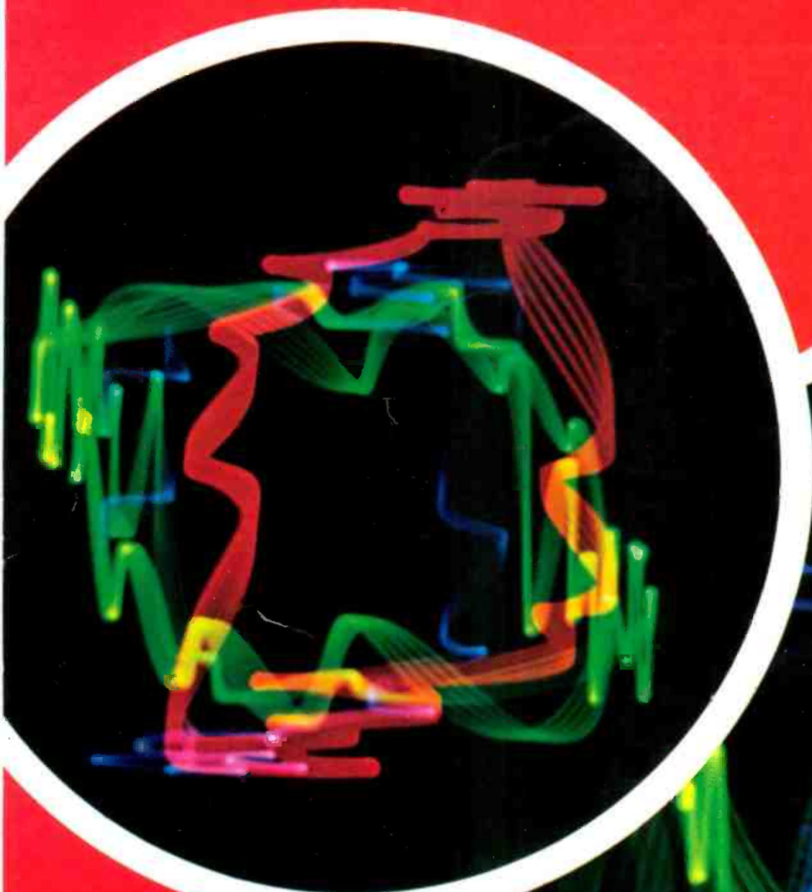
wireless world

JULY 1977 40p

Intruder alarm
Ladder crystal filters



Kinetic images from sound

WW—001 FOR FURTHER DETAILS

wireless world

Electronics, Television, Radio, Audio

JULY 1977 Vol 83 No 1499

Contents

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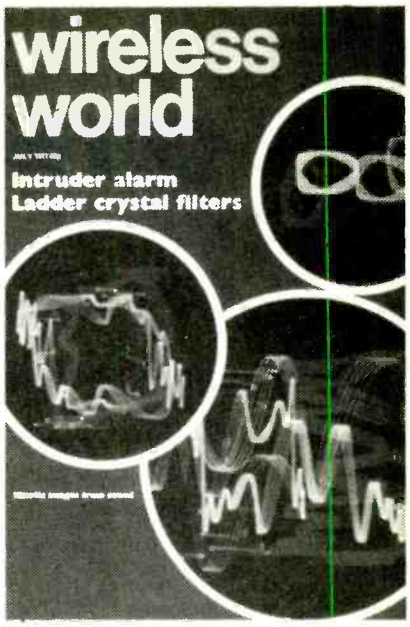

Front cover shows multi-colour projected laser traces produced from sound signals. System is outlined in "Kinetic images from sound" p.40

IN OUR NEXT ISSUE

Shortwave broadcasting efficiency. System developed by Radio Canada International to measure how successful a s.w. broadcasting service is in reaching its intended listeners.

Distortion in audio amplifiers analyses the mechanism of distortion resulting from transistor non-linearities in low-noise circuits. A design example follows later.

Amateur radio equipment. A survey outlining design and performance trends in commercial transmitters, receivers and transceivers at present available for amateur operators.

ISSN 0043 6062

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ABC

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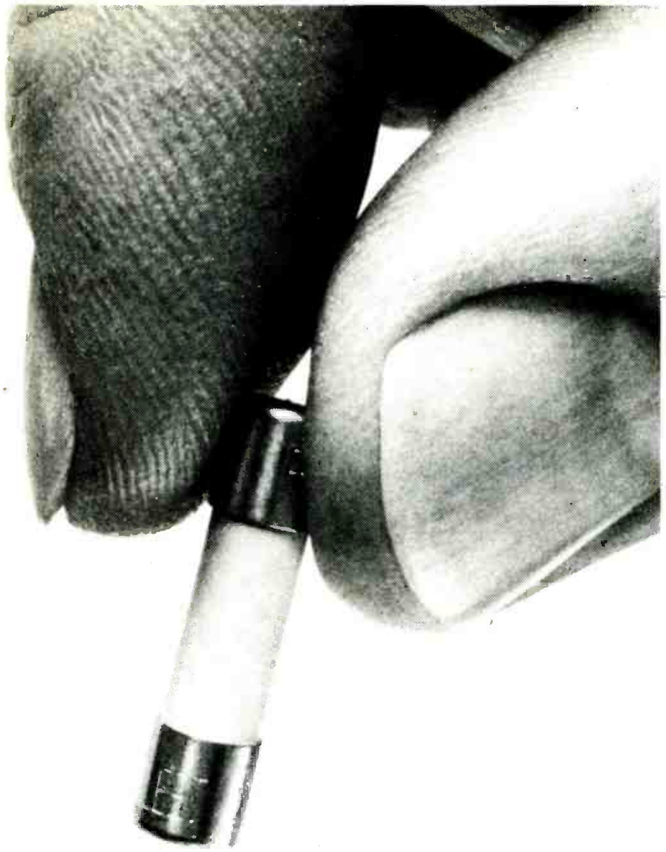

Overload the Avometer 73 and it'll cost you this much to repair it.

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Thorn Measurement and Components Division

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All have low loss, low distortion, low phase-shift, low pick-up, BUT wide frequency range.

Cat. No.	Impedance (OHMS) Input	Output	Turns Ratio Sec/Pri	Operating Level dBm at 50Hz	Frequency Response
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MU 7503	0 200 600	100k	13/23 1		± 1 dB
MU 7514	600	600/2.4k	1 + 1 1	8	50Hz–10kHz
MU 7518	10k CT	10k	1 1 CT		
MU 7521	3.75/15	600 CT	6.32/12.64 1		
MU 7522	3.75/15	100k*	82/164 1		
MU 7524	150/600	600 CT	1/2 1		
MU 7525	600 CT	300/1.2k	1 + 1 1.41 CT	16.5	± 0.5 dB
MU 7530	10k CT	10k	1 1 CT		30Hz–20kHz
MU 7534	50/200	100k*	22.4/44.8 1		(* ± 1dB at 20kHz)
MU 7566	600 CT	10k/2.5k	4.08/2.04 1		
MU 7567	600/150	50k	9.13/18.26 1	12	
MU 7582	200/50	600 CT	1 73/3.46 1	20	± 0.5dB 10Hz–100kHz
VM 7461	15/3.75	600	6.35/12.7 1		
VM 7464	600/150	600	1/2 1		± 1dB 30Hz–22kHz
VM 7466	600	10k/2.5k	4.14/2.07 1	4.75	
VM 7468	50/12.5	50k	32/64 1		± 1dB 30Hz–12kHz

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WW7/77

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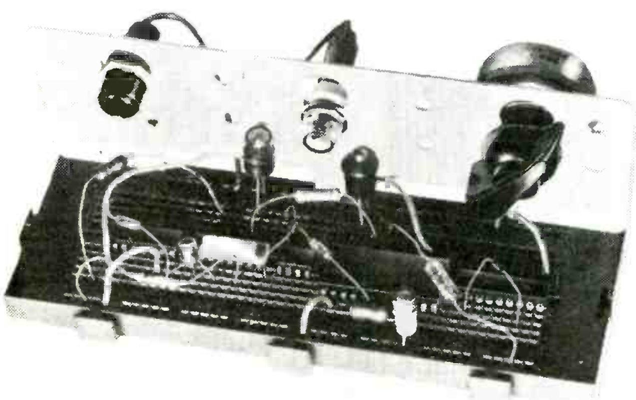

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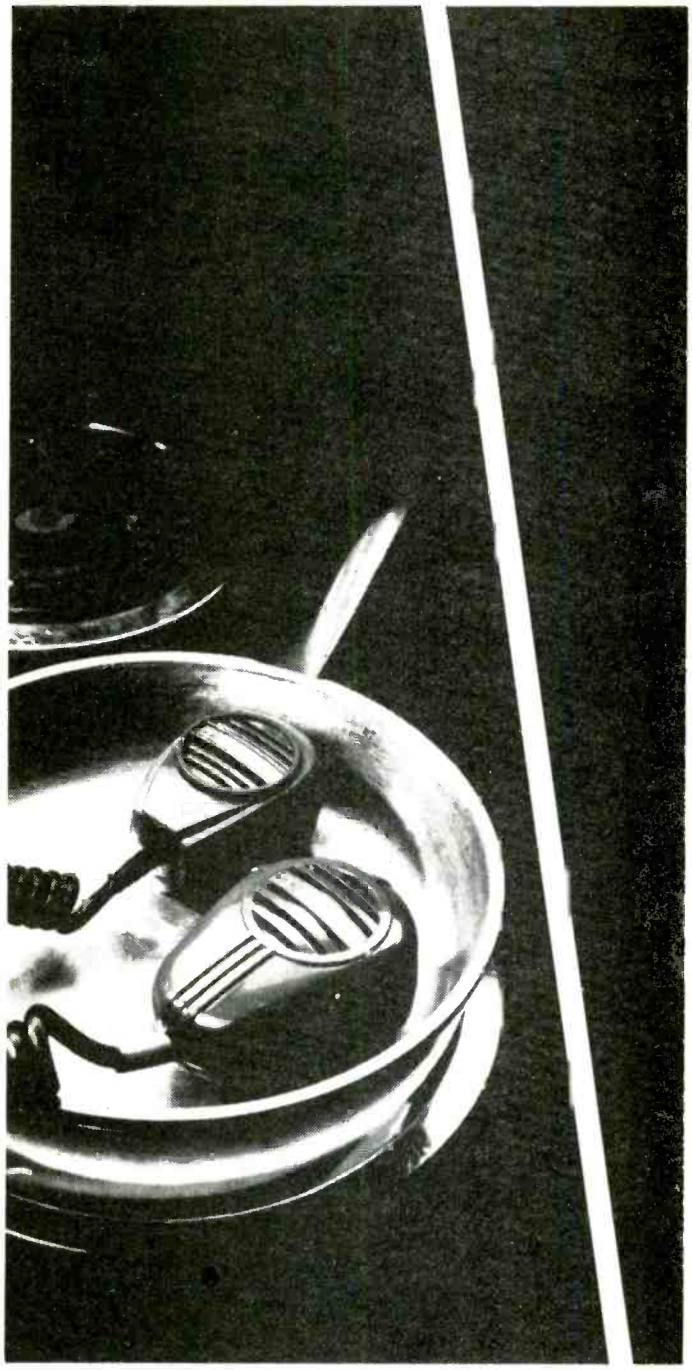

Shure fries 'em

Shure Safety Communications Microphones are tested for level and response at a searing 69.4° ... often up to an incredible 85° C. for day-long periods and even though the inside parts are too hot to touch

...They work

WW-059 FOR FURTHER DETAILS

The potentiometer with greater potential

The new DC Potentiometer Model T7100 is, without doubt, an exceptional piece of laboratory equipment. What makes it so, is its high accuracy over its six decades of measurement available at the same time. Dial 1 offers an accuracy of $+(0.001\% + 0.1\ \mu V)$; Dial 2 $+(0.001\% + 0.1\ \mu V)$ and Dials 3-6 $+0.1\ \mu V$.

This 'triple pot' offers not only exceptional long term accuracy and stability, but also a built-in self calibration check. Added to this, wound components have been replaced by resistors printed on a heat sink substrate – so there is virtually no source of drift or thermal emfs.

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Sullivan

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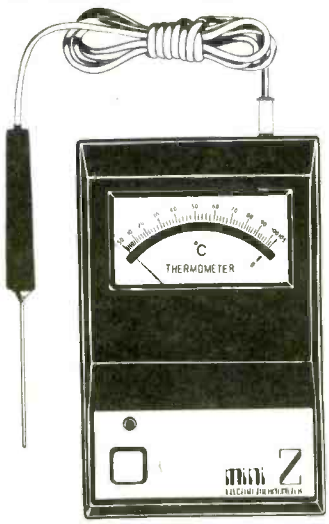
ELECTRONIC INDUSTRIAL THERMOMETER



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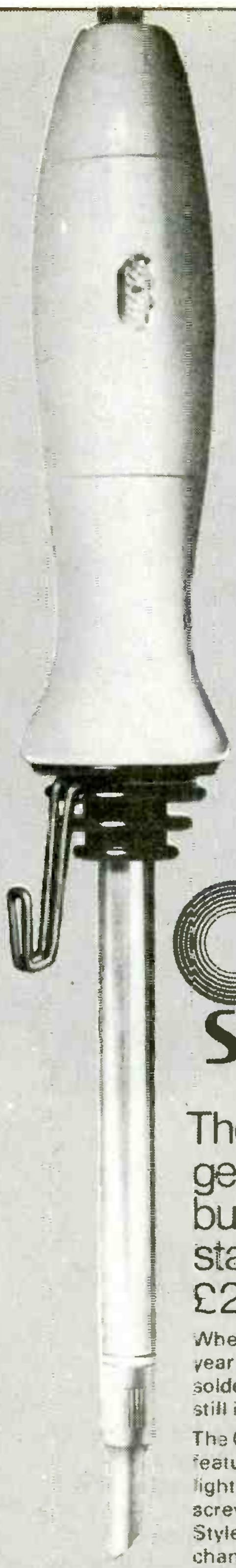

*Illustration actual size

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When we introduced the Super 30 last year it was the best general purpose soldering iron at its price in Britain—it still is, at only £2.95p. (plus 8% VAT)

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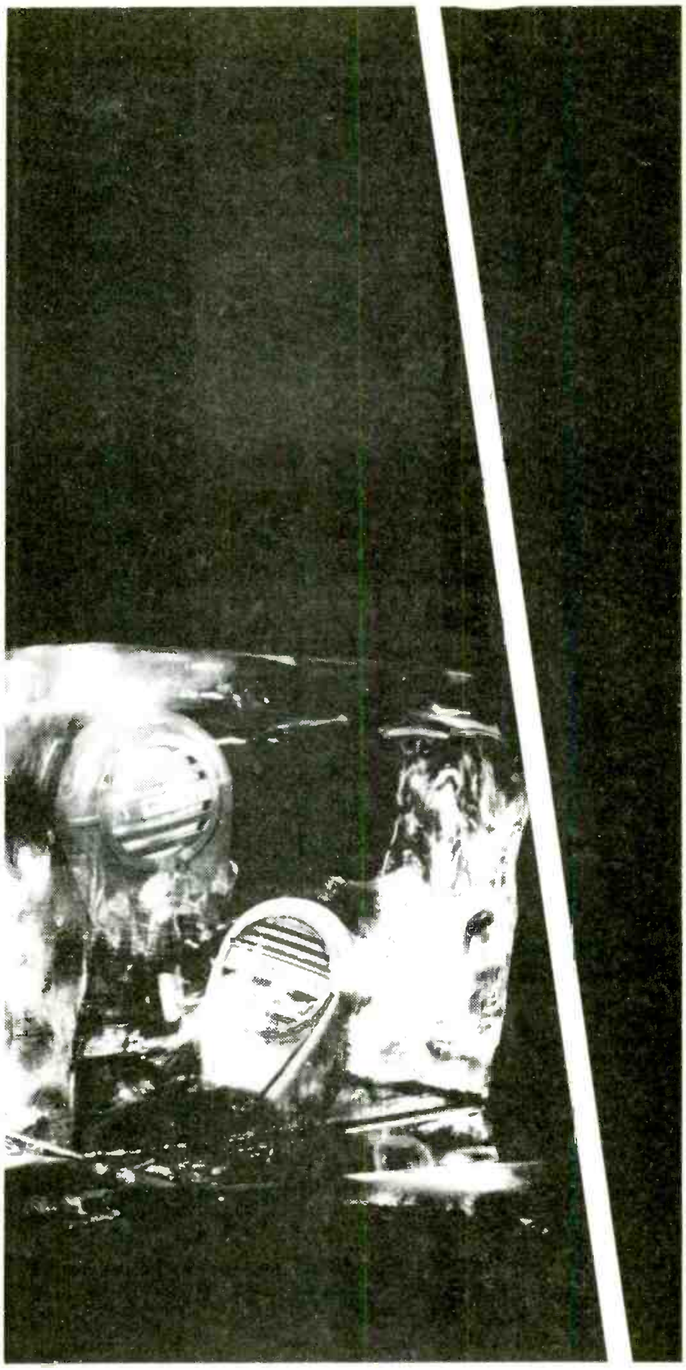

Shure freezes 'em

Shure Safety Communications Microphones are plunged to an appalling −45.6° C. for ½ hour periods during severe temperature tests, and even though they're covered with frost

...They work

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IMO relays. You shouldn't pay more.

Although at IMO we have a fine range of relays which suit many needs, we'd be the first to say there are some applications that would be better off with Omron relays.

True, *some* Omron relays are more expensive than the IMO equivalents, but understandably so. Because they're designed to be used in specifications where a *critically* higher standard of reliability is vital.

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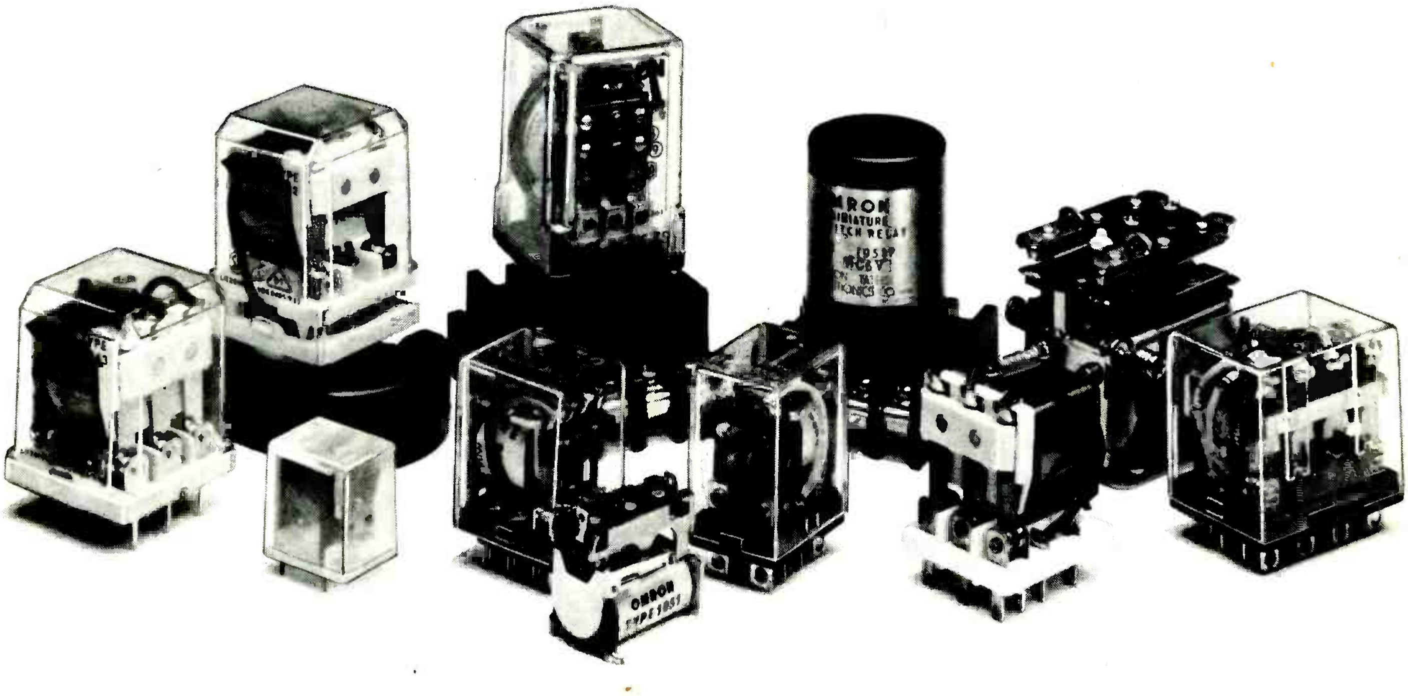
IMO and Omron; a combined range that covers just about every need in every price bracket. Why settle for less?

Omron relays. You shouldn't pay less.



IMO. Now most people know

WW 7/77

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Please send me full details on IMO and Omron relays.

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Company ______________________

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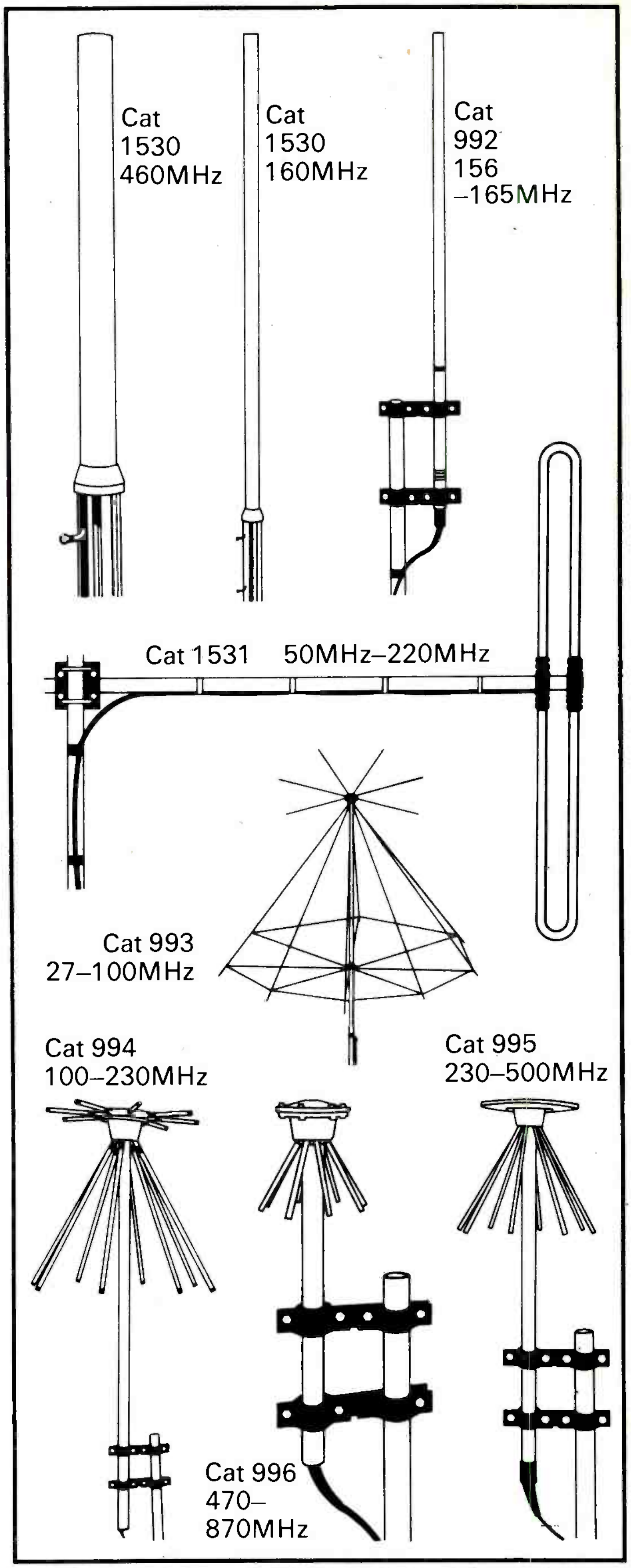
Eddystone VHF/UHF antennae



VHF Sleeve Dipoles

Available in versions from 100MHz to 500MHz for general mast or tower mounting (Cat. 1530) and as special marine version covering 156–165MHz (Cat. 992).
Strong, weatherproof, potted construction of Fibreglass sealed with epoxy resin. Cat. 1530 aerials are slide fit inside standard scaffolding mast, but sherardised mild steel mounting brackets can be provided (standard for Cat. 992 marine dipole).
Bandwidth 5% of centre frequency. Gain is unity over half-wave dipole, 3dB over isotropic. Impedance 50 Ω or 75 Ω.

Heavy Duty Folded Centre Fed Dipoles

Cat. 1531 available for frequencies 50MHz to 220MHz. Most standard radiotelephone bands can be covered with wide bandwidth and good VSWR characteristics. Gain is unity over dipole, 3dB over isotropic. Impedance 50 Ω. Very rugged construction of anodised aluminium alloy with low density polythene insulator. Boom and brackets supplied. Marine version available in stainless steel.

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Four main versions cover range 27MHz to 870MHz with 75 Ω or 50 Ω impedance, and special versions can be provided if required. Gain is unity 1dB compared with a half-wave dipole.
Rugged construction of anodised aluminium with epoxy resin sealing. All versions supplied with brackets for mounting on masts of 1½" to 2½" diameter.

PLEASE WRITE FOR FULL DETAILS

Eddystone Radio Limited
Member of Marconi Communication Systems Limited
Alvechurch Road, Birmingham B31 3PP, England
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Eddystone

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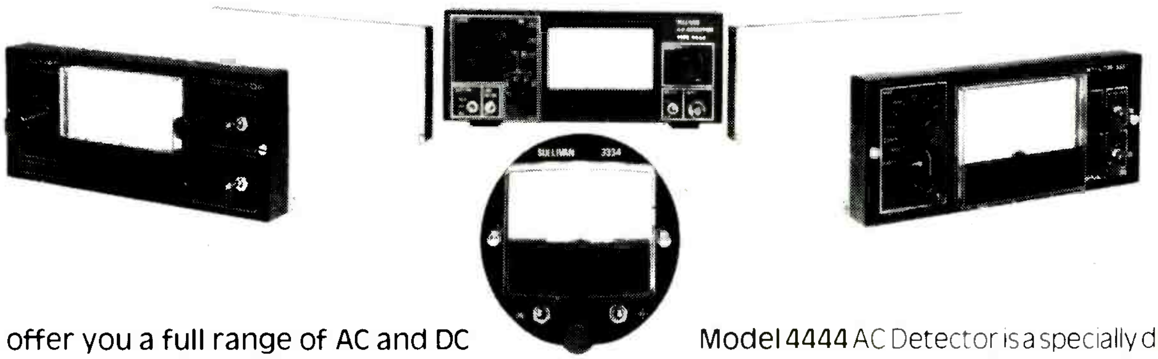
The detectors



Sullivan offer you a full range of AC and DC Null Detectors. There is a wide span of ranges available, with battery operation, portability and high quality being common to all.

NEW Model 3336 DC Detector is a versatile production and laboratory instrument offering discrimination of 1µV in 10kΩ and sensitivity of 10µV. This instrument offers low zero drift, linear or logarithmic response and high stability.

NEW Model 3337 Microvolt Detector has 9 centre zero ranges from 10V to 1µV. It has a resolution of 0.1µV into 10kΩ. Battery operation eliminates mains voltage interference. There are many other features, too, not least of which is a surprisingly competitive price.

Model 4444 AC Detector is a specially designed, battery operated solid state AC detector for the detection of very low level imbalance signals from modern AC bridge and potentiometric measuring systems.

Model 3334 DC Null Detector is a compact unit specially designed for null point measurement. It is small in size, low cost and rugged and these are just three of the features that make it ideal when replacing pot galvanometers in potentiometers and bridges.

For fuller facts about Sullivan Detectors, simply contact:

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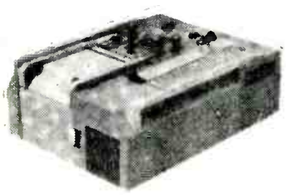
Thorn Measurement and Components Division

WW — 071 FOR FURTHER DETAILS

FAST RESPONSE STRIP CHART RECORDERS

Made in USSR

Series H3020



Basic error: 2.5%
Sensitivity: 8mA F.S.D.
Response: 0.2 sec.
Width of each channel
Single and three-pen recorders: 80mm
Five-pen recorders: 50mm

Chart speeds, selected by push buttons: 0.1-0.2-0.5-1.0-2.5-5.0-12.5-25 mm/sec.
Chart drive: 200-250V 50Hz
Recording: Syphon pen directly attached to moving coil frames. Curvilinear co-ordinates.
Equipment: Marker pen, timer pen, paper footage indicator, 10 rolls of paper, connectors, etc.

