each rated at 10 amps. Extremely well made by a German Electrical Company. Overall size 2¼ × 2 × 2 in. **£1** each.

SIMMERSTAT CONTROL SWITCH

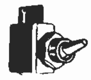
Combined on-off switch and "heat on" regulator intended for automatic temperature regulation of electric hot plates up to 3kW. Official rating 15A 200-250v A.C. size 2 × 1¼ × 2in. deep. Single hole fixing **63p**. Knob 23p extra.

AUTO—ELECTRIC CAR AERIAL



with dashboard control switch—fully extendable to 40in. or fully retractable. Suitable for 12v positive or negative earth. Supplied complete with fitting instructions and ready wired dashboard switch. **£6** plus 25p post and ins.

TOGGLE SWITCH



3 amp 250v. with fixing ring. **7½p** each **75p** doz.

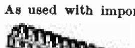
MICRO SWITCH

5 amp. changeover contacts, **9p** each, **90p** doz. 15 amp. on/off **10p** each or **£1·05** doz.

MINIATURE EAR PIECE

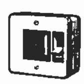
As used with imported pocket radios. **8p** each **75p** doz.

15/20 AMP CONNECTORS



Polythene insulated 12-way strip. **13p** each **£1·20** doz.

13 AMP FUSED SWITCH

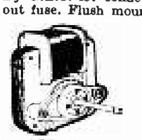


Made by G.E.C. For connecting water heater etc., into 13 amp ring main. Flush type **18p** each **£1·50** doz. Metal boxes for surface mounting **8p** each **75p** doz.

13 AMP SPUR UNIT

By G.E.C. for connecting clock, etc., to ring main. Pull-out fuse. Flush mounting. Cream. **13p** each; **£1·20** doz.

MAINS MOTOR



Precision made—as used in record decks and tape recorders—ideal also for extractor fans, blower, heater, etc. New and perfect. Snip at **50p**. Postage 15p for first one then 5p for each one ordered. 12 and over post free.

MINIATURE WAFER SWITCHES

2 pole, 2 way—4 pole, 2 way—3 pole, 3 way—4 pole, 3 way—2 pole, 4 way—3 pole, 4 way—2 pole, 6 way|1 pole, 12 way. All at **18p** each, **£1·80** dozen, your assortment.

MINIATURE SLIDE SWITCH

3 pole change-over. **15p** each **£1·50** doz. **Heavy duty 250 watt Model**, not Weller, but by a famous Italian maker. **£4** plus 33p postage and insurance.

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1B	25–33–40–50	10	£7·75	50p
1C	25–33–40–50	6	£6·75	50p
1D	25–33–40–50	3	£4·00	40p
2A	4–16–24–32	12	£7·25	45p
2B	4–16–24–32	8	£5·50	45p
2C	4–16–24–32	4	£3·75	40p
2D	4–16–24–32	2	£2·50	30p
3A*	25–30–35	40	£16·50	75p
3B*	25–30–35	20	£10·25	65p
3C	25–30–35	10	£7·25	60p
3D	25–30–35	5	£4·25	45p
3E	25–30–35	2	£3·25	45p
4A*	12–20–24	30	£13·00	75p
4B	12–20–24	20	£8·25	50p
4C	12–20–24	10	£4·50	50p
4D	12–20–24	5	£3·75	45p
5A	3–12–18	30	£9·75	45p
5B	3–12–18	20	£7·25	50p
5C	3–12–18	10	£4·50	45p
5D	3–12–18	5	£3·00	40p
6A	48–56–60	2	£3·75	40p
6B	48–56–60	1	£2·75	35p
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7C	6–12	10	£3·75	35p
7D	6–12	5	£2·75	35p
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9A	17–32	8	£6·25	35p
10A*	9–15	2	£1·50	35p
11A	6·3	15	£2·50	35p
12A	30–25–0–25–30	2	£3·75	35p
13A	36	45	£16·50	75p

Note: By using the intermediate taps many other voltages can be obtained.
Example: No. 1 .. 7–8–10–15–17–25–33–40–50v.
No. 2 .. 4–8–12–16–20–24–32v.
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Sub Chassis	8	1200	70	**75p**	20p
111	8	1000	60	**60p**	15p
921M	8	750	60	**45p**	15p
82	8	500	60	**37p**	10p
CP123K	8	250	71	**28p**	10p
CP147H	8	200	71	**20p**	10p
92M	6	750	60	**37p**	10p
CP153GO	4	1500	70	**45p**	15p
CP153Y	4	1200	70	**37p**	10p
111M	4	1000	60	**37p**	10p
921M	4	750	60	**32p**	10p
CP147T	4	600	70	**25p**	7p
821M	4	500	60	**22p**	7p
Sub Chassis	4	450	100	**22p**	7p
621M	4	350	60	**17p**	5p
1111M	2	1000	60	**37p**	7p
CP150GO	2	1500	71	**42p**	7p
TCSQH	2	500	60	**15p**	5p
CP141H	2	200	71	**10p**	3p
CP143V	1	800	71	**20p**	3p
CP142T	1	600	71	**10p**	3p
131	0·5	2000	60	**25p**	3p
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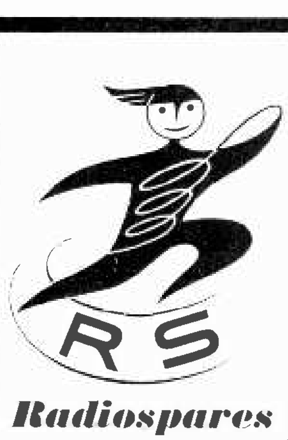

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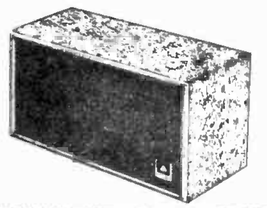

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C	1/8W	5%	4·7Ω–330KΩ	E24	1	0·8	0·7
C	1/4W	10%	4·7Ω–10MΩ	E12	1	0·8	0·7
C	1/2W	5%	4·7Ω–10MΩ	E24	1·2	1	0·9
C	1W	10%	4·7Ω–10MΩ	E12	2·5	2	1·9
MO	1/2W	2%	10Ω–1MΩ	E24	4	3·5	3
WW	1W	10%±1/20Ω	0·22Ω–3·9Ω	E12	7	7	6
WW	3W	5%	12Ω–10KΩ	E12	7	7	6
WW	7W	5%	12Ω–10KΩ	E12	9	9	8

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MO = metal oxide, Electrosil TR5, ultra low noise.
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NEON chrome bezel, round red NR/R, **24p;** chrome bezel, round amber NR/A, **24p;** chrome bezel, round clear NR/C, **24p.** Neon, square red type LS5C/R, **17p;** amber type LS5C/A, **17p;** clear type LS5C/C, **17p.** All above are for 240v. mains operation. **Filament types:** 6v. 0·04A square red type LS5C/R-6v., **20p;** 6v. 0·04A amber type LS5C/A-6v., **20p;** 6v. 0·04A clear type LS5C/C-6v., **20p;** 6v. 0·04A green type LS5C/G-6v., **20p;** 12v. 0·04A LS5C/R-12v., **23p;** 28v. 0·04A LS5C/R-28v., **28p.**

DIN CONNECTORS

		plug	socket
Loudspeaker	2-pole	**12p**	**10p**
Audio	3-pole	**13p**	**10p**
Audio	4-pole	**14p**	**12p**
Audio	5-pole 180deg.	**15p**	**12p**
Audio	5-pole 240deg.	**15p**	**12p**
Audio	6-pole	**15p**	**13p**

TOGGLE SWITCHES, 250V a.c. 1·5A.
chrome dolly and chrome milled nut S.P.S.T. **19p,** S.P.D.T. **25p** D.P.D.T. **29p;** S.P.D.T. centre off **22p**
WAVECHANGE SWITCHES
LONG SPINDLES
1P 12W; 2P 6W; 3P 4W; 4P 3W **24p each**
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CORED SOLDER—64/40 alloy, 20 s.w.g. 8oz. reel, **65p,** 1lb. reel, **£1·20.**

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B12H	1·75	ECH84	0·37	KT88	1·75
CY31	0·35	ECH200	0·62	N78	1·25
DAF96	0·38	ECL80	0·45	OA2	0·35
DF96	0·37	ECL82	0·32	OB2	0·35
DK96	0·41	ECL83	0·65	PABC80	0·37
DL92	0·32	ECL86	0·40	PC97	0·40
DL94	0·40	EF36	0·17	PC900	0·47
DL96	0·41	EF37A	0·45	PCC84	0·37
DM70	0·30	EF39	0·40	PCC89	0·45
DY86	0·30	EF40	0·50	PCC189	0·55
DY87	0·32	EF41	0·62	PCE800	0·75
DY802	0·48	EF80	0·25	PCF80	0·30
E88CC/01	1·35	EF83	0·47	PCF82	0·33
E180CC	0·45	EF85	0·32	PCF84	0·46
E181CC	0·45	EF86	0·31	PCF86	0·57
E182CC	1·15	EF89	0·26	PCF200	0·77
EABC80	0·32	EF91	0·15	PCF201	0·77
EAF42	0·50	EF92	0·37	PCF801	0·48
EB91	0·10	EF95	0·25	PCF802	0·48
EBC33	0·50	EF183	0·32	PCF805	0·72
EBC41	0·52	EF184	0·35	PCF806	0·65
ECC81	0·20	EFL200	0·77	PCF808	0·72
EBF80	0·37	EL34	0·51	PCH200	0·70
EBF83	0·30	EL41	0·57	PCL81	0·47
EBF89	0·30	EL42	0·52	PCL82	0·37
ECC81	0·20	EL84	0·23	PCL83	0·65
ECC82	0·28	EL85	0·36	PCL84	0·42
ECC83	0·27	EL86	0·40	PCL85	0·42
ECC84	0·30	EL90	0·30	PCL86	0·42
ECC85	0·60	EL95	0·35	PFL200	0·57
ECC86	0·37	EL500	0·85	PL36	0·53
ECC88	0·35	EM31	0·25	PL81	0·50
ECC189	0·48	EM80	0·40	PL82	0·40
ECF80	0·32	EM84	0·35	PL83	0·42
ECF82	0·32	EM87	0·55	PL84	0·35
ECF83	0·77	EY51	0·40	PL500	0·73
ECF801	0·62	EY86	0·35	PL504	0·68
ECF802	0·62	EY81	0·35	PY33	0·60
ECH35	0·60	EY88	0·40	PY80	0·35
ECH42	0·65	EZ41	0·42	PY81	0·27
ECH81	0·28	EZ80	0·25	PY82	0·27
ECH83	0·42	EZ81	0·27	PY83	0·35
		GZ34	0·52	PY88	0·37
		KT66	1·60	PY800	0·52
				PY801	0·52
				QQVO 3-10	1·25

	£		£		£		£		£		£
QQVO 6-40A	5·25	UBC41	0·47	VR150/30	0·30	5B254M	1·80	6AQ5	0·30	6C4	0·28
R17	0·40	UBF80	0·35	Z759	1·75	5B/255M	1·75	6AQ5W	0·45	6C6	0·20
R19	0·37	UBF89	0·35	Z801U	1·25	5R4GY	0·52	6AS6	0·30	6CH6	0·55
STV 280/40	3·00	UCC85	0·40	Z803A	1·25	5U4G	0·27	6AS7G	0·80	6CL6	0·48
STV 280/80	9·00	UCF80	0·50	Z900T	0·60	5V4G	0·37	6AT6	0·22	6D6	0·15
TT21	2·55	UCH42	0·62	1L4	0·12	5Y3GT	0·35	6AU6	0·25	6EA8	0·55
U25	0·72	UCH81	0·30	1R5	0·30	5Z4	0·70	6AX4	0·40	6F23	0·75
U26	0·72	UCL82	0·35	1S4	0·25	5Z4GT	0·60	6AX5GT	0·65	6F33	1·00
U27	0·40	UCL83	0·60	1S5	0·22	6AB7	0·20	6B7	0·27	6H6M	0·15
U191	0·70	UF41	0·50	1T4	0·15	6AC7	0·15	6BK7	0·40	6J4WA	0·70
U801	1·00	UF80	0·36	1X2A	0·37	6AH6	0·57	6BA6	0·22	6J5	0·35
UABC80	0·35	UF89	0·33	1X2B	0·37	6AK5	0·25	6BE6	0·25	6J5GT	0·25
UAF42	0·52	UL41	0·60	3A4	0·20	6AK8	0·32	6BG6G	0·55	6J6	0·17
		UL84	0·30	3D6	0·15	6AL5	0·10	6BJ6	0·42	6J7G	0·25
		UU5	0·35	3Q4	0·37	6AL5W	0·35	6BQ7A	0·33	6J7M	0·40
		UY41	0·42	3S4	0·33	6AM6	0·15	6BR7	0·80	6K6GT	0·40
		UY85	0·28	3V4	0·40	6AN8	0·50	6BW6	0·80	6K7	0·42
		VR105/30	0·30					6BW7	0·65		