H3020-1 (Single pen): 285mm wide x 384mm deep x 165mm high . . . . . . **PRICE £108.00**
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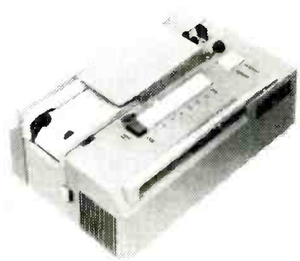
H3020-5 (Five pen): 475mm wide x 384mm deep x 185mm high . . . . . . **PRICE £295.00**

Series H327



Polarized moving iron movements with syphon pens directly attached. Built-in solid state amplifier (one per channel) provides 8 calibrated sensitivity steps. Two marker pens are provided.
Basic error: 4%. Frequency response from DC to 100Hz 2dB.

Sensitivity: 0.02 - 0.05 - 0.1 - 0.2 - 0.5 - 1 - 2 - 5 volts/cm
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Chart speeds: 1-2-5-10-50-125-250mm/sec

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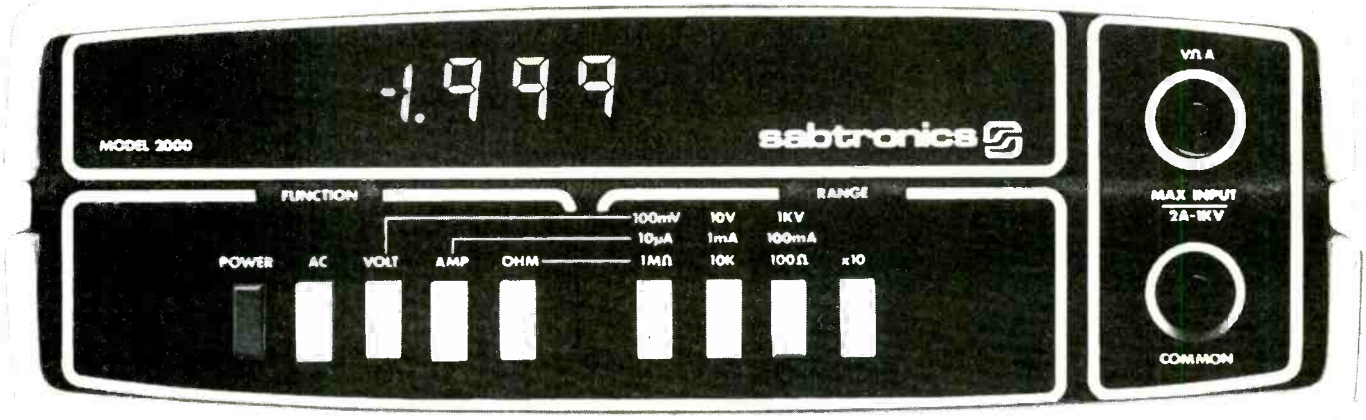

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So you end up with a professional quality 3½ digit DMM for the unheard of price of less than £70. From Sabtronics, specialists in digital technology. And manufacturers of the impossible.

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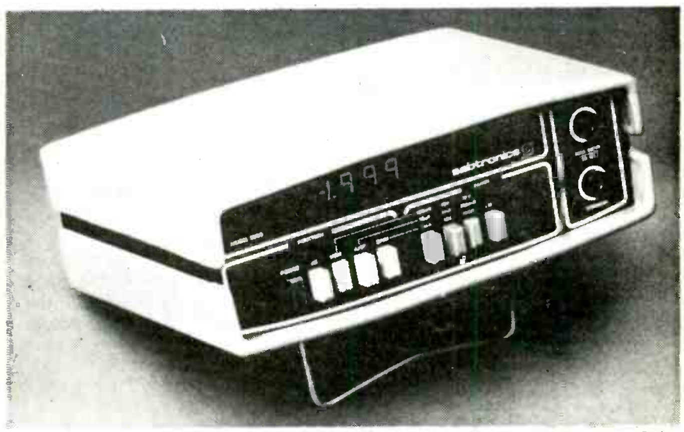

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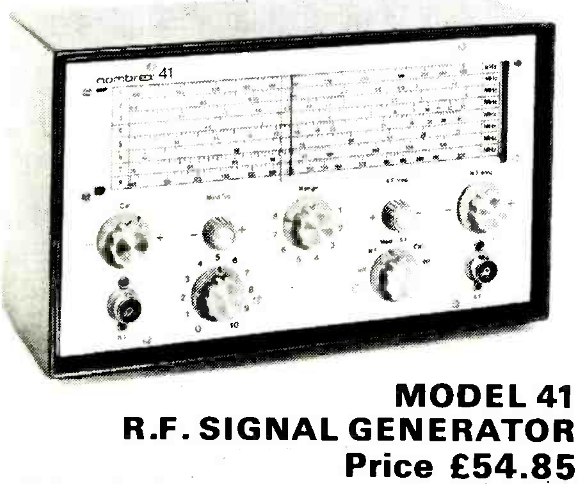

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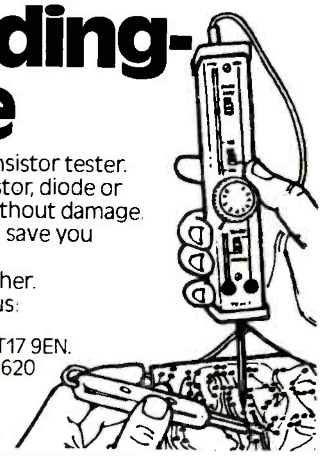
fault finding-no fiddle



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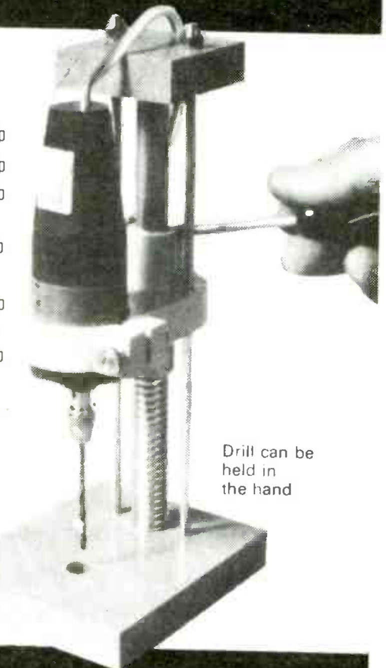

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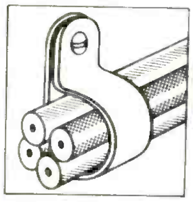

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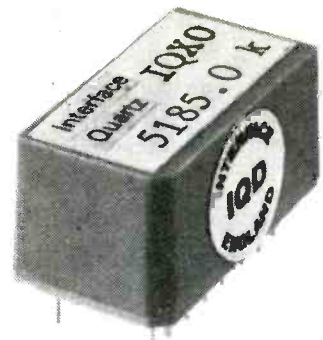

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DETECKNOWLEDGEY ?

Not a spelling mistake, but a new publication from AMBIT that sets out to explain some of the basic theory that surrounds metal location techniques. It is an explanation, that builds up from first principles, why iron sometimes reacts like a non-ferrous metal, what determines detector range, what the shortcomings are, how to avoid them. In fact, it explains about BFO, IB, VCO and Pulse Induction techniques, as a result of research carried out to produce our range of locators, and why we chose the methods we used. As a general purpose reference work for designers, constructors, users etc., we think you will find it unique. £1.00 inc. postage.

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The Ernie and Arnie show?

Mr Ernest Harrison, chairman and managing director of Racal Electronics, has been calling for further rationalization of the British electronics industry. It is "bound to come" he declared at a press lunch. And "it won't be too long in coming, I believe". Asked if he had had any discussions with the National Enterprise Board, he replied "Yes, we've all been involved, not just Racal but all the other companies as well". Mr Harrison's main concern is to improve Britain's chances of obtaining big overseas orders. He feels that the present system, of several UK companies bidding competitively, without Government support, fares badly against that of other countries which have their governments assisting one or two large groups. Mr Harrison made it clear what he had in mind, at least for Racal. "We want another group matching GEC" he said. "A bit of competition might be good for Arnold Weinstock, good for his company and good for the country".

In principle rationalization is a good thing. Its purpose is to eliminate wasteful duplication of resources, the splitting in too many ways of capital investment, materials, labour and other factors of production inevitable in normal business competition. It should mean that whatever resources are available in an industry they will all be used continuously and efficiently. And the government, which has to be seen to be even-handed, is much more likely to give diplomatic and financial support to a single large group tendering for an overseas contract than it is to favour invidiously one of several companies in a freely competitive situation.

In practice, however, rationalization means take-overs. These can be achieved by agreement, when the willing "victim" is in a weak financial state, or covertly, by secret buying of shares on the stock market (as Racal started to do with Ultra some months ago). Now one immediate effect of rationalization for merger purposes is loss of jobs, as happened in GEC, for the improved efficiency required can seldom be achieved without this shedding of labour. With unemployment as serious as it now is in Britain, those considering rationalization of the electronics industry will have to weigh very carefully the certain social consequences against the expected economic benefits.

Another problem inherent in rationalization is that it can create a business monopoly. One could argue that if we had two big groups in electronics, say GEC and Racal, there would be competition between them. Well, there is competition between ICI and Unilever, but no sign that these two giants are fighting each other to the death. Between them they dominate the market for a wide range of household products in Britain. Experience shows that when a small group of companies holds a captive market there is a tendency towards price fixing – remember the telephone equipment "ring" of the 1950s – and the people who work for them feel they are in a safe job, so there is no need to labour hard but just keep one's nose clean. Both of these facts of life are against the interests of the public.

Finally, if an industry is concentrated into one or two big groups that industry is ripe for nationalization. We have just seen the British Aircraft Corporation and Hawker Siddeley Aviation being merged and nationalized into British Aerospace. What this will achieve remains to be seen. But a recent French parliamentary report on their aircraft industry considers that the possible nationalization of Dassault and merging with the already nationalized Aerospatiale to form a single national group would do more harm than good. It would eliminate competition which, the report says, is essential and "exerts a decisive influence on export sales". Maybe there are some experiences here for our electronics industry chiefs to ponder on.

Microwave intruder alarm

Construction of Doppler radar to detect movement

by M. W. Hosking, M.Sc., M.I.E.E., *British Aircraft Corporation*

Based on the Doppler frequency shift principle, this domestic intruder alarm system uses straightforward and simple techniques, together with materials that are readily available to everyone and brings what has hitherto been a costly and professional system within the reach of a domestic budget. Most of the components can also be used to make a simple voice communications link, with the main addition of an audio modulator. Construction of a voice link, including the microwave transmitter and receiver will be described in a later article.

The microwave transmitter and detector circuits are constructed in waveguide. But, for those who do not wish to go to the lengths of building these components, a complete intruder alarm kit is available with these items already built and set to the correct frequency. This complete system has been given type approval by the British Home Office as satisfying their transmission regulations.

General principles

The microwave intruder alarm operates on the principles of a small radar system. It transmits a signal at the appropriate frequency which travels outward as a radio wave until it meets an object, whereupon a portion of the signal is reflected back again toward the receiver. If this returned signal can be detected and suitably processed, then information can be extracted about the reflecting object.

With the advent of solid-state sources of microwave signals ("Realm of microwaves" *Wireless World* Feb. 1973) the way has opened for very small, cheap, low-power transmitters operating from low-voltage, d.c. power supplies. In this instance, the transmitter is a Gunn diode operating from a 7V rail. The device is encapsulated in a package about the size of a match head, but to control the frequency spectrum and to extract power efficiently, it is mounted in a waveguide resonant cavity. The detector, a Schottky barrier diode, is also waveguide-mounted. Further details, including a method of fabrication for those who wish to build their own will be given in a later article.

If the reflecting object shown in the schematic arrangement of Fig. 1 is moving toward or away from the receiver then, in similar fashion to the train-whistle example usually cited at school, the receiver frequency will differ from that transmitted. The difference between the two is the Doppler frequency. In addition to the directly transmitted signal, a small portion is arranged to couple directly into the receiver and acts as a local oscillator drive. The returning frequency-shifted signal at frequency $f_o \pm f_d$ is thus mixed with this local oscillator at frequency f_o and the output circuit bandwith adjusted to extract the beat frequency difference, f_d.

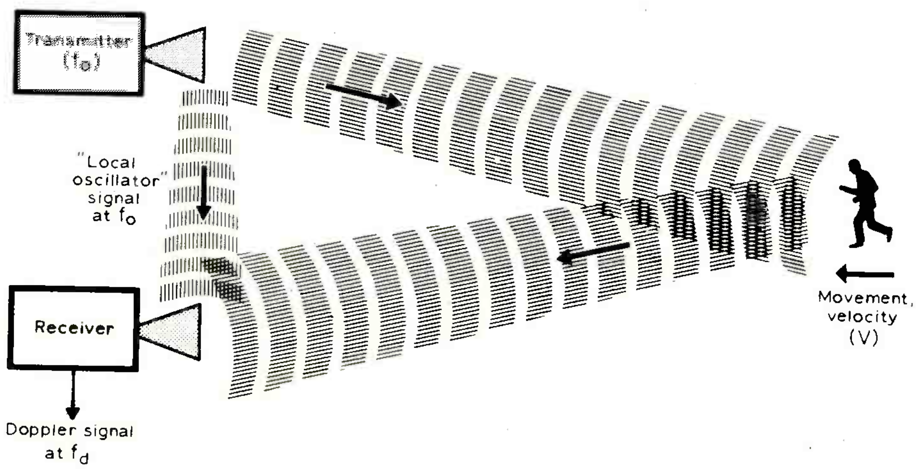


Fig. 1. Principle of the c.w. Doppler radar wherein the transmitter is also the local oscillator.

The creation of a Doppler shift in frequency can be visualized by considering the two waveforms in a little more detail. As the transmitted signal moves out, with its amplitude varying sinusoidally, its phase angle relative to the starting point will change by 2π radians (360 degrees) every time the distance increases by a wavelength. In this case, the wavelength is about 28mm. Exactly the same thing is happening to both the returning signal and to that forming the local oscillator. These two are mixed together in the diode to form the beat or difference frequency.

The amplitude at this i.f. is a phase function of the two input signals. If the path, 2R, traced by the reflected signal was half a wavelength different than that taken by the direct local oscillator wave, then the two would subtract at the receiver. The output would not actually go to zero, as the two signals are not normally comparable in amplitude, but would be a minimum. Conversely, when both inputs had traversed an integral number of whole wavelengths, they would combine in phase to produce an i.f. output of maximum amplitude. If the reflecting object happens to be moving, then the relative phase of the two inputs is also changing. The local oscillator path remains constant, but the path taken by the radar signal is varying at twice the reflector speed, 2Vm/s.

Back at the mixer, the effect is as if the two wavetrains were sliding past each other at $2V/\lambda$ wavelengths per second to produce an alternating output voltage at this rate as they reinforced or subtracted from each other. This is the Doppler frequency $f_d = 2V/\lambda$

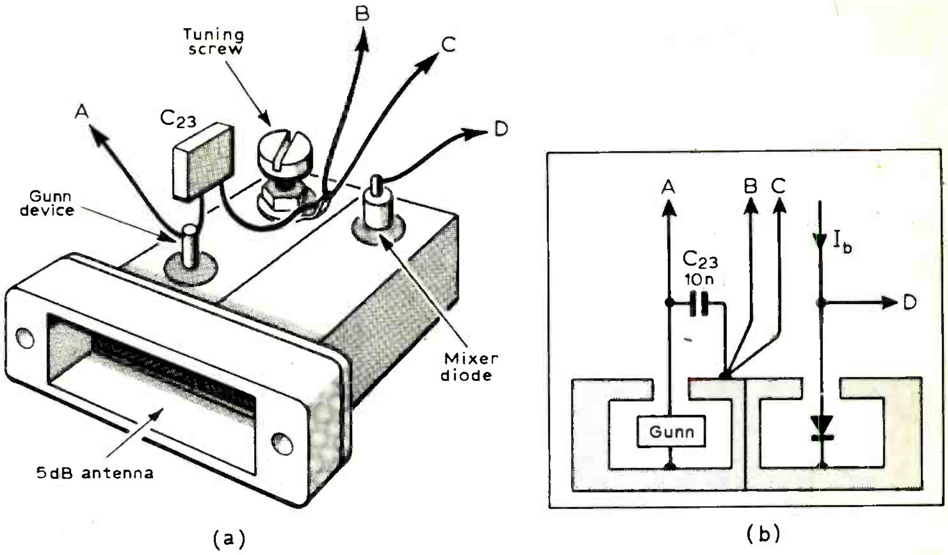
To comply with the regulations, the transmitter must operate at 10.687GHz i.e. $\lambda =$ 28.07mm. Thus, the Doppler frequency is 71.25Hz for each m/s of reflector speed, or 31.85Hz per mile/h. Fig. 2 shows this relationship in graphical form.

Extraction of this Doppler signal can be used as an efficient means of detecting a moving object against a stationary background. For use as in intruder alarm, the reflections from walls and furniture will all be stationary in phase difference and so will produce no alternating beat frequency, whereas a moving object will generate an i.f. typically in the low audio range. This signal can then be amplified and used to trigger an alarm. This type of system thus gives the type of selectivity that is required and, operating as it does in this relatively uncluttered area of the frequency spectrum, is not so vulnerable to interference. There are no beams to break, as in some systems, as the signal fills the whole room and movement anywhere can trigger the alarm. Nor is it sensitive to spurious acoustic noises as are another class of alarm systems. A gain control on the alarm allows the triggering threshold to be adjusted to suit the size of room and the reflecting target, i.e. to choose the larger reflection from a human as opposed to that from the the domestic pet.

Transmitter and receiver

The general design of the transmitter and receiver cavities for the ready-made Mullard CL8960 unit are shown in Fig. 3(a) and Fig. 3(b) the schematic electrical connections. The operating frequency is controlled by the length of the transmitter waveguide between the Gunn device and the back wall. However, insertion of the tuning screw perturbs the field within the cavity in such a way as to appear initially as an inductance and to lower the resonant frequency. The side-by-side arrangement is to allow coupling of the local oscillator signal which occurs by direct leakage into the receiver waveguide. However, the level of signal is very low at about 10μW and a small amount (30-35 μA) of forward bias is necessary on the mixer diode.

Some precautions are necessary when making the electrical connections to avoid damage to the microwave semiconductor devices. The mixer diode is easily damaged by voltage transients on the mains supplies, so it is recommended that soldering appliances be disconnected from the mains just prior to making the mixer connection and during any subsequent contact with this component. Forward bias should not be allowed to exceed 1 mA. The gunn device will not tolerate a reversed supply voltage, so check before connecting. As supplied, the mixer is fitted with a shorting wire to the case and this should be left in place until assembly is finally completed and then removed. The Gunn device appears as a dynamic negative resistance and it is possible for oscillations to be induced in the supply circuit. To avoid this, connect a small 10nF capacitor directly across the terminals as shown in Fig. 3(b).



▲ *Fig. 3. General view of the Doppler module (a) and schematic electrical connections (b)*

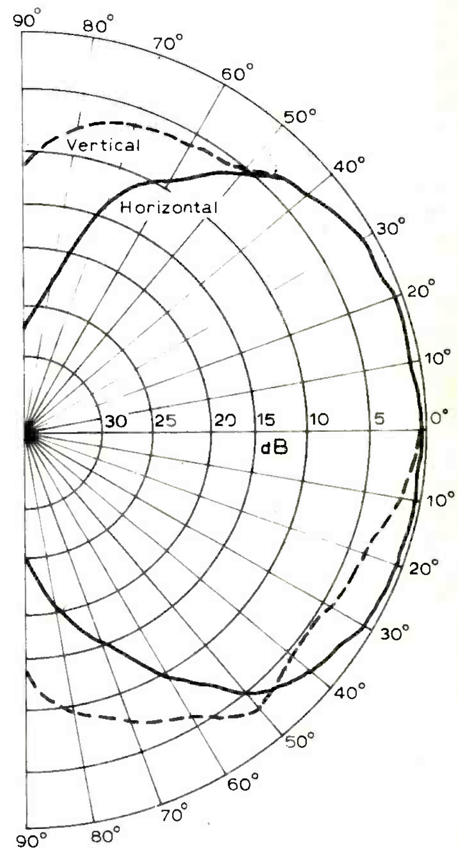
General conditions of operation for the assembly are:

Frequency 10,687 ± 12 MHz (preset)
Gunn device supply voltage + 7.0 ± 0.1V (+7.5V max.)
Gunn device supply current 130 to 165mA (140mA typ.)
Mixer diode forward bias 30 to 34μA.
Power output 8mW typ. (10mW max.)

The microwave module is supplied with a small, 5-dB gain antenna, constructional details of a 20dB gain horn will be given later. The magnitude of the Doppler output at the mixer terminals is a function of the size of the reflecting object and its range. Typically, however, a man would have a radar cross section of $1m^2$ and, using the 5dB antenna, the received signal would be 100 dB down on that transmitted at a range of 15m. This will produce about 40μ V of Doppler signal for signal-plus-noise to noise ratio of 18dB.

Fitted with the 5dB gain antenna, the Doppler module is reasonably matched to free space and has a polar pattern of the form shown in Fig. 4. The wide-beam coverage together with the filling-in effect from multiple reflections means that comprehensive coverage of a room is effectively achieved.

Fig. 4. Beamwidth of the Doppler module in two planes using the 5dB antenna which illustrates the wide angular coverage obtainable. ▼



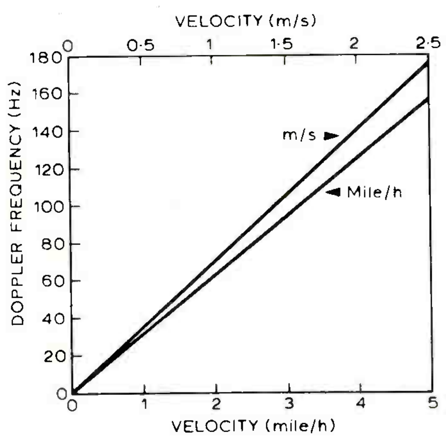


Fig. 2. Graph shows how the Doppler frequency varies with target speed for the case of a transmitter at 10,687MHz.

An interesting game has evolved at home: in a room about 30ft long, children endeavour to creep and crawl up on the intruder alarm without being detected. No matter how subtle the approach, this has not so far been achieved without triggering the alarm.

Receiver and alarm

It is necessary to selectively amplify the Doppler signal to a level sufficiently high to trigger an alarm, whilst at the same time rejecting false alarms from spurious noise levels (Fig. 5).

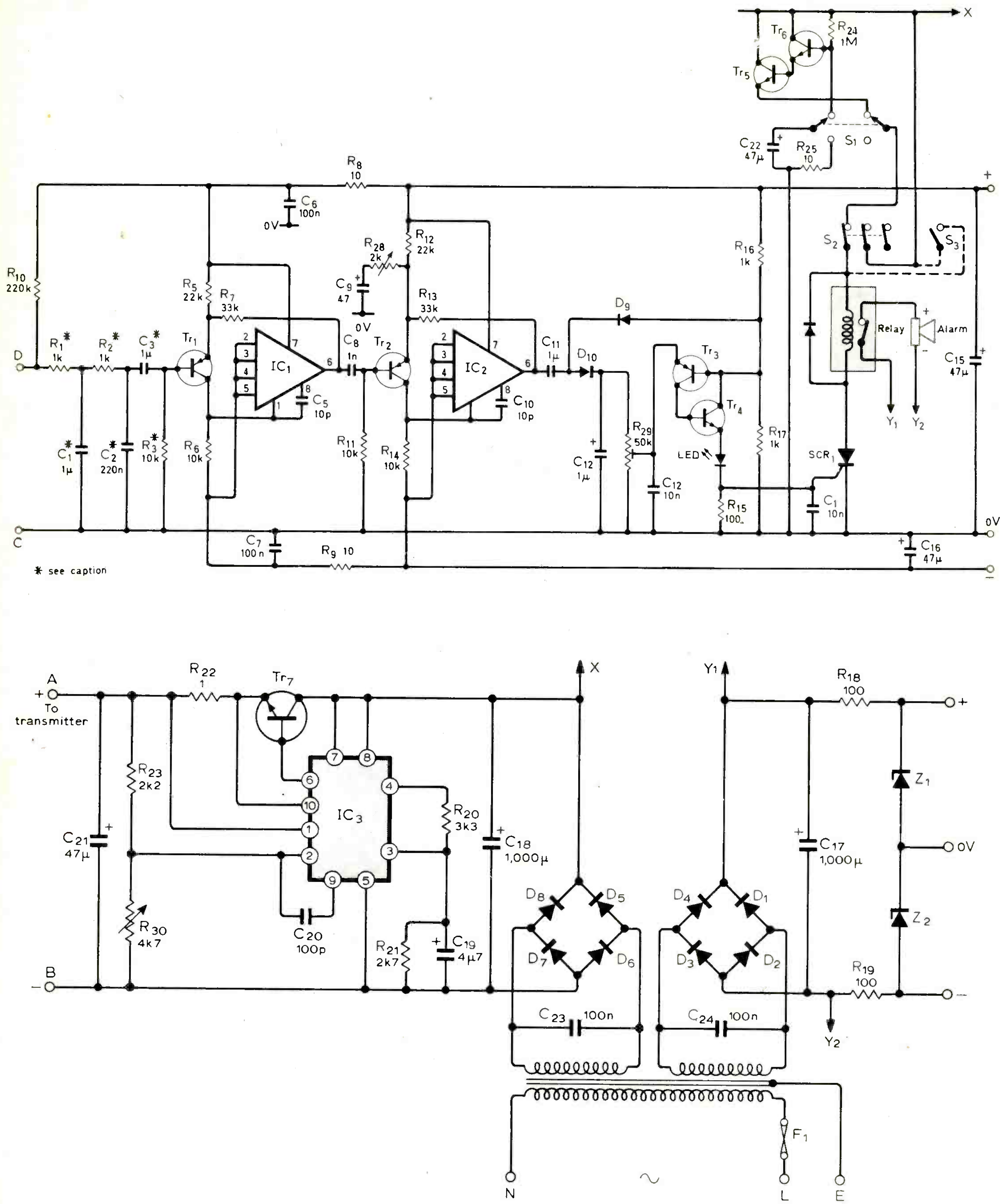


Fig. 5 (top). Amplifier and alarm trigger circuit with power supply (bottom) to p.c.b. and transmitter.

Components marked with an asterisk may have different values in the kit design.

More conventional circuits could be used for the amplifier, but the intruder system has been developed side-by-side with a voice link and as much commonality as possible has been built into the two systems.

Sensitivity of the Doppler receiver is a function of the i.f. amplifier input noise figure and bandwidth. The narrower the bandwidth, the less the contribution of thermal noise power. Thus, the first section of the circuit is an RC filter having the measured bandpass characteristic of Fig. 6. The combination of Tr_1 and IC_1 provide a first stage voltage gain of about 1000, together with a reasonable input noise figure. The slightly unusual connections to the operational amplifier are mainly for the benefit of the voice link receiver, as they provide a means of achieving a high slew rate from a normal 748 op-amp by by-passing the input stages.

Resistors: ¼-watt rating except where indicated.

R_1	1kΩ	R_{16}	1kΩ
R_2	1kΩ	R_{17}	1kΩ
R_3	10kΩ	R_{18}	100Ω
R_4	33Ω	R_{19}	100Ω
R_5	22kΩ	R_{20}	3.3kΩ
R_6	10kΩ	R_{21}	2.7kΩ
R_7	33kΩ	R_{22}	1Ω
R_8	10Ω	R_{23}	2.2kΩ
R_9	10Ω	R_{24}	1MΩ
R_{10}	220kΩ	R_{25}	10Ω, ½ watt
R_{11}	10kΩ	R_{26}	56Ω, 5 watt
R_{12}	22kΩ	R_{27}	1kΩ
R_{13}	33kΩ	R_{28}	2kΩ
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Relay 18V, 1kΩ coil with internal diode. Contacts rated 250mA, 50V.
Alarm 18V audible warning device, 60mA mean current, 1A peak.

F_1	500mA mains fuse
S_1	miniature d.p.d.t.
S_2	3-pole screened jack plug and socket
S_3	s.p.s.t. on/off

Doppler module Mullard CL8960 or approved alternative.
Self-oscillating mixer Mullard CL8630S or approved alternative.

Capacitors

C_1	1μF	C_{14}	10nF
C_2	0.22μF	C_{15}	47μF, 10V
C_3	1μF	C_{16}	47μF, 10V
C_4	47μF, 10V	C_{17}	1000μF, 25V
C_5	10pF	C_{18}	1000μF, 25V
C_6	0.1μF	C_{19}	4.7μF, 10V
C_7	0.1μF	C_{20}	100pF
C_8	1μF	C_{21}	47μF, 20V
C_9	47μF, 10V	C_{22}	47μF, 20V
C_{10}	10pF	C_{23}	0.1μF
C_{11}	1μF	C_{24}	0.1μF
C_{12}	1μF, 16V	C_{25}	47μF, 10V
C_{13}	10nF	C_{26}	10nF

Semiconductor devices

$Tr_{1,2,3}$	ZTX 500 or equivalent
$Tr_{4,5,6}$	ZTX 302 or equivalent
Tr_7	Plastic style 3055
$IC_{1,2}$	SN72748 or equivalent
IC_3	μA 723 or equivalent
D_1 to D_8	1N4001 or equivalent
$D_{9,10}$	1N914
SCR_1	TIC44 or equivalent
LED_1	small red
$Z_{1,2}$	BZY88-C8V2

Suppliers

The system built around the CL8960 module can be obtained as a kit of parts or in ready-built form — see advertisement by Integrex.