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6K7G	0·10	25L6GT	0·36	6057	0·50
6K8GT	0·36	30C15	0·75	6060	0·37
6K25	0·70	30C17	0·80	6064	0·35
6SA7	0·35	30C18	0·75	6065	0·65
6SA7GT	0·32	30F5	0·83	6080	1·37
6SC7GT	0·25	30FL1	0·75	6146	1·40
6SG7	0·30	30FL12	0·92	8020	1·75
6SJ7	0·37	30FL13	0·46	9001	0·15
6SJ7GT	0·32	30FL14	0·77	9002	0·22
6SK7	0·35	30L15	0·85	9003	0·50
6SL7GT	0·32	30L17	0·80	9004	0·12
6SN7GT	0·35	30P12	0·80	9006	0·12
6SQ7	0·38	30P19	0·70		
6SQ7GT	0·38	30PL1	0·65	**CR. Tubes**	
6V6G	0·17	30PL13	0·90	VCR97	4·50
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6X5G	0·25	35W4	0·25	5FP7	1·32
6X5GT	0·27	35Z4GT	0·45	88D	9·00
6Y6G	0·55	42	0·35	88J	9·00
6-30L2	0·70	50C5	0·35	88L	9·00
6Z4	0·25	50CD6G	1·50		
7B7	0·35	50EH5	0·60	**Photo Tubes**	
7C5	0·72	75	0·27	CMG25	1·25
7C6	0·30	76	0·30	931A	3·12
7H7	0·27	78	0·25	6097C	17·50
7Y4	0·60	80	0·45		
9D6	0·37	803	3·00	**Special Valves**	
11E2	1·50	805	8·00	CV1031	7·00
12AT6	0·22	807	0·45	CV2339	20·00
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12AU7	0·28	832A	2·75	K301	5·00
12AV6	0·27	866A	0·75	K305	12·00
12AX7	0·27	954	0·22	K308	16·00
12BA6	0·30	955	0·20	K337	12·00
12BE6	0·30	956	0·10	KRN2A	3·50
12BH7	0·17	957	0·30	WL417A	1·50
12C8	0·27	991	0·30	3J/92/E	37·50
12E1	0·85	1622	0·85	5C22	15·00
12K5	0·50	2051	0·50	714AY	4·00
12K7GT	0·33	5933	1·12	725A	10·00
12K8GT	0·37				
12Q7GT	0·27				
128G7	0·35				
1487	0·75				
19AQ5	0·38				
19G3	3·50				
19G6	1·00				
19H4	4·25				
20P4	0·87				

SPECIAL OFFER O9J TUBE £1·75

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OA5	0·12	OC35	0·50	1N21B	0·25	2N5109	2·05	AF127	0·17	CRS1/30	0·17
OA10	0·30	OC38	0·42	1N25	0·60	40362	0·67	AF139	0·37	CRS1/35	0·42
OA70	0·10	OC44	0·20	1N43	0·10	82303	0·50	AF178	0·47	CRS1/40	0·47
OA71	0·10	OC45	0·12	1N70	0·07	3F100	0·62	AF186	0·45	CRS3/05	0·30
OA73	0·07	OC70	0·12	1N702-725	0·36	3FR5	0·32	AFY19	1·12	CRS3/20	0·37
OA74	0·10	OC71	0·15	1N746A series	0·26	3N128	0·87	ASY26	0·27	CRS3/30	0·42
OA79	0·08	OC72	0·25	1N823A	1·30	3N138	1·75	ASY28	0·27	CRS25/025	0·75
OA81	0·07	OC73	0·30	1ZMT5	0·35	3N140	0·97	ASY67	0·47	CRS3/40	0·50
OA91	0·06	OC75	0·22	1ZMT10	0·33	3N154	0·95	BAW19	0·27	GET103	0·20
OA200	0·08	OC76	0·25	1ZT5	0·67	3N159	1·45	BC107	0·15	GET115	0·45
OA202	0·10	OC81	0·25	1ZT10	0·63	6FR5	0·45	BC108	0·15	GET116	0·50
OA210	0·25	OC81D	0·20	2G385	0·51	12FR60	0·73	BC113	0·30	GEX66	0·75
OA211	0·37	OC81DM	0·20	2G403	0·51	10D1	0·16	BC118	0·37	NKT222	0·20
OAZ200	0·55	OC82	0·25	1N4785	0·55	40954	1·37	BCY72	0·37	NKT304	0·35
OAZ201	0·50	OC82DM	0·15	2N277	0·50	40595	1·37	BF115	0·25	SD918	0·26
OAZ202 to OAZ206	0·42	OC83	0·22	2N918	0·37	40636	1·45	BF173	0·30	SD928	0·31
OAZ207	0·47	OC83B	0·15	2N1304	0·25	40668	1·35	BF187	0·50	SD938	0·32
OAZ208 to OAZ213	0·32	OC84	0·25	2N1306	0·25	40669	1·45	BFY51	0·22	SD94	0·21
OAZ223 to OAZ225	0·50	OC122	0·50	2N1307	0·25	AC126	0·21	BFY52	0·22	SD988	0·46
OC16	0·42	OC139	0·25	2N2147	0·75	AC127	0·21	BS05	0·37	V405A	0·38
OC22	0·42	OC140	0·37	2N2904A	0·37	AC128	0·20	B8	0·45		
OC25	0·37	OC170	0·25	2N3053	0·25	AC176	0·25	B82	0·46		
OC26	0·25	OC171	0·30	2N3054	0·95	ACY17	0·25	BSY29	0·17		
OC28	0·62	OC172	0·37	2N3055	0·75	ACY28	0·20	BU100	1·80		
OC29	0·62	OC200	0·37	2N2730	1·25	AD149	0·55	BYZ13	0·20		
		OC201	0·47	2N3731	1·25	AD161	0·35	BYZ10	0·62		
		OC206	0·50			AD162	0·35	CRS1/10	0·25		
		1N21	0·17			AF118	0·32	CRS1/20	0·37		

ZENER DIODES

All preferred voltage

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¼W	0·17
1W	0·37
1.5W	0·25
7W	0·37

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VALVES & TRANSISTORS PHONE 01-743 4946

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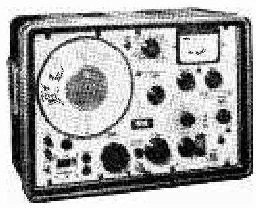
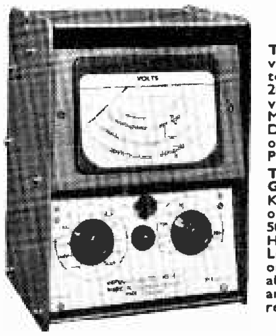
MARCONI TEST EQUIPMENT



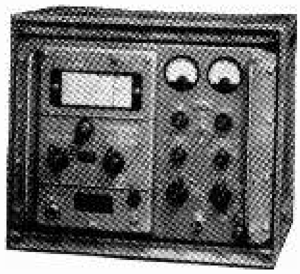
TF1041C VTVM A.C. voltage range 300 MV to 300V in 7 ranges. 20 Hz-1500 MHz. D.C. voltage ranges 300 MV-1000V in 8 ranges. D.C. resistance 50 ohms to 500 Mohms. Price £62·50.

TF144H SIGNAL GEN. Freq. range 10 KHz-72 MHz. R.F. output 2uV to 2V at 50 ohms 400 and 1000 Hz internal mod. Limited qty. only available. Full spec and price on request.



SIGNAL GENERATOR TF 801/A. 10-300 Mc/s. in 4 bands. Internal at 400 c/s. 1 kc/s. External 50 c/s to 10 kc/s. Output 0-100 db below 200 mV from 75 ohms source. £85. DITTO but **801/A/1** with additional high level output. £89. Both P. & P. £1, including necessary connectors, plugs, and instruction manual.

TF 144G SIGNAL GENERATOR. To clear. In very good "as seen" condition. Complete with mains and battery cables, etc. £15.



AM/FM SIGNAL GENERATOR TF 937 (CT 218) Frequency range 85kHz-30mHz. 8 bands. Main dial total 56 foot. Built in crystal calibrator 200kHz and 2mHz. RF output ·1μV to ·1V. Four internal mod. freq. FM deviation up to 9kHz. £115. Carriage £1/5/0.

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CD 643.2. Single beam Laboratory Model, DC to 14MHz price upon application.

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AR88 SPARES. We hold the largest stock in U.K. Write for list.

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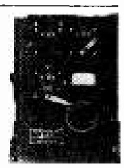

Originally made to work with Hallicrafters BC 610E transmitters. 2mc to 18mc, for output up to 450 watts. Brand new £8·50. Carriage £1.

PRECISION VHF FREQUENCY METER TYPE 183. 20-300 Mc/s with accuracy 0.03% and 300-1,000 Mc/s with accuracy 0.3.%. Additional band on harmonics 5.0-6.25 Mc/s with accuracy + —2× 10-4. Incorporating calibrating quartz 100 kc/s + —5× 10-5 120/220 v. A.C. mains. £85. Carriage £2.

MUIRHEAD-WIGAN DECADE OSCILLATORS. TYPE 650A 9650B. Frequency range 1 to 111,100 Hz. Accuracy ± 0.2%. Power supply 100-250 v. D.C. 65 and 75 respectively. carr. £1.75.

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

29/41FT. AERIALS each consisting of ten 3ft., ⅞in. dia. tubular screw-in sections. 11ft. (6-section) whip aerial with adaptor to fit the 7in. rod, insulated base, stay plate and stay assemblies, pegs, reamer, hammer, etc. Absolutely brand new and complete ready to erect, in canvas bag, £4. P. & P. £0·50.

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53 TRANSMITTERS. All spares available. COLLINS TCS. Complete installations and spare parts.
COLLINS TYPE 231D 5KW TRANSMITTERS. 10 channel, autotune and manual tuning. Complete with very comprehensive spares. Full specification and price on application. Complete installations and all spares. No. 19 WIRELESS SETS. H.P. SETS and all spares R.210 RECEIVERS with all necessary accessories.
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STANDARD GPO DIAL TELEPHONES (black) with internal bell. **87p.** P. & P. 25p. Two for **£1·50.** P. & P. 37p.

SURVEY METER RADIAC No. 3. Hand portable size 9½×5×5½ ins. 3 ranges (scale changes) 0.03; 0.3; 3 R/H. Internal Ion Chamber. Nice condition **£3** ea. P. & P. 50p.
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PHOTOMULTIPLIERS. EMI 6097X at **£8·50** ea. 6097B—**£5** ea.
TRANSISTOR OSCILLATOR. Variable frequency 40 c/s to 5 kc/s. 5 volt square wave o/p, for 6 to 12v DC input. Size 1½×1½×1½in. Not encapsulated. Brand new. Boxed. **57p** ea.
CRAMER TIMER 28V DC Sweep 1/100th sec & sweep 60 secs. 4" dial. Remote control stop/start reset **£5·00.**

RELAYS
G.E.C. Sealed Relays High Speed 24V. 2 make 2 break. **23p** ea.; 12v 180 ohm **33p** ea.
S.T.C. sealed 2 pole c/o, 2,500 ohms. (okay 24v) **13p** ea; 12v **35p** ea.
CARPENTERS polarised Single pole c/o 20 and 65 ohm coil as new, complete with base **37p** ea.
Single pole c/o 14 ohm coil **33p** ea; Single pole c/o 45 ohm coil **33p** ea.

POTENTIOMETERS
COLVERN Brand new. 50; 100; 250; 500 ohms; 1; 2.5; 5; 10; 25; 50k all at **13p** ea. Special Brand new.
MORGANITE 2.5K; 250K; 500K 2.5 meg. 1" sealed. **17p** ea.
STANDARD 2 meg Log pots. Current type. **15p** ea.
INSTRUMENT 3" Colvern. 5; 25 ohms **35p** ea.
BOURNE TRIM POTS. 10; 20; 50; 100; 200; 250;. 5 00 ohms; 1; 2.5 5; 25K at **35p** ea.
ALMA precision resistors 100K; 400K; 497K; 998K; 1 meg—0·1.. **27p** ea.; 3·25K—0·1.. **20p** ea.
DALE heat sink resistors, non-inductive 50 watt. Brand new 8.2K at **13p** ea.
MULLARD VINKORS. Brand new boxed. LA2411 **45p** ea.; LA2503 **30p** ea.
SILVER ZINC Non-spill. Brand new. 7½V 5 cell. Size 1½ × 1 × 1½ 2 oz. weight **£1** ea. Single cell 1.5V 4AH size 1½ × ¾ × 3½. 4oz. weight **£1** ea.
MALLORY CELLS. 25p per set of 5.

CAPACITORS
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Sub-min. **TRIMMER** ½ square. 8. 5pf. Brand new **13p** ea.
Concentric **TRIMMER** 3/30 pf. Brand new **7p** ea.
ELECTROLYTICS. Brand new. 250 mfd. 70V **23p** ea.
E.H.T. 2 mfd 5 KV. Brand new **£1·50** ea.
E.H.T. 0.1 mfd 7 KV at **40p** ea.; 0.1 mfd 5 kv at **35p** ea.

DECADE DIAL UP SWITCH. Finger-tip. Engraved 0/9. Gold plated contacts. Size 2¼" high, 2½" deep ½" wide. **75p** ea. Bank of 4 with escutcheon plates, etc. 2½" high, 2½" deep, 2½" wide **£2·50.**

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CANNON. 50 way DDM50P **75p** ea.; DDM50S **50p** ea. **£1** per pair.
As above but 25 way **50p** ea. plug; **35p** ea. socket; **75p** per pair; 9 way **33p** ea. plug and socket. **50p** per pair.
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TRANSFORMERS. All standard inputs.
STEP DOWN ISOLATING trans. Standard 240v AC to 120V tapped 60-0-60 700W. Brand new. **£5** ea.
Transformer 0-215-250 120 MA; 6.3V 4A CT×2; 2×6.3v 0.5A and separate 90v 100 MA **£1·25** ea. P. & P. 20p.
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RACAL RA17L's and **RA17** Mk II's from **£175** (Part ex. considered).
EDDISTONE Receiver Models 770U and 770R, **£140.**

MARCONI Wide Range Oscillator TF1370's and TF1370A's. 10c/s—10mc/s from **£140.**

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CT52	Min. scope. **£17·50.**

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4 DIGIT RESETTABLE COUNTERS. 1000 ohm. coil. Size 1½ × ¾ × 4½in. As new. by Sodeco of Geneva. **£2·50** ea.
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COMPONENT PACK consisting of 2-2 pole 2 amp push on/off switches; 4 pots 1 double; 1-small double pole vol control; 250 resistors ½ and ¼ watt many high stabs. Fine value at **50p** per pack. P. & P. 17p.
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USM-24C OSCILLOSCOPE: 3 in. oscilloscope with 2c/s to 10Mc/s vertical response, and 8c/s to 800Kc/s horizontal response. Sensitivity 50 mv. rms/inch. Triggered sweep, built-in trigger pulses and markers. Mains input 115V, 50c/s. Complete with all leads, probes and circuit diagram. £42·50 each, carr. £2.