Both kit and ready-built system have been given type approval by the Home Office for internal use on premises, under the type name Intruder 1 and have undergone thorough performance and reliability testing.

A set of two p.c.bs is available for £4 inclusive from M. R. Sagin, 23 Keyes Road, London NW2. One board accommodates the intruder alarm circuit together with the power supply components, and the second board accommodates the voice link circuit.

The second amplifier provides a good voltage gain which can be varied with the potentiometer R_{28}. The diode pump and clamping circuit of C_{11}, C_{12}, D_9 and D_{10} defines the voltage threshold and time constant necessary to switch on the Tr_3, Tr_4 Darlington drive to fire the s.c.r. Potentiometer R_{29} provides additional control of the drive level and the l.e.d. gives a visual indication of each time that a trigger signal is generated. It is also used for initially setting the maximum gain that can be obtained from IC_2 before any instability occurs.

In the prototype, the alarm itself is an 18V audible warning device which emits a penetrating, modulated wail at about 3kHz. However, as the alarm trigger takes place through a relay, it would be a straightforward matter to connect up to other warning devices such as a door bell, or to add an extra feature such as camera and flash unit.

Assuming that the intruder alarm will be fitted in a room or hallway of domestic premises, it is obviously necessary that the circuit should be activated when everybody is out of the way, otherwise one's own movement would trigger the alarm. Two options are provided in Fig. 5 for achieving this. Firstly, the positive supply rail for the s.c.r. and relay is routed via the Tr_5, Tr_6 combination, so that sufficient current to operate the relay can only flow when Tr_5 and Tr_6 are switched on. This can

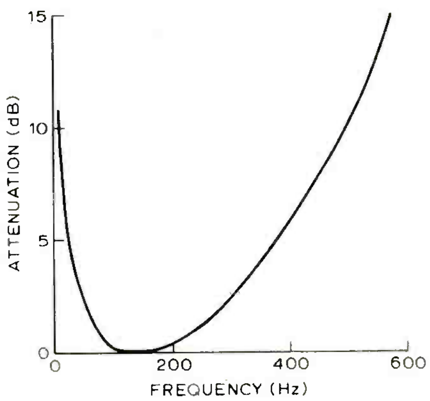

Fig. 6. Typical input filter response for the amplifier showing emphasis placed on the Doppler frequency from slow-moving objects.

only occur when C_{22} has charged through the high resistance path of R_{24}. Thus, when the overall system is switched on, the Doppler module, amplifiers and supply rails are all activated, but the relay will not operate to trigger the alarm until after a short delay. This delay is set by the timeconstant of R_{24} and C_{22} which, in this case has been chosen as 45-60 seconds: ample time to leave the room and close the door. Using this method, the alarm will be triggered on re-entering the room, say the next morning. If this was acceptable, then it could be looked upon as providing a daily check on the system.

An alternative uses the jack plug and socket arrangement. Inserting the plug by-passes the delay circuit and allows the alarm to be set by a remote switch taken out of the room and located at some convenient point. The circuit has been tested with over 100ft of flex between alarm and switch. Whichever method is used, once fired, the s.c.r. and hence the alarm will remain on until reset by the appropriate switch.

To be concluded

An end to listen-only answering machines

The proliferation of telephone answering machines is likely to advance even more rapidly if a device made by LMG Electronics gains wide acceptance. Normally the user of one of these hideously unsociable devices has to travel back to his office in order to hear the rude things people have shouted into it, but the LMG system enables an accredited caller to dial into the machine from a distant telephone and hear the messages over the phone.

According to an article by the company's founder, Mr Graham Bent, in *NRDC Bulletin* number 45 the idea is not new "but operation hitherto has been cumbersome, and only a single rewind could be initiated." The LGM device controls stop, start, rewind, playback and erase on the answering machine by means of coded pulses of tone generated by the user on a distant phone. The audible tone pulses are produced by a pocket unit the interrogator holds against the mouthpiece of the telephone he is using. One control button provides an operating code of five trains of pulses. Only this pulse can open the machine to remote operation. "There are over 40,000 possible combinations," the article says. Once the recognition code has been established the machine receives short common pulse trains enabling control of the machine from four buttons. The unit is powered from a 9V battery which should last 12 months.

When LGM approached the National Research and Development Council they asked for £3,000 repayable over 12 months but the NRDC thought they were being optimistic and lent them £4,000 repayable over three years. The loan was unsecured at 20% instead of the more usual royalty on sales. In addition the firm had £5,000 of Bent's money and a similar amount from the bank. That was in 1972. The NRDC loan was repaid "A few months ago," according to Graham Bent.

Kinetic images from sound

American developments in a modern art form

by Thomas E. Mintner, *University of Iowa*

With the advent of certain technologies such as video, lasers and integrated electronic circuitry the contemporary artist or composer has resources available which allow forms of expression unheard of as little as fifteen years ago. One obvious example is the field of electronic music, where the proliferation of synthesizers and similar devices has resulted in a deluge of electronic music studios, compositions, live performances and commercial applications. A related area is concerned with devices and compositions designed to take advantage of simultaneous presentation of music with light and images.

Historically, this area ranges from essays on "colour music"[1] dating from the early part of this century to devices utilizing the latest technology. Now, as in the past, efforts in this area come not from any one discipline, but from composers, artists and sculptors, engineers, dancers and architects. Technologically, there is a wide span from simple colour light boxes to video or laser devices incorporating advanced combinations of electronic and electro-optical techniques. This article is not intended to be a comprehensive listing of all such aural/visual devices or works, but rather an overall view with detailed information on some projects with which the author has been associated.

If there can be one conclusion drawn from most of the artistic attempts at correlation of audible and visual information, it is that effective and natural co-ordination is difficult to achieve.

Although some early attempts were severely hampered by a lack of suitable technology, there is a still more basic problem. The fundamental differences in the two sensory systems involved are many. Since our senses of sight and hearing tend to complement each other in day-to-day activities, we may tend to overlook the many perceptual differences which must be confronted when we attempt to create a set of stimuli (a composition) that will utilize both senses together. Investigation of these two sensory systems is still at the level of basic research and modelling for even relatively simple stimuli. Complex signals such as music or visual arts can also be analysed in terms of their content, both from the point of view of their respective disciplines (e.g. music theory) and from the more general basis of information theory.

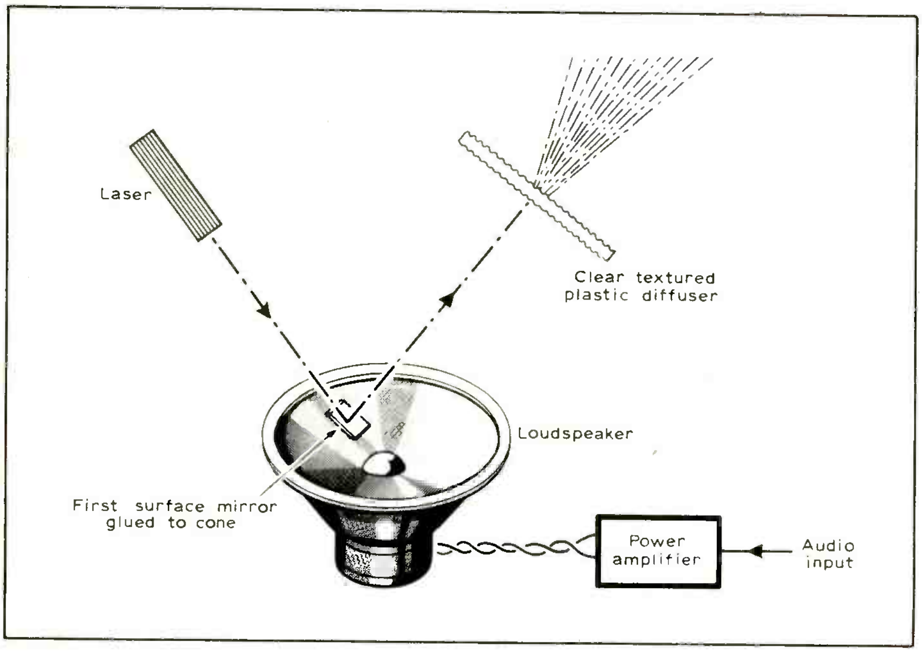

Fig. 1. One method of deflecting a laser beam by a sound source: a small mirror is attached to the loudspeaker cone. The laser beam is further modified by passing it through a clear diffuser.

Given these facts, it is not hard to understand the limited success of early "colour organ" type efforts at music-light correlation. Generally, it was assumed that there would be some sort of fixed relation between the colour spectrum and the musical scale (12 note), with perhaps differences in colour intensity used to represent octave displacement of pitches. There were also numerous other schemes, all with similar problems. However, it should be noted that at least one major composer wrote an orchestral work, still performed and recorded, with a notated part in the score for "tastiera per luce" or keyboard of light. This is A. N. Scriabin's *Prometheus, The Poem of Fire* (1909-10). Scriabin's correlation theories are somewhat more interesting than those above, and in fact a modern realization of his composition has been performed.

Colour organs, along with the pioneering work of artists such as Thomas Wilfred, who was the originator of the Lumia (or light box) in art, are part of a broad range of efforts relating more to colour than image. With the development of the cathode-ray tube it became relatively simple to generate visual image analogues to sound and music through the use of X-Y display techniques. This involves routing two sets of signal information or two similar components of the same information (e.g. left and right stereo channels of recorded music) to the vertical and horizontal inputs respectively of a cathode-ray tube. As early as 1953 an American artist exhibited his Oscillons – images created by photographing specially generated signals fed to a c.r.t.[2]

In the mid and late 1960s there was increased development of new techniques. Lowell Cross described his experiments and compositions with

X-Y display art as a kinetic form with music in articles for *Source* magazine.[3,4] The use of this type of display as an adjunct to electronic music allowed for another level of interest in a live or taped performance. Although the analogues produced with these methods are not necessarily the only way to interface the elements of sound and visual information, they are generally effective, and have been used in many works in recent years. Cross progressed from oscilloscopes to specially modified television sets and eventually to laser deflection systems, as we shall see later.

During the same period, various artists and composers began experimenting with video imagery. One technique which was "discovered" for artistic purposes was video feedback. In its simplest form, a camera is pointed at the video monitor that it is feeding. As in the familiar situation in audio, oscillations are set up because of the relatively uncontrolled feedback path. By controlling this path, it is possible to use feedback as a versatile method of image generation. Various limiting and processing devices may be inserted into the feedback loop to modify and control the images. The author's introduction to this method was in 1969 in work with Glenn R. Sogge and Timothy Skelly, both composers and artists. At that time, considerable effort was sometimes necessary to convince studio supervisors that video feedback experimentation under controlled situations would not necessarily leave the video chain in flames! However, once this was done, it became possible to present a series of concerts/events with specially generated video imagery and electronic music.

Up to this point there was no actual electronic interface between the two domains. The initial attempt in this direction, which was moderately successful, was as follows. Oscillators being used in the generation of musical sounds were connected and mixed so that their outputs were fed to a balanced modulator as well as to their normal destinations. These oscillations were then modulated with a frequency high enough that the upper sidebands were in a video frequency range. The output of the modulator was then sent through an encoder to produce a composite video signal. In the intervening years various video processors and "synthesizers" have been developed using i.c. technology and methods borrowed from electronic music. Composers, film-makers, and video artists are continuing to experiment in this area.

One example of such experimentation from the Center for New Performing Arts of the University of Iowa is the Video Colour Quantizer System. The basic system is a modification of a standard unit manufactured by Colorado Video, Inc., an American firm. Franklin Miller, a film-maker at the university, started the experimentation with this unit. Basically the quantizer is a device which accepts a monochrome video signal and has sixteen adjustable signal comparator thresholds relating to the amplitude of the video signal. At these various levels from black to white along the grey scale, sixteen points can be set to trigger production of sixteen different pre-assigned, synthetically generated colours. With the colour mixing unit incorporated in this version any combination of colours may be set to allow modifications such as synthetic colour generation, grey scale reversal and other effects.

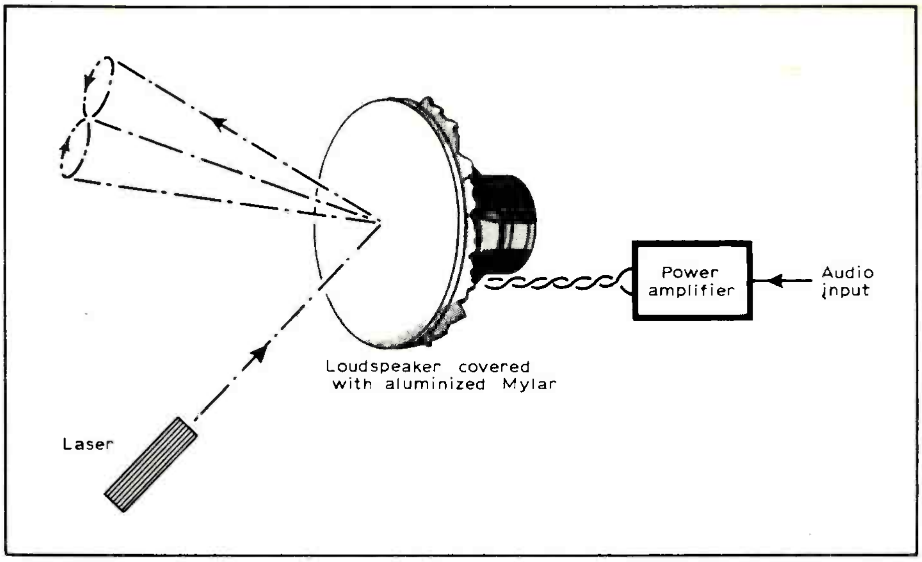

Fig. 2. Method of laser beam deflection used in the Sonovision system.

A recent grant has allowed the design and construction by the author of a voltage control interface for the quantizer system. With this interface the sixteen threshold points, or "slice levels," can be determined by the application of a d.c. or a.c. control voltage. This means that a colour assigned to a given grey level range may be made to change with the applied voltage, or that a threshold can be shifted electrically to alter (by colour addition) several other colour areas in the image. In addition, the master outputs of red, green, and blue can each be gated with a control trigger. Signals routed to this total of nineteen control inputs may be used directly, as in the case of electronic music, or may be generated from other music through the use of an amplitude detector or a pitch-to-voltage converter. Another performance possibility is to use control signals derived from other than musical sources, or to split the allocation of control inputs, with some control voltages coming from musical material, and some from other sources, such as devices sampling video signals or sensors attached to dancers. As a part of the grant programme, two colour films are to be produced, one by the author, and one by Peter Tod Lewis, composer and director of electronic music at the University of Iowa. These films will have specially composed sound tracks to control the video colour quantizer interface.

Another interface project is a work realized by West Coast US artists and engineers Bob Watts, Bob Diamond and David Behrman. The work, called the *Cloud Music*, uses a video camera trained on the sky during daytime periods. As clouds pass into the field, the changing video signal, sampled at various cursor points on the screen, controls a system by composer David Behrman which produces electronic music "on the spot." The piece functions as a kind of performing sound sculpture (depending, of course, on the weather).

Shortly after small lasers became commercially available, artists began experimenting with them in a variety of ways. The laser light itself is the object of some of these investigations. The highly collimated beams lend themselves to a variety of illumination tasks, including large outdoor geometric constructs using the stationary beams of high power lasers. On the question of light and sound correlation, however, we find that most uses of lasers involve methods of scanning the beam. Various approaches have been tried, and the most sophisticated systems in use today use galvanometer mirror scanners to produce X-Y scanning. Thus we find that principles of music-light correlation applicable to oscilloscope type displays find a new and much larger scale medium in X-Y laser scanning.

In addition to this simple X-Y scanning there are other techniques which are sometimes combined with X-Y systems. By passing a laser beam through an uneven glass or plastic surface, for example, one can generate patterns of a "cellular" nature which results from the interference of the laser light with itself as it passes through the material. If the beam is deflected slightly as it passes through the material, kinetic images related to the deflection signal (e.g. music) may be generated. One of the deflection methods which

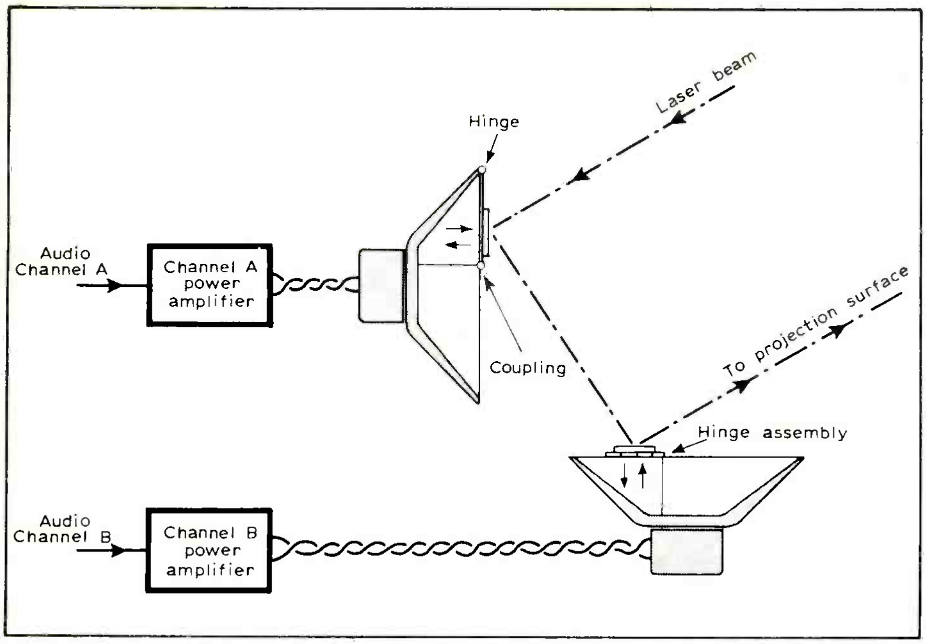

Fig. 3. Beam deflection system using two loudspeakers, each with a hinged mirror moved by a connecting member attached to the cone.

could be used in this application involves attaching a small first surface mirror to a loudspeaker (Fig 1). A signal fed into the speaker will cause the mirror to move and deflect the beam. An early experimenter in this area was Lloyd Cross (not to be confused with Lowell Cross), who developed a system called Sonovision[5] using a loudspeaker covered with a reflective membrane (Fig. 2). In addition, the system, which was intended to be commercially available, had a rotating prism assembly for generating more complex multiple images. A slightly more useful version of this idea uses two loudspeakers (Fig. 3), each of which has a hinged mirror assembly connected to the cone. The hinges restrict the movement of each mirror to one axis. Thus a simple X-Y scanning system is formed. The deflection is limited to relatively low frequencies and the system response is not at all linear because of the many mechanical resonances.

More sophisticated X-Y scanning systems use commercially available galvanometer mirror scanners. The first such system assembled for the artistic purpose of exploring kinetic inter-relationships between light and sound was Video/Laser I, an experimental laser deflection system initiated by Lowell Cross, Carson Jeffries and David Tudor at Mills College, USA. This was in May 1969. Soon after, another such system was commissioned for use in the Pepsi-Cola Art and Technology Pavilion at the 1970 World Exhibition in Osaka, Japan. Both of these early systems have been dismantled. However, Video/Laser III, the latest system constructed by Cross and Jeffries for the Center for New Performing Arts at the University of Iowa had its premiere in a concert with orchestra on November 29, 1972.[5] Improvements and additional electronic control devices are being added on a continual basis by Lowell Cross and the author.

The system used is as follows. The output beam of a 2-watt krypton-argon laser is split into its component beams. This is achieved by passing the initial greenish-white output beam through a direct vision prism. Any four of the approximately sixteen available colours may then be selected and routed to the four beam deflection systems. Each system contains a beam chopper/interrupter and two mirror scanners for deflection (X and Y). Each deflection component of each channel has its own direct coupled amplifier, and any audio signal may be fed to the systems. The devices used have certain frequency response limitations because of necessary compromises between maximum scanning angle and frequency response.

The maker of the scanners, General Scanning, Inc., through a subsidiary, is now involved in X-Y scanning systems for artistic purposes also. One such system, called Skywriter, is designed with X-Y inputs and an accompanying vector generator system to produce a variety of line images, including a kind of animation.

Multi-colour laser systems using large lasers are capable of creating extremely large images on any suitable projection surface, indoors or out, though generally the area must be in relative darkness for best results. The Video/Laser III system mentioned above is used in a variety of performance situations, often with electronic music as a sound source. It is conceived of as an experimental performance and research instrument.

One fairly recent performance with the Video/Laser III system may demonstrate how the original art of "colour music" has progressed to its current position. A performance of A. N. Scriabin's *Prometheus* was given on September 24, 1975, with the laser system functioning to realize fully, perhaps for the first time, Scriabin's wishes for the keyboard of light. A specially constructed keyboard interface was used, with a performer playing the written part as indicated in the orchestral score. The keyboard controlled the gating of the various colours, while the images were generated both directly from the orchestral sound and also by electronic means with auxiliary equipment. In addition to the lighting effects, fog and various scents were present in the hall at appropriate points in the performance.

This unusual meeting between the latest technology for realization of one type of kinetic music/light performance and the ideas of one of the earliest and most interesting proponents of this art form may serve as an appropriate point to conclude this brief survey. However, work involving video, lasers, and other systems for the realization of this very old dream of "music light" will undoubtedly be continuing for years to come.

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3. Lowell Cross, Carson Jeffries, David Tudor, "Audio/Video/Laser," *Music of the Avant Garde,* issue No. 8.
4. Lowell Cross, "Musica Instrumentalis-Video II(b), Video II(c), VideoII(1) *Music of the Avant Garde,* issue No. 9.
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The front cover of this issue shows examples of projected multi-coloured images produced by the Video/Laser III equipment described by the author.

Teletext a permanent service?

Officials of the British Radio Equipment Manufacturers' Association estimate that there should be about 12,000 teletext receivers in operation by the end of this year. This figure will include purpose-built sets by British manufacturers, existing colour TV sets fitted with external teletext adaptors, and sets with external decoders similar to the *Wireless World* design. BREMA members are hoping to get the price of sets down to about £750 to £800.

The set makers are anxious for a statement from the government that teletext, at present an experimental service, will soon be established as a permanent public service. Unless this happens they seem unlikely to achieve any substantial sales to the public. Sources close to the Home Office hint that such an announcement could come in the autumn of this year.

Surround sound decoders — 6

Multi-system ambisonic decoder

1—Basic design philosophy

by Michael A. Gerzon, M.A., *Mathematical Institute, Oxford*

This series of articles describes a decoder capable of decoding all major existing and proposed two-channel surround-sound systems, including the Ambisonic System 45J, SQ, Regular Matrix, BMX and BBC Matrix H. For systems other than SQ, the decoder gives full psychoacoustically optimized results using NRDC Ambisonic decoding technology. In addition, Ambisonic playback of mono, stereo and of three-channel studio-format signals is provided. The decoder is suitable for three-amplifier/four-speaker, four amplifier/four-speaker, and four-amplifier/six speaker reproduction.

The NRDC Ambisonic project has developed a comprehensive technology for creating, encoding and decoding sound[1-4]. While this ambisonic technology can give of its best only with optimized programme material and encoding (i.e. the System 45J described in reference 1), the methods can be applied to getting improved results from nearly all existing surround-sound systems. Later articles in this series will give the detailed circuit and some constructional details for a decoder for all the above-listed two-channel systems. As this decoder does a great deal more than any previously-published decoder designs, it is necessary to describe its many facilities in some detail, as well as giving some idea of what the circuitry is intended to do.

The aim of any surround-sound decoder is to provide the listener with an illusion of sounds coming from all (horizontal) directions around him. Moreover, if the decoder is well designed, the directions should be those intended by the recording engineer, and should be heard by a listener through the usuable listening area. Conventional "quadraphonic" decoder designs give very poor images for sounds in inter-loudspeaker directions, especially at the sides, resulting in a rather gimmicky 'ping-pung-pang-pong' effect at the four corners.

The full theory used to design ambisonic decoders is mathematical, and computing facilities are required to carry out the extremely complex design calculations involved. It is clearly not possible to give full details here of why the various parts of the decoders have the exact values that they do, but some idea of what is going on can be given.

Two previous articles in *Wireless World*[1,5] have described some, but not all, of the psychoacoustics lying behind ambisonic decoder design. Essentially, the ears use different methods of localizing sounds, not just one or two. The more of these hearing mechanisms that are satisfied the better the sound and accuracy of the result. In particular, if a decoder satisfies several different methods of hearing, the brain has to do far less work to unscramble the complex sound reaching the ears, and the result is particularly "relaxed" listening, with little listener fatigue. While the mathematics of the design is aimed at getting accurate sound localization for all directions, it is undoubtedly true that the biggest musical benefit comes from this consequent low listening fatigue, rather than from any ability to "shoot the pianist".

Some aspects of sound that ambisonic decoders are designed to optimize are now described. At low frequencies, below 500 or 700Hz, there are three important aspects of sound localization: the "Makita" direction of a sound (the direction one turns to to face the apparent sound direction), the "velocity magnitude" (the degree to which the sound stays in its correct localization as one turns to other directions), and the "phasiness" (the degree to which unwanted components of sound not in phase with the desired sound are heard). It turns out that for all systems other than SQ, it is possible to design a decoder matrix below 700Hz to get the Makita localization correct for all encoded sound directions. In addition, a careful adjustment of the gain of the various signal components in the decoder permits the velocity magnitude to be made correct also. Thus, at low frequencies, a listener will hear all directions correctly reproduced in direction, no matter which way one faces.

Phasiness is more of a problem with two-channel systems, as it is not possible to design decoders that get rid of it altogether. The effect of phasiness is not only to blur the sound image, but also to create an unpleasant sensation often described as "pressure on the ears" that actually makes some people feel sick, although others don't seem to notice it much. Studies by the BBC[6, 7] and NHK[8] have given a good indication of how much phasiness can be tolerated. In addition, it is found in practice that phasiness is more acceptable for sounds behind the listener than for sounds in front. Two-channel ambisonic decoders are therefore designed for very low phasiness in the front sector of sounds, while giving rather higher phasiness in the rear.

There is another reason why phase shifts cause poor directional reproduction that comes into action below 300Hz. In a real-world listening room, the loudspeakers are at a finite distance from the listener (often about 2.5 metres for British listening rooms), which means that the sound wave from each loudspeaker arrives as a curved wavefront at the listener, rather than as a plane wave. This curvature can be shown to cause the "phasiness" components of the reproduced directional sound to be converted into rotations of sound images around the listener at low frequencies. However, it is possible to remove these low-frequency errors by means of two high-pass filters in the "velocity signal" paths in the decoder. These speaker-distance compensation filters are RC types with −3dB points at about 20Hz for 2.7m speaker-to-listener distance. this may seem too low to worry about, but listening tests here confirmed the design theory and show that image displacements of as much as 15 to 30° can occur for instruments such as double basses when situated behind the listener unless distance compensation is used. Distance compensation does not turn a bad decoder into a good one, but it does give a "tighter" and more well-defined sound to an already good decoder design.

The ears use different methods of locating sounds at higher frequencies say from 700Hz to 5kHz. However, a rather magical result emerges from the

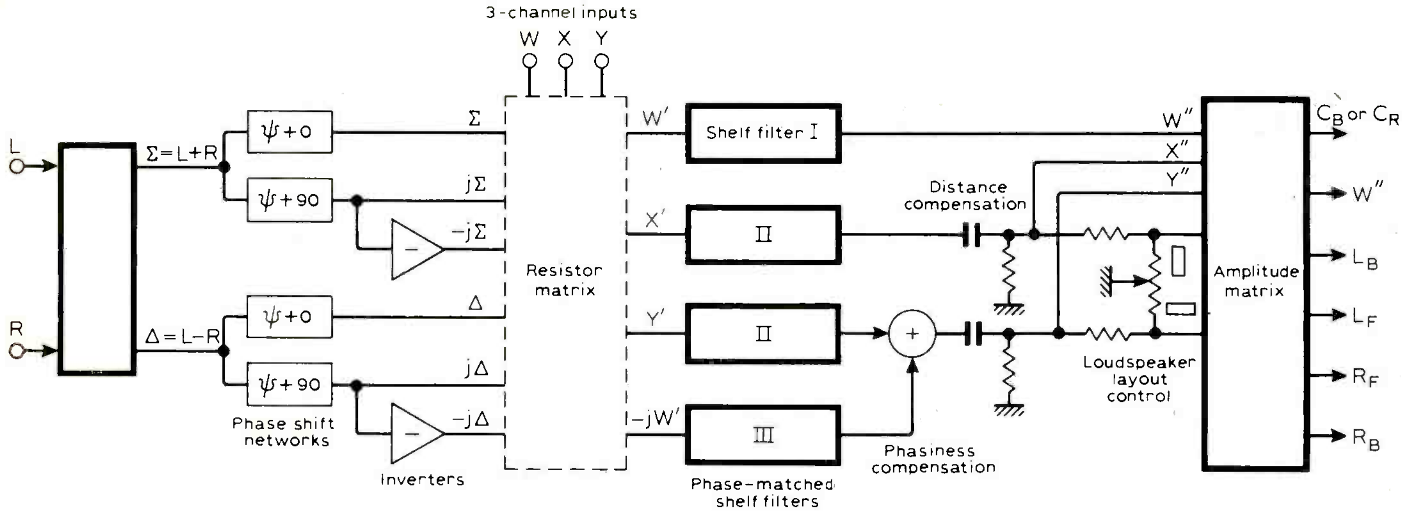


Fig. 1. Block diagram of multi-system ambisonic decoder, switching arrangements omitted. Shelf filters, inoperative for SQ decoding, depend on system being decoded, as does the resistor matrix. Also not shown is switching for C_B or C_R output.

design theory that states that, in effect, the basic sound localization of a decoder will automatically be the same at low and higher frequencies provided that the loudspeaker outputs of the decoder are derived via a particular type of amplitude matrix, the matrix involved depending only on the loudspeaker layout being used by the listener.