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SIGNAL GENERATOR TS-510A/U: (Hewlett Packard). A general-purpose signal generator designed to furnish signals with a very low spurious energy content, suitable for alignment of narrow-band amplitude modulated receivers. It may be amplitude modulated by internally generated sine waves or by externally applied sine waves or pulses. Freq. Range—10-420 Mc/s in 5 bands, ±0.5% accuracy. Emission—AM, CW, Pulse. O/put Voltage—0.1V-0.5V, calibrated ±2 db accuracy. Modulation—Internal 400, 1000 c/s (0-90%). Built-in Crystal calibrator (1, 5 Mc/s). Price: £150 each, complete with transit case, manual and all leads; OR £125 each, Sig. Gen. only. Carr. both types £2.

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TEST SET TS-147C: Combined signal generator, frequency meter and power meter for 8500-9600 Mc/s. CW or FM signals of known freq. and power or measurement of same. *Signal Generator:* O/put —7 to —85 dbm. Transmission—FM, PM, CW. Sweep Rate—0-6 Mc/s per microsec. Deviation—0-40 Mc/s per sec. Phase Range—3-50 microsec. Pulse Repetition Rate—to 4000 pulses per sec. RF Trigger for Sawtooth Sweep—5-500 watts peak. 0.2-6 microsec. duration, 0.5 microsec pulse rise time. Video Trigger for Sawtooth Sweep—Positive polarity, 10-50V peak. 0.5-20 microsec duration at 10% max. amplitude, less than 0.5 microsec rise time between 90% and 10% max. amplitude points. *Frequency Meter:* Freq. 8470-9360 Mc/s. Accuracy—+2.5 Mc/s per sec. absolute, + 1.0 Mc/s per sec. for freq. increments of less than 60 Mc/s relative, ±1.0 Mc/s per sec. at 9310 Mc/s per sec. calibration point. Accuracy measured at 25° C and 60 humidity. *Power Meter:* Input: + 7 to + 30 dbm. Output — 7 to — 85 dbm. Price: £75 each + £1 carr.

SIGNAL GENERATOR TS-418/URM49: Covers 400-1000 Mc/s range. CW, Pulse or AM emission. Power Range—0-120 dbm. Price: £105 each + £1·25 carr.

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TCS MODULATION TRANSFORMERS, 20 watts, pr. 6,000 C.T., sec. 6,000 ohms. Price £1·25, post 25p.

SOLENOID UNIT: 230 v. A.C. input, 2 pole, 15 amp contacts, £2·50 each. post 30p.

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APNI ALTIMETER TRANS./REC., suitable for conversion 420 Mc/s., complete with all valves 28 v. D.C. 3 relays, 11 valves, price £3 each, carr. 50p.

ANTENNA WIRE: 100 ft. long. 75p + 25p post.

APN-1 INDICATOR METER, 270° Movement. Ideal for making rev. counter. £1·25, post 25p.

VARIABLE POWER UNIT: Complete with Zenith variac 0-230V., 9 amps.; 2½ in. scale meter reading 0-250V. Unit is mounted in 19 in. rack. £15 each, £1·50p carr.

AIRCRAFT SOLENOID UNIT D.P.S.T.: 24V, 200 Amps, £2 each, 25p post.

RADAR SCANNER ASSEMBLY TYPE 122A: Complete with parabolic reflector (24 in. diameter), motors, suppressors, etc. £35 each, £2 carr.

DECADE RESISTOR SWITCH: 0.1 ohm per step. 10 positions. 3 Gang, each 0·9 ohms. Tolerance ± 1% £3 each, 25p post. 90 ohms per step. 10 positions, total value 900 ohms. 3 Gang. Tolerance ± 1% £3·50 each, post 25p.

MARCONI DEVIATION TEST SET TF-934: 2.5-100Mc/s (can be extended up to 500Mc/s on Harmonics). Dev. Range 0-75Kc/s in modulation range 50c/s-15Kc/s. 100/250V. a.c. £45 each, £1·50 carr.

CRYSTAL TEST SET TYPE 193: Used for checking crystals in freq. range 3000-10,000Kc/s. Mains 230V, 50c/s. Measures crystal current under oscillatory conditions and the equivalent parallel resistance. Crystal freq. can be tested in conjunction with a freq. meter. £12·50 each, £1 carr.

LEDEX SWITCHING UNIT: 2 ledex switches, 6 Bank and 3 Bank respectively, 6 Pos.; 1 Manual switch, 16 Bank 2 Pos. £4 each, 50p post.

GEARED MOTOR: 24c. D.C., current 150mA, output 1 rpm, £1·50 each, 25p post. **ASSEMBLY UNIT** with Letcherbar Tuning Mechanism and potentiometer, 3 rpm, £2 each 25p post. **SYNCHROS:** and other special purpose motors available. List 3p.

DALMOTORS: 24-28V d.c. at 45 Amps, 750 watts (approx. 1hp) 12,000rpm. £5 each, 50p post.

GEARED MOTOR: 28V d.c. 150 rpm (suitable for opening garage doors). £4 each, 50p post.

SMALL GEARED MOTOR: 24V d.c., output 200 rpm. Meas'm'ts 1⅛in. dia. × 3½in. long. £2 each, 23p post.

FUEL INDICATOR Type 113R: 24V complete with 2 magnetic counters 0-9999, with locking and reset controls mounted in 3in. diameter case. Price £2 each, 25p post.

COAXIAL TEST EQUIPMENT: COAXWITCH—Mnftrs. Bird Electronic Corp. Model 72RS; two-circuit reversing switch, 75 ohms, type "N" female connectors fitted to receive UG-21/U series plugs. New in ctns., £6·50 each, post 37p. CO-AXIAL SWITCH—Mnftrs. Transco Products Inc., Type M1460-22, 2 pole, 2 throw. (New) £6·50 each, post 25p. 1 pole, 4 throw, Type M1460-4. (New) £6·50 each, post 25p.

PRD Electronic Inc. Equipment: FIXED ATTENUATOR; Type 130c, 2·0-10·0 KMC/SEC. (New) £5 each, post 25p. FIXED ATTENTUATOR: Type 1157S-1 (New) £6 each, post 25p.

MOVING COIL INSERT: Ideal for small speakers or microphones. Box of 3 £1, post 23p.

HAND MICROPHONE: (recent design) with protective rubber mouthpiece. £2, post 23p.

MICROLINE IMPEDANCE METER MODEL 201: 5300-8100Mc/s. £75 each, £1 carr.

MICROLINE DIRECTIONAL COUPLER MODEL 209: 5260-8100Mc/s. 24DB. £12·50 each, post 35p.

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3-B TRULOCK ROAD, LONDON, N17 OPG
Phone: 01-808 9213

G. F. MILWARD Mail Orders: DRAYTON BASSETT, TAMWORTH, STAFFS

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TRANSISTORS AND I.C.s ALL BRAND-NEW WITH MANUFACTURERS MARKINGS

ASY22	10p	2N709	50p
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ASZ17 (OC35)	25p	2N1309	23p
BC167	15p	2N1613	25p
BCY70	18p	2N1711	25p
BFX12	20p	2N2646	58p
OC41	20p	2N2926	15p
OC42	23p	2N3053	25p
OC43	20p	2N3055	75p
OC44	15p	2N3702	18p
OC45	10p	2N3703	13p
OC46	15p	2N3704	18p
OC141	22p	2N3707	15p
OC139	22p	2N3877A	40p
OC74	20p	7401	40p
OC204	25p	7410	40p
2G345	10p	7430	40p
2G371	10p	7472	55p
2G378	10p	7473	90p
		7475	£1·15

4,000,000 DIODES

SILICON, GERMANIUM OR ZENER (STATE CHOICE)

LOTS OF 100,000—£150
10,000—£20
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1,000,000 GERMANIUM TRANSISTORS (OC71/OC75)

LOTS OF 100,000—£250
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SPECIAL 50p PACKS. ORDER 10 PACKS AND WE WILL INCLUDE AN EXTRA ONE FREE ! ! ! !

RESISTORS, ¼/½ watt assorted	100	50p
Wire-wound 1 to 3 watt	20	50p
5 to 7 watt	15	50p
10 watts	10	50p
Multi-tapped	12	50p
PAPER CONDENSERS		
Tv types	50	50p
Miniature	100	50p
ELECTROLYTIC CONDENSERS		
Suitable for Mains Radio/Tv	10	50p
Transistor types	20	50p
Mixed (both types)	15	50p
POLYSTYRENE CONDENSERS	100	50p
MULLARD POLYESTER COND.	50	50p
SILVER MICA	100	50p
WIRE-WOUND 3-Watt SLIDERS	15	50p
VOLUME CONTROLS Assorted	5	50p
NUTS AND BOLTS. Mixed length/type		
8 B.A.	100	50p
6 B.A.	100	50p
4 B.A.	100	50p
2 B.A.	100	50p
METAL SPEAKER GRILLES 7½in. × 3½in.	6	50p
EARPIECES, MAGNETIC		
No Plug	6	50p
No Plug	6	50p
2·5mm Plug	4	50p
3·5mm Plug	4	50p
500 MICRO-AMP LEVEL METERS	1	50p
VEROBOARD. TRIAL PACK 5 BOARDS + CUTTER		50p

TRANSISTORS

P.N.P. Untested but mainly O.K.	50	50p
N.P.N. Untested but mainly O.K.	50	50p
OCP 71 equivalent	5	50p
Light-sensitive Diodes	10	50p
(*These produce up to 1ma from light*)		
OC44 Mullard 1st grade	4	50p
OC45 Mullard Boxed	4	50p
2G378 Output, Marked	4	50p
2G371 Driver, Marked	4	50p
ASY 22, Marked	5	50p
BY 127 Rectifiers	4	50p
IN4007 Rectifiers (1200V peak)	4	50p
STC 3/4 Rectifiers	6	50p
DIODES (0A 81 & OA 91)	40	50p
WIRE		
Solid Core. Insulated	100yds.	50p
Stranded ditto	50yds.	50p
SOLAR CELLS		
Large Selenium	2	50p
Small	3	50p
(6 cells will power a Micromatic radio)		
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CRYSTAL TAPE RECORDER MIKES	1	50p
CRYSTAL EARPIECES 3·5mm Plug	2	50p
TRANSISTORISED Signal Injector	1	50p
TRANSISTORISED Signal Tracer	1	50p
TRANSISTORISED CAR REV. COUNTER KIT (Needs 1 ma. meter as indicator)	1	50p

NEW! NEW! NEW! NEW! NEW!

A light-sensitive spray which enables you by photographic means to produce printed circuits in any quantity from a simple drawing. No lenses or timers needed. Just a light bulb.

Light-sensitive aerosol spray .. .. £1·00
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TRANSISTOR RADIOS

Once again we have a supply of these excellent radios which offer superb quality sound and excellent sensitivity. They are packed in a colourful presentation box complete with battery, earpiece and carrying case. Each one is guaranteed. You would expect to pay at least £5—but our price due to bulk purchase is only **£1·98.**

SINCLAIR AMPLIFIERS AND SPEAKERS: Complete range in stock. All at 10% discount on list.

VEROBOARD

2½in × 1in × 0·15in **6p**	5in × 3¾in × 0·15in **28p**	3¾in × 3¾in × 0·1in **24p**
3¾in × 2½in × 0·15in **16p**	17in × 2½in × 0·15in **55p**	5in × 2½in × 0·1in **23p**
3¾in × 3¾in × 0·15in **20p**	17in × 3¾in × 0·15in **74p**	5in × 3¾in × 0·1in **28p**
5in × 2½in × 0·15in **20p**	3¾in × 2½in × 0·1in **21p**	

Spot Face Cutter **38p.** Pin Insert Tool **48p.** Terminal Pins (0·1 or 0·15) 36 for **18p.** Special Offer Pack consisting of 5 2½in × 1in boards and a Spot Face Cutter—**50p.**

RECORD PLAYER CARTRIDGES. Well below normal prices!
G90 Magnetic Stereo Cartridges, Diamond Needle, 6mV output, **£4.** ACOS GP 67/2 (Mono, Crystal) **75p.** ACOS GP 91/3 (Compatible, Crystal) **£1.** ACOS GP 93/1 (Stereo, Crystal, Sapphire) **£1·25.** ACOS GP 93/1D (Stereo, Crystal, Diamond) **£1·63.** ACOS GP 94/1 (Stereo, Ceramic, Sapphire) **£1·50.** ACOS GP 94/1D (Stereo, Ceramic, Diamond) **£1·88.** ACOS GP 95/1 (Stereo, Crystal with two L.P./Stereo needles) **£1·25.**

TRANSISTORISED FLUORESCENT LIGHTS, 12 volt. All with reverse polarity protection. 8 watt type with reflector, suitable for tents, etc., **£3.** Postage/Packing 25p. 15 watt type, batten fitting for caravans **£4.** Postage/Packing 25p. 13 watt type, batten with switch. 22in × 2in × 1in **£5.** Postage/Packing 25p. THESE CAN BE SENT ON APPROVAL AGAINST FULL PAYMENT.

MULLARD POLYESTER CONDENSERS
1,000pf, 1,200pf, 1,500pf, 1,800pf, 2,200pf, **15p** per dozen (all 400V working). 0·15µf, 0·22µf, 0·27µf, **30p** per dozen (all 160V working). 25% discount for lots of 100 of any one type.

RESISTORS
¼ and ½ watt Most values in stock. **50p** per 100. **10p** per dozen of any one value. WIRE WOUND MAINS DROPPERS. Hundreds of values from 0·7 ohm upwards. 1 watt to 50 watts. A large percentage of these are multi-tapped droppers for radio/television. Owing to the huge variety these can only be offered "assorted" at **50p** per dozen.

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Large range in stock, 75p per 100 of any one value. 15p per dozen.

RECORDING TAPE BARGAIN! The very best British Made low-noise high-quality Tape! 5in Standard **38p.** Long-play **45p.** 5¾in Standard **45p.** Long-play **60p.** 7in Standard **60p.** Long-play **82p.** We are getting a fantastic number of repeat orders for this tape. Might we suggest that you order now whilst we still have a good stock at these low prices?

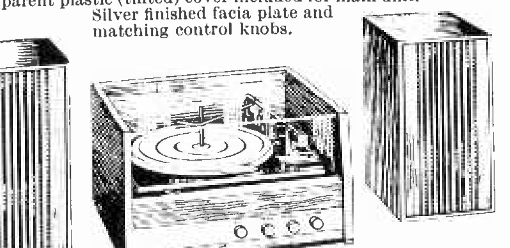
£5 WORTH OF COMPONENTS FREE ! ! ! !
Thinking of learning another language? If so apply to us for details of LINGUAPHONE courses. We will GIVE you £5 worth of components of your selection quite free of charge when you purchase a course ! ! ! !

G. F. MILWARD, Drayton Bassett, Tamworth, Staffs. Postage (minimum) per order 10p.

AUDIOTRINE A55 HIGH QUALITY STEREO SYSTEM

5 + 5 WATT OUTPUT
Garrard 5200 Changer with low mass pick-up arm and Stereo Cartridge. Controls: TREBLE, BASS, VOLUME, STEREO, BALANCE.
Operation on 200-250 v. A.C. mains. Output rating I.H.F.M.

Luxurious Teak Veneer Finished Cabinets. Transparent plastic (tinted) cover included for main unit. Silver finished facia plate and matching control knobs.



PAIR OF LOUDSPEAKER UNITS incorporating high flux 8in. × 5in. speaker. Size approx. 13 × 7½ × 8½ ins.

PRICE COMPLETE ONLY £42 Carr. £1·25

Terms: Deposit £5.50 and 9 monthly payments £4.50 (Total £46).

A REALLY SURPRISING STANDARD OF QUALITY IS OBTAINED FROM THIS COMPACT LOW PRICED SYSTEM

FANE 807 HIGH FIDELITY LOUDSPEAKER

A full range 8in. 10 watt Unit for excellent sound quality in suitable enclosure. Roll P.V.C. cone surround and long throw voice coil to achieve very low fundamental resonance at 30 c.p.s. Tweeter cone is fitted to extend high note response. Frequency range 25 Hz to 15 KHz. Impedance 3 Ω or 8-15 Ω. Cast Chassis. REMARKABLE VALUE AT ONLY **£3·50**

AUDIOTRINE HIGH FIDELITY LOUDSPEAKERS

Heavy construction. Latest high efficiency ceramic magnets. Treated Cone surround or "L" indicates Roll Rubber surround. "D" indicates Tweeter Cone providing extended frequency range up to 15,000 c.p.s. Exceptional performance at low cost. Impedance 3 or 8-15 ohms.

WHEN ORDERING PLEASE STATE IMPEDANCE

HF 801D 8" 8W	£2·71	HF 120D 12" 15W	£4·49
HF 102D 10" 10W	£3·40	HF 126 12" 15W	£5·25
HF 120 12" 15W	£3·99	HF 126D 12" 15W	£5·75

FANE ULTRA HIGH POWER LOUDSPEAKERS

All power ratings are R.M.S. continuous. 2 years' guarantee. High flux ceramic magnets. Heavy cast chassis. ALL CARRIAGE FREE.

'POP' 100 — 18in. 100 watt 14,000 gauss 8/15 ohms **£22·05** Dep.: £6 and 9 monthly payments £2·10 (Total £24·90).

'POP' 60 — 15in. 60 watt 14,000 gauss 8/15 ohms **£12·90** Dep.: £3·30 and 9 monthly payments £1·30 (Total £15).

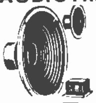
'POP' 50 — 12in. 50 watt 13,000 gauss 15 ohms **£10·50** Dep.: £2 and 9 monthly payments £1·15 (Total £12·35). PAIR SUITABLE ALL PURPOSES.

FOR BASS GUITAR OR ELECTRONIC ORGAN, ETC.

FANE LOUDSPEAKERS 'POP'25/2

Dual cone 15Ω (for uses other than Bass Guitar or Electronic Organ. **12in. 25watt** Carr. free. Or dep.: £1 and 9 monthly payments 75p (Total £7·75). **£6·75**

AUDIOTRINE HI-FI SPEAKER SYSTEMS



Consisting of matched 12in. 11,000 line 15 watt 15 ohm high quality speaker, cross-over unit and tweeter. Smooth response and extended frequency range ensure surprisingly realistic reproduction. Carr. 30p. **£5·75**
Or SENIOR 15 WATT inc. HF126 15,000 line Speaker £6·75. Carr. 35p.

HI-FI LOUDSPEAKER ENCLOSURES

Teak or Afrormosia veneer finish. Modern design. Acoustically lined. All sizes approx. Carr. 25p extra.

JE8 Size 16 × 11 × 9in. Pressurised. Gives pleasing results with any 8in. Hi-Fi speaker. **£4·75**

SE8 For optimum performance with any 8in. Hi-Fi 'speaker. 22 × 15 × 9in. Ported **£5·75**

SE10 For outstanding results with Hi-Fi 10in. speaker. 24 × 15 × 10in. Ported **£5·99**

SE12 For high performance with 12in. Hi-Fi speaker and Tweeter. Size 25 × 16 × 10½in. Pressurised. **£6·99**

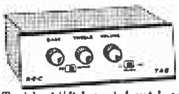
TA12 MK III 6·5 + 6·5WATT STEREO AMPLIFIER

FULLY TRANSISTORISED, SOLID STATE CONSTRUCTION HIGH FIDELITY OUTPUT OF 6.5 WATTS PER CHANNEL

Designed for optimum performance with any crystal or ceramic Gram P.U. cartridge, Radio tuner, Tape recorder, 'Mike' etc. ★ 3 separate switched input sockets on each channel ★ Separate Bass and Treble controls ★ Slide Switch for mono use ★ Speaker Output 3-15 ohms ★ For 200-250 v. A.C. mains ★ Frequency Response 20-20,000c.p.s. —2dB ★ Harmonic Distortion 0.3% at 1000c.p.s. Hum and noise —70dB ★ Sensitivities (1) 50 mV (2) 400 mV (3) 100 mV ★ Handsome finish Facia Plate and Knobs. Output rating I.H.F.M. Complete kit of parts with full wiring diagrams and instructions. Carr. 40p. **£15·50**
FACTORY BUILT WITH 12 MTH GNTEE. £19·50. Or dep. £3 and 9 mnthly pymts. £2·05 (Total £21·45). Or in Teak veneer housing. £23. Or Dep. £3 and 9 mthly. pymts £2·55 (Total £25·95).

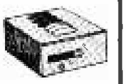
SELENIUM RECTIFIERS F.W. Bridged 6/12v. D.C. Output Input Max. 18v. A.C. 1a., 25p; 2a., 35p; 3a., 50p; 4a., 65p; 6a., 80p.

R.S.C. TA6 6 Watt High Fidelity Solid State Amplifier



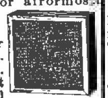
200-250v. A.C. mains operated Frequency Response 30-20,000 c.p.s. —2dB. Harmonic Distortion 0.3% at 1,000 c.p.s. Separate Bass and Treble 'lift' and 'cut' controls. 3 input sockets for Mike, Gram, Radio or Tape. Input selector switch. Output for 3-15 ohm speakers. Max. sensitivity 5mV. Output rating I.H.F.M. In fully enclosed enamelled case, approx. 9¼ × 2¾ × 5¼in. Attractive brushed silver finish facia plate 10¼ × 3¼in. and matching knobs. Complete kit of parts with full wiring diagrams and instructions. **£7·50** Carr. 40p
OR FACTORY BUILT with 12 months' g'tee. **£9.45**

R.S.C. BATTERY/MAINS CONVERSION UNITS



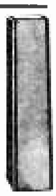
Type BM1. An all-dry battery eliminator. Size 5½ × 4½ × 2in. approx. Completely replaces batteries supplying 1.5 v. and 90 v. where A.C. mains 200/250 v. 50 c/s. is available.
COMPLETE KIT WITH DIAGRAM **£3** or READY FOR USE **£3·50**.

HIGH QUALITY LOUDSPEAKERS



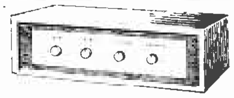
In teak or afrormosia veneered cabinets. **L13** 3 or 15 ohms. 13 × 8in. 8-10 Watt Model Gauss 10,000 lines, Carr. 40p **£5·25**
L12 12in. 20 Watt Model Gauss 11,000 lines. Size 18 × 18 × 10 in. approx. 15 Ω. Carr. 45p. **£9·50.** Or dep **£2** and 9 mthly pymts **£1**. (Total **£11**).

R.S.C. COLUMN SPEAKERS



Covered in Rexine and Vynair, ideal for vocalists and Public Address. 15 ohm matching.
TYPE C488, 30 watts. Fitted four 8in. high flux 8w. speakers. Or dep. **£3** and 9 mthly pmts **£2** (Total **£21**). Carr. 50p. **£17·75**
TYPE C4128, 50 watts. Fitted four 12in. 11,000 lines 15 watt Speakers. Or dep. **£4** and 9 mthly. pymts. of **£3** (Total **£31**). Carr. 75p **£27·50**

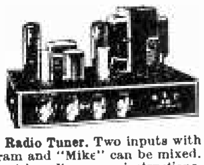
R.S.C. G66 6+6 WATT HIGH QUALITY STEREO AMPLIFIER



Individual Ganged controls: Bass, Treble, Volume and Balance. Printed circuit construction employing 10 Transistors plus Diodes. Output rating I.H.F.M. Suitable for Crystal Pick-ups etc., and for loudspeaker output impedances of 3 to 15 ohms. For standard 200-250 v. A.C. mains operation. Attractive silver finished metal facia plate and matching control knobs. Complete KIT of PARTS INCLUDING FULLY WIRED PRINTED CIRCUIT and comprehensive wiring diagram and instructions. **£9·99**
Or FACTORY BUILT in Teak veneered cabinet as illustrated **£12.50**. Carr. 40p. Or Deposit **£2** and 9 monthly payments of **£1.45** (Total **£15.05**).

PACKAGE OFFER, SAVE APPROX. £4. Above G66 assembled in cabinet plus pair DORCHESTER LOUDSPEAKER UNITS. **£27·50** Carr. £1
Or Deposit **£5·25** and 9 monthly payments **£2·85** (Total **£30·90**).

R.S.C. A10 30 WATT ULTRA LINEAR HI-FI AMPLIFIER



Highly sensitive. Push-Pull high output, with Pre-amp./Tone Control Stages. Hum level —70dB. Frequency response ±3dB 30-20,000 c/s. All high grade components. Valves EF86, EF86, ECC83, 807, 807, GZ34. Separate Bass and Treble Controls. Sensitivity 36 millivolts. Suitable for High Impedance mic. or pick-ups. Designed for **Clubs, Schools, Theatres, Dance Halls** or **Outdoor Functions**, etc. For use with **Electronic Organ, Guitar, String Bass**, etc. Gram, Radio or Tape. Reserve L.T. and H.T. for **Radio Tuner**. Two inputs with associated volume controls so that two separate inputs such as Gram and "Mike" can be mixed. 200-250 v., A.C. For 3 & 15Ω speakers. **Complete Kit parts, wiring diagrams, instructions.** Twin-handled perforated cover **£1·75**. Or factory built with EL34 output valves and 12 months' guarantee for **£19·75**. Tech. figs. apply to factory built units. Carr. 65p. **£15·75**
TERMS: Deposit £4·00 and 9 monthly payments of **£2·10** (Total **£22·90**). Send S.A.E. for leaflet.

RSC BASS-REGENT 50 watt AMPLIFIER

A powerful high quality, all purpose unit. For lead, rhythm, bass guitar, vocalists, gram., radio, tape. Peak output rating. Employing current valves and reliable components. FOUR JACK INPUTS and TWO VOLUME CONTROLS for simultaneous use of up to 4 pick-ups or 'mikes'. SEPARATE BASS AND TREBLE CONTROLS. **£30·50** Carr. 90p
OR SUPPLIED COMPLETE with matched twin loudspeaker unit as illustrated for £60. Carr. £1·50. Terms: Dep. £16 and 9 monthly payments £5·75 (Total £67·75).

THE 'YORK' HIGH FIDELITY 3'SPEAKER SYSTEM

Moderate size (**approx.** 25 × 14 × 10 in.). Range 30-20,000 c.p.s. Impedance 15 ohms. **Performance comparable with units costing considerably more.** Consists of (1) 12in. 15 watt Bass unit with cast chassis. Roll rubber cone surround for ultra low resonance, and ceramic magnet. (2) 3-way quarter section series cross-over system. (3) 8 × 5in. high flux middle range speaker. (4) High efficiency tweeter. (5) Appropriate quantity acoustic damping material. (6) Teak veneered cabinet. (7) Circuit and full instructions. Complete kit **£22** Carr. 63p
REMARKABLE VALUE HEAR IT AT ANY BRANCH

INTEREST CHARGES REFUNDED
On Credit Sales settled in 3 months

R.S.C. MAINS TRANSFORMERS

FULLY GUARANTEED. Interleaved and Impregnated. Primaries 200-250v. 50c/s. Screened

MIDGET CLAMPED TYPE 2½ × 2¾ × 2¼in.

250v., 60mA, 6.3v. 2a.	90p
250-0-250v., 60mA, 6.3v. 2a.	95p
FULLY SHROUDED UPRIGHT MOUNTING	
250-0-250v. 60mA., 6.3v. 2a., 0-5-6.3v. 2a.	£1·25
250-0-250v. 100mA, 6.3v. 4a., 0-5-6.3v. 3a.	£1·99
300-0-300v. 100mA, 6.3v. 4a., 0-5-6.3v. 3a.	£1·99
300-0-300v. 130mA, 6.3v. 4a., c.t., 6.3v. 1a. For Mullard 510 Amplifier	£2·40
350-0-350v. 100mA., 6.3v. 4a., 0-5-6.3v. 3a.	£1·99
350-0-350v. 150mA. 6.3v. 4a., 0-5-6.3v. 3a.	£2·40
425-0-425v. 200mA, 6.3v. 4a. c.t., 5v. 3a.	£4·49
425-0-425v. 200mA, 6.3v. 4a., 6.3v. 3a, 5v. 3a	£4·69
450-0-450v. 250mA. 6.3v. 4a., c.t., 5v. 3a.	£4·99
TOP SHROUDED DROP-THROUGH TYPE	
250-0-250v. 70mA, 6.3v. 2a., 0-5-6.3v. 2a.	£1·20
250-0-250v. 100mA, 6.3v. 3.5a.	£1·40
250-0-250v. 100mA, 6.3v. 2a., 6.3v. 1a.	£1·45
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SMOOTHING CHOKES 150mA, 7-10H. 250 Ω **65p**; 100mA. 10H. 200 Ω **55p**; 80mA. 10H. 350 Ω **45p**; 60mA. 10H. 400 Ω **25p**.