Besides getting the basic high frequency localization correct, it is necessary to minimize phasiness in this frequency range also, and to ensure that the sound image does not move around as the listener faces other directions. To get this last requirement right, it turns out that the best decoder design at higher frequencies involves different relative signal gains from those apt at low frequencies, so that the decoder has to be made frequency-dependent. The effect of minimizing the image movement as the listener rotates his head is to avoid an unpleasant "in-the-head" sensation often, but incorrectly, described as "closeness" of sound by other authors[9].

There are numerous other detailed aspects of decoder design, particularly those involving the way reverberation is reproduced (where a careful choice of encoding system such as 45J[1] can help), the effect heard by listeners seated away from the centre of the listening area, and the tone quality of the sound. It may seem strange that absolutely flat frequency response reproduction can sound coloured when reproduced through several speakers, the coloration depending on the precise speaker feeds used in the decoder. Many simple "matrix quadraphonic" decoders suffer from a tubby bass or harsh treble due to these effects. However, it is possible to account for most of these effects by the psychoacoustic design theory, and to minimize them in the decoder design. In practice, sounds encoded at the back are allowed to sound a little more colored than frontal sounds in ambisonic designs, because the ears appear to be more tolerant of marginal faults at the back, although one should assume that they are infinitely tolerant!

All decoder designs for two-channel encoding systems are a compromise between conflicting factors, and no design can achieve perfect performance in all ways. In this respect, the design of decoders is akin to loudspeaker design in being in the final analysis an art based on experience and listening. However, the science (i.e. the comprehensive psychoacoustic theory) is a very necessary part of reducing the almost infinitely complex design problem to a point where the designer can be sure of achieving his particular compromise as well as possible. The compromises inherent in these designs are based on the requirements:

- for front-stage material, the surround-sound should be subjectively superior to stereo for musical listening (few existing designs meet this minimal requirement!),
- good results for listeners facing non-frontal directions and in non-central listening positions, especially behind-centre, and
- "musicality" of effect on both "ambient" and "surround" programme material, leading to low listening fatigue.

To some extent these requirements conflict with those based solely on the localization of direct sounds, such as in the experimental results quoted in ref. 10, where image sharpness for a forward-facing central listener has been achieved in a simple matrix decoder at the expense of "in-the-head" sound and severe image mislocation for non-forward-facing and non-central listeners. Good single-sound localization for most directions and listening positions can be achieved using a signal-actuated variable matrix decoder, but such decoders give a high level of listening fatigue on music due to the constant variation of signal parameters. Such decoders may be useful for surround-drama, where accuracy of localization becomes more important than "musicality" or low listening fatigue, and a fully-fledged ambisonic 'variable matrix' design is under development for such specialist applications. However, there is no doubt that a non-variable decoder is going to remain the preferred method of serious listening to music despite its superficially less "impressive" performance.

The basic diagram of the ambisonic decoder to be described in detail in later parts is shown in Fig. 1. Left and right signal inputs are fed to a sum-and-difference matrix to derive the sum $\Sigma = L + R$ and difference $\Delta = L - R$, because this leads to simplification of the later parts of the decoder, as well as to a slightly greater tolerance to small component errors. These two signals are each fed to 0° and 90° phase shift networks, and the 90°-shifted signal is also phase inverted to yield a −90° phase shifted signal in each case. The

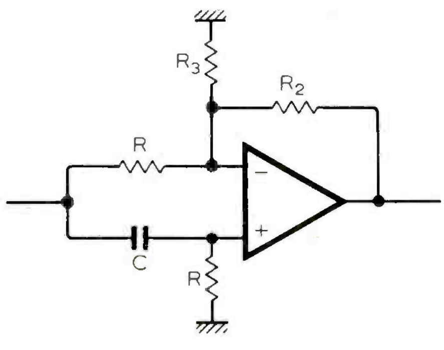
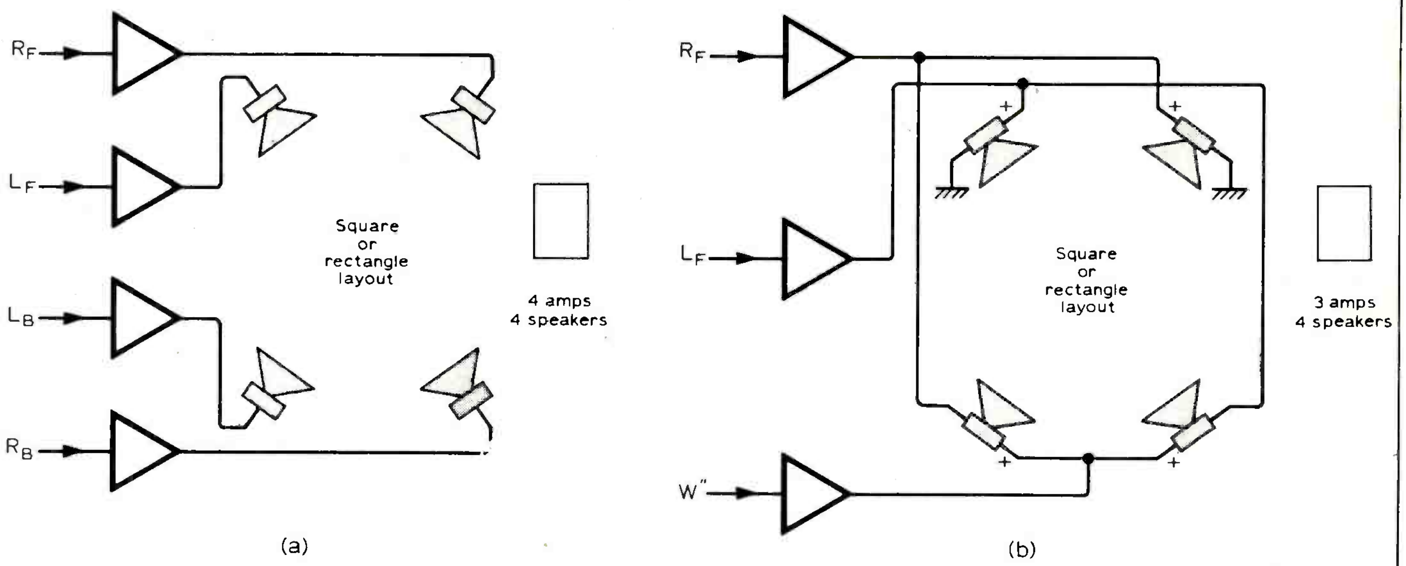
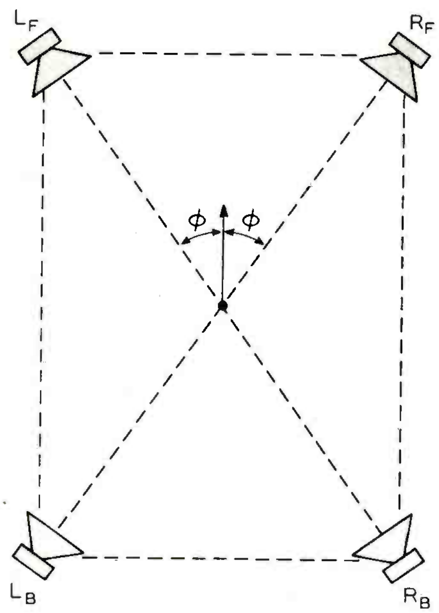


Fig. 2. Phase-compensated shelf-filter circuits allow frequency-dependent decoding. Conventional RC shelf filters would cause unwanted phase differences between signal paths.





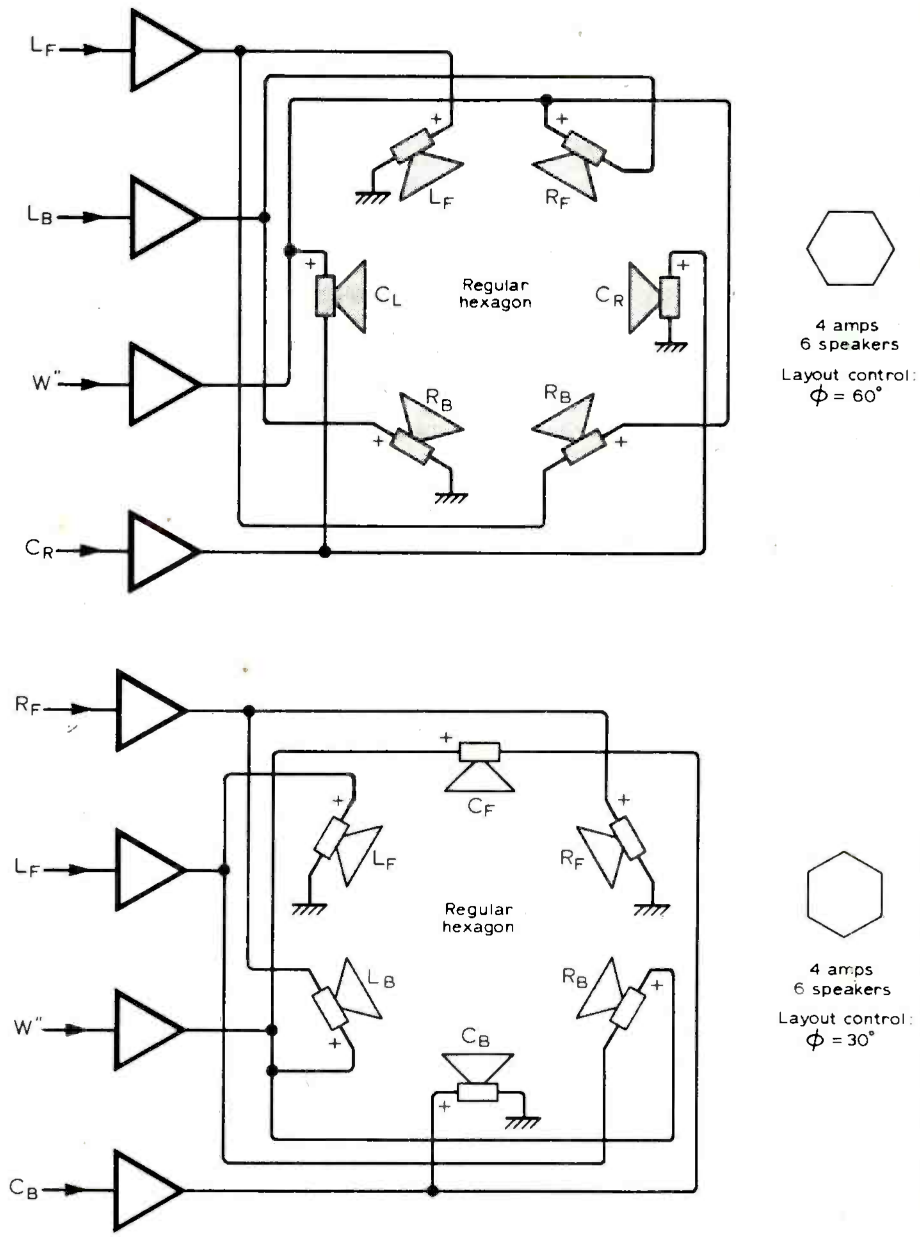


Fig. 3. Methods of feeding four loudspeakers using four amplifiers (a), and three amplifiers (b). Speaker terminals marked + are the positive-phase terminals in each case.

Fig. 4. Compensation is provided for non-square layouts. Angle φ is set on a layout control.

Fig. 5. Better results can be obtained from four-amplifier, six-speaker regular hexagon decoding. Connections are shown for two hexagon layouts with the angle φ used in the equations of the output matrix.

phase-shifters used are high precision types, as the ears are capable of hearing very small errors in localization (as little as 2° in real life). Previous "quadrophonic" decoders have not required such high precision mainly because they gave in any case a poor decoded effect due to sup-optimal design.

The six signals are then fed to a resistor matrix, which derives the required combination of these signals to produce the correct pressure and velocity signals W′, X′, Y′, for the particular encoding system in use. (For a discussion of this aspect see ref. 1, in particular in connection with its Fig. 2). The resistor matrix used is different for different encoding systems, so that switching is provided for different matrix resistance values. The resistor matrix, which involves no active circuitry, also includes a switched three-channel input option suitable for use with three-channel ambisonic mastertapes. In a later article we hope to describe live ambisonic recording for the keen tape enthusiast. These three channel inputs only cost a few resistors and input sockets in the present decoder, and so come virtually for free; in addition, they provide useful test signal inputs for setting-up purposes. We shall give the resistor matrix formulas for the various encoding systems for the signals W′, X′, Y′ in part 2 of this series. An output −jW′ is provided for phasiness-control in some systems, as described in references 1 and 3.

The frequency-dependent aspects of the decoder are provided by the shelf filters which give one decoding matrix at low frequencies and a second at high frequencies, with the transition centred at 400Hz. Were conventional RC shelf filters to be used, there would be phase shifts between the various signal paths, which would cause quite bad localization errors. For this reason, the shelf filters are designed to give phase shifts identical to one another by making them "all-pass" types. The basic circuit of the phase-compensated shelf filters is shown in Fig. 2. The particular arrangement shown has an input impedance of R at all frequencies, which means that it is seen by the resistor matrix as a resistive load, suitable for terminating a matrix circuit. The value of R_2/R controls the ratio of high-to-low-frequency gain of the shelf, and R_3 provides extra h.f. gain to make up the losses of the preceeding resistor matrix.

Thus the shelf filters are made to do five different jobs: terminate the matrix circuit, provide gain, give a different matrix circuit at low and high frequencies, give matched phases over the transition frequency band, and give an overall flat frequency response to the decoder at all frequencies.

An additional complication arises because different methods of encoding require different shelf filters in the decoder. In practice, the shelf filters required for BMX, RM, 45J and BBC H differ only slightly, so that a compromise choice has been made to do all these systems. Decoding mono, stereo and three-channel studio format requires, for best results, a different set of shelf filters, and SQ requires that no shelf filters be used. (SQ decoders cannot be designed to give full ambisonic results; there is a mathematical theorem to this effect. The decoder for SQ provided is, however, less phasey in quality than the SQ designs on the market, and was designed specifically for incorporation into this design. It is not in accordance with CBS Laboratories' SQ specification, but in the author's opinion, it is better than decoders that are.)

The switching of the shelf filters involves equipping the op-amps of Fig. 2 with several filter circuits, which are switched in and out as required.

The outputs of shelf filters acting on Y′ and −jW′ (see Fig. 1) are added to reduce front-stage phasiness, and the velocity signals are then subjected to the RC high-pass distance compensation. This gives us three signals W″, X″ and Y″ representing respectively the signal pressure, forward component of acoustic velocity, and leftward component of acoustic velocity heard by the listener. These are fed to an output amplitude matrix, which includes a layout control adjustment to adjust the outputs of the decoder to match different shapes of rectangular loudspeaker layout in the room.

The decoder provides six different outputs L_B (left back), L_F (left front), R_F (right front), R_B (right back), W″ (pressure) and either C_B (due back) or C_R (due right), switched. The way these six outputs can be used is itself an interesting story, for they can be used to provide decoding via four loudspeakers in a wide range of rectangle shapes using either four amplifiers, Fig. 3(a), or, remarkably, using just three power amplifiers as shown in Fig. 3(b). The three-amplifier set-up in no way means that there is any compromise in the psychoacoustics of the decoded signal, as precisely the same speaker signals are produced as in Fig. 3(a)!

To see this, we first remark that the outputs of the decoder are given by the formulae

$$L_B = \tfrac{1}{2}(W'' - \sqrt{2}\sin\phi\, X'' + \sqrt{2}\cos\phi\, Y'')$$
$$L_F = \tfrac{1}{2}(W'' + \sqrt{2}\sin\phi\, X'' + \sqrt{2}\cos\phi\, Y'')$$
$$R_F = \tfrac{1}{2}(W'' + \sqrt{2}\sin\phi\, X'' - \sqrt{2}\cos\phi\, Y'')$$
$$R_B = \tfrac{1}{2}(W'' - \sqrt{2}\sin\phi\, X'' - \sqrt{2}\cos\phi\, Y'')$$

where ϕ depends on the setting of the layout control, being 45° for a square layout, and being equal to the angle ϕ shown in Fig. 4 for a rectangle layout. From these formulae

$$L_B + R_F = L_F + R_B = W'',$$

so that

$$L_B = W'' - R_F$$
$$R_B = W'' - L_F,$$

and it will be seen that the rear speakers of Fig. 3(b) indeed are connected so that the potentials of their "positive phase" terminals relative to their negative phase terminals are $W''-R_F$ and $W''-L_F$ respectively.

Even more remarkable however, are the four-amplifier six-loudspeaker arrangements possible with this decoder. It has been known for several years that decoders using six loudspeakers are capable of better results than is possible using four, no matter how well-designed the decoder may be. If properly used, the extra speakers give more solid image location over a larger area, with less tendency for the image to hug the loudspeakers than when using four, particularly on difficult waveforms such as audience applause. It has not been possible to market six-speaker equipment; few homes could properly accommodate it, and the market for such special equipment was thus too small to justify manufacture. However, the ambisonic decoding method permits the same decoder and the same four amplifiers to be used for six speakers for the few who can manage it, making this improved form of decoding domestically available for the first time. We emphasise that in no way does the use of four amplifiers imply substandard results: exactly the same speaker signals are given as one would design a psychoacoustically optimized six-amplifier decoder to give.

The six-speaker connections for two shapes of regular hexagon layout are shown in Fig. 5. The three speakers that are fed in a "simple" manner in each case form an equilateral triangle of speakers; this helps minimize the subjective effects of slight mismatches of amplifier gain. The signals C_B and C_R are

$$C_B = \tfrac{1}{2}(W'' - \sqrt{2}\,X'')$$
$$C_R = \tfrac{1}{2}(W'' - \sqrt{2}\,Y'').$$

Although detailed instructions for calibrating and using the decoder will be given at the end of this series of articles, it is worth emphasizing now that all amplifiers and loudspeakers

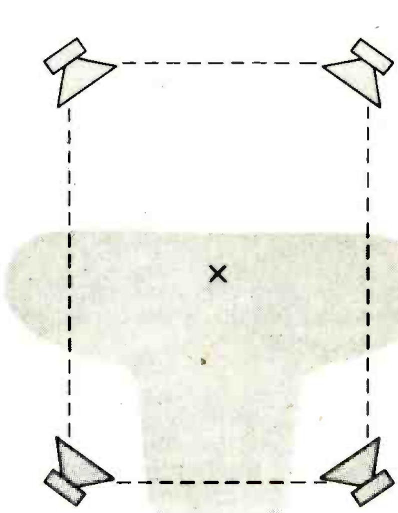


Fig. 6. Approximate listening area for ambisonic decoding (shaded) with a rectangle speaker layout obtained for BMX, 45J, Matrix H and RM systems as well as stereo. Optimal listening is at the centre (X).

must be accurately matched for correct ambisonic results. Unlike "quadraphonic" decoders, both front and rear loudspeakers co-operate to produce sounds in any direction. Thus, for example, the rear speakers provide outputs that help to reinforce the localization of sounds that are reproduced in front of the listener. Thus one cannot try turning the rear speakers up or down in the mistaken idea that the front and rear are independent of one another. When the outputs are not matched, the sound field tends to "fall apart"; in fact turning down the rear speakers often makes them much more audible (as distracting noises at the back) than in a correct balance.

While it is not absolutely necessary to have all power amplifiers of the same make, they should be adjusted for identical gains and phases, and one should check (e.g. by using an X-Y oscilloscope display) that they have substantially identical phase responses over the audio band. If in doubt, identical amplifiers should be used. While identical speakers should be used, a small number of speaker manufacturers (e.g. IMF Electronics) have taken trouble to match the different models in their range carefully, and in such cases different models can be used at front and rear. Again, if in doubt, use identical speakers for best results.

The decoder not only reproduces surround sound from a variety of existing systems, but also handles mono and stereo, using ambisonic techniques to get the most natural possible reproduction (using four or six speakers) from existing records and broadcasts. Except for exceptional stereo material, the decoder does not create "pseudo surround sound", but reproduces stereo over a conventional frontal stage with a subtle enhancement over two-speaker stereo, and without any gimmickry. The mono decode mode reproduces a mono source from straight in front, but the

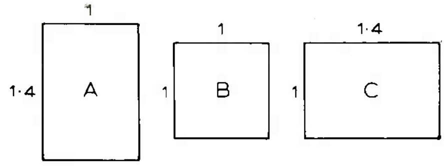


Fig. 7. Most stable front images are provided by arrangement (a), most stable side images by (c), while (b) is a compromise between these extremes.

rear speakers help to lock the image solidly in space behind the front loudspeakers. Neither mono or stereo decode modes enhance badly recorded material, but neither do they degrade it any further. In practice, many ambient SQ classical recordings, such as those released by EMI, will be found to reproduce better in the stereo decode mode than via SQ decode mode, owing to the inherent limitations of the SQ system.

Fig. 6 shows the approximate usable listening area for most decoding modes (excluding SQ) in a typical domestic room using a rectangle layout. The listening area will in practice depend on the loudspeakers used, the room acoustics, the layout shape used, the programme material, and also on the system being decoded. The type of listening area shown has been obtained both with ambisonic recordings made in concert halls, and with commercial "easy listening" (*sic*) music in the BMX, 45J, Matrix H and RM systems, as well as with stereo material played in stereo decode mode.

It is found that a longer-than-wide layout of four speakers as in Fig. 7(a) gives the most stable front images for non-central listener and the least stable side images. A wider-than-long layout as in Fig. 7(c) gives excellent stable side images for most listeners, although the front stage tends to be drawn over to the nearest speaker. A square layout, Fig. 7(b), is a compromise in terms of image stability between these extremes. Extremely thin rectangles (whether long or wide) cannot be expected to give good results, although the layout control adjustment will help to minimize the inevitable defects.

Part 2 will give details of the decoding matrices used. Patent rights in circuits described in this and subsequent parts of this article are owned by the National Research Development Corporation. A kit of parts for the decoder will be available from Integrex Ltd – see advertisement.

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Broadcasting satellite receivers

Mullard's research laboratories have released details of the microwave receivers which they, in co-operation with Philips at Eindhoven, have built for picking up broadcast television signals from "Hermes", the Canadian-American Communications Technology Satellite (News, April, p.40). The receivers convert the 12GHz f.m. broadcast signals picked up by small dish aerials to a form suitable for feeding into the aerial socket of standard NTSC colour television sets. Five receivers and associated 1.6m (or in some cases 1.2m) diameter metal-coated glass-fibre-reinforced polyester parabolic aerials were supplied by Philips, and one receiver of somewhat different design but using the same aerial was supplied by Mullard. To accommodate satellite drift provision was made for remote control motor tracking of the aerials on a single axis.

An outdoor part of the receiver with an integral waveguide horn is placed at the focus of the aerial and provides fixed-tuned conversion from 12GHz to 410MHz, with a noise figure of about 7dB. It consists of a microstrip Schottky-barrier-diode mixer, followed by a 40dB amplifier. The local oscillator is a Gunn device delivering about 10mW at approximately 11.7GHz and, in the Mullard version, this is located in an aluminium cavity integral with the converter. Dielectric temperature compensation maintains frequency drift within 5MHz (over the range −40°C to +40°C) which is well within the range of the automatic frequency control applied to the second mixer. This is located in an indoor unit fed with the 410MHz signal by a coaxial cable.

The indoor part of the receiver provides further conversion to 120MHz prior to limiting and frequency discrimination to yield the NTSC composite video colour signal and 5.14MHz f.m. sound signal. The last-mentioned is converted to the normal 4.5MHz intercarrier frequency and with the video is used to amplitude-modulate a 500MHz carrier to provide a 10mV signal suitable for the aerial input of a standard NTSC colour television set. Extensive use is made of integrated circuit techniques.

The Mullard receiver is installed at the Canadian government communications research centre in Ottawa. The aerials were aligned first by a simple level of compass then final adjustment was made by means of the satellite signal itself and a signal strength meter. Mullard say excellent picture and sound quality was achieved and the received signal strength was close to the expected level of −105dBW.

News of the Month

Plessey chief wants social responsibility

Sir John Clark, chairman and chief executive of Plessey, has expressed concern about unemployment caused by technical change. Plessey workers making electromechanical telephone exchange equipment are threatened with redundancies as a result of the Post Office's unexpectedly sudden decision to change to electronic exchanges. Speaking at the opening of the London Electronic Component Show, Sir John asked "Should technology be pursued for technology's sake? And what impact will the changes caused have on people? We are constantly being told we live in the technical age. But there is, I think, an optimum beyond which it is not cost-effective to go. The impact of change on people should be given the most urgent consideration. Not only how it will affect the jobs they do and how they do them, but also on the crucial social question of whether some jobs will remain to be done at all.

"In contemplating the equation of change", continued Sir John, "the social consequences must be taken into account and weighed carefully against any other advantages which might accrue. This is why one of your major customer-industries – namely telecommunications, which as you know Plessey has a considerable interest in – has appealed to the Government against the cumulative effects of Post Office cuts, recently announced, in the traditional electromechanical telephone systems. Of course we believe the British telecommunications industry should move forward quickly into the new technical area with equipments brought to modern technical standards. But some regard must be paid to social responsibility by the decision-makers. By their decisions, they have the power to wipe out the livelihood of thousands of people without adequate time being given for an orderly and manageable transition from the old to the new. In my view, it should not be done without due regard to the consequences."

Plessey is one of the companies mentioned by Mr Ernest Harrison, chairman of Racal, as possibly being involved in a rationalization of the British electronics industry (see leader).

A to D conversion at 30MHz

A design group at Cambridge Consultants working on high speed analogue-to-digital conversion have developed a convertor which they describe as the fastest eight-bit a.d.c. in Europe. It will perform, they say, "a full accuracy eight-bit conversion every 33ns." Two have now been delivered, one each to Plessey Ltd, whose Allen Clark Research Centre developed a high speed comparator using the circuit element, and the Admiralty Surface Weapons Establishment.

Two years ago CC were working on a military contract for which they developed a six-bit, 30MHz convertor. Cambridge believed the technology available would allow the development of an eight-bit version. With the completion of the previous contract, however, they needed funding and a client to build both the circuit element to Cambridge's specifications and a circuit in which to use it. The money came from the Ministry of Defence directorate for Components, Valves & Devices (CVD), and Plessey's comparator circuit provided an opportunity to use Cambridge's expertise.

The Cambridge equipment is designed for use in radar signal processing and transient recorder applications where low aperture uncertainty, a parameter affecting the accuracy of sampling at a signal's zero crossing point, and full accuracy at high sampling rates are required.

A commercial version, the ADC30.8 is available from Cambridge Consultants. It includes a matched, high speed, low jitter sample hold, operates from a 50 ohm analogue input and samples with an aperture time uncertainty of 10ps r.m.s. The sample command input and the offset binary coded digital output, overrange and internal 30MHz clock signals are all of 50 ohm impedance and e.c.l. compatible. The unit, priced at £3,510, comes with power supplies in a 19in case. The designers were Dr Chris Davies and Julian Coles, and the project manager was Dr Robin Smith-Saville.

A new independent viewing centre for use with the EMI X ray scanner. It provides a display and data reprocessing at a point remote from the main scanner. The area of interest can be enlarged and there are other image manipulation facilities.

Post Office buys solid state stored speech

The Post Office have installed two prototype, automatic, changed-number intercept equipments for service trials in Birmingham and Chelmsford telephone exchanges. If, at the moment, a number is changed the caller, on dialling the old number normally has his call intercepted by the operator, who then tells him the new number. The new system puts the caller through to an automatic spoken message which is stored digitally in memory. This stored message is passed on to the caller.

The equipment supplied by Pye TMC, builds up the message from a limited vocabulary of words and phrases. Each word or phrase is decoded from its digital form and kept going round an audio highway. If one were to listen to one of these highways one would hear a single word or phrase repeated continuously. Line circuits which recognise that a call has reached a disused line are programmed to select the highways in the correct sequence to build up a message for that line. A test message is available by dialling Chelmsford 62101.