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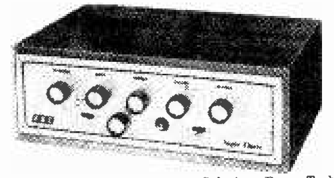

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3300-4700-6800-10,000pF	24p per 20
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0·022μF..	25p per 20
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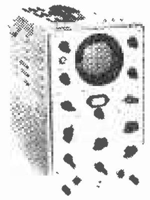

CI-5 SINGLE BEAM OSCILLOSCOPE

10 mc/s passband, triggered sweep from 1 μ sec. to 3 milli-sec. Free running time base from 20 c/s to 200 kc/s. Built-in time marker and amplitude calibrator, 3-in. cathode ray tube with telescopic viewing hood. **£39·00**

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OB3	0·60
OC2	1·00
OC3	0·38
OD3	0·35
1A3	0·30
1A5GT	0·32
1B3GT	0·38
1B24	4·00
1C5GT	0·35
1CP31	6·00
1G4GT	0·45
1G6GT	0·40
1H5GT	0·42
1L4	0·20
1N5GT	0·48
1Q5GT	0·50
1R4	0·35
1R5	0·35
1S4	0·27
1S5	0·25
1T4	0·25
1T5GT	0·45
1U4	0·27
1U5	0·50
1V2	0·45
1X2B	0·40
2A3	0·40
2AP1	2·25
2C26A	0·50
2C39A	7·00
2C40	3·50
2C51	0·45
2C53	4·50
2CW4	0·65
2D21	0·35
2E24	2·55
2K25	8·00
2X2	0·37
3A4	0·35
3B28	2·15
3BP1	2·75
3D6	0·20
3D21A	2·00
3Q4	0·40
3Q5GT	0·45
3S4	0·35
3V4	0·45
4-250A	13·00
4-400A	16·00
4B32	4·00
4HA5	0·48
4THA	0·45
5AR4	0·60
5B/254M	2·25
5B/255M	2·00

Valve	£
5CP1	5·00
5D21	5·00
5R4GY	0·60
5U4G	0·33
5U4GB	0·42
5V4G	0·42
5W4GT	0·40
5X8	0·50
5Y3GT	0·32
5Z3	0·50
5Z4G	0·40
6/30L2	0·75
6A8G	0·35
6AB4	0·35
6AC7	0·25
6AF4A	0·50
6AG5	0·22
6AG7	0·40
6AH6	0·50
6AJ8	0·30
6AK5	0·30
6AK5W	0·40
6AK6	0·57
6AL3	0·43
6AL5	0·20
6AM5	0·32
6AM6	0·33
6AN8	0·50
6AQ5	0·35
6AQ6	0·55
6AR5	0·35
6AR6	0·40
6AR11	1·25
6AS5	0·35
6AS6	0·37
6AS7G	0·80
6AT6	0·30
6AU6	0·25
6AV5GTA	0·70
6AV6	0·30
6AW8A	0·55
6AX4GTB	0·45
6AX5GT	0·65
6B4G	1·00
6B7	0·40
6B8G	0·20
6BA6	0·25
6BE6	0·30
6BF5	0·80
6BF6	0·50
6BH6	0·45
6BJ6	0·45
6BK4B	1·20
6BK7A	0·55
6BL7GTA	0·65
6BN6	0·40
6BQ5	0·25

Valve	£
6BQ6GTB	0·65
6BQ7A	0·40
6BR7	0·85
6BR8	0·65
6BS7	1·30
6BW6	0·85
6BW7	0·70
6BX6	0·25
6BX7GT	0·75
6BZ6	0·35
6C4	0·33
6CB6	0·30
6CD6GA	1·15
6CG7	0·50
6CH6	0·55
6CL6	0·50
6CU6	0·65
6CW4	0·63
6CY7	0·65
6D3	0·45
6DC6	0·75
6DK6	0·48
6DQ6B	0·63
6DS4	0·75
6E5	0·55
6EA8	0·58
6EH7	0·30
6EJ7	0·35
6F5	0·50
6F6G	0·30
6F11	0·38
6F13	0·38
6F14	0·65
6F15	0·65
6F17	0·50
6F18	0·45
6F22	0·30
6F23	0·80
6F24	0·75
6F25	0·75
6F28	0·60
6GK6	0·60
6J4	0·50
6J5GT	0·30
6J7	0·45
6K6GT	0·55
6K7	0·35
6K8G	0·35
6K8GT	0·50
6K23	0·55
6K25	0·75
6L6GT	0·45
6L7	0·40
6L18	0·45
6LD20	0·40
6N7GT	0·40
6P1	0·60
6P28	0·65
6Q7	0·40
6R7G	0·45
6S2	0·40

Valve	£
6S4A	0·60
6SA7	0·40
6SC7	0·70
6SG7	0·35
6SH7	0·35
6SJ7	0·40
6SK7	0·35
6SL7GT	0·35
6SN7GT	0·35
6SQ7	0·40
6SR7	0·40
6SS7	0·20
6T8	0·35
6U4GT	0·60
6U8A	0·40
6V6GT	0·38
6X4	0·30
6X5GT	0·35
6X8	0·55
6Y6G	0·65
6Z4	0·35
7B5	0·75
7B6	0·70
7B7	0·45
7C5	0·85
7F8W	0·65
7Y4	0·60
7Z4	0·50
9BW6	0·50
10C2	0·50
10D1	0·50
10D2	0·40
10F1	0·90
10F9	0·50
10F18	0·45
10L1	0·45
10LD11	0·60
10P13	0·55
10P14	1·10
11D3	0·45
11D5	0·45
11E2	2·50
11E3	4·00
12AB5	0·60
12AC6	0·40
12AD6	0·55
12AH7GT	0·30
12AL5	0·45
12AQ5	0·43
12AT6	0·30

Valve	£
12AT7	0·33
12AU6	0.30
12AU7	0·30
12AV6	0·33
12AV7	0·50
12AX4GTB	0·55
12AX7	0·30
12AY7	0·70
12B4A	0·55
12BA6	0·35
12BA7	0·35
12BE6	0·35
12BH7	0·40
12BY7	0·55
12C8	0·35
12E1	1·35
12E14	3·57
12H6	0·30
12J5GT	0·25
12J7GT	0·45
12K5	0·55
12K7GT	0·35
12K8	0·50
12Q7G	0·30
12SC7	0·35
12SG7	0·35
12SH7	0·30
12SJ7	0·30
12SK7	0·45
12SN7GT	0·45
12SQ7	0·50
12SR7	0·35
12X4	0·45
1487	0·80
20CV	3·15
20D1	0·45
20L1	1·10
20P1	0·50
20P3	0·60
20P4	1·10
20P5	1·20
25L6GT	0·45
25Z4G	0·30
25Z6GT	0·65
30A5	0·45
30AE3	0·40
30C1	0·30

Valve	£
30C15	0·80
30C17	[illegible]
30C18	0·75
30F5	[illegible]
30FL1	0·70
30FL12	0·93
30FL14	0·75
30L1	0·40
30L15	0·85
30L17	0·80
30P12	0·80
30P19	0·80
30PL1	0·70
30PL13	0·93
30PL14	0·90
35A5	0·75
35B5	0·65
35C5	0·40
35D5	0·70
35L6GT	0·50
35W4	0·30
35Z3	0·60
35Z4G	0·30
35Z5GT	0·40
42	0·50
50A5	0·70
50B5	0·45
50C5	0·40
50CD6G	1·65
50EH5	0·60
50L6GT	0·50
52KU	0·40
53KU	0·70
75B1	0·50
75C1	0·45
80	0·50
83	1·10
85A2	0·40
85A3	0·50
90AG	2·40
90AV	2·50
90CM	0·60
90CG	1·25
90CV	1·25
108C1	0·35
150B2	0·60
150B3	0·60
150C4	0·60
305	0·65
310A	1·50
311A	2·00

Valve	£
328A	2·00
329	1·15
329A	1·90
715A	2·50
715C	5·00
723A/B	7·00
725A	16·00
807	0·50
811A	1·60
813	3·75
829B	3·50
833A	17·00
837	0·85
866A	0·75
872A	3·00
884	0·60
889RA	50·00
927	3·00
931A	3·50
955	0·25
4378	1·40
4687	1·75
5544	6·50
5551A	16·00
5654	0·40
5670	0·50
5751	0·60
5763	0·70
5796	14·00
5814A	0·50
5894	5·50
6072	0·85
6080	1·50
6146	1·50
6146B	2·50
6293	3·25
6360	1·25
6870	2·50
6883	2·50
6939	2·15
7199	0·75
7586	1·25
7591A	1·00
7895	1·25
8005	7·00
9002	0·35
9003	0·50
A1834	0·80
A2293	1·35

Valve	£
AC/HL/DD	0·50
AC/TH1	0·45
AX50	2·25
AZ31	0·55
C1K	4·50
CBL1	0·80
CBL31	0·90
CL4	0·60
CL33	1·00
CY31	0·35
DAF41	0·50
DAF91	0·25
DAF92	0·50
DAF96	0·42
DC90	0·45
DF91	0·25
DF92	0·20
DF96	0·42
DH76	0·35
DH81	0·60
DH101	0·55
DK40	0·55
DK91	0·35
DK92	0·50
DK96	0·42
DL66	1·25
DL68	0·65
DL69	1·75
DL91	0·27
DL92	0·35
DL93	0·35
DL94	0·45
DL95	0·40
DL96	0·42
DY86	0·33
DY87	0·35
DY802	0·50
E55L	2·75
E80CC	1·10
E80CF	1·50
E80L	0·95
E81L	1·15
E83F	1·10
E84L	0·50
E86C	0·90
E88C	1·15
E88CC	0·65
E88CC/01	1·90
E90CC	0·45
E91H	0·60

Valve	£
E130L	5·00
E182CC	1·20
E186F	1·25
E188CC	0·90
E280F	2·10
E810F	2·90
EA50	0·20
EA52	4·50
EABC80	0·35
EAF42	0·55
EAF801	0·50
EB34	0·20
EB91	0·20
EBC33	0·50
EBC41	0·55
EBC81	0·30
EBC90	0·30
EBC91	0·30
EBF80	0·40
EBF83	0·40
EBF89	0·30
FBL31	1·50
EC53	0·50
EC86	0·60
EC88	0·60
EC90	0·33
EC92	0·35
EC93	0·50
EC8010	2·25
ECC34	0·40
ECC40	0·60
ECC70	0·85
ECC81	0·33
ECC82	0·30
ECC83	0·30
ECC84	0·30
ECC85	0·40
ECC86	0·50
ECC88	0·40
ECC89	0·50
ECC91	0·20
ECC189	0·60
ECF80	0·35
ECF82	0·35
ECF86	0·65
ECF804	1·50
ECH35	0·60
ECH42	0·70
ECH81	0·30
ECH83	0·40
ECH84	0·45

Valve	£
ECL80	0·40
E180F	0·95
ECL81	0·45
ECL82	0·35
ECL83	0·65
ECL84	0·55
ECL85	0·55
ECL86	0·40
ECLL800	1·50
EF9	0·50
EF37A	0·60
EF39	0·40
EF40	0·50
EF41	0·65
EF42	0·70
EF80	0·25
EF83	0·55
EF85	0·35
EF86	0·30
EF89	0·28
EF91	0·33
EF92	0·40
EF93	0·25
EF94	0·25
EF95	0·30
EF96	0·22
EF97	0·65
EF98	0·65
EF183	0·30
EF184	0·35
EF800	1·00
EF804	1·25
EF811	0·75
EF812	0·80
EF814	0·75
EH90	0·40
EK32	0·45
EK90	0·30
EL5	0·55
EL33	1·25
EL34	0·50
EL35	0·40
EL36	0·50
EL37	1·25
EL41	0·55
EL42	0·58
EL81	0·55
EL83	0·42
EL84	0·25
EL85	0·43
EL86	0·40
EL90	0·35

Valve	£
EL91	0·32
EL95	0·35
EL360	1·15
EL803	1·00
EL821	0·55
EL822	0·90
ELL80	0·75
EM34	0·90
EM71	0·75
EM80	0·40
EM81	0·60
EM85	1·00
EM87	0·55
EN10	4·00
EN11	3·50
EN32	1·50
EN91	0·35
EY51	0·40
EY80	0·45
EY81	0·40
EY83	0·55
EY84	0·55
EY86	0·40
EY87	0·43
EY88	0·43
EZ35	0·35
EZ40	0·45
EZ41	0·45
EZ80	0·25
EZ81	0·28
EZ90	0·30
FG17	4·50
FW4/500	0·75
FW4/800	0·75
GC10B	3·75
GN4	1·50
GR10M	1·50
GS10C	5·00
GS10D	5·75
GS10H	3·10
GS12D	7·00
GS47X	3·00
GU50	1·75
GY501	0·80
GZ30	0·40
GZ31	0·33
GZ32	0·48
GZ33	0·70
GZ34	0·60
HABC80	0·45

Valve	£
HBC90	0·30
HBC91	0·33
HF93	0·35
HF94	0·30
HK90	0·35
HL23	0·40
HL23DD	0·40
HL42DD	0·50
HL92	0·40
HL94	0·45
KT8	2·00
KT36	1·00
KT44	0·50
KT45	2·00
KT66	2·05
KT71	0·50
KT76	0·40
KT88	2·00
KTW63	0·50
ME91	0·45
MH4	0·50
ML4	0·45
ML6	0·40
MSPEN/T	0·50
MT17	4·50
MU12/14	0·60
N78	1·45
NSP1	3·50
NSP2	4·00
PABC80	0·40
PC86	0·60
PC88	0·60
PC900	0·48
PCC84	0·40
PCC85	0·40
PCC88	0·55
PCC89	0·50
PCC189	0·55
PCC805	0·85
PCC806	0·80
PCE800	0·70
PCF80	0·30
PCF82	0·35
PCF84	0·50
PCF86	0·60
PCF87	0·85
PCF800	0·80
PCF801	0·50

Valve	£
PCF802	0·50
PCF805	0·75
PCF806	0·70
PCF808	0·75
PCH200	0·70
PCL81	0·50
PCL82	0·35
PCL83	0·65
PCL84	0·45
PCL85	0·40
PCL86	0·45
PCL88	0·90
PCL800	0·93
PCL801	0·70
PCL805	0·50
PD500	1·50
PEN4DD	0·50
PEN36C	0·70
PEN45	0·40
PEN45DD	0·75
PEN46	0·40
PEN383	0·55
PEN384	0·60
PEN453DD	0·60
PF86	0·60
PF818	0·85
PFL200	0·70
PL33	0·35
PL36	0·55
PL81	0·50
PL82	0·45
PL83	0·45
PL84	0·40
PL302	0·80
PL504	0·80
PL508	0·90
PL509	1·30
PL801	0·80
PL802	0·75
PLL80	0·55
PM84	0·50
PX25	2·00
PY31	0·30
PY33	0·63
PY80	0·35
PY81	0·30
PY82	0·30
PY83	0·38
PY88	0·40
PY500	1·00
PY800	0·50
PY801	0·50
PZ30	0·35
QQV02-6	2·15
QQV03-10	1·25

Valve	£
QQV03-20A	5·25
QQV06-40A	5·50
QS83/3	0·40
QV03-12	0·70
QY4-400A	16·00
R10	1·00
R18	0·55
RG3-250A	0·75
RL18	0·50
S130	1·75
S130P	1·75
SP2	0·50
SP4	0·50
SP41	0·45
SP61	0·55
TP22	0·60
TP25	0·40
TT21	2·65
TT22	2·80
U17	0·75
U18/20	0·75
U19	2·80
U20	0·75
U25	0·75
U26	0·75
U31	0·45
U37	1·50
U50	0·32
U52	0·33
U76	0·30
U78	0·30
U191	0·75
U201	0·35
U281	0·40
U282	0·40
U301	0·40
U403	0·50
U404	0·40
U801	1·00
UABC80	0·35
UAF41	0·50
UAF42	0·55
UB41	0·60
UBC41	0·50
UBC81	0·40
UBF80	0·40
UBF89	0·35
UBL1	0·50
UBL21	0·60
UC92	0·35
UCC85	0·40
UCF80	0·55
UCH21	0·60
UCH42	0·70
UCH43	0·75

Valve	£
UCH81	0·35
UCL81	0·60
UCL82	0·35
UCL83	0·60
UF9	0·60
UF11	0·50
UF41	0·60
UF42	0·60
UF43	0·60
UF80	0·35
UF85	0·40
UF89	0·35
UL41	0·65
UL84	0·30
UM4	0·40
UM84	0·20
UU5	0·60
UY1N	0·50
UY11	0·65
UY41	0·45
UY82	0·50
UY85	0·30
VLS631	1·90
VP41	0·75
VP133	1·00
VR75/30	0·45
VR105/30	0·38
VR150/30	0·35
VU33	0·60
VU39A	0·60
VU111	0·60
VU120	0·80
VU133	0·60
W107	0·50
W729	0·60
X65	0·55
X66	0·55
X76M	0·50
XC11	0·75
XC12	0·35
XC12T	0·40
XC15	0·25
XC15T	0·40
XC23	0·90
XC25	0·35
XR1-1600	14·00
XR1-3200	6·50
Z329	0·85
Z520M	1·50
Z700U	0·40
Z700W	0·75
Z719	0·25
Z729	0·30
Z749	0·80
Z759	1·85
Z800U	1·75
Z801U	1·75
Z803U	0·90
Z900T	0·75

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Cables: ZAERO LONDON
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WE WANT TO BUY:
SPECIAL PURPOSE VALVES. PLEASE OFFER US YOUR SURPLUS STOCK. MUST BE UNUSED.

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BOX NUMBERS: Replies should be addressed to the Box number in the advertisement, c/o Wireless World, Dorset House, Stamford Street, London, S.E.1.
No responsibility accepted for errors.

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WORK AS A RADIO TECHNICIAN ATTACHED TO SCOTLAND YARD

You'd be based at one of the Metropolitan Police Wireless Stations. Your job would be to maintain the portable VHF 2-way radios, tape recorders, radio transmitters and other electronic equipment which the Metropolitan Police must use to do their work efficiently.

We require a technical qualification such as the City & Guilds Intermediate (telecommunications) or equivalent.

Salary scale: £1,161 (age 21) rising by increases to £1,590 plus a London Weighting Allowance. Promotion to Telecommunications Technical Officer will bring you more.

For full details of this worthwhile and unusual job, write to:

METROPOLITAN POLICE
Room 733 (RT/WW), New Scotland Yard
Broadway, London, SW1
or telephone 01-230 1212 extension 2605

1046

TEST ENGINEERS

The leading U.K. Manufacturers of high grade T.V. monitors and ancillary T.V. studio equipment require Test Engineers for their rapidly expanding test department.

Situated in the Berkshire town of MAIDENHEAD the company offers pleasant working conditions, good salaries, and a friendly environment.

Duties will cover the testing of our complete range of equipment.

Previous experience on television equipment is not essential but candidates must have a thorough knowledge of electronics and testing procedures.

Reply to:

PROWEST ELECTRONICS LTD.,
Boyn Valley Road, Maidenhead, Berks.
Telephone: Maidenhead 29612

1077

LATIN AMERICA Transmitter/communications engineer for educational radio network in Honduras. Required to work with existing medium power transmitters and VHF links. Do you like working with people in a job which really makes sense?

We have many vacancies in health, education, engineering and agriculture, for single persons or married couples without children.

Write without delay to Dave Brown, Overseas Volunteers CIIR, 41 Holland Park, LONDON, W.11.

1148

NORTHWICK PARK HOSPITAL,
Watford Road, Harrow, Middx. HA1 3UJ Tel: 01-864 5311

ELECTRONICS TECHNICIAN

Salary Scale £1,446—£1,854

The hospital is new and is closely allied with a clinical research centre. Eventually there will be over 800 beds. The current vacancy involves the servicing and calibration of a wide range of electronic equipment used for medical, surgical and engineering purposes, and the successful applicant will work closely with medical and other professional staff.

Good staff facilities and a pleasant working atmosphere. Active social club. Temporary accommodation available.

For further details contact Mr. J. Sully, Staffing Officer.

1118

RADIO OPERATORS

There will be a number of vacancies in the Composite Signals Organisation for experienced Radio Operators in 1971 and subsequent years.

Specialist training courses lasting approximately 8 months are held at intervals. Applications are now invited for the course starting in September 1971.

Salary Scales

During training with free accommodation provided at the Training School:

Age 21	£848 per annum
,, 22	£906 ,,
,, 23	£943 ,,
,, 24	£981 ,,
,, 25 or over	£1,023 ,,

On successful completion of course:

Age 21	£1,073 per annum
,, 22	£1,140 ,,
,, 23	£1,207 ,,
,, 24	£1,274 ,,
,, 25 (highest age point)	£1,351 ,,

then by 6 annual increments to a maximum of £1,835 per annum.

Excellent conditions and good prospects of promotion. Opportunities for service abroad.

Applicants must be United Kingdom residents, normally under 35 years of age at start of training course, and must have at least 2 years operating experience or PMG qualifications. Preference given to those who also have GCE 'O' level or similar qualification. Exceptionally well qualified candidates aged from 36-40 may also be considered.

Interviews will be arranged throughout 1971.

Application forms and further particulars from:

Recruitment Officer, Government Communications Headquarters, Oakley, Priors Road, CHELTENHAM, Glos., GL52 5AJ. Tel: Cheltenham 21491 Ext 2270

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PETERBOROUGH TECHNICAL COLLEGE
Required for September 1st, 1971

LECTURER GRADE I

to teach Radio and Television Servicing subjects.

Applicants should have relevant qualifications and practical experience.

Salary £1,230 to £2,075 per annum, starting point according to qualifications and experience.

Application forms obtainable from:

The Principal,
Peterborough Technical College,
Park Crescent, Peterborough, PE1 4DZ 1149

Colour Film Services
22 Portman Close, London, W.1
have a vacancy for an

ELECTRONIC ENGINEER

with experience in Sound installation and maintenance. Minimus qualifications required O.N.C. The position is one of responsibility and the applicant should therefore be capable of working unsupervised when required. Salary negotiable up to £2000 but will not be less than £1800 p.a. Applications stating qualifications etc., should be made to Mr. J. W. L. Watson, Electronics Department, at 10 Wadsworth Road, Perivale, Middx.

1119

Transformer Designer

(Radio & Television)

We, at Rank Bush Murphy, are renowned for the quality of our products, a quality that is seen in the high standard of the components used in our equipment. The Components Laboratory team plays a key part in maintaining this standard and we are now looking for a man, experienced in transformer and wound components design to join them.

The Designer will initiate design for low power transformers, chokes, and other wound components, and be responsible for the assessment of magnetic material, winding components and other insulating materials. Aged 28 + he will have H.N.C. or similar, and will be looking for a salary of up to £2,000 p.a. In addition he will receive fringe benefits as generous as one would expect from an organisation of our strength and profitability.

To apply, send details of your career to date, quoting reference WW to:

David Jux, Rank Bush Murphy Ltd,
Power Road, Chiswick, London, W.4,
or telephone 01-994 6491.

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REUTERS

ASSISTANT ENGINEER FOR REUTERS

An assistant engineer with communications experience is required to join a support team for operations in South America, Africa, The Pacific and Middle East.

Specialist knowledge of both TDM and VFT terminals together with operational experience in H.F. radio systems is necessary. Though based in London the successful applicant will have every opportunity to travel abroad for short periods.

This post carries a salary of between £2000-£2200 dependent upon experience.

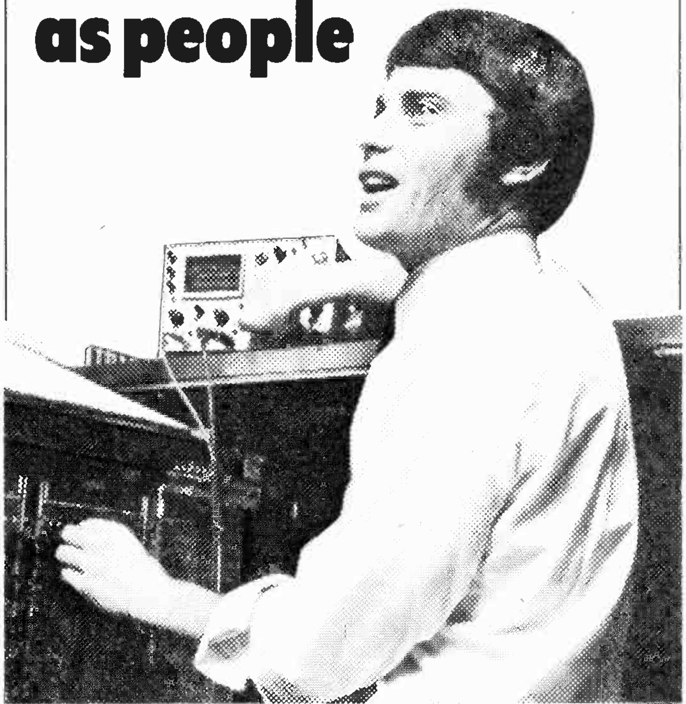
Applications please in writing to:

D. P. Russell, Esq.
Manager of Technical Services,
Reuters Ltd. 85 Fleet Street E.C.4.

1135

Engineers

If you understand machines as well as people



...then you could become a Customer Engineer at IBM.

Wherever there are computers, people are needed to keep them running. These people are known as either Service Engineers, Field Engineers or Maintenance Technicians. Because of their close involvement with the customer, IBM calls them Customer Engineers.

Today, computers are becoming essential to industry, science, government and commerce. And no computer manufacturer can operate without Customer Engineers. So the field is wide open, and this could be your opportunity to move into today's major growth industry.

What you will do

There are four groups of Customer Engineers. Three are in Data Processing and cover between them the entire range of D.P. equipment from card punching and Teleprocessing to highly sophisticated computer systems. The fourth group is the Office Products division which covers basic electric typewriters and typewriting systems, dictating equipment and composer systems. Whichever group you may join you will be given a first class training.

Qualifications

You should be between 20 and 35, educated to 'O' Level standard. In addition to a knowledge of basic electronics, a good mechanical aptitude is also necessary as part of the work involves repair and maintenance of the electro-mechanical devices. For engineers who will be trained for computer systems, a basic knowledge of electronics is also necessary. If you also have a logical mind then you could have a career as a Customer Engineer with IBM.

Your prospects

Starting salaries are excellent. IBM offers many fringe benefits such as non-contributory pension scheme, free Life Assurance and an excellent career-path. And it is IBM policy to promote from within.

Write now

Interested? Then write with details of your age, qualifications and experience to: Mr. D. J. Dennis, IBM United Kingdom Limited, 389 Chiswick High Road, London W.4. quoting reference WW/958.