MRUA call for mobile radio "Annan"

Following the Home Secretary's call for comments before the 1979 World Administrative Radio Conference the Mobile Radio Users' Association have published their submission to the Home Office. The Association, who say they represent 80% of all private mobiles in the UK, submit that

- Mobile radio use should be encouraged on economic grounds.
- Demand will increase, also because of the need for economies.
- The Home Office's predictions of spectrum requirements "are based on reports which appear negative in spirit."
- 100MHz extra spectrum is needed for mobile radio, the extra frequencies being found by moving fixed services to higher bands, standardising on 12.5kHz channel spacing, and releasing frequencies from bands 1 and 3, and other places in the spectrum allocated but under-used.
- Mobile radio is important enough to justify setting up a body like the Annan Committee whose conclusions should be published.

The MRUA say the submission is based on feedback from their members, study of the Home Office Warden Report and Pye's Pannell report, a survey which MRUA did of all p.m.r. users in the UK, and other submissions which they have seen. The MRUA believe that mobile radio is the one use of spectrum which gives tangible and measurable economic benefits and, since most western countries' problems at the moment appear to be economic, mobile radio ought to have first priority. The UK commercial and industrial world was not yet conscious of the benefits offered by p.m.r. and so the government should actively encourage them to use it, instead of restricting p.m.r's use. Demand may be artificially low, say MRUA, because of delays in issuing licences. The submission continues: "Our main objection to the policy apparently to be followed by the UK delegation is that their attitude from all indications to date appears to be negative. It seems to be a matter of how few people should use radio and how small the necessary allocation can be, whereas we feel the attitude should be the opposite."

MRUA also say they believe that if the government has allocated to it large areas of the spectrum which they do not use they should release them for p.m.r.

To standardise on 12.5kHz would "in some measure degrade system performance, but this must be tolerated in the interests of spectrum economy. However we are of the opinion that any further channel splitting is not a true economy with existing modulation systems owing to degradation of signal to noise ratio." This view had been expressed before when channels had been progressively split as technology developed. "Our objection to a further split in channels is not based on any shortcomings of the equipment, which may well be capable of performing at narrower spacings; it is based on the degraded signal-to-noise performance resulting from the reduced bandwidth. The MRUA would oppose any move away from the general policy of two frequency working as a result of pressure from any other administration. They also believed that fixed point to point links should be moved eventually to beyond 512MHz. Propagation difficulties and high costs would prevent the use, for the time being, of frequencies in the 850-960MHz band for p.m.r.

"We believe that in the interests of progress it is too easy to underestimate the information capacity of simple speech. Speech has the advantage of infinite flexibility and to a small extent an additional range of meanings resulting from tone of voice. It is unlikely that data systems will ever match this, and they are costly both in capital and maintenance terms. We believe that there are a few p.m.r. applications which could usefully consider data, whereas we believe that many government services, such as police and fire brigades, could make great use of data for routine messages, and thus effect spectrum economy in those regions of the bands."

No two uses of p.m.r. are alike, they add, and they would oppose any blanket for measuring channel occupancy.

The British Gas Corporation have published a paper presented to a private meeting of the Joint Radio Committee of the nationalised industries held at Lincoln College Oxford in late March. The main points of the speech made by East Midlands Gas Marketing Board director Peter Quinn are that: the use of self-identification in the calling procedure takes up to 20% of the message length, and can exceed the message time; that the greater demands on operators made by selecting among a number of base stations "is not ideal, and that his time could be more beneficially spent controlling work allocations, etc"; that operators need to be well trained to control incoming calls, and to ensure that all calling mobiles are correctly acknowledged, passed on immediately or put on standby; the amount of information that has to be passed on by a fitter takes some time and "represents poor use of the channel"; and the passing on of a message to a third party often involves bringing whoever is to receive the message into the radio room to take over the equipment for the duration of the call, with considerable disturbance.

On selective call systems Mr Quinn noted that their use in the gas industry had reduced call sign transmission time, shown a caller immediately that his call had been received, alerted fitters returning to vehicles that a call had been made while they had been away, all of which produced "better channel management and hence the possibility of supporting more mobiles per channel."

The normal view of selective calling systems among other users appears to be that until interference becomes very much worse the selective calling equipment would provide unrequired facilities at greater cost. Hence Mr Quinn's remark that they had been "slow to find supporters." He added that they would be an essential part of future fully automated systems.

Viewdata cracks the PO armour

Details are emerging of the Post Office's delayed Viewdata market trial, to begin in the middle of next year. One thousand sets are to be distributed among interested viewers selected to represent an exact cross-section of the British population, according to income and social class, chosen from 6,000 applicants. The Post Office have even stipulated that the suppliers of the sets, ITT, Philips, Thorn, GEC and so on, supply a proportion of the 1,000 according to their market share. Although the news that the Post Office and the manufacturers were co-operating closely was published in the annual report of the British Radio Equipment Manufacturers' Association, issued on May 19, the Post Office is reluctant to discuss the experiment as yet. In a statement issued to *Wireless World* they said: "We have agreed with BREMA on an integrated approach to the development of Viewdata decoders. This employs a unit in the tv sets which will also include the line interface with the telephone network and as such will demodulate the incoming signals from the telephone line and also generate appropriate loop-disconnect pulses for calling the designated Viewdata computer." They said they would be making an announcement shortly.

The Post Office originally requested that the sets used for the test should be as near as possible to the final production models but the manufacturers told them this would be out of the question in the time available. For that reason rather more equipment will be hanging outside the set than the viewer who buys Viewdata equipment would expect to see if the trial is successful. In addition the Post Office will be providing isolating equipment and "line terminating units" which perform the same function as the standard PO modem but have a lighter specification. When the full Viewdata service is operating the Post Office will make available higher quality lines to make possible this slight easing of tolerances. The manufacturers will be building into the sets or connecting to them a teletext decoder and a Viewdata decoder module.

Clearly this is the first time the Post Office has moved from its determination to prevent anyone connecting any equipment to a telephone line other than that it has supplied itself. Equally clear is that unless it agreed to this the Viewdata service would founder. While the Post Office is taking no chance of risk to its personnel or equipment – there is some talk of using two stages of isolation from the telephone line – there is no doubt that some in the electronics industry will see this as setting a precedent.

Meanwhile in Germany the competition to run the Viewdata service is hotting up, and for once British manufacturers are making the running in supplying to whoever wins. At the end of May representatives of the German press met in Hamburg to decide their tactics for running the proposed teletext service, and at the largest German electronics show, the Funkaustellung, (August 26 — September 4) both they and the broadcasters will be competing to show that they and not the other are the ones who deserve the prize. The German press are arguing that teletext is a newspaper of the air, while the broadcasters argue that it is part of their medium. And with Viewdata coming the German PTT in Bonn, who have already bought the Viewdata software programme, want to keep a grip on the system whoever wins. The German post office have already taken the BBC's Ceefax service and shown it to some of their staff, and the BBC have German sub-editors working with them. At the Funkaustellung there will be demonstrations, including those by British tv manufacturers, notably GEC. Philips and ITT will also be involved.

GEC have also announced that they have delivered to the German Post Office a 4080 computer system for the proposed German equivalent to Viewdata, the Bildschirmtext. The hardware also includes a 128kbyte core store, 4.8/4.8 Mbyte fixed/exchangeable cartridge disc, magnetic tape storage and paper tape equipment. GEC say the equipment was installed at Darmstadt five weeks after official receipt of the order.

In February we reported (p.40) on a system which used teletext to provide information for the deaf. Now teletext is being used for the blind. Clarke and Smith last year developed with the National Research & Development Council a Braille computer terminal that would fit into a suitcase. It consists of a typwriter keyboard for writing and a 48 character, 14 inch long touch strip operated by t.t.l. controlled solenoids. The information is put in one line at a time and the operator signals "next line" for the tactile display to be changed. The operator can also skip back to previously-read lines.

The snag at the moment is the high price, £2,800, but a read-only version is available at around £500.

Alternative to cellular radiotelephone proposed

Three radio common carrier firms have asked the FCC for permission to build and test a new radio telephone and paging system in competition with the ART cellular system in the Washington-Baltimore area (WW June p40). The alternative would cost just over $1 million with equipment and technical help to be provided by Harris Corporation. The group have told the FCC they could test and install the service by the 1979 deadline. It would, according to Harris, be less costly to build and maintain, and would use digital transmission to provide the "ultimate in communications security." The pocket pagers and radiotelephones provided to customers would be lighter and less expensive than those currently in use.

The Harris system would use a single powerful transmitter to cover the same area instead of the many base station transmitters within small geographic cells proposed in the cellular system. It would also operate in the 900MHz band. The single, high power, broadband transmitter, similar to that used in broadcasting, would cover 30 to 50 miles in radius. Ninety-six or more channels could be accommodated by time division multiplexing to mobile units. Broadband remote receivers could pick up conventional narrow band f.m. signals from the mobile units. The receivers would "transmit the spectrum occupied by mobile units back to the central base station via microwave links, where signal processing will occur. The system does not require wireline links between satellite receivers and the base station. The only telephone lines that will be required are those interfacing the [radio common carrier's] main terminal with the telephone company's central office equipment".

Naval weapon life study

The Royal Navy has initiated a three year study aimed at reducing the life cycle costs of naval weapons equipment. Announcing the contract to carry out the study, Mr Brian Mair, manager of Plessey's Product Assessment Laboratories, said the analytical study was intended "to produce rules by which designers of future weapons equipment can predict the life cycle cost of that equipment." The reasons for the study "will become apparent when you consider the way modern technology has changed the Navy's equipment."

Naval equipment has become much more complicated, and difficult to repair. It is no longer possible to keep a full set of spare parts on board ship and expect sea-going personnel, no matter how well trained, to be able to repair it on the spot. It is more likely that plug-in modules would be used which can be repaired when the ship is returned to port. All that is needed is to identify a faulty module and replace it. The difficulty, which the Navy hopes the Plessey study will sort out, is that ships may be at sea for long periods. It is not certain which equipment is more likely to fail, or how much spare equipment it is economical to store in a ship, even with the high reliability the Navy needs. The design of the equipment can make these variables more predictable. As Mr Mair said, "There is an increasing cost of materials support to the Navy for modern weapons equipment. The designer can make trade-offs between reliability of equipment and subsequent maintenance costs. The study is to understand these trade-offs and to study how they can be more effective in the use of money in future.

The cost of the study is undisclosed, but most of the expenditure will be in the salaries of the 14 scientists who will be engaged on it for the next three years. According to a Plessey statement, "The Plessey team will be devising a series of computer operated models in a form which can easily be used by project design teams. The data, vital to validate the models, is being obtained with the co-operation of other major defence contractors."

Brian Mair is now taking charge of an expanded business. Product Assessment Laboratories is now augmented by Plessey Reliability Service and Plessey Calibration Service. The group is called Plessey Assessment Services, of which Mair is business manager. His previous post as manager of PAL will be taken over by Geoff Matthews. The expansion means that PAS will be recruiting over 50 engineers and technicians over the next two years to work at their Titchfield, Hants, base.

Digital television via satellite

Multiplexed 60Mbit/s PAL television and sound signals sent through Intelsat IV from Goonhilly

by M. E. B. Moffat, M.A, D.Phil, M.I.E.E., M.Inst.P. *BBC Research Department*

For many years now the transmission of colour television and sound signals via geostationary satellites has made possible the world-wide exchange of programmes for broadcasting, either "live" or with a few hours delay to suit programming. Such transmissions usually involve analogue baseband signals and f.m. techniques, but in recent years interest has grown in digital coding in conjunction with multi-phase-shift keying modulation.

Provided that efficient bit-rate reduction and modulation methods are used, theory shows that digital coding can form the basis of a better tv transmission system than f.m. for the economic use of r.f. bandwidth and power. The DITEC system of Comsat Laboratories in the USA, described in 1972[1], was the first practical attempt to realise a digital system of this kind. It has been used in North America for the experimental transmission of NTSC 525 line, 60 field/s, 4.2MHz bandwidth colour television signals in the form of a 33.6Mbit/s digital signal through geostationary satellites. Four-phase-shift keying modulation was used, occupying an r.f. bandwidth of about 20MHz, which is about half of that available in an Intelsat IV transponder.

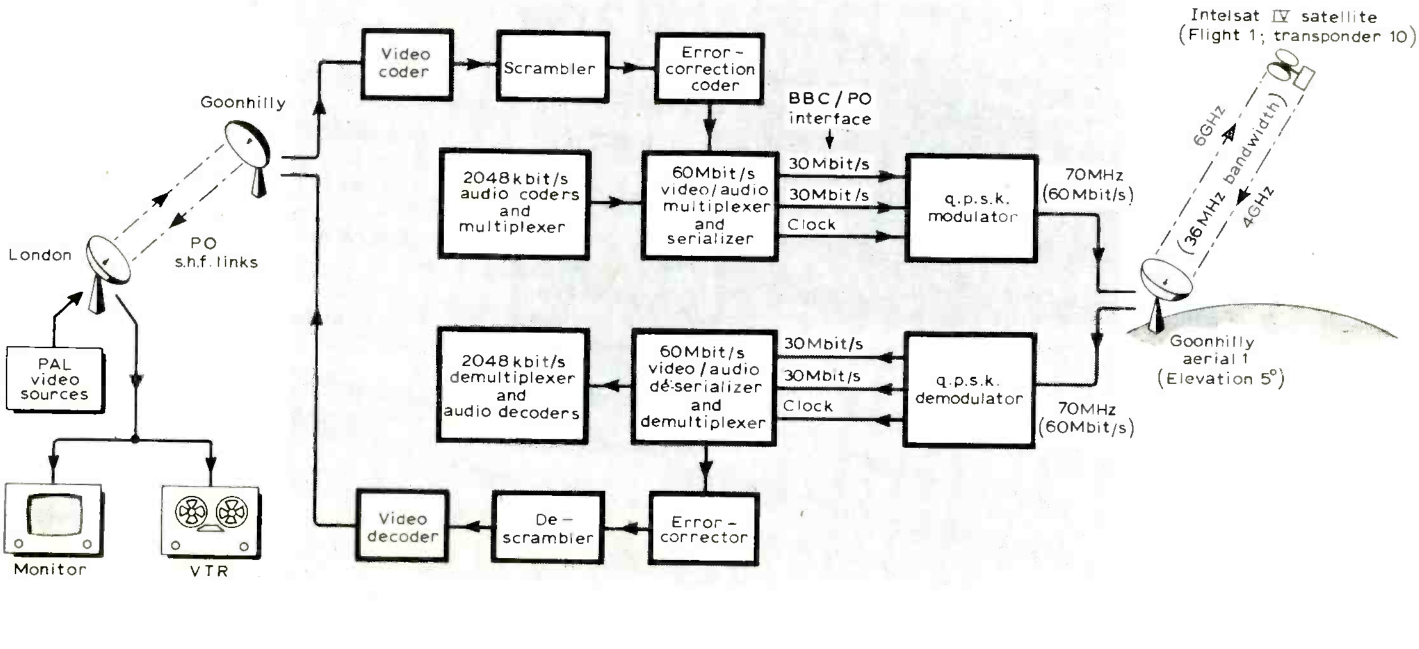
To transmit a high-quality picture using 33.6Mbit/s for PAL 625 line, 50 field/s, 5.5MHz bandwidth colour television signals, i.e. for System I signals as broadcast in the UK, is a more difficult problem than DITEC had to cope with. This is because of the higher horizontal and vertical resolution, offset somewhat by the reduced field-rate.

In 1974 the UK Post Office agreed to support a BBC Research Department proposal that experimental digital transmissions of System I signals should be attempted via an Intelsat IV satellite. The bit-rate envisaged for the video signals was between 44Mbit/s and 54Mbit/s. Added to this would be bit-rates corresponding to error-correction and audio signals, bringing the total bit-rate of the "package" up to 60Mbit/s, the capacity of the experimental channel through the satellite.

The experiments took place in April and May 1976 (see *Wireless World*, August 1976, page 71); they were envisaged as a further contribution to a programme of field-research into digital tv and audio transmission. They were not the first PO-BBC co-operative exercise on digital video transmission. 120Mbit/s video waveguide-transmission experiments were demonstrated jointly by the Post Office, the BBC and GEC in September 1970 at the inauguration of the first 1km length of circular waveguide at the Post Office Research Department. In 1971, Standard Telecommunications Laboratories and the BBC demonstrated 120Mbit/s video transmission through an optical fibre at the IEE's centenary celebrations. In 1975, the BBC co-operated with the PO, STC, GEC and Plessey in 120Mbit/s cable-transmission tests, involving two 60Mbit/s video-audio packages provided by the BBC Research Department (see News of the Month, *Wireless World*, February 1976, and Reference 2).

Further transmission tests with satellite, cable, optical fibre, s.h.f. link, and waveguide systems are envisaged, and some of these tests may use a video bit-rate as low as 30 to 34Mbit/s, if the continuing work on bit-rate reduction leads to satisfactory picture quality at these rates. A precise choice of bit-rate in the 30 to 34Mbit/s region would take into account the bit-rates of 34368kbit/s

Fig. 1. Diagram outlining the transmission system used in the 60Mbit/s experiments at Goonhilly Downs.



and 32064kbit/s from the transmission bit-rate hierarchies proposed for Europe and Japan respectively.

Experimental transmission system

The transmission system used in the 1976 satellite experiments is shown in Fig. 1. The primary video sources were provided in London by the BBC Designs Department; they comprised a flying-spot colour slide-scanner, BBC Television network channels, conventional test-waveform generators, and a transverse-scan video-tape recorder.

Much use was made of the slide-scanner, with a wide selection of colour transparencies drawn from a new set prepared by the European Broadcasting Union – one of which is shown in Fig. 2(a) – together with other slides often used by television authorities in subjective assessments of picture quality.

The analogue video signal was transmitted by the Post Office via permanent cables and s.h.f. f.m. links to and from their Earth station at Goonhilly Downs in Cornwall. For the digital tests, the analogue video signal was fed to BBC Research Department equipment temporarily located at Goonhilly; this equipment was by-passed on one occasion to afford a brief test using an f.m. channel through a satellite.

The digital video signal was incorporated in a video-audio 60Mbit/s multiplex, which was fed as two 30Mbit/s signals and a clock signal to a quadrature phase-shift keying (q.p.s.k.) modulator, built by the Post Office Telecommunications Development Department.* The 36MHz bandwidth, 70MHz i.f. output from the modulator was up-converted to s.h.f., amplified, and transmitted through Aerial 1 to and from the Intelsat IV Flight 1 satellite stationed over the Indian Ocean, occupying virtually the full bandwidth available in one transponder. Video and audio monitoring was provided at Goonhilly and at the BBC Designs Department in London. Audio transmission, both ways, between the Designs Department and Goonhilly was provided by BBC sound-in-syncs equipment.

*The corresponding demodulator was developed by Marconi Research Laboratories.

Video coding

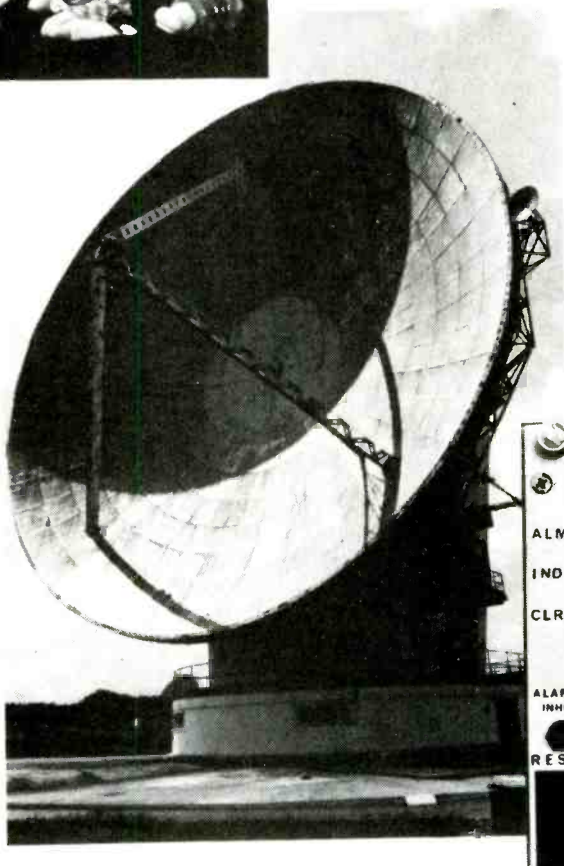
In the digital video coder the analogue PAL signal was sampled at precisely twice the PAL colour subcarrier frequency, i.e. at $2f_{sc}$, about 8.87MHz. According to Nyquist's theory this is too low a sampling frequency to conserve the video information. However, G. J. Phillips and M. Weston of the BBC Research Department had shown that, because of the nature of the line spectrum of the video signal, sub-Nyquist sampling at $2f_{sc}$ conserves virtually all of the wanted video information; unwanted "alias" components fall halfway between the lines of the video spectrum and are removed by comb-filtering, with the teeth of the comb spaced at line-frequency.[3]

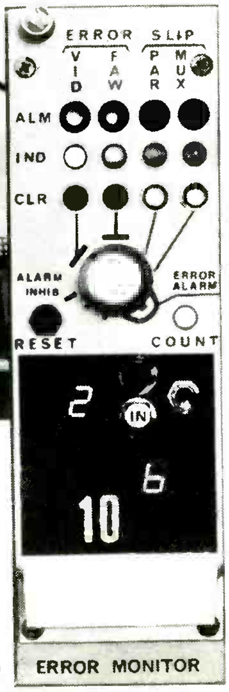
Eight bits per sample were used in the initial video signal quantisation, including its line and field synchronising signals.

The eight-bit sample-words were re-quantised non-linearly as six-bit words, or, optionally, five-bit words, using differential pulse-code modulation (d.p.c.m.) or a hybrid of differential and "straight" p.c.m. termed h.d.p.c.m. When five-bit video words were used, a dummy sixth bit was added for instrumental convenience. Six-bit straight p.c.m. was also provided. The essence of h.d.p.c.m. is that straight p.c.m. is used for a sample when the numerical difference between its actual value and its value predicted in the d.p.c.m. coder is large. In this $2f_{sc}$ equipment the second-previous sample is used as the prediction. Large differences result from sharp luminance transitions, for which the eye accepts relatively coarse quantising, perhaps because they are relatively rare. When the difference is small, and can therefore be accurately represented by five-bit or six-bit words, differential p.c.m. is used, i.e. the five-bit or six-bit word gives the value of the difference rather than the absolute value of the sample; in plain coloured areas the difference is zero.

Of the various options available, six-bit h.d.p.c.m. was the one mostly used.


(a)


(b)



(c)

Fig. 2. One of the pictures and two examples of equipment used in the tests: (a) "girl with toys," one of a set of EBU test pictures; (b) Aerial 1 at the Post Office Earth Station, Goonhilly Downs; and (c) error and slip monitor from the BBC Research Department equipment.

Video scrambling

During preliminary tests with the q.p.s.k. modem it was found that the channel performance was not independent of the transmitted bit-sequence. The salient problem arose with carrier recovery in the demodulator, where recovery was quite all right with pseudo-random bit-sequences but was somewhat picture-dependent with digital video signals; certain pictures gave rise to troublesome and lengthy bit-sequences. The problem arose because the troublesome bit-sequences contained insufficient carrier-recovery information for the particular type of recovery circuit used, which was designed for digital telephony applications and not for the experiments described here. The problem was overcome by scrambling the digital video signal to make it appear pseudo-random for transmission, and de-scrambling it before decoding. The way in which this was done is outlined in Fig. 3, where the modulo-2 addition is equivalent to the exclusive OR logic function. The square boxes represent one-bit shift registers clocked at the serial bit-rate. The modulo-2 sum on the figure shows how the output of the de-scrambler always equals the input to the scrambler.

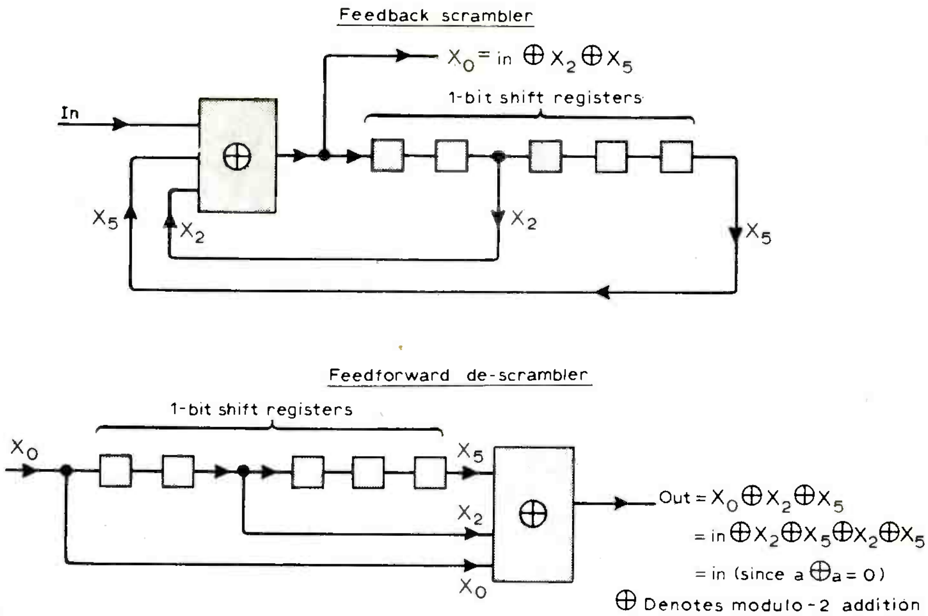


Fig. 3. Five-stage scrambler and de-scrambler.

Video error-correction

P.c.m. video-transmission errors cause small points of enhanced or reduced brightness to appear in the picture. But d.p.c.m. transmission errors are more serious since the effect of a single error is to cause a streak across the picture from the point at which the error occurred to the right-hand side where the sample difference is reset to zero. H.d.p.c.m. transmission error-streaks do not often extend so far because they stop where the coding mode changes from d.p.c.m. to p.c.m.; indeed this effect is the main advantage of h.d.p.c.m. However, even h.d.p.c.m. is not rugged enough to withstand a random transmission-error rate of more than about 1 in 10^8, without more than a very-slight picture impairment, and the error-rate on the satellite channel was expected to be somewhat higher than 1 in 10^8. Therefore a form of video error-protection was provided in the BBC equipment.

The method used is known as Wyner-Ash convolutional error-correction with a (16,15) code.[4] The numbers mean that the ratio of the number of error-correcting bits to the number of video-data bits is 1:15. Six error-correctors of this kind were provided to operate independently on each bit of the six-bit video words. Six-bit words at a rate of $2f_{sc}$ give a serial bit-rate of 53.2Mbit/s. Adding the error-correcting bits brought this rate up to 56.8Mbit/s.

The use of six independent error-correctors meant that a burst of up to six consecutive bit-errors could be corrected. This feature was important because the use of q.p.s.k. could extend a single phase-shift error beyond a single video-bit period. Placing the error correction coders downstream from the scrambler avoided upsetting the burst-error correcting feature by scrambling.

The performance of this error-correction method was such that an actual random transmission-error rate of 1 in 10^5 was reduced in effect to a rate of about 1 in 10^8.

Audio coding

The 3.2Mbit/s between the bit-rate of the error-corrected video signal and the 60Mbit/s satellite channel capacity was used for audio signals, and for multiplexing and synchronisation. The audio coding equipment was designed to multiplex six high-quality 15kHz sound signals into 2048kbit/s (including audio synchronisation and error-protection signals) using "near-instantaneous" digital companding.[5] This is a companding technique in which, in this case, a block of 32 ten-bit sound-sample words is coded to a quantising accuracy which corresponds to 13, 12, 11 or 10 bits per sample depending upon the peak value of the audio signal occurring in the block of 32 samples. In the equipment used in the satellite experiments two of the possible six audio channels were equipped with coders and decoders.

Multiplexing

The audio multiplexer and demultiplexer were designed to give and receive a serial 2048kbit/s signal, coded and timed for interfacing with national and international digital transmission paths meeting CCITT standards. The 60Mbit/s video-audio multiplexer combined the serial 2048kbit/s signal with the parallel 56.8Mbit/s error-protected video signal, the latter being provided on six wires each bearing approximately 9.5Mbit/s. Because the protected video signal thus comprised six-bit words, it was convenient to form up the multiplex "frame" from six-bit words, some of them audio, most of them video, a few for synchronisation, and a few bits spare in some of them for auxiliary signalling. The frame length was 1800 bits (30μs).

To maintain the proper relationship between the output (60Mbit/s) and input bit-rates, without locking any of them together, the content of some of the synchronisation words was controlled to comprise either dummy data or real video or audio bits; this "elastic" timing method is known as "positive justification."

The 60Mbit/s output was then divided into the two serial 30Mbit/s signals and a clock signal to drive the Post Office q.p.s.k. modulator; similar signals were returned from the q.p.s.k. demodulator to the 60Mbit/s demultiplexer, as shown in Fig. 1.

Error and slip monitor

Perhaps the most important parameter to monitor on a digital transmission channel is the bit-error rate. It is a sensitive indicator of the state of most parts of the channel equipment and transmission path. The error-monitor module used in the experiments is shown in Fig. 2(c). Fed with data from the error-correction and multiplexing equipment, it gave a clear presentation of the overall error rate or error count, together with a display of lights and audible alarms to indicate bit-errors in the video (VID) and synchronising (FAW), signals, and slips in overall synchronisation (MUX) and synchronisation of video error-correction (PAR).

The test transmissions

For most of the test transmissions the slide-scanner in London was used as the video source, but some more critical tests were done using a BBC digital video waveform generator[6] located at Goonhilly. The audio source was usually a stereophonic tape-recorder at Goonhilly, replaying orchestral or piano music, but synthesised audio signals and live speech were also used, the latter chiefly as a commentary to accompany the transmitted video signals for tape-recording in London.

The elevation of the Goonhilly aerial beam above the horizon was necessarily small, namely about five degrees, which is about the smallest elevation for satisfactory analogue or digital transmission. Consequently, careful adjustment of parameters such as group-delay equalisation of filters was needed. When this was done, a bit-error rate of about 1 in 10^6 was attained, which was random in nature and adequate, using error protection, for high-quality picture and sound transmission. Indeed, with this channel condition, the video and audio qualities were negligibly affected by transmission to and from the satellite. This was shown by bridging across the transmission path at the 70MHz i.f. stage or at the 60Mbit/s BBC/PO interface.

A brief comparison was made between the picture quality attained with the 60Mbit/s package using six bits per video sample (h.d.p.c.m.) and that with an analogue f.m. arrangement provided by the Post Office, virtually the full bandwidth of one transponder on the satellite being occupied in both cases. The consensus was that, although both picture qualities were very good, the digital picture was slightly better than the f.m. picture. The absolute impairment of the digital picture was known from previous research to be "just perceptible," the salient feature of the impairment being a small loss of diagonal resolution, a characteristic of sub-Nyquist sampling. The salient impairment of the f.m. picture was slightly increased chrominance noise.

Conclusions

The informal subjective assessments of picture and sound quality obtained during the experiments suggested the long-term possibility of attaining slightly higher quality using digital techniques rather than analogue f.m. techniques, without requiring additional r.f. bandwidth or incurring unacceptable interference between satellite channels. This possibility will be studied further in the broader context of efficient use of satellite channels having usable r.f. bandwidths both narrower and wider than the 36MHz used in these experiments. However, the current use of equipment employing f.m. transmission techniques, which provides a service even under degraded propagation conditions or in reduced bandwidth situations such as two television channels per 36MHz transponder, makes it unlikely that analogue f.m. will be superseded by digital techniques in the near future.

Acknowledgements. The author acknowledges the valuable contributions to the experimental work made by a large number of colleagues in the BBC Research, Designs, and Communications Departments, and in the Telecommunications Development and Service Departments and External Telecommunications Executive of the UK Post Office. The permission of the BBC Director of Engineering to publish this paper is also acknowledged. The co-operation of the authorities responsible for Intelsat operations in providing free use of the satellite channel for the experiments was greatly appreciated.

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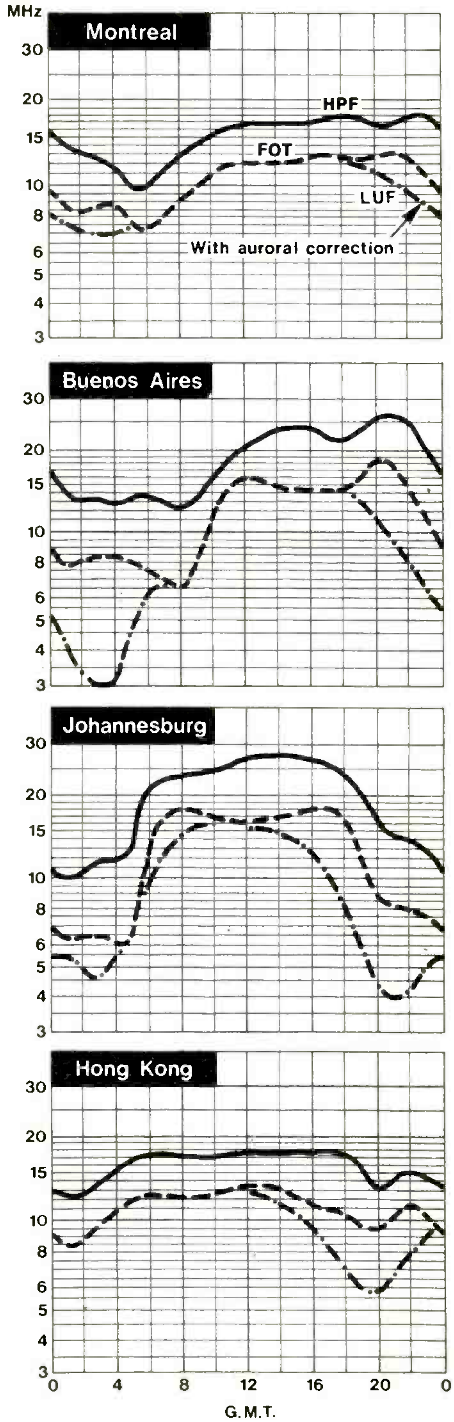
HF predictions

As an example of the use of the charts take reception of 14MHz. From South Africa the earliest that signals can be expected is 0500. Reception should always be possible between 0630 and 1830 but signal-to-noise ratio will be poor between 0730 and 1500. Fadeout will occur between 1830 and 2100.

From South America a skywave path should always be possible between 1100 and 2200 but a workable signal-to-noise ratio is likely only after 1900.

Availability of North America and the Far East will be erratic with generally poor signal-to-noise ratios.



Eliminating adjacent-channel interference

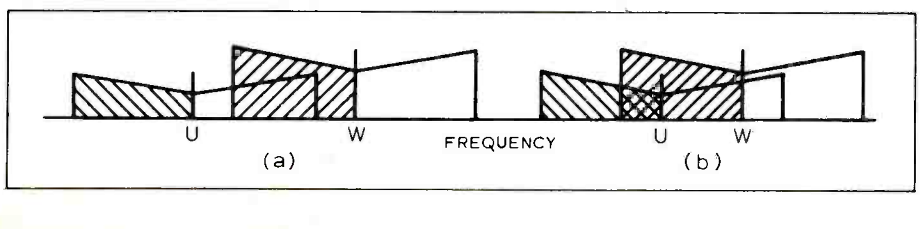
by P. L. Taylor, M.A., F.I.E.E., F.I.M.A., *University of Salford*

Adjacent-channel interference between amplitude-modulated signals can be overcome, even when the carrier frequencies are so close together that the sideband of one signal overlaps the carrier of the other.

The problem of adjacent-channel interference has been with us almost since radio communiction began. Fig. 1 illustrates the situation in which it arises: the carrier frequency of an unwanted amplitude-modulated signal *U* is too close to the carrier frequency of a wanted signal *W*. The result is that some of one sideband of *U* intrudes into the part of the spectrum occupied by *W*. A receiver tuned to *W* must have a pass-band sufficiently wide to accept the sidebands of *W*, and so cannot reject the unwanted sideband of *U*. The audible result, after detection, is unintelligible and annoying "sideband splash" or "monkey chatter" caused by the beating of the unwanted frequencies with the carrier of *W*.

If *U* is not too close to *W*, as in Fig. 1(a), then it is possible to design the receiver to accept only the "clean" sideband of *W* (which contains all the modulation information in itself) and to treat the result as a single-sideband signal; but this requires very sharp and precise filtering, which of course is expensive. If the two carrier frequencies are as close together as is shown in Fig. 1(b) it has been generally thought that there is nothing one can do about the situation. In addition to the monkey chatter one must put up with an inter-carrier whistle at the difference frequency between the two carriers.

Fig. 1. If the carrier of an unwanted signal U *is too close to that of a wanted signal* W *there is interference. In case (a) it is possible to filter out the "clean" sideband of* W*. Up to now it has been thought that nothing could be done in a situation such as (b).*



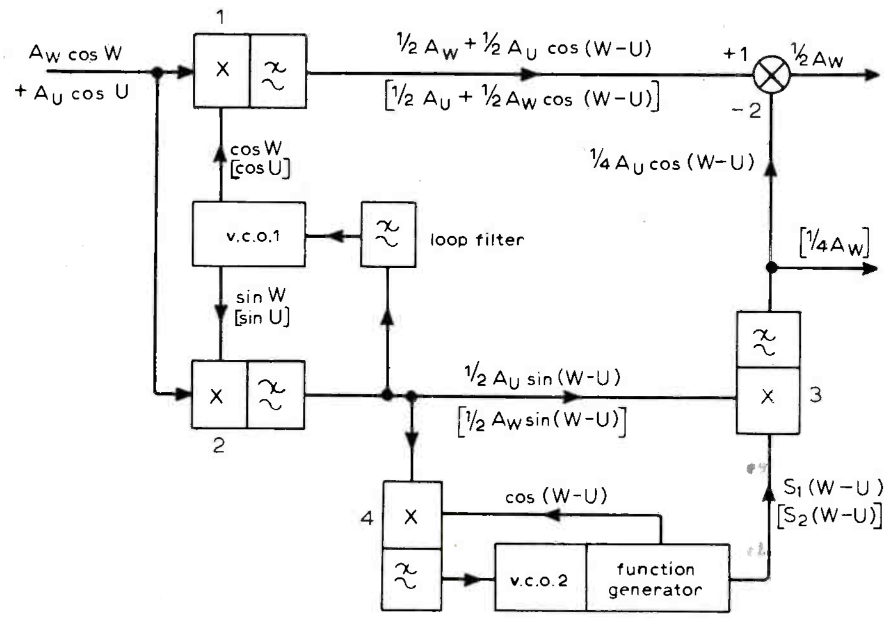


Fig. 2. Block diagram for both methods of overcoming interference.

Here are two methods[1,2] which provide solutions to the problem. Both begin with synchronous demodulation of the wanted signal, as in the homodyne and synchrodyne receivers.† For brevity, the wanted signal will be represented by $A_W \cos W$, where $W = 2\pi f_W t$, f_W being the frequency of the wanted carrier. Similarly, the unwanted signal will be represented by $A_U \cos U$. We want to recover A_W, uncontaminated by A_U.

In synchronous demodulation, the wanted carrier is multiplied by an oscillation having exactly the same frequency and phase. The result is

$$A_W \cos W \times \cos W = \tfrac{1}{2}A_W + \tfrac{1}{2}A_W \cos 2W$$

(Table I may be a helpful reminder).

Thus the wanted signal A_W is recovered, together with an oscillation at twice the carrier frequency, which is easily removed by filtering.

Table I

$\cos A \cos B = \frac{1}{2}\cos(A-B) + \frac{1}{2}\cos(A+B)$
$\sin A \sin B = \frac{1}{2}\cos(A-B) - \frac{1}{2}\cos(A+B)$
$\sin A \cos B = -\frac{1}{2}\sin(A-B) + \frac{1}{2}\sin(A+B)$

$\cos(-C) = \cos C$; $\sin(-C) = -\sin C$

First method

Figure 2 is the block diagram, in which the expressions in square brackets should be ignored, since they relate to

† *This is history repeating itself. When Professor Tucker did his work on the synchrodyne he was led to consider the present problem, and suggested an approximate solution. Some while ago the author was casting round for projects for his final-year undergraduate students and thought it might be interesting to see what could be made of the synchrodyne using modern technology. He, too, was led to consider the problem; this time the suggested solution is exact.*

the second method. The combined signals are applied to demodulator 1, where they are multiplied by cos W. The output of this demodulator (after filtering) is now $\frac{1}{2}A_W + \frac{1}{2}A_U \cos(W-U)$. The second term in this expression is the audible interference. The multiplier cos W is obtained from a voltage-controlled oscillator VCO_1 which is phase-locked to the wanted carrier via demodulator 2. VCO_1 produces quadrature outputs. The phase-lock loop will settle itself so that the v.c.o. output which is presented to demodulator 2 is in quadrature with the wanted signal, so this output must be represented by sin W and the quadrature output will be cos W. It is arranged that when capture has occurred the loop bandwidth is reduced to about 1Hz by extra filtering so that the oscillator is not disturbed by the other frequencies present in the signals. Also, the loop includes an integrator so that the phasing is exact.

Now the output of demodulator 2 contains the component $\frac{1}{2}A_U$ sin $(W-U)$, but no component involving A_W. The clue is too obvious to be missed: if the phase of this oscillation could be changed from sin $(W-U)$ to cos $(W-U)$ it could be used to cancel the unwanted component in the output of demodulator 1. This could be done by multiplying, in a third demodulator, by sin 2 $(W-U)$:

$$\tfrac{1}{2}A_U \sin(W-U) \times \sin 2(W-U) = \tfrac{1}{4}A_U \cos(W-U) - \tfrac{1}{4}A_U \cos 3(W-U)$$

Thus the desired phase-shifting has been accomplished but at the cost of introducing a 3rd-harmonic oscillation, and, if $(W-U)$ is small, it may not be possible to filter it out. But if $\frac{1}{2}A_U$ sin $(W-U)$ is multiplied by the series

$$S_1(W-U) = \sin 2(W-U) + \sin 4(W-U) + \dots + \sin 2n\,(W-U),$$

the result is:

$$\tfrac{1}{4}A_U \sin(W-U)\, S_1(W-U) = \tfrac{1}{4}A_U \cos(W-U) - \tfrac{1}{4}A_U \cos(2n+1)(W-U).$$

The intermediate products give rise to sum- and difference-frequency terms which cancel, leaving the interfering oscillation at a frequency which may be made as high as desired by a suitable choice of n; this oscillation may now be filtered out easily. Thus, the desired cancellation signal is obtained, and processing is completed as shown in Fig. 2.

A waveform, whose Fourier series components form $S_1(W-U)$, is obtained from a function generator which is described later. The generator is phase-locked via VCO_2 and demodulator 4 to the beat frequency $(W-U)$. Note that the series S_1 is one in which all the first $(n-1)$ harmonics are equal in amplitude to the fundamental, which has a frequency twice that of the beat frequency.

Second method

If the unwanted signal is stronger than the wanted signal it will probably be easier to lock VCO_1 on to the unwanted carrier, so that (taking the expressions in brackets in Fig. 2) the output of demodulator 2 becomes $\frac{1}{2}A_W$ sin $(W-U)$. Thus, the unwanted signal is rejected directly at this stage, but the problem now is that the wanted signal is modulated on a carrier frequency that lies within the audio range.

The wanted signal could be demodulated by multiplying by sin $(W-U)$:

$$\tfrac{1}{2}A_W \sin(W-U) \times \sin(W-U) = \tfrac{1}{4}A_W - \tfrac{1}{4}A_W \cos 2(W-U)$$

but this introduces an interfering oscillation, at twice the beat frequency, which may still be too low to filter out. But if $\frac{1}{2}A_W$ sin $(W-U)$ is multiplied by the series

$$S_2(W-U) = \sin(W-U) + \sin 2(W-U) + \dots + \sin(2n+1)(W-U)$$

the result is

$$\tfrac{1}{2}A_W \sin(W-U) S_2(W-U) = \tfrac{1}{4}A_W - \tfrac{1}{4}A_W \cos(2n+2)(W-U).$$

The intermediate products give rise to sum- and difference-frequency terms which cancel, leaving the interfering oscillation at a frequency which may be made as high as desired by suitable choice of n; it is thus easily filtered out. In this method the wanted signal is taken from the output of demodulator 3.

Function generation

It would be possible to generate the series S_1 or S_2 by taking a number of oscillators, of appropriate harmonic frequencies, and phase-locking them together and to the beat frequency $(W-U)$. But this would be clumsy, and would also require that the demodulator 3 should be a true multiplier. The simplicity of a switching demodulator may be retained as follows.

In normal use a switching demodulator acts to change the sign of the signal to be demodulated in step with alternate half-cycles of the multiplier oscillation. That is, it effectively multiplies the signal by a square wave switching function f, drawn as the solid line in Fig. 3, which alternates between the values +1 and −1 with the same period T as the multiplier oscillation. As drawn in Fig. 3, the function f is odd (in the mathematical sense), that is, $f(-t) = -f(t)$, and the graph has rotational symmetry about the point $t = 0$. Hence its Fourier series consists of odd functions (sine terms) only:

$$f(t) = \frac{4}{\pi}\left[\frac{2\pi}{T} + \frac{1}{3}\sin 3\frac{2\pi}{T} + \frac{1}{5}\sin 5\frac{2\pi}{T} + \dots\right]$$

Thus, the demodulator does multiply the signal by the required frequency (the first term in the series). It also multiplies by the higher frequencies in the series, but the results are usually filtered out.

Now, suppose that two extra edges are introduced, at t_1 and t_2, to give the dotted wave. Since S_1 consists only of sine terms the rotational symmetry must be preserved, by introducing corresponding edges at $-t_1$ and $-t_2$. Now t_1 and t_2 can be chosen at will; the question is, can we choose them so that the first two harmonics of the new waveform have amplitudes equal to the fundamental? The answer is yes, and the result is quite general: if n extra edges are introduced, then the first n harmonics can be made to have amplitudes equal to the fundamental.

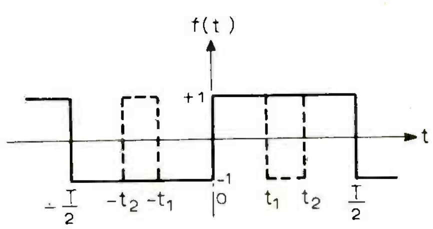
The correct instants $t_1, t_2 \dots t_n$ are found as follows. The expression for the Fourier series of the new waveform is found in the usual way, and from it the conditions that the coefficients of the first n harmonics shall be equal are found. This results in a set of simultaneous equations in the unknown t. However, the equations are non-linear, so the solution of them is best entrusted to a computer.

Thus a square waveform can be designed such that the first terms in its Fourier series form S_1. A similar argument leads to a waveform the terms of which form S_2. There is a small complication in this case because only the odd harmonics are required. Both series continue with higher-order terms, but these do not matter because the unwanted products to which they give rise will be filtered out anyway.

The waveforms may be generated quite easily by digital techniques. VCO_2 is made a high-frequency oscillator, the cycles of which are presented to a digital counter. The counter output is presented in turn to a number of digital comparators (one for each edge) which are hard-wired with numbers defining the instants at which the edges occur. Whenever a coincidence is detected, an edge is generated by triggering a bi-stable.

In an alternative method, numbers representing the *differences* between successive edges are placed in a read-only memory (r.o.m.). A presettable counter is loaded with the first number, and is counted down to zero by VCO_2. When zero is reached an edge is generated, the number in the next address in the r.o.m. is loaded into the counter and so on until the cycle is

Fig. 3. Illustrating the derivation of the special switching functions.



completed and control is returned to the first address in the r.o.m. This method is more economical of hardware, and more flexible because the numbers for several series can be stored in one r.o.m. Any waveform can be selected simply by choosing the appropriate starting address.

Sidebands

Though the mathematical analysis given above indicates that the methods should work, and experiment shows that they do work, it is not so far clear exactly how it is that the overlapping sidebands are disentangled.

Take as an example the first method. Suppose that initially VCO_1 has not locked on to the wanted signal, but is running at some frequency F higher than W. The output of both demodulators 1 and 2 is a group of signals at the sum- and difference-frequencies, as in Fig. 4(a). Only the lower frequency group is retained; the other is eliminated by the low-pass filter.

Now suppose that F is reduced towards W. The lower frequency group moves towards zero frequency and a stage is reached when some of the sideband frequencies of the wanted signal should become negative, as shown at (i) in Fig. 4(b). The practical effect differs in the two demodulators. In the case of demodulator 1 the product is cos $W \times \cos F$, and therefore is also a cosine. The cosine of a negative quantity is the same as the cosine of the same positive quantity (see Table I) so the negative frequency components are reflected about zero frequency, without change of sign, to become positive frequency components as shown at (ii). In demodulator 2, which is multiplying cos $W \times \sin F$, the output is a sine; and the sine of a negative quantity is minus the sine of the same positive quantity, so in this case the reflected components must be shown as negative, as at (iii).

Finally, let F be reduced to equal W so that VCO_1 locks. In the output of demodulator 1 the lower sideband of the wanted signal folds back to reinforce the upper sideband, and both now start from zero frequency, i.e. the wanted signal is demodulated. This is shown in Fig. 4(c). The unwanted signal is modulated on to the beat frequency $(W-U)$ and its lower sideband is folded back. In the output of demodulator 2, Fig. 4(d), the sidebands of the wanted signal exactly *cancel* each other, being of opposite sign, so the wanted signal does not appear in the output of this demodulator.

Now consider the effect of multiplying (d) by the series S_1. The resulting spectrum of the output of demodulator 3 is shown at (e). First, there are sum- and difference-components centred on the frequency of the first term in the series, $2(W-U)$. We are now dealing with a sine×sine product, which is a cosine, so the part of the lowest sideband which is partially reflected about zero is reflected without change

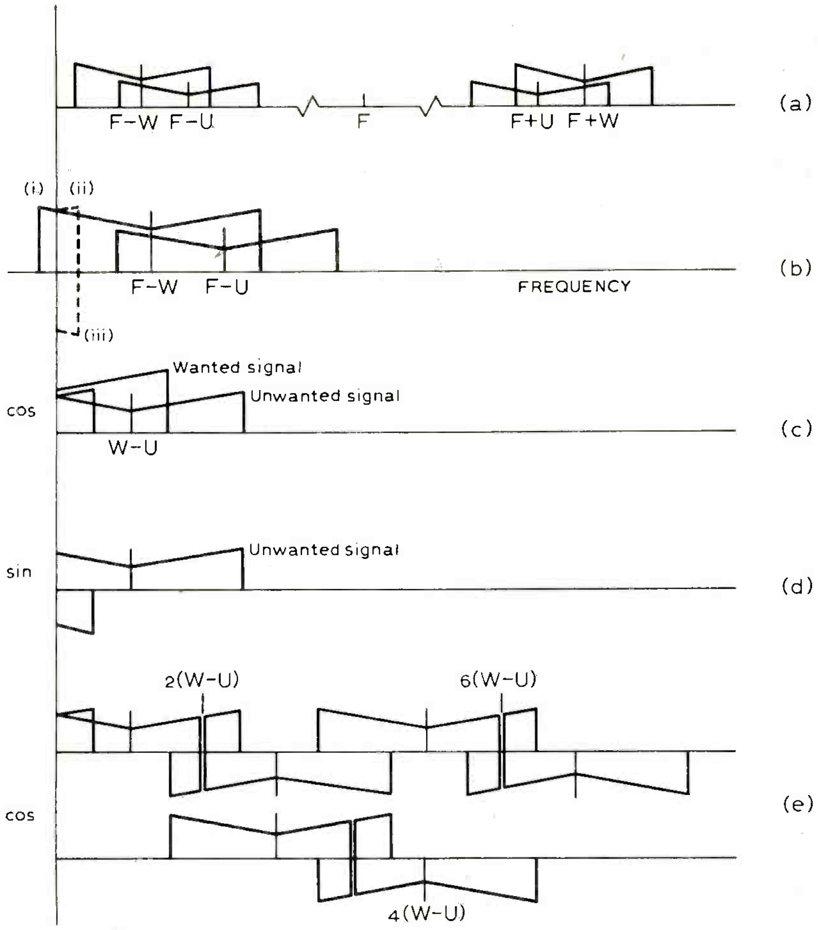


Fig. 4. (a) Result of multiplying the incoming signals by a frequency F *greater than* W. *(b) If* F *is only slightly greater than* W *some reflection of the lower sideband occurs. (c), (d) Outputs of demodulators 1 and 2 respectively when* F = W. *(e) The result of multiplying (d) by the series* S_1.

of sign; and the sum-frequency components have a negative sign.

For clarity, the sum- and difference-frequency components centred on the frequency of the next term, $4(W-U)$, are shown on a lower line. The diagram is drawn for the case where it is necessary to go only as far as the third term in the series, of frequency $6(W-U)$. When all the various bands are added together there is a lot of mutual cancellation; there are left only the lowest group of frequencies, which are now of the right form for subtraction from (c), and the highest group; in between there is a big gap, so that filtering out the highest group is easy.

The foregoing description makes it clear that the methods are really exploiting the fact that an a.m. signal has two symmetrical sidebands to effect mutual cancellation of unwanted signals. It is also clear that the cancellation will be less than exact if the sidebands suffer differential gain and/or phase shift in their passage through the r.f. and i.f. stages of a receiver. It is unlikely, therefore, that these methods will form a satisfactory basis for an "add-on" unit for an existing receiver, in which these aspects of performance will probably not have received much attention. It is also clear that, unfortunately, they will not work for s.s.b.!

I am very grateful to Mr L. J. Unsworth for constructing the experimental apparatus in which these ideas were tested.

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2. Taylor, P. L. 'Methods of separating overlapping amplitude-modulated signals', *Electronics Letters*, 19th August 1976, **12**, 17, pp. 424-425.
3. Tucker, D. G. 'The history of the homodyne and synchrodyne', *J. Brit. I.R.E.*, April 1954, **14**, pp. 143-154.

Space shuttle comms

The Battelle Institute say the communications industry could save millions of dollars in the 1980s if their satellites used the space transportation system of which the shuttle is a part. A NASA funded study is being carried out at Battelle's Columbus Laboratories with five satellite manufacturers to make their systems compatible with s.t.s.

Letters to the Editor

ANNAN AND CABLE

The Annan Committee was asked to report, among other things, on the future technology of broadcasting and any changes in organisation which would be required as a result. It was perhaps a silly question to put to a group of academics, politicians, trade unionists and assorted odd bodies and it has drawn a silly answer. At the time of its appointment some senior engineers in broadcasting recommended that it should have a technical sub-committee which could keep it straight on the facts and prevent it from having the wool pulled over its eyes by important people with their own interests to serve. That this, unfortunately — but inevitably — has happened is shown most clearly by the Committee's report on cable. They accept, quite correctly, that the future of broadcasting lies primarily in cable and that the next 15 years will be the swan-song of conventional broadcasting (paragraph 25.2); but they provide no guidance as to how the inevitable transfer from wireless to wire might be made and prefer to leave it all to the woolly generalisation of the Post Office about the possibilities of integrated national networks in the late 1990s.

How little they have understood the technology of cable is clear from their reference (paragraph 25.41) to broad band Post Office systems on the one hand and private narrow band networks on the other. The Post Office system in Milton Keynes, to which so much importance is attached, is a conventional f.d.m. type using a v.h.f. trunk network with final distribution at v.h.f. for 405 lines and sound programmes and at u.h.f. for 625 lines. It is no "broader" than anybody else's network of that type and nothing like as "broad" as the switched h.f. system which has been developed in the private sector.

In short, the Committee was overcome by the air of unchallengeable authority in which the Post Office managed to present themselves and refused to allow that the people of this country should be permitted — while waiting for the Post Office's new millennium — to pay the existing cable operators for a wider choice of programmes if they wanted to. In spite of all their expressed desire for diversity and the claim that "we act in accordance with the concept of pluralism which has been the leitmotiv of all of us in this Report", they have rejected for no discernible reason the one immediate possibility of achieving those ends. A possibility, moreover, which involves no cost to anybody except those who wish to pay for more diversity and those who are prepared to risk their own money in providing it.

This is the answer to those, including both Annan and yourself in last month's issue, who quote the cost of a national broad band network from the Technical Sub-Committee of the Television Advisory Committee and rule it all out because we cannot afford a billion. Nobody is suggesting we should but, even so, it does not sound so much when related to the 6 billion which we are cheerfully spending to equip ourselves for colour. What is suggested is that the investment already made in networks with a capacity of six channels or more should be put to use so that the public can decide what extra services, if any, it will support. When we know that, the basis of any further investment in cable will be secure.

Having recognised both the importance of cable for the future and the need to conserve the frequency spectrum, one might have expected the Committee to look with some care at the proposal that the remains of Phase I of the u.h.f. transmitter programme covering groups of population exceeding 1,000 and Phase II for populations between 500 and 1,000, might employ wire instead of wireless wherever it was simpler and cheaper to do so. This proposal was first made by the TAC/TSC in 1972 and was supported by the Crawford Committee in November 1974. Nothing has happened, mainly because there is a genuine difficulty about how such cable networks might be financed. Everyone concerned had hoped that the Annan Committee might make some sensible recommendation for finance and administration but all they do is to propose that Phase II should be completed at once by transmitters at a cost of £114 per person or over £300 per home covered. That is around five times as much as it would cost to do the job by cable which would also avoid altogether the need for still more space for broadcasting in the frequency spectrum. Here again, they have simply bowed to the authority of the BBC with its insatiable appetite for the frequency spectrum and its determined view of cable as a rival instead of an ally and a source of extra revenue for them which it so easily could be.

As you say, the proposal for a telecommunications advisory committee to determine national policy for all telecommunications, not only broadcasting, is overdue and very welcome. Considering its importance and the intensity of the opposition such a proposal will meet from the heavily entrenched broadcasting and telecommunications establishments, it is a pity that the Committee did not devote more than the odd paragraph or two to the reasons for it and the form it should take.

R. P. Gabriel,
Rediffusion Ltd,
London, SW1.

IMPROVING MATRIX H SURROUND-SOUND?