IBM

958

BROADCASTING ENGINEER THE GAMBIA

* Salary up to £2454
* Low taxation
* Education & outfit allowances
* 25% gratuity
* Subsidised accommodation
* Contract 24 months
* Appointments Grant payable in certain circumstances

Required by the Posts & Telecommunications Dept. to be responsible for the operation and maintenance of all the technical equipment in the studio building, which includes a main control room, outside broadcast & recording equipment, the air conditioning plant and an emergency diesel generator and to assist with the training of local staff.
Candidates, 25-50 years, must possess a recognised qualification in telecommunications such as the City and Guilds Intermediate Certificate or O.N.C. They should preferably have experience of medium and shortwave transmitter operation and of maintaining and operating broadcast studio equipment in a tropical country.

Apply to CROWN AGENTS,'M' Division, 4 Millbank, London, S.W.1., for application form and further particulars stating name, age, brief details of qualifications and experience and quoting reference M2K/710345/WF.

1154

Engineers
Do you want to get into sales?

We require a development engineer without previous sales training for an internal sales engineer. This position offers excellent scope for personal advancement into the sales field. Salary negotiable plus special bonus and pension schemes.

Please 'phone T. Jermyn or P. Baker at Sevenoaks (0734) 51174.

Jermyn Industries
Vestry Estate Sevenoaks Kent

JERMYN

1100

ELECTRONICS TECHNICIAN

Experienced Electronics Technician required to assist in development, maintenance and construction of a wide range of research equipment. Appointment will be to Junior Technical Officer grade £769 to £1,631, plus London weighting.

Minimum Qualifications:
2 'A' Levels or ONC if under 22
HNC or equivalent if over 22.

Apply to Mr. A. J. Flack, Medical Research Council Biophysics Unit, Department of Biophysics, King's College, 26-29 Drury Lane, London, W.C.2, or ring 836 8851.

1134

LADY ENGINEERS

We require one of those lady engineers who complain that we males never want to employ them. She will take charge of a small electronic service department at Chertsey. Dealing with repairs of solid state circuits, and must be fully conversant with semi-conductor circuitry.
Staff appointment. 40-hour week. Salary £1150-£1350.

CASS ELECTRONICS LTD.,
White Hart Yard, Guildford Street, Chertsey, Surrey.
Chertsey (09328) 63481.

1142

IF YOU ARE A
RADIO/T.V. ENGINEER

We are interested in making a change, and have vacancies for servicing and constructing High Power Studio Electronic Flash Equipment; used in the Photographic field.

Letters only to:—
STROBE EQUIPMENT LTD.,
56 Turnmill Street,
London, E.C.1

1123

LEC

TELEVISION AND RADIO TRAINING
(DAY ATTENDANCE COURSES)

This private College provides theoretical and practical training in Radio and TV Servicing. Courses of one year's duration, with daily attendance, are available for beginners and shorter courses for men with previous training in Electronics and Radio. Training courses in Radar and Radio Transmission are also available following the TV course. Write for prospectus to: **London Electronics College, Dept. B/5, 20 Penywern Road, Earls Court, London, S.W.5. Tel. 01-373 8721.**

84

Sea-going Radio Officers can now make sure of a shore job and good pay.

If you'd like a job ashore, at a United Kingdom Coast Station, the Post Office will start you off on £1,080—£1,360, depending on age, with annual rises up to £1,850. There are good prospects of promotion to higher posts, opportunities exist for overtime and you would receive additional remuneration for attendance during the late evenings, at night and on Saturday afternoons and Sundays.

You will need to be 21 or over, with a 1st Class Certificate of Competence in Radiotelegraphy issued by the Postmaster General or the Ministry of Posts and Telecommunications, or a Radiocommunication Operator's General Certificate issued by the Ministry of Posts and Telecommunications, or an equivalent certificate issued by a Commonwealth administration or the Irish Republic.

Find out more by writing to:
The Inspector of Wireless Telegraphy,
I.M.T.R.
Wireless Telegraph Section (W.W.)
Union House,
St. Martins-le-Grand,
London,
EC1A 1AR.

Post Office
Telecommunications

93

RACECOURSE TECHNICAL SERVICES LIMITED

OPERATE

TELEVISION UNIT FOR HORSERACING

and require a

TELEVISION ENGINEER

for operation and maintenance of the MCR

QUALIFICATIONS

★HNC, City & Guilds or equivalent.
★Experience in operation and maintenance of outside broadcast television equipment.
★Willing to travel.

OPPORTUNITIES

★The Company is planning further expansion in the fields of television and electronics.
★Post carries A.C.T.T. category B salary.
★Expenses paid on location.

Applications stating age and experience should be sent to:

RACECOURSE TECHNICAL SERVICES LTD.,
88 Bushey Road, Raynes Park, London, S.W.20. 1140

AER LINGUS · IRISH

Simulator Maintenance Technicians

DUBLIN

If you have:

- a sound knowledge of electronics
- experience in the maintenance of aircraft avionic systems or computers

Aer Lingus would like to hear from you. If you have experience in the maintenance of flight simulators, your application will be even more welcome.

At Dublin Airport you will enjoy

- outstandingly good working conditions
- generous travel concessions
- superannuation scheme

Salary commensurate with qualifications and experience.

Please write, giving details of age, qualifications and experience to:

Head of Employment
Section V.B. 35
Aer Lingus — Irish
P.O. Box 180 Dublin Airport
Ireland

TECHNICIAN/ TECHNICIAN ENGINEER

EDUCATIONAL TELEVISION UNIT

Required at Guildford County Technical College to join an existing team in an expanding College Television Service. The person appointed will assist the lecturer-in-charge and supervise the installation, operation and maintenance of studio and mobile equipment as well as initiate the development of new facilities. Experience with helical-scan V.T.R. equipment essential, together with some knowledge of studio operational procedures and audio visual aids.

Salary will be on the N.J.C. scale with additional allowance depending on qualifications and experience. Desirable minimum qualifications are the final Radio and Television Servicing and Colour Television Servicing Certificates (C.G.48).

General relocation assistance in approved cases.

Application form and further particulars from the Vice-Principal, Guildford County Technical College, Stoke Park, Guildford, Surrey, on receipt of S.A.E.

1150

CRANFIELD INSTITUTE OF TECHNOLOGY

invites applications for appointment as

RADIO ENGINEER

in the Department of Flight to maintain the VHF/UHF communication, navigation, and instrument landing system equipment.

£30·30 for a 40-hour week of five days, rising with service to £32·65 p.w. Local Government superannuation, excellent working conditions, 3 weeks annual holiday increasing to 4 weeks, sick pay scheme. Subsidised transport over a wide area.

Application form from Staff Records Officer, Cranfield Institute of Technology, Cranfield, Bedford.

1124

CITY AND COUNTY OF BRISTOL
BRUNEL TECHNICAL COLLEGE
Department of Marine & Aero-Electronics

Applications invited for post of

SENIOR TECHNICIAN
(Grade T.3)

Candidates should be over 21 years of age and hold Intermediate City & Guilds in Electronics or Radio Communications, or other appropriate qualifications. Duties include servicing and maintenance of electronic and electrical equipment as used in Merchant Ships and Civil Aircraft.

Starting salary in range **£1,089—£1,272** p.a., according to age, experience and qualifications.

Further particulars and application forms from Registrar (S), Brunel Technical College, Ashley Down, Bristol, BS7 9BU, by quoting reference 71/5. Closing date 3rd May.

1131

BUSINESS OPPORTUNITY

Earn a substantial extra income through a fascinating part-time business of your own that you could share with your wife and operate from your own home. This is an outstanding business opportunity with rewards exceeding £5000 per annum at the higher levels. We are looking for organisational and managerial ability.

Telephone for an appointment.

VISTA MARKETING MAIDENHEAD 28754

1002

WALSALL AND STAFFORDSHIRE TECHNICAL COLLEGE

LECTURER GRADE 1
TELECOMMUNICATIONS

Applications are invited for the following post from the 1st September, 1971:

LECTURER GRADE 1 in TELECOMMUNICATIONS

Applicants should be prepared to teach Telecommunication Principles and Telephony to the Final Year of the City and Guilds Course in Telecommunication, Course C.G.L.I. No. 49, and to assist in the organization of the Telephony Laboratory.

Qualifications should include the Final Certificate of the C. & G. Course in Telecommunications Technicians and Post Office experience is essential.

SALARY for the above post will be in accordance with the Burnham Further Education Scale, viz. Lecturer Grade I **£1,110** to **£1,955** per annum with appropriate additions for education and training.

APPLICATION FORM and further particulars may be obtained by applying to the Principal, Walsall and Staffordshire Technical College, St. Paul's Street, Walsall, WS1 1XN. Applications should be returned by Friday, 7th May, 1971.

Assistance with cost of removal will be granted in approved cases.

R. D. NIXON
Secretary to the Joint Education Committee

1130

BRUNEL UNIVERSITY
DEPARTMENT OF PSYCHOLOGY

A TECHNICIAN

with experience of electronics and an interest in working with animals in the field of physiological psychology is required for this new post. An initial training period will be arranged as appropriate and the successful candidate will help plan the animal accommodation.

Holidays start at two weeks four days per year (the University also closes for Easter and Christmas weeks).

Salary within the scale **£1011—£1461** per annum plus **£75** London Weighting.

Postcard for application form to Establishment Officer, Brunel University, Kingston Lane, Uxbridge, Middlesex quoting reference PSY/1, or telephone UXBRIDGE 37188, extension 35. Closing date: 30th April, 1971.

1133

NORTH OF SCOTLAND HYDRO-ELECTRIC BOARD

Laboratory Technician

Technician required to join the Board's Research Laboratory at Pitlochry. Preference will be given to candidates holding, or studying for, their H.N.C. in Electrical Engineering. Work will involve construction and testing of electrical/electronic equipment but the successful candidate will be given opportunities in a broad field of research covered by the Board's activities.

Salary within the range £1011—£1338 + £60 p.a. N.J.B. Schedule "A" (Area Board) Grade 15.

The post is superannuable.

Application forms, obtainable from the Chief Personnel Officer, 16 Rothesay Terrace, Edinburgh EH3 7SE, should be returned by Wednesday 28th April.

115

SITUATIONS VACANT

A FULL-TIME technical experienced salesman required for retail sales; write giving details of age, previous experience, salary required to—The Manager, Henry's Radio, Ltd., 303 Edgware Rd., London, W.2. [67

A SENIOR TECHNICIAN is required in the Department of Mechanical and Production Engineering for work on electronic and mechanical equipment. Duties will include the construction and development of instrumentation for various research projects within the Department. Scope will be given to the man with initiative in this area. In addition the Senior Technician will be responsible for the routine maintenance of electronic instruments. Preference will be given to a man with experience in precision mechanical engineering, besides his electronic background. Salary within the scale £1,493-£1,883 per annum according to age, qualifications and experience (minimum age 21). Apply in writing to the Secretary and Clerk to the Council, Polytechnic of the South Bank, Borough Road, London, S.E.1, giving full particulars of age, qualifications and experience and quoting the reference M/ST. [1126

DRAUGHTSMEN. Mechanical and Electrical required by expanding electronics company specialising in lighting control and audio visual products. This position is salaried and gives ample opportunity for advancement. Please apply Electrosonics Ltd., 47 Old Woolwich Road, Greenwich, London, S.E.10. Tel. 858 4764. [22

EXPERIMENTAL OFFICER. Research and development electronics engineer required to join a Unit carrying out biophysical research at Cambridge. Applicants should possess H.N.C., degree or equivalent qualification and appropriate practical experience. Duties will include the design and development of advanced electronic equipment for biological research and some administration as assistant to the Director, Dr. J. E. Treherne. Salary (minimum age 26) will be £1,725 rising by six annual increments to £2,177. In addition, a non-pensionable allowance of 5½% of basic salary will be payable in respect of superannuation contributions. An electronics technician will be appointed to act as assistant. Applications giving full details of qualifications and previous experience should be sent to: The Director, A.R.C. Unit of Invertebrate Chemistry and Physiology, Department of Zoology, University of Cambridge, Downing Street, Cambridge, CB2 3EJ. [1152

MARINE Radio Engineer with experience of R.T., MF and VHF, Autopilots, Radar, etc. for field installations. Must be based in London area but able to work anywhere without supervision. Salary £1,300-£1,500 according to experience. Telesonic Ltd. 01-387 7467. [1101

ADM BUSINESS SYSTEMS LIMITED

Require

SERVICE ENGINEERS

To cover their range of desk top calculators

Vacancies exist at our London (Sunbury-on-Thames), Manchester (Sale, Cheshire) and Birmingham Branches. Interviews will be arranged at the above centres for workshop engineers. Applicants should have a sound knowledge of electronics or some previous experience of the repair of desk top calculators. Salary according to age and experience.

Applications giving full details of qualifications and experience to:

R. Wardlaw, Esq., ADM Services Ltd., ADM House, Windmill Road, Sunbury-on-Thames, Middlesex.

1146

SITUATIONS WANTED

BROADCASTING ENGINEER, 27, returning to U.K. from responsible position abroad, seeks senior position in broadcasting. Many years' experience in studio operations in commercial and B.B.C. TV and colour experience, especially in Video-Tape. Available for immediate employment beginning May, 1971.—Box WW 1139, Wireless World.

PROFESSIONAL ENGINEER (40) electro-mech., familiar with metric system, seeks position for design and construction of high-quality tape-decks and ass. equipment.—B. Tary, 14 Maldon Rd., Wellington, Surrey. [1145

ARTICLES FOR SALE

AMPLIFIER A21 Series Two J. E. Sugden. Brand new used 2 hours only. Offers invited. Box W.W. 1128 Wireless World.