Reading the surround-sound articles in *Wireless World*, 45J by Michael Gerzon in April 1977, and Matrix H by Dr P A. Ratliff and D. J. Meares in May 1977, it is apparent that the main difference between the two systems is the effect of the coding of the back sector sounds.

In Matrix H the better mono and stereo compatibility of a bent locus is considered more important, whilst in 45J the listener with a surround-sound decoder is favoured with the improved side image localization and ambience reproduction of a circle locus (whose side view on the energy sphere is a straight line).

Those who have to choose between the two systems will resort, inevitably, to decision by committee.

However, Michael Gerzon mentions other properties of 45J coding which are not referred to in the BBC article and which, if incorporated, might offer in improvement to Matrix H coding. If my understanding is correct they are:

1. Reduce the centre-front interchannel phase angle from 48° to 45° to improve the stereo phasiness of front-sector sounds and to improve mono compatibility.

2. Reduce the curvature of the pan locus until it just touches the "speaker position" curve and, therefore, no longer goes through the left-only and right-only points. If the circle locus of 45J is better than a bent locus for ambience reproduction, it is intuitively obvious that reducing the curvature of the Matrix H locus will improve its ambience reproduction.

3. Optimize the distribution of the different encoded directions within the elliptical cross-section of the pan locus, to improve the reproduced ambience in surround-sound and to widen the stereo presentation for front stage sounds and, therefore, improve the stereo compatibility.

Perhaps the BBC men would be kind enough to comment, favourably or otherwise.

Andrew Sturt,
London Weekend Television,
London, SE1.

RADIO SETS OF THE FUTURE

Further to the interesting article by Duncan MacEwan in the May issue ("Radio in the '80s"), the following observations come to mind.

The average listener to the portable radio of today probably doesn't find station finding very difficult, and just listens to background music on Radio 1 or 2 all the time.

Is there really a need for a "better" portable set with improved f.m. reception (for the serious listener)? This probably couldn't be all that cheap: for a few pounds more he or she could obtain a budget priced hi-fi tuner-amplifier and get far better results if "serious" music listening is the object.

What I suggest we do not need is legislation, the effect of which is costly, and multi-channel push-button complicated receivers that are not wanted or necessary, that could spring into life when the great gods news and sport come on the air every few minutes!

There is room for improved, easily readable printed information on programmes: the poor design, layout, typography and general presentation of the *Radio Times* is perhaps the obvious example.

E. Gilbert,
London N18.

Mr MacEwan replies:

I think Mr Gilbert may be overestimating people's ability to find their way around the crowded dial; certainly our own extensive Audience Research supports this. Radio has to be interested in not only the average litener, but in the others including potential listeners. Radio 3 has a weekly patronage figure of 5 million people, Radio 4 a daily following of 6 million and Local Radio about 2 million; the BBC has no wish to neglect what our correspondent might regard as minorities – quite the reverse.

I believe there is a growing market for the higher quality portable – listening in the kitchen, study or bedroom should surely not be confined to narrow band a.m. transmissions or limited to daylight hours – and what of the music lover, those following educational courses, etc. Radio today is very much about choice – choice of programme and choice of quality.

On the *Radio Times* issue he makes a fair point, but the truth of the matter is that the extra page (or even two pages which would be necessary to meet his wishes and mine) would change the journal's balance sheet from a fairly healthy if faint black colour to a very bright red and that the BBC cannot afford.

Duncan MacEwan.

DIGITAL FILTERS USING MICROPROCESSORS

It was with great interest that I read recently V. J. Rees' article "Digital filter design" in your October 1976 issue. I am impressed with much of what he said. With a variety of digital filtration algorithms available, it is indeed useful to check out the response to a simple sawtooth or square-wave input, whether aided by calculator or computer. Not only does this, as Gérald Garon (Letters, May issue) indicates, increase understanding, it may also point out some of the pitfalls. In V. J. Rees' example the input was a ±10V 50Hz sawtooth, the single-pole low-pass filter had a turnover frequency of 180/πHz and the sampling period was 1ms. In Fig. 1 I have drawn the actual filter response as the smooth solid curve. The algorithm used by V. J. Rees was:

$$V_0 = AV_1 + BV_0' \qquad (1)$$

with $A = \tau/CR = k$, and $B = e^{-\tau/CR} = e^{-k}$, where V_1 and V_0 are the input and output voltages for the present sample, V'_0 is the output in the previous sample, τ is the sampling period and CR the time constant of the filter. Taking V. J. Rees' figures, I have plotted out the result of formula (1) as a staircase – as the output of one's d.-to-a. converter would be. The error at the peaks is over 20%. The performance of formula (1) would indeed correspond to the theoretical curve if k were small – like 0.01. In practice one can rarely afford the luxury of such a high sampling rate. Normally, either one's computer is too slow or a great deal of other real-time signal processing is required as well as the filtration.

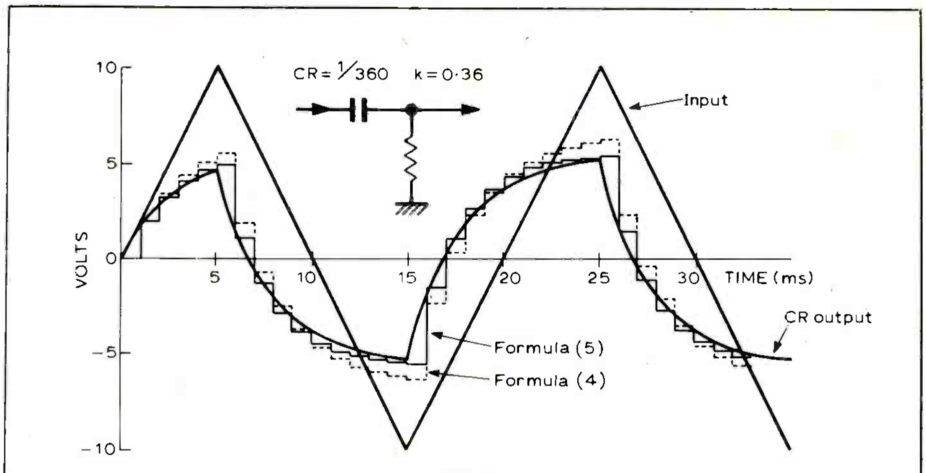


Fig 2

An alternative low pass algorithm is as follows:

$$V_0 = AV_1 + BV_0' \qquad (2)$$

with $A = 1 - e^{-k}$, $B = e^{-k}$ and $k = \tau/CR$.

The performance of this formula is shown as the solid staircase in Fig. 1. Not only is formula (2) much more accurate at sizeable values of k but, as shown by Gérald Garon, it is also faster when rearranged to use only one multiplication:

$$V_0 = {}_1 - C(V - V'_0) \qquad (3)$$

with $C = e - k$ Gérald Garon also obtained in his elegant M6800 programme a "high pass" output as well as the low pass output of formula (3). This high pass algorithm may be written:

$$V_0 = V_1 - V'_1 + BV_0 \qquad (4)$$

with $B = e^{-k}$ where V'_1 is input in previous sample (4)

In Fig. 2 I have again used the sawtooth input and kept τ and CR at the same 1ms and 1/360 respectively. Again the response of the capacitor and resistor high pass filter is shown as the solid curve (also courtesy a PD P12). The effect of formula (4) is indicated by the dotted staircase. Once more there are errors of nearly 20% at the peaks. A rather more accurate high pass formula that still only requires one multiplication is:

$$V_0 = V_1 - V_1' + BV_0' \qquad \text{with } B = 1 - k \qquad (5)$$

Formula (5) is plotted as the solid staircase in Fig. 2 – the errors at the peaks seem to be around 4%.

Finally, I'd just like to add the filtration of e.e.g. to the list of applications where a "slow" microprocessor like the M6800 has proved adequate. In a 2ms sampling period there is still plenty of time left over for other useful processing.

T. A. Perkins,
MRC Neurological Prostheses Unit,
London, SE5.

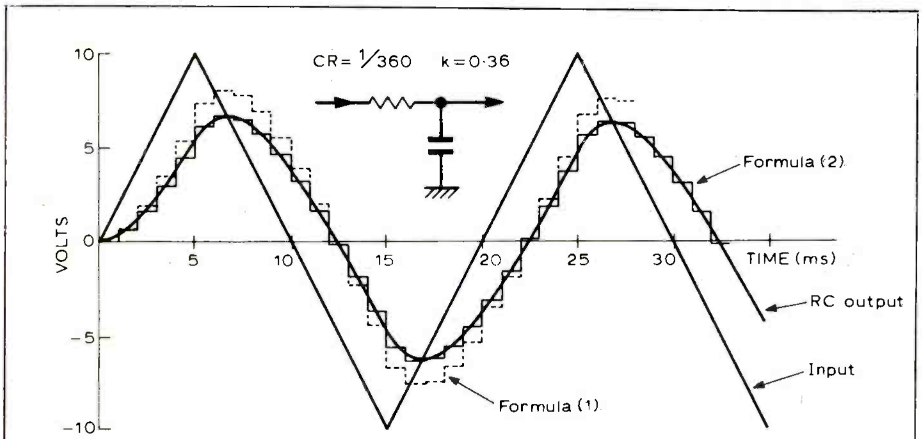


Fig 1

REVIVING NICKEL-CADMIUM CELLS

I ran across Mr Johnson's article on reviving NiCd cells in the February issue and used the method successfully to rejuvenate a set of four cells which had been in the discard bin for some months.

These four AA cells had perished when a young visitor left my pocket calculator on, a fact which went unnoticed for a week or so. When I found they would then not hold a charge, they were replaced and left on the back of the bench for about six months. After reading the article, I checked them and, sure enough, each cell was shorted and read zero volts.

I first processed one cell as described, with a battery charger as the current source and an ammeter as the load – the only deviation being that the low-current was removed during the high-current phases. The cell came "unstuck" after the first jolt, eventually responded to the overcharge state, and provided 500 mAh on slow discharge. I then processed the other three cells as a series unit and achieved the same results, in much less time than it would have taken to do each one individually. Perhaps I was fortunate in having cells in approximately the same condition.

After a 24-hour normal 50mA charge, all four cells in series were drained across a dummy load at 50mA, and lasted close to eleven hours, with the No. 1 cell going dead first. Two more charge-discharge cycles were then tried, this time with a portable radio drawing 10-15 mA as a load; with intermittent use of 4-5 hours per day, the cells provided approximately 500mAh each time, with the No 2 cell going dead first in these cases. Fully charged voltage was 1.30V (1.35 in overcharged state); at the time of one cell going down the remaining three read 1.25-1.27V.

The cells are completely anonymous, no type of manufacturer's marking, so I do not know what quality they represent. The fact is, though, that thanks to Mr Johnson's article, they represent a handsome salvage.

B. G. Doutre,
Montreal,
Quebec, Canada.

LONG WAVES FOR AMATEURS?

Mr May's announcement (Letters, May issue) that he is "normally in favour of amateur radio" must have caused all amateurs to read the rest of his letter with justifiable suspicion.

His present approval, or disapproval, of us appears to be based on a lamentable lack of research. It is a shame to see in the pages of *Wireless World* the suggestion that amateur radio is "just for low power local broadcasting." We will happily accept the accusation that we use low power, indeed we do so with a certain pride in our aerial systems and operating techniques. On the other hand we must point out that contacts with the antipodes are routine and that amateur signals have been bounced off the Moon, which is hardly local! The use of the term "broadcasting" instead of "transmitting" displays an almost unbelievable ignorance and must have upset many people, including, no doubt, some at the Home Office.

In reply to Mr May's warning about interference, we can only point out that amateurs have learnt to live with interference from domestic machines and broadcast stations as well as from each other. We often operate on channels the professionals would describe as unusable.

It may be recalled that in the early days of radio the amateurs were given frequencies thought to be too high for "serious" use. It is tempting, but inaccurate, to draw a parallel here; we merely suggest that anyone truly concerned that the very low frequencies are being underrated could do worse than give them to radio amateurs.

N. R. W. Long (G4BIN), J. G. Morgan (G3ZHL) and R. A. L. Williams (G4EAL),
Cambridge University Wireless Society.

INTERFERENCE FROM AMATEUR STATIONS

Sporadic listening to professional usage of the "ether" leaves me with the impression that interference by amateurs is but a drop in the ocean of the problem as a whole. I look forward anyway to the second part of the article by I. Jackson in the issue of March 1977 [see June issue — Ed.]. In the meantime, you can see from the enclosed cutting from the *Electrician* of February 9, 1912, that, like the poor, interference by amateurs has always been with us.

"Wireless Telegraph Notes. — *The "Electrical World" states that an investigation of the extent of interference by amateur wireless-telegraph operators in the transmission of legitimate messages between ship and shore stations has been undertaken by the United States Navy Department. The immediate cause of the investigation was a delay of more than one hour in the transmission of messages of distress from the torpedo-boat destroyer "Terry". During this delay the wireless-telegraph apparatus on the vessel was disabled, and the exact position of the ship in distress could not be ascertained. It is estimated that at least 500 stations are in use and owned by amateur operators in the neighbourhood of New York."*

Or is it that amateurs have always been a vulnerable minority, and therefore a convenient scapegoat? Having no personal involvement, I could wish only that *all* users of the radio spectrum would turn over a new leaf, starting with the commercial stations that sit on top of the standard frequency transmissions. Blatant use of 2182kHz for personal chit-chat during the silent listening periods is not at all uncommon, almost certainly maritime mobile users fouling their own nest. And yet there are parts of the radio spectrum which get very little use at all!

Desmond Thackeray,
Department of Chemical Physics,
University of Surrey,
Guildford.

AURAL SENSITIVITY TO PHASE

Though I believe that the effects of phase shift on the waveform and the sound quality of the signal in a monaural channel are of no importance provided that the concomitant time delays stay within the CCIR limits, Mr Lipshitz's letter in the May issue draws attention to one of the many situations where phase shifts are of importance in their effect on sound quality. There are many others.

It has long been the practice of amplifier designers to arrange for the compensation of distortion between the stages in an amplifier by adjusting the operating conditions of successive stages to allow the distortion introduced by one stage to be reduced by the introduction of distortion in the opposite phase by the following stage, the explanation of Mr Lipshitz's results. Similarly, it has been the practice of recording engineers to minimise the peak signal amplitudes and hence the amplitude dependent distortions by appropriate phasing of the signal components. These phase dependent distortion compensating effects make it difficult to measure and specify the amplitude distortion in any good f.m. receiver. The distortion introduced by the best signal generators is of the same order as that introduced by the best current receivers and in consequence the measured overall distortion may vary between almost zero and twice that introduced by the receiver, depending upon the relative phase of the distortion introduced by generator and tuner.

The sound quality of a loudspeaker is subtly dependent upon the relative polarity (phase) of the studio microphone and the listener's loudspeaker but, unless equipment of professional quality is used throughout, the effect is extremely difficult to detect, in part because it is critically dependent upon volume setting.

These are some of the many situations where phase shifts may introduce audible effects but little use can be made of this by the ordinary user, for the distortion cancellation is dependent upon the relative phase and relative amplitude of the recorder-reproducer distortions.

Mr Lipshitz's letter draws attention to a situation where nature anticipated engineers in this practice of distortion cancellation. It has long been known that the negative and positive peaks in ordinary conversation speech are of unequal amplitude, but nature apparently arranged this to compensate for the non-linear stiffness relation of the ear drum. Which effect came first is difficult to identify.

James Moir,
Chipperfield,
Herts.

I suggest that if one regards the ear as a non-linear transducer followed by a set of high-Q tuned circuits each driving a mean amplitude meter, the outputs of which are separately sent to the brain, all arguments are resolved and all observations and tests accounted for, are they not?

As far as the brain is concerned it only receives one parameter for each frequency, namely amplitude of the signal arriving at the resonator; it receives no information concerning phase. However, when a sine wave arrives at the ear, because of non-linearity it produces its own harmonics. if now for example a given amplitude of second harmonic is added to the signal this will be reinforced or reduced in amplitude by the time it reaches the inner ear by the harmonic of the original signal produced by the distortion of the first stage of the ear. In this sense the ear is phase sensitive, as altering the *phase* of the 2nd harmonic fed to the outer ear alters the *amplitude* of the second harmonic received by the inner ear.

If, however, we have a generator in which we can control the amplitude of all the harmonics, after altering the phase of one or more we can usually by altering the amplitude only of these and the other harmonics apparently reproduce the original sound. This is because changes in amplitude of applied signal correct for the changed cancellation reinforcement pattern of the "ear produced" harmonics. In this sense the ear is not phase sensitive.

There are cases when this is not true. If for example the amount of second harmonic applied is of the right amplitude and phase to cancel the ear-produced 2nd harmonic, the amount of this arriving at the inner ear will be nil. If we now alter the phase of the 2nd harmonic from our speaker, cancellation will no longer take place and second harmonic will reach the inner ear. No amount of change of amplitude will cause the amount of second harmonic reaching the inner ear to be reduced to zero.

One cannot answer the question "is the ear sensitive to phase?" by a yes/no answer, only by "the inner ear is insensitive to phase but the outer ear distorts".

J. H. Asbery,
Wembley,
Middlesex.

Perhaps I may be allowed to reply to Mr Coleman's letter in the February 1977 issue, even in isolation from the long correspondence on aural phase sensitivity. There is, I think, very little in that letter which relates to his earlier convictions (as expressed in September 1976 letters), whilst those few points he chooses to expand from my reply in December 1976 show further misconceptions or even mistakes.

The phasor representation of amplitude and angle defines the variation of output amplitude and phase of a linear realisable system to an input sinusoid, to which it is responding in the steady-state. In this condition, any characteristic phase advance or delay may be assigned. The concept may be extended to isolated waveforms, wherein the Fourier Integral allows the response of the system in the transient state to be described in terms of its steady-state characteristics. There are cases, for example in simultaneous amplitude and angle modulation, where the concept of instantaneous phase may be defined, though this cannot be done simply by specifying an elementary reference time. If Mr Coleman wishes to attach any meaning to system phase other than the widely accepted one, he should specify the conditions and give his own reasons for doing so.

I am content to be identified with James Moir, in a commonsense approach to resolving any problem; in teaching or in research, to picture a problem in another domain may help its understanding, which is advantageous. Commonsense is not born of ignorance, as Mr Coleman would seem to baffle your readers into accepting; it is a quality by which the truly knowledgeable scientist may be distinguished from the untrained academic mind.

My grasp of basic principles is not so uncertain that I could believe Coleman's claim that "tone bursts which differ in the framing of phase of the sine wave with respect to the burst envelope have spectra of different shapes." A little commonsense would reveal that by shifting the carrier with respect to the pulse train in this waveform a simple linear phase shift of all spectral lines is produced, as was the purpose of my experiment. Hence it is Mr Coleman's conclusions which are invalid, not mine.

Roger C. Driscoll,
The Polytechnic of North London,
London, N7.

TRANSIENT INTERMODULATION DISTORTION

I would like to comment on the very informative article on transient intermodulation distortion by Bert Sundqvist published in your February 1977 issue.

He has shown by analysis that in order to prevent transient intermodulation distortion in an amplifier, the method proposed by Professor M. Otala[1] (that of extended open-loop bandwidth in the power amplifier with subsequent passive band limiting in the preamplifier) need not be adhered to rigidly and the simpler method of band limiting the first stage of the amplifier achieves the same result. He suggested three methods for producing this band limiting: (1) input lag compensation, (2) use of a high-impedance current source as collector load, (3) operation of the first stage with a very low collector current. Of these, however, only the third seems to be new, as far as preventing transient intermodulation distortion is concerned.

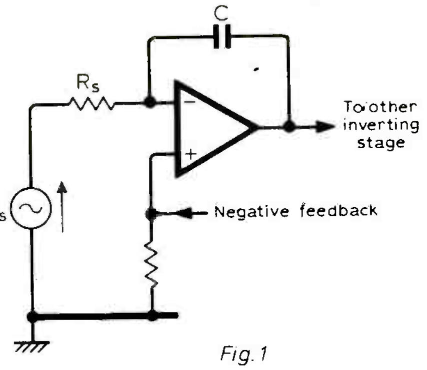


Fig. 1

To see why this is so, consider the frequency limiting mechanisms at work in the basic common emitter stage. There are mainly two. Firstly, the transfer mechanism, which is a physical motion of charge carriers, introduces dispersion and delay of the carriers and this results in the fall off of current gain (produces f_t). Secondly, existing between the various terminals of the transistor are frequency dependent impedances that are predominantly capacitive and these contribute to frequency limiting.

Considering Fig. 1, *C* represents the collector to base capacitance of the common emitter stage. Using Miller's theorem, this capacitance can be replaced by C_1 and C_2 as shown in Fig. 2, where A_v is the voltage gain between the inverting input and output

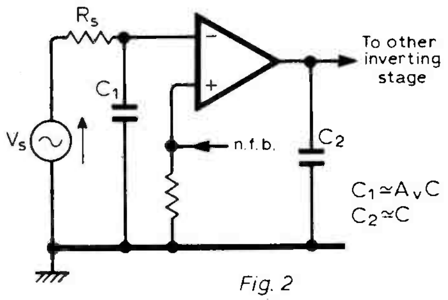


Fig. 2

(corresponding to the base and collector of the transistor). The time constant introduced by R_s and C_1 produces a dominant pole, and in general this is the mechanism that produces frequency roll-off in the common emitter stage. Input stage lag compensation increases *C* and a very high-impedance collector load increases A_v. Both result in a reduction of the bandwidth of the resulting input *RC* network. However, this *RC* network lies outside the loop of the feedback amplifier of which this stage is a part and indeed corresponds to the passive *RC* filter that Professor Otala recommends be placed before the input of power amplifiers in order to prevent the transmission of frequencies outside their open-loop bandwidths.

Thus, the only new technique which the results of Mr Sundqvist's analysis has uncovered is the reduction of the cut-off frequency of the input transistor which can be done by lowering the collector current, as he suggests. In fact, this method is more directly as a result of his analysis since the first pole within the loop encountered by an input signal is that due to fall-off of current gain of the input transistor.

Stephan Gift,
University of the West Indies,
St Augustine, Trinidad.

Reference

1. M. Otala, J. Lohstroh. An Audio Power Amplifier for Ultimate Quality Requirements, *IEEE Transactions on Audio*, vol. AU-21, no. 6, December 1973.

Mr Sundqvist replies:

I would like to thank Mr Gift for his clear explanation of the input stage frequency roll-off mechanisms. When I wrote my article I had not yet considered the details of how the frequency roll-off should be effected in practice. However, I would suggest that any band limiting procedure that gives a high input capacitance should be avoided, as this could give trouble when using a pre-amplifier with high output impedance, especially in combination with long connecting cables.

I have two other comments on my article which could be of interest to the readers. Using the original Otala design method, one ends up with a power amplifier with very wide bandwidth. However, the total audio system bandwidth is still limited by the pre-amplifier roll-off at 20-30 kHz. Although I do not think that an excessively large bandwidth is always desirable, this has always seemed to me to be a waste of good design work. Using the method outlined in my article the system bandwidth can be made as large or small as desired, as no frequency limits are involved in the design.

I would also like to point out that there are other methods to avoid t.i.m. without using Professor Otala's design method. My article was written in January, 1976, and since then Malmqvist[1] has published an interesting analysis of why t.i.m. is not produced by the Xelex range of amplifiers in spite of their relatively heavy feedback.

Bert Sundqvist,
Umeo,
Sweden.

Reference

1. M. Malmqvist, "Transient distortion", *Musiktidningen*, vol. 4, no. 4, p.53, Aug. 1976 (in Swedish); presented at the 56th AES Convention, Paris, March 1977.

INDUSTRIAL CONSULTANCIES IN UNIVERSITIES

I noticed with interest your article in the February 1977 issue on the "Crisis in scientific and engineering education," and am writing to comment on certain statements made in the article.

Most of the universities in the UK have established industrial consultancy or liaison offices of one kind or another. The current count is some 33 universities with such offices. In general, consultancy work carried out for industry using university facilities is conducted or monitored by these units and the universities require a proper return to them for such use. While it would be highly undesirable to restrict the contact of individual academics with their industrial counterparts, most universities now require that academic staff be given permission for any consultancy work that they undertake and there is normally some limit as to the level of additional remuneration they can receive from such work.

In conclusion I would comment that most of the universities have established liaison bureaux and industrial consultancies which are free to exploit results of research, and there is a growing degree of co-operation between university staff and their opposite numbers in industry.

R. J. L. McLaren,
Centre for Industrial Research and Consultancy,
University of Dundee.

Crystal ladder filters

How to build low-cost s.s.b. filters using surplus crystals

by J. Pochet, F6BQP

This article gives design calculations for making crystal filters for s.s.b. applications and includes results of tests made on samples constructed by the author. The arrangement used in each case is that of a ladder filter where the crystals are connected in series. This very simple arrangement, see Fig.1, enables constructors to make low-cost filters, in comparison with commercial units, by using crystals having identical resonant frequencies.

The filters to be described in this article were made using 8314kHz crystals, as these were readily available to the author. The measurements were made in a laboratory with automatic instruments of high precision. Table 1 gives the results of measurements on one of the filters compared with the well-known XF9A filter. Definitions of the terms are shown in Fig. 2.

The results obtained from these tests are very satisfactory; the ultimate out-of-band rejection, better than 95dB, is excellent, the slopes of the sides of the filter are a little less steep than those of the XF9A, and the pass-band at −6dB is a little narrower. It should be mentioned that the measured characteristics of the XF9A filter are better than those claimed by the manufacturers.

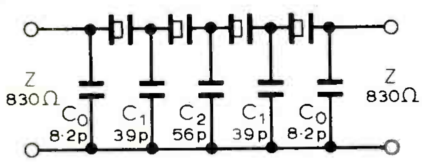


Fig. 1. Typical crystal ladder filter for 830 ohms impedance. In the ladder arrangement all the crystals, in this case devices having resonant frequencies of 8314kHz, are connected in series.

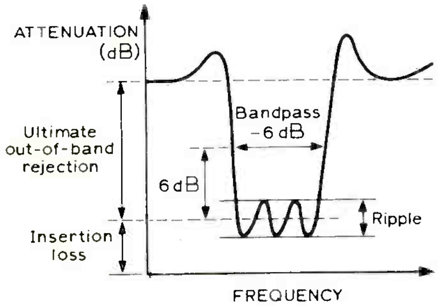


Fig. 2. Attenuation/frequency characteristic for a crystal ladder filter indicating the definitions used in the text.

Table 1 — Comparative results between a four-crystal ladder filter and the XF9A filter

	Ladder filter	XF9A filter
Insertion loss	1.4dB	2.5dB
Ripple	0.8dB	0.8dB
Bandpass:		
−3dB	1800Hz	2350Hz
−6dB	2050Hz	2540Hz
−20dB	2950Hz	3200Hz
−40dB	5200Hz	4250Hz
−50dB	6950Hz	4650Hz
Ultimate out-of-band rejection	>95dB	>48dB
Impedance	830 ohms	500 ohms

How to design the filter

A filter of this kind can be made using two, three or four crystals in series. Fig. 3 gives the values of the capacitors as a function of the impedance and frequency values adopted. The choice of impedance is important because, in effect, the more this is reduced the more the pass-band is reduced and the higher will be the insertion loss. This is because the series resistance of the crystal becomes more significant in relation to the impedance.

On the other hand, if one chooses an impedance which is too high, the calculations will result in low capacitance values, and construction then becomes limited by the stray circuit capacitances.

In practice, for a frequency of about 8 to 10MHz, the impedance should be about 800 to 1000 ohms to obtain a pass band of 2100Hz, suitable for s.s.b.

It is necessary to underline the importance of the impedance of a filter, no matter what type is used. It is also of paramount importance that the filter should be correctly terminated because any significant mismatch could lead to a pass-band ripple of some 10dB.

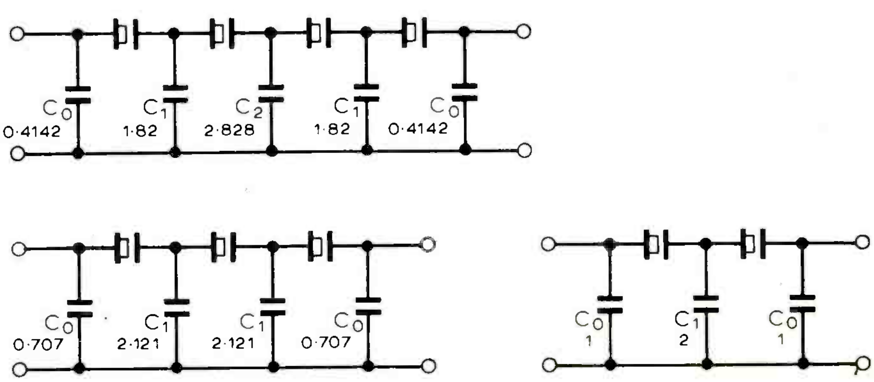


Fig. 3. Typical crystal ladder filters. All crystals are of the same resonant frequency – preferably between 8 and 10MHz for s.s.b. units. The coefficients indicated against each capacitor should be multiplied by 1/2πfR, where R is the design impedance and f is the resonant frequency of the crystal in hertz, to give the correct capacitor value. Three and four-crystal filters are capable of giving very good results. Two-crystal filters, although reasonably good, have relatively poor shape factors. See text.

It is possible to adjust the values of the capacitors; reducing them increases the passband but also increases the ripple in the pass-band (If a ripple of 2dB can be accepted, the passband can be increased by up to 20%). Note that it is advisable not to take advantage of this opportunity unless the necessary test instruments are available to check the results of any such adjustments (a wobbulator and oscilloscope are the ideal instruments for this type of adjustment).

The following is an example of how to calculate capacitor values for crystal ladder filters.

When R is the design impedance and f is the resonant frequency of the crystal in Hz, if f is 8314kHz, and R is 830 ohms, then $1/2\pi fR$ is equal to 23pF. From this one may obtain capacitor values for a four-crystal filter, as follows.

$C_0 = 0.4142 \times 23 = 9.5$pF (8.2pF)
$C_1 = 1.82 \times 23 = 41.8$pF (39pF)
$C_2 = 2.828 \times 23 = 65$pF (56pF)

and for a three-crystal filter:

$C_0 = 0.707 \times 23 = 16.3$pF (15pF)
$C_1 = 2.121 \times 23 = 48.8$pF (47pF)

and for a two-crystal filter:

$C_0 = 1 \times 23 = 23$pF (22pF)
$C_1 = 2 \times 23 = 46$pF (47pF)

The values in brackets refer to 10% preferred values.

These three filters have been built and the results obtained are shown in Table 2. In all three cases the passband ripple is less than a decibel. The results showed that with three or more crystals one may obtain a very good filter. Although the two-crystal filter gives a reasonably good out-of-band rejection (50dB), the sides are not very steep and the shape factor is modest. With a single crystal the out-of-band rejection is only about 20dB.

Table 2 — Measurements on two, three and four crystal ladder filters (for 8314kHz and 830 ohms impedance)

	Two crystals	Three crystals	Four crystals
Insertion loss	0.9dB	1.1dB	1.4dB
Bandpass:			
−6dB	2150Hz	2050Hz	2050Hz
−10dB	2700Hz	2350Hz	2250Hz
−20dB	4850Hz	3400Hz	2950Hz
−30dB	8900Hz	5050Hz	3900Hz
−40dB	16,100Hz	7500Hz	5200Hz
Ultimate out-of-band rejection	>50dB	>75dB	>95dB

Remarks

In the cases described above the passband extends from approximately 8314 to 8316kHz. The series-resonant frequency of the crystals therefore determines the lower limit of the passband; this is of interest since it is necessary only to use an additional crystal, of the same frequency as the others, for the carrier, to permit the selection of the upper sideband.

The choice of filter frequency depends on the availability of the crystals. It is possible to use frequencies from 5 to 20MHz, but if one has the choice it is preferable to use 8 to 10MHz. As an example, for a frequency of 5MHz it would be necessary to use an impedance of at least 1500 ohms in order to obtain the necessary bandwidth for s.s.b.

By using a lower frequency and lower impedance, it is possible to make an excellent c.w. filter.

The filters described above could be constructed on a p.c.b. and fitted into a small metal box, which should be connected to ground to avoid stray leakages.

An example circuit arrangement

Let us finish with an example of a circuit arrangement allowing the filter to be inserted at points of impedance equal to its own. This circuit is shown in Fig. 4. The output impedance of the first stage is practically equal to the collector resistance of Tr_1 (common emitter configuration) and the input impedance of the second stage (Tr_2 in common collector configuration). In this way the correct termination of the filter is obtained with the advantage of a very low output impedance (that of Tr_2), suitable for connection to the mixer on transmit and the i.f. stage on receive.

This circuit could also be very useful for measuring the filter's response curve with a sufficiently stable h.f. generator, a digital frequency meter and a voltmeter incorporating an h.f. probe, or better still a wobbulator.

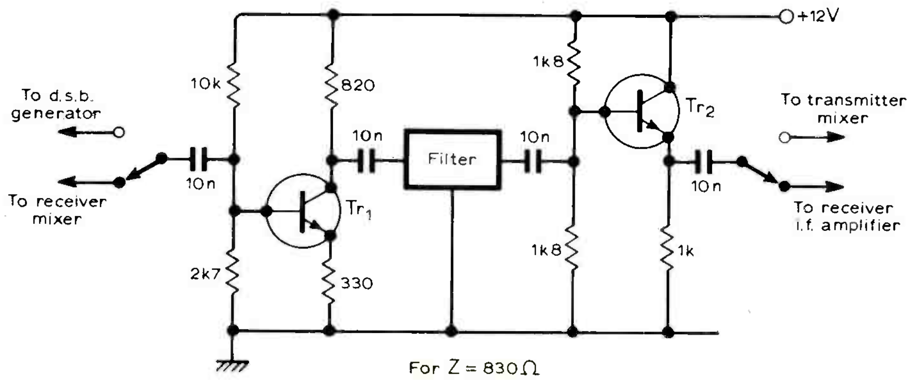
In conclusion the author recognizes that it would be interesting to study this technique further; trying for example readily-available surplus FT243 crystals, or low-cost 27MHz crystals having 9MHz fundamentals.

Pat Hawker comments: This is a free translation of an article, "Essais, mesures et realisation de filtres a quartz" by J. Pochet, F6BQP, published in *Radio-REF*, journal of the Reseau des Emetteurs Francais, in May 1976. For many years the vast majority of crystal bandpass filters used in h.f. communications have been based on the half-lattice or lattice configuration, plus some limited use of the bridged-T approach. The recent use of higher frequency filters, particularly around 5, 9 and 10.7MHz has opened the way to greater use of the attractive ladder filter. At these frequencies it is possible with three or four identical frequency crystals and with practical values of impedance and capacitors to achieve passbands of between 2 to 3kHz, reasonably good shape factors and high ultimate out-of-band rejection.

While it would seem possible to obtain better shape-factors and ultimate rejection by using more crystals, this will usually require careful adjustment of capacitor values and is less easy to arrange in a symmetrical form having equal input and output impedances.

Fig. 4. One method of connecting a crystal filter into a transceiver circuit to ensure correct impedance matching. See text.

Acknowledgement. *Wireless World* thanks Pat Hawker, G3VA, for translating this article from the original French.



Logic design — 6

Examples of clock-driven circuits

by B. Holdsworth* and D. Zissos†

*Chelsea College, University of London
†Dept. of Computing Science, University of Calgary, Canada

Some examples of the design of clock-driven circuits using the techniques set out in the last article can now be considered.

Example 1. Paper Tape Reader
Design a circuit that will stop the paper tape reader, shown in Fig. 9(a), by turning signal m off when the character sequence 4-5-6 is detected, and at the same time generates a buzzer signal b.

A synchronizing pulse is generated by the reader each time a new character is output.

(1) **I/O characteristics.** See Fig. 9(a)

(2) **Internal characteristics.** A suitable state diagram is shown in Fig. 9(b)

(3) **State reduction.** The state table corresponding to Fig. 9(b) is shown in Fig. 9(c). Examination of this table shows that merging of rows is not possible.

(4) **Primitive circuits.** Suitable binary codes are allocated on the state diagram. By direct reference to this diagram the input equations to the JK flip-flops are obtained.

$$S_A = S_15 + (S_26)$$

where the term in brackets is an optional product.

$$S_A = \bar{A}B5 + (AB6)$$

The optional product cannot be used for reduction purposes.

Hence, $S_A = \bar{A}B5$ and $J_A = B5$

$$R_A = S_24 + S_2\bar{4}\bar{6} + (S_0)$$
$$= S_2\bar{6} + (S_0)$$
$$= AB\bar{6} + (\bar{A}\bar{B})$$

The optional product cannot be used for reduction purposes.

Hence, $R_A = AB\bar{6}$ and $K_A = B\bar{6}$

$$S_B = S_04 + (S_14) + (S_15) + (S_24)$$
$$= \bar{A}\bar{B}4 + (\bar{A}B4) + (\bar{A}B5) + (AB4)$$

The optional product $(\bar{A}B4)$ need not be used for simplification purposes since $\bar{B}$ will be eliminated when converting from S_B to J_B.

Hence, $S_B = \bar{A}\bar{B}4$ and $J_B = \bar{A}4$

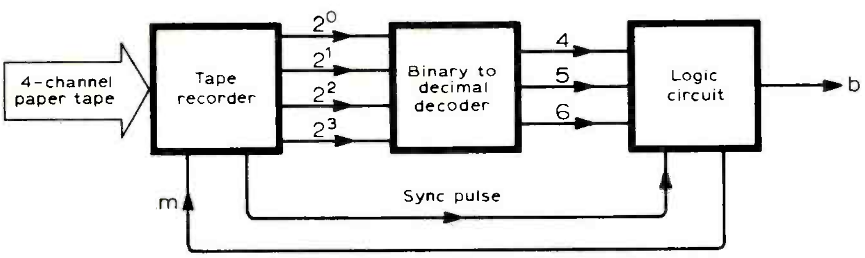
$$R_B = S_1\bar{4}\bar{5} + S_2\bar{4}\bar{6} + S_26 + S_0\bar{4})$$
$$= S_1\bar{4}\bar{5} + S_2\bar{4} + (S_0\bar{4})$$
$$= \bar{A}B\bar{4}\bar{5} + AB\bar{4} + (\bar{A}\bar{B}\bar{4})$$
$$= B\bar{4}\bar{5} + AB\bar{4} + (\bar{A}\bar{B}\bar{4})$$

The optional product cannot be used for simplification purposes, hence

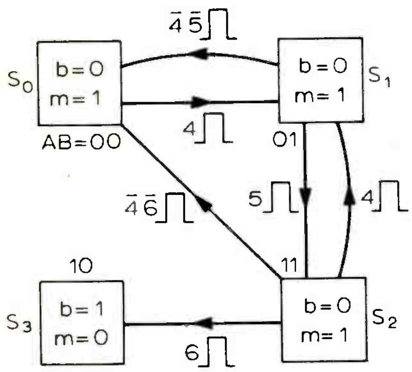
$$R_B = B\bar{4}\bar{5} + AB\bar{4} \text{ and } K_B = \bar{4}\bar{5} + A\bar{4}$$

The circuit is shown in Fig. 9(d).

Example 2. One-shot circuit
High-frequency clock pulses are fed to terminal X in Fig. 10(a). Design a circuit



(a)

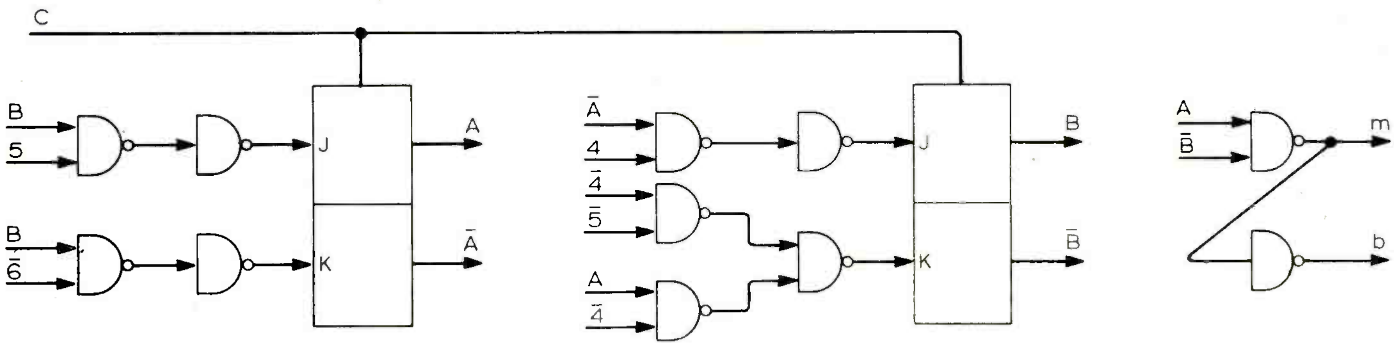


(b)

Input	4	5	6	$\bar{4}\bar{5}\bar{6}$
S_0	S_1 m=1 b=0	S_0 m=1 b=0	S_0 m=1 b=0	S_0 m=1 b=0
S_1	S_1 m=1 b=0	S_2 m=1 b=0	S_0 m=1 b=0	S_0 m=1 b=0
S_2	S_1 m=1 b=0	S_0 m=1 b=0	S_3 m=0 b=1	S_0 m=1 b=0
S_3				

(c)

Fig. 9. Circuit of Example 1 is shown at (a). Its state diagram is at (b) and its state table at (c). The resulting circuit is shown at (d).



(d)

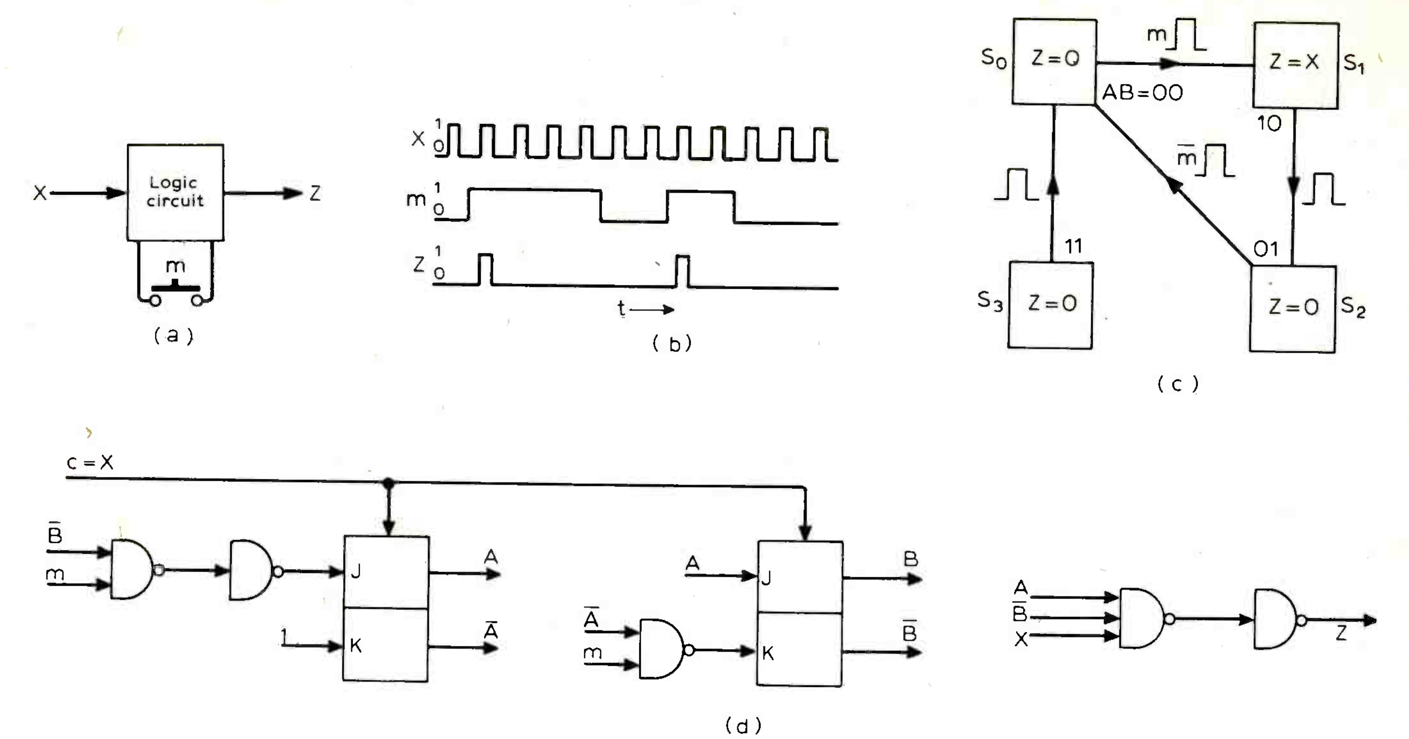


Fig. 10. Problem of Example 2, (a) and the required timing at (b). The state diagram is seen at (c) and the circuit realization is shown at (d).

so that each activation of a manual switch m allows one complete clock pulse output on line Z. The duration of signal m can be assumed to be greater than the pulse width.

(1) **I/O characteristics.** These are shown in the time diagrams of Fig. 10(b).

(2) **Internal characteristics.** A suitable state diagram is shown in Fig. 10(c).

(3) **State reduction.** It is left as an exercise for the reader to construct the state table and examine the possibility of state reduction.

(4) **Primitive circuit.** By direct reference to the state diagram the following turn-on and turn-off equations are obtained.

$S_A = S_0 m = \bar{A}\bar{B}m$. Therefore $J_A = \bar{B}m$.

$$R_A = S_1 + S_3 + (S_2) + (S_0\bar{m})$$

$$= A\bar{B} + AB + (\bar{A}B) + (\bar{A}\bar{B}m)$$

$$= A. \text{ Therefore, } K_A = 1.$$

$S_B = S_1 + (S_2 m) = A\bar{B} + (\bar{A}Bm) = A\bar{B}$. Therefore $J_B = A$.

$$R_B = S_2\bar{m} + S_3 + (S_0)$$

$$= \bar{A}B\bar{m} + AB + (\bar{A}\bar{B})$$

$= B\bar{m} + AB$. Therefore $K_B = \bar{m} + A$.

$$Z = S_1 X = A\bar{B}X$$

The circuit implementation of these equation is shown in Fig. 10(d).

Example 3. Pulse distributor

Signal X in Fig. 11(a) is a pulse train. The input pulses are to appear at the output terminals as shown in Fig. 11(b).

continued on p.74

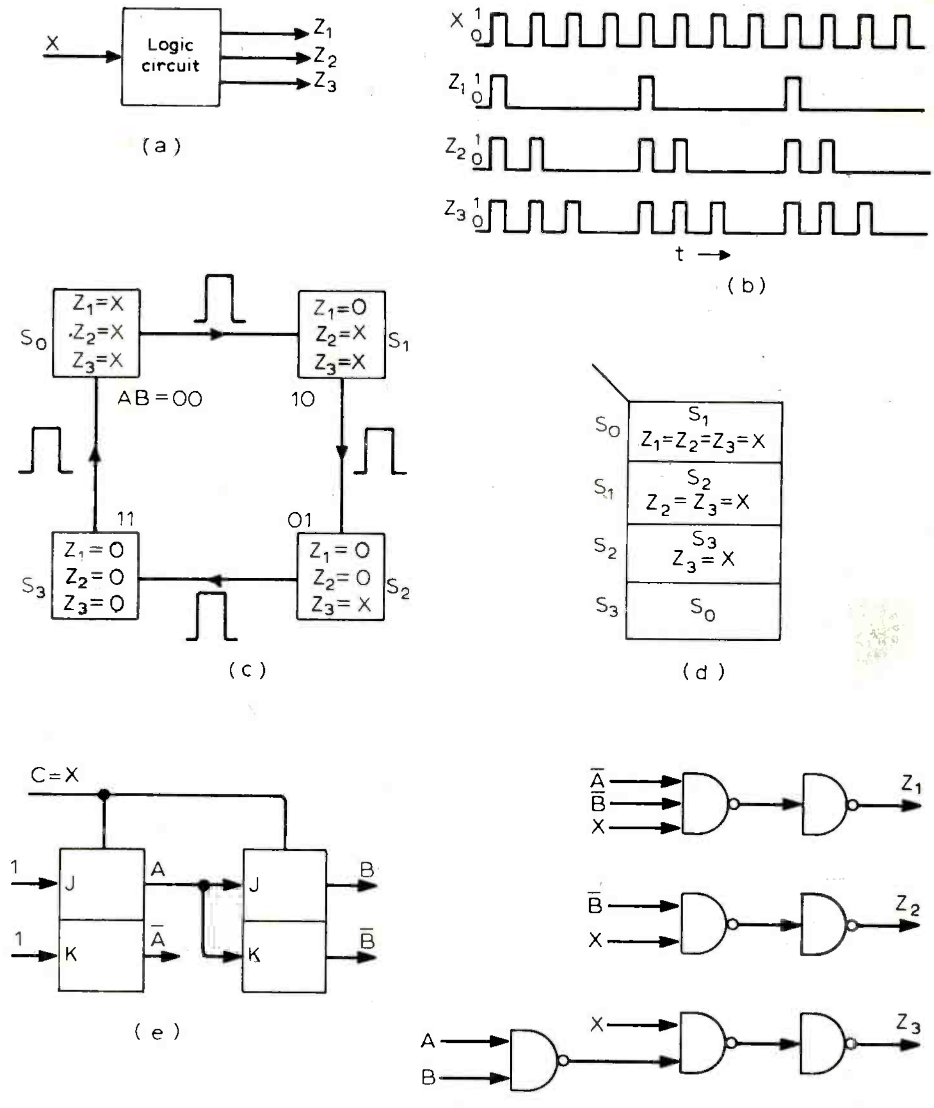


Fig. 11 (a) is the problem for Example 3, with the specified output at (b). State diagram (c) and state table (d) result in the circuit shown at (e).

World of Amateur Radio

Cost of new licences

Somewhere, sometime, somebody in authority will have to make his mind up whether amateur radio should be treated purely as a tolerated hobby or as a socially useful form of technical self-training. For it is becoming more and more expensive for a youngster to obtain a British amateur licence. The latest increase in the fee for taking the Post Office amateur-licence Morse test — it goes up from £4 to £6 on July 1 — means that this charge (which was only 50p until October 1970) will have gone up by a factor of 12 in less than 7 years! It is similarly difficult to keep abreast of the steadily rising cost of taking the Radio Amateurs Examination, since this involves not only the City & Guilds fee but also the local centre fee. Applicants for these examinations may also have to meet substantial travelling costs, and, of course, if successful pay the first annual licence fee. All of this is certainly not a way of encouraging a new generation of amateurs.

Yet such costs could surely be greatly reduced by adopting some elements of the system used in some overseas countries of bringing the local clubs and groups into the licence-issuing process. Is it for instance really necessary for the Morse Test to be given by one of the now relatively small number of trained Post Office operators? There are plenty of local amateurs who could do this, with any necessary precautions against abuse.

If Lord Wallace, the RSGB president, can argue that the communications industry has reason to be grateful for the enthusiasm and expertise implanted in young industry apprentices by their participation in amateur radio, is it not time that the whole procedure was looked at with a view to making this more possible? One can understand the Post Office view that it cannot be expected to subsidise the cost of Morse tests — the real question is should they be involved at all?

European v.h.f./u.h.f. records

The following is a listing of current European distance records for the amateur bands above 144MHz as published recently in the Dutch journal *Electron*:

144MHz F5JC/SM5AGM (tropo, 1930km); SM6FBQ/UA3TCF (aurora, 1830km); SM5LE/UA9GL (meteor scatter, 2200km); SM7BYU/9H1CD (sporadic E, 2250km).

70-cm F8MM/SM5LE (tropo, 1560km); SM5CUI/UA3ACY (aurora, 1260km); SM5LE/VK2AMW (moonbounce, 15,680km).

23-cm G3LQR/SM5CCY (tropo, 1100km); PAOSSB/VK3AKC (moonbounce, 20,000km).

13-cm OK1KIR/OK1WFE (tropo, 400km)

9-cm PAODBQ/G3LQR (tropo, 230km)

6-cm G3BNL/G3EEZ both portable (tropo, 160km)

3-cm OK1VAM/OK1WFE (tropo, 200km).

This list brings out several interesting contacts although the two records attributed to Czech stations appear to have been overtaken by the G3LQR/OZ9OR tropo contact on 13cm (760km) and the G4BRS/GM3OXX contact on 9cm (521km) recorded during the past year.

Band scan

Microwave beacons are now operational on The Wrekin (GB3WRN) on 1296.91MHz and near Sheffield (GB3UOS) on 3456MHz.

The weekly GB2ATG rtty news bulletins transmitted on Sunday mornings (1200 local time on 3590kHz, 1230 and 1245 on 144.6MHz) are now also being sent on 3590kHz at 1900 local time on Sunday evenings.

The well-known New Zealand short-wave listener, Arthur Cushen, was heard recently being interviewed on the Club Forum programmes transmitted by Radio Australia on Saturday mornings. This is one of a number of amateur and s.w.l. programmes broadcast regularly on the h.f. broadcast bands; the Dutch programmes on Radio Netherlands were recently judged the most popular in a ballot organised by I.S.W.L.

The "Phase 1" programme of amateur u.h.f. repeaters has been completed with the coming into operation of GB3IH at Ipswich, GB3LV at Cheshunt and GB3LW in Central London.

859 certificates of Morse proficiency have been issued by the Royal Naval Amateur Radio Society since the regular transmissions on G3BZU were begun in 1962. These transmissions are made on the first Tuesday of every month on or about 3520kHz at 2000 hours local time. Speeds from 15 to 40 words per minute in increments of 5 w.p.m. are sent for 3 minutes each, and must be copied without any errors to obtain a certificate or endorsement. A charge of 30p is made for a 15 or 20 w.p.m. certificate and endorsement "stickers" for other speeds require only a stamped addressed envelope. Present manager of the service is Mick Puttick, G3LIK, and transmissions are made from the RNARS headquarters station in Hampshire using a KW Viceroy transmitter and dipole aerial (RNARS, G3BZU, HMS Mercury, Leydene, Petersfield, Hampshire).

The American National Association of Broadcasters has recently petitioned the FCC, seeking the right to rebroadcast transmissions made on Citizens' Band and amateur radio bands. It has been suggested to broadcast stations that they could broadcast emergency traffic or weather reports and information vital to public safety and convenience.

In the picture

Mike Cox, G8HUA, of Brigg, South Humberside has taken over from Joe Rose, G8CTG, as general secretary of the British Amateur TV Club. *CQ-TV* also shows, in a letter from Peter Cossins, VK3BFG, that there are now some 20 fast-scan amateur tv stations in the Melbourne area. A weekly WIA news bulletin is transmitted on amateur tv every Sunday morning and pictures are from time to time exchanged with VK7EM in Tasmania some 400km distant.

Several British amateurs are now using standard u.h.f. transverters driven from h.f. or v.h.f. standard equipment with simple homebuilt video modulators: for example, Lawrence Woolf, GJ8AAZ (formerly GC6RAX/T) uses an FT620 drive source, Modular Electronics 50 to 432MHz transver. To receive 70-cm atv signals the output from the transverter is fed into a Band 1 tv receiver; for transmission a 50MHz video modulator uses just one transistor plus an SL610c integrated circuit.

In brief

The number of amateur licences in the USA has for the first time passed the 300,000 mark, an increase of over 10 per cent in a year.... Of 2351 Austrian licences, 1317 are for h.f./v.h.f. operation, 980 for v.h.f. only and 54 are club stations.... The RSGB's VHF National Field Day runs from 1600 GMT July 2 to 1600 GMT July 3 with groups operating up to four separate stations, one each for the 70, 144, 432 and 1296MHz bands.... The Royal Naval Amateur Radio Society is holding its annual mobile rally at "HMS Mercury" (a shore establishment between Clanfield and East Meon, near Petersfield, Hants) on Sunday, June 19 with trade stands, arena events and a static display of pre-1963 racing cars. Talk-in stations GB3SN on 144MHz, 70MHz and 3660kHz.... *Sprat*, the journal of the G QRP (low power) Club, points out that it is illegal for a station to sign /QRP but calling CQ QRP is within the terms of the licence.

PAT HAWKER, G3VA

Time code clock alarm

by N. C. Helsby, M.A. *University of Essex*

The provision of an alarm circuit is relatively simple and requires the digital comparison between a stored alarm time in b.c.d. form and the current received time also in b.c.d. The alarm time is determined by the positions of thumbwheel switches, which are easy to set and give a continuous read-out. The received time is present on the inputs to the display of the clock, except during the instant that the new code is being received serially. The alarm is blanked during this time by the application of waveform G to the digital comparator circuit. When the GMT to BST changeover is carried out automatically, and the alarm is connected to the output of the converter, a further blanking signal is applied in the form of waveform H. During the time that H is high the alarm is inhibited while the output of the converter continuously changes until all of the information has been received by the date decoder.

Exclusive-OR gating is used to make the comparison between the actual time and the alarm time. This system is cheaper than digital comparators, and full information about the comparison such as greater-than and less-than is not required. The output of each exclusive-OR gate is only low when both inputs are either high or low. Any exclusive-OR output being high will keep Tr_1 turned on, including the outputs G and H previously mentioned. However, when all outputs are low the collector of Tr_1 goes high and clocks $IC_{5(a)}$. Although rarely occurring in normal use, it should be noted that a break in transmission or noisy conditions could cause a particular display to be "skipped" and prevent detection of the required alarm time. The virtue of high accuracy may justify the extension of the alarm time to include seconds, which requires two more sections to the thumbwheel switch unit and one extra 7486 i.c. plus diodes. It is equally possible to reduce the precision and hence reduce the chance of skipping the alarm time, by not including the minutes' comparison, and setting the alarm to the nearest ten minutes or even to the nearest hour.

The time at which the alarm is cancelled is determined by counting minutes, although seconds may be substituted if preferred, and resetting the D type flip-flop after a pre