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

COLOUR, UHF and TV SERVICE SPARES. SPECIAL OFFER, leading Brit. maker's Colour Monitor Panels designed to BBC standards. Pal filter and delay £6, chrominance £6, luminance £4·50, encoded video input £2·50 P/P 25p (or set of 4 £17·50 P/P 35p). Also quantity Colour TV Camera Panels. Plessey colour scan coils £5·75 P/P 35p, convergence coils £3·80 P/P 25p, Blue lateral £1·25 P/P 10p (or complete set £10 P/P 50p). Leading Brit. maker's surplus, colour scan coils £3·50 P/P 35p, convergence coils £2·75 P/P 25p. Colour LOPT assembly incl. EHT output and focus control £4·50 P/P 35p, luminance/chrominance panel £1 P/P 25p. Integrated transistd. decoder unit incl. circuits £1·25 P/P 10p. SPECIAL OFFER, leading Brit. maker's surplus 625 single standard TV chassis, latest design, almost complete, includes transistd IF stages, frame and line time bases, transformers, etc., incl. circuit, £8·65 P/P 50p. B9D valve bases for colour valves and PL500 series 12½p P/P 5p. UHF tuners transistorised, rotary slow motion drive or push button £5·25 P/P 25p. Integrated UHF/VHF 6 position push button transistorised tuner easily adjusted as 6 position UHF tuner, incl. circuit £4·50 P/P 50p. Transist. UHF/VHF IF panels £4·75 (or salvaged £2·50) P/P 25p. MURPHY 600/700 series complete UHF conversion kits incl. tuner, drive assy., 625 IF amplifier, 7 valves, accessories, housed in special cabinet plinth assembly, £7·50 or less tuner £3 P/P 50p. SOBELL/GEC 405/625 switchable IF amplifier and output chassis, £1·50 P/P 30p. Ultra 625 IF AMP chassis and circuit £1·50 P/P 30p. Philips 625 IF AMP panel and circuit, £1 P/P 30p. SOBELL/GEC 2015 series 405/625 printed circuit IF panel incl. circuit £1·95 P/P 30p. UHF list available on request. VHF tuners AB miniature with UHF injection suitable K.B., Baird, Ferguson 75p P/P 30p, Cyldon C £1 P/P 30p, Pye 13 ch. incremental

£1·25 P/P 30p. Ekco, Ferranti, Plessey push button tuner with UHF injection £1·50 P/P 30p. New fireball tuners Ferguson, HMV, Marconi type £1·90 P/P 30p. Philips export continental turret tuners 75p P/P 30p. Many others available. Large selection channel coils, LOPTs, Scan Coils. FOPTs available for most popular makes. Surplus Ultra, Murphy 110° Scan coils 75p P/P 30p. Sobell frame o/p transformers 90p P/P 30p. Transistorised time base panel for Ferguson portable £2·50 P/P 30p. Pye/Labgear transistd. masthead UHF booster £5·25, UHF/VHF/FM set back booster, mains operated £7·90. Wolsey masthead amplifier power unit £2·50 P/P 25p. Surplus BBC2 Belling Lee "Skyline" distribution amplifiers £3 (Callers only).—MANOR SUPPLIES, 172 WEST END LANE, LONDON, N.W.6 (No. 28 Bus or W. Hampstead Tube Station). MAIL ORDER: 64 GOLDERS MANOR DRIVE, LONDON, N.W.11. Tel. 01-794 8751. [60

COUNTY COUNCIL OF ESSEX

EDUCATION DEPARTMENT

RCA Type TR4c Television Tape Recorder

The Authority wishes to dispose of the above broadcast standard recorder purchased in 1967. The equipment includes two 5 mil. air bearing head-wheels both recently re-worked to 150 hour rate. Hour meter reads less than 300. 'Pixlock' and A.T.C. incorporated. Wired to take colour and editing modules. 2 audio record and play channels. Extender, tools etc., 14 nearly new tapes, 20 used tapes. 20 empty spools. Further details and appointment to view from The Visual & Aural Aids Officer, County Gardens, Rainsford Road, Chelmsford. Tel: Chelmsford 54248.

Forms of tender obtainable from the County Supplies Officer, Westway, Chelmsford, should be returned to the Clerk of the County Council, County Hall, Chelmsford, in the envelope provided which should bear no evidence of the sender's name or organisation.

1122

DAWE ANALYSER 1410A. 6 ranges. Manual £15. Airmec frequency meter 726. 230V. Manual £20. 32 Glenshesk Park, Dunmurry, Belfast. [1110

E.M.I. 4 decade resistance boxes up to 99·99kΩ tol. 1%. 3 decade capacitance boxes up to 0·999μF tol. 2% (P.E.T. capacitor) £8 each. NEW, guaranteed. —Hughes Electronics, 71 Travellers's Way, Hounslow, Middx. Tel 01-759 0039. [1136

HEAVY DUTY E.H.T. mains transformers 2,000-0-2,000V 400mA. Multi-taped primary 10V steps. £5·50 each. Phone 01-690 1465 after 6 p.m. [1115

IMPULSE ELECTRONICS power supply heart in Diecast box with attached heat sink. Requires only 30V A.C. to give full regulated 0-25V D.C. at up to 2A. Overcurrent protected at 2·5A. only £9·62. Suitable transformer £3·09 or both for £12. Fifteen volt 1A version £8·37, trans. £1·96 or both £10. S.A.E. for list of new test gear Impulse Electronics, 106 Howard Road, London, E.17. [1129

NEW CATALOGUE No. 18, containing credit vouchers value 50p, now available. Manufacturers' new and surplus electric and mechanical components, price 22½p, post free. Arthur Sallis Radio Control Ltd., 28 Gardner Street, Brighton, Sussex. [94

OCTAL VALVES C.R.T. 6EP31, Pots, Edge connectors, carbon and W/W Resistors, Mains waterproof couplings. S.A.E. for lists. 128 Elincroft Road, Ipswich, Suffolk. [1158

POWER Supply, 240v. single phase to 110v. 40 amp. D.C. Suitable fairground or amusement park, £68; Plating Unit, 240v. A.C. input out 12 volt 300 amp. D.C., £86; Emergency Lighting Unit, 240 volt giving 12 volt 10 amp., as required by L.C.C. regulations, £32.—Kingston Electrical Supplies, 134 London Road, Kingston Upon Thames, Surrey. Tel. 01-546 7534. [1141

QUANTITY AKG 224E microphones, Uher and Ampex stereo mixers. ¼" and ½" tape, and associated equipment. S.A.E. for list. Box W.W. 1112. Wireless World.

SOLARTRON POWER UNIT, £7·50 Marconi deviation meter, £7·50, Clystron oscillator 1-3'5Ge/s £7·50, S.T.C. signal generator £5·00, Small audio oscillator with power supply £5·00, variable delay line. 0-9 micro seconds, cost £900. What offers? Samwell Hutton wobbulator, model 41B £22·00, Marconi B.F.O. model TF195L £15·00, Marconi signal generator TF144G/4 £20·00, Airmec Frequency meter, type 265, £10·00, Airmec Wave analyser, type 853 £7·50. Furzehill stabilised power supply type P300, £7·50. Phone 01-449 1769. [1117

TAME these db's . . . Plug in professional quality FET compressor module, £15·50. For the "slick operator" . . . "Voice over" module £15·50. S.A.E. details Cathedral Sound W.W. "Fourways," Morris Lane. Halsall. Lancs. L39 8SX. [1116

VACUUM pumps, coating plant, pyrometers, recorders spectrophotometers/ovens, etc. Free catalogue. Barrett, 1 Mayo Road, Croydon, CRO 2QP, Surrey. Phone 01-684-9917. 1056

VHF 80-180 MHz. Integrated receiver, tuner, converter Kit. Remarkable results from single semiconductor. Comprehensive kit £4 post paid or send for free literature enclosing s.a.e. Johnsons (Radio) Worcester, WR1 2DT. [99

60 kc/s Rugby & 75 kc/s HBG Neuchatel Radio Receivers. Signal and Audio outputs. Small compact units, £35. Toolex, 6 Warwick Close, Hertford (4856). [98

TEST EQUIPMENT — SURPLUS AND SECONDHAND

SIGNAL generators, oscilloscopes, output meters, wave voltmeters, frequency meters, multi-range meters, etc., etc., in stock.—R. T. & I. Electronics, Ltd., Ashville Old Hall, Ashville Rd., London, E.11. Ley. 4986. [64

TYPE 661 Tektronix Sampling Oscilloscopes, Pulse Generators, Marconi Signal Generator and EH 123 Pulse Generators all fully maintained.—Write Box WW 1138 or ring Winchester 4433 Ext. 6398 or 384.

RECEIVERS AND AMPLIFIERS—SURPLUS AND SECONDHAND

HRO Rx5s, etc., AR88, CR100, BRT400, G209, S640, etc., etc., in stock.—R. T. & I. Electronics, Ltd., Ashville Old Hall, Ashville Rd., London, E.11. Ley. 4986. [65

NEW GRAM AND SOUND EQUIPMENT

GLASGOW.—Recorders bought, sold, exchanged; cameras, etc., exchanged for recorders or vice-versa.—Victor Morris, 343 Argyle St., Glasgow, C.2. [11

TAPE RECORDING ETC.

IF quality, durability matter, consult Britain's oldest transfer service. Quality records from your suitable tapes. (Excellent tax-free fund raisers for schools. Modern studio facilities with Steinway Grand.—Sound News, 18 Blenheim Road, London, W.4. 01-995 1661. [28

SPARES for discontinued Tape Recorders and Projectors. State requirements, or call at John King (Films) Limited, 15 Bond Street, Brighton. Tel.: 25942. [1108

YOUR TAPES TO DISC.—£6,000 Lathe. From £1·50. Studio/Location Unit. S.A.E. Leaflet. Deroy Studios, High Bank, Hawk St., Carnforth, Lancs. [70

FOR HIRE

FOR HIRE CCTV equipment, including cameras, monitors, video tape recorders and tape—any period. —Details from Zoom Television, Chesham 6777 [75

ARTICLES WANTED

HIGHEST CASH PRICES for good-quality Tape Recorders 9.30-5.00. Immediate quotations. 01-472 2185. [102

ISOLATION Transformer and Rectifier Set. Secondary of transformer fully isolated from primary. Input single of three phase, output 220V 10 amp. Rectifier set to suit above. Young & Power Ltd., 4 Station Road, Abingdon, Berkshire. Tel.: Abingdon 3772. [1113

NAGARD OSCILLOSCOPE types DT 103 and DE 103A circuit diagrams and workshop manuals required. Kitrick, 31 Barnway, Wembley, Middlesex. 01-904 3780. [1114

PYE BANTAM HP1AM required. Reiss, 34 Nursery Lane, Leeds 17, OLE2-683884. [962

REASONABLY sized Portuguese Company would like to hear from Wholesalers who could supply the following equipment. Resistors, condensers and electronic components in general; urgently required. Apply to GRETE, R. Artilharia UM, 39 6° D. To Lisbon 1 Portugal. [990

WANTED, all types of communications receivers and test equipment.—Details to R. T. & I. Electronics, Ltd., Ashville Old Hall, Ashville Rd., London, E.11. Ley. 4986. [63

WANTED, televisions, tape recorders, radiograms, new valves, transistors, etc.—Stan Willetts, 37 High St., West Bromwich, Staffs. Tel. Wes. 0186. [72

WANTED redundant TV Tube regunning plant.—Tel. St. Albans 50971 after 6 p.m. [1098

WANTED, mains power supply Redifon type 6211/A for Redifon GR 410 SSB transceiver. Capt. M. G. Taylor, R Signals, G SD Branch, Headquarters, 1st British Corps., BFPO 39. [1127

VALVES WANTED

WE buy new valves, transistors and clean new components, large or small quantities, all details, quotation by return.—Walton's Wireless Stores, 55 Worcester St.. Wolverhampton. [62

CAPACITY AVAILABLE

AIRTRONICS LTD., for Coil Winding—large or small production runs. Also PC Boards Assemblies. Suppliers to P.O., M.O.D., etc. Export enquiries welcomed. 3a Walerand Road, London, S.E.13. Tel. 01-852 1706 [61

COIL winding capacity. Transformers, chokes R.F. coils, etc., to your specification. Sweetnam & Bradley Ltd., Bristol Road, Malmesbury, Wilts, or Tel. Malmesbury 3491. [905

DESIGN, development, repair, test, and small production of electronic equipment, low rates. YOUNG ELECTRONICS, 54 Lawford Rd., London, N.W.5. 01-267-0201. [1057

DESIGN WORK, modifications and wiring of all types of electronic and electro-mechanical systems carried out. Standards in accordance with P.O., C.E.G.B. and M.O.D. Apply to Box No. 1153.

ELECTRONIC CIRCUITS and equipment designed by Electronics Engineer with wide industrial experience. Amplifiers, Oscillators, Modulators, Filters, etc., for any application and frequency from D.C. to U.H.F. Prototypes and drawings supplied. Box W.W. 1155. Wireless World.

ELECTRONICS DESIGN CONSULTANT has capacity for design or evaluation of digital systems. Box W.W 1111. Wireless World.

METALWORK, all types cabinets, chassis, racks, etc., to your own specification, capacity available for small milling and capstan work up to 1in bar.—PHILPOTT'S METALWORKS, Ltd., Chapman St., Loughborough. [17

TURNED parts, automatic capstan capacity available also milling, grinding, fitting. Low rates, Ministry approved.—Desmond Engineering, Combe Martin, N. Devon. Combe Martin 2412. [1036

WE undertake the manufacture of transformers singly or in quantities to any specification. All work guaranteed for 12 months.—Ladbroke Transformer Co. Ltd., 820a Harrow Road, Kensal Rise, N.W.10. Tel. 01-969 0914. [100

TECHNICAL TRAINING

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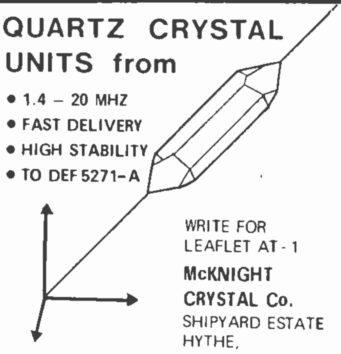

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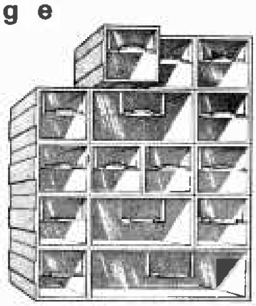

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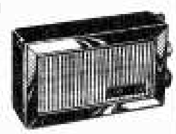

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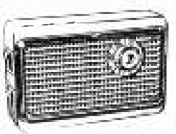

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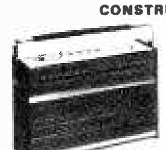

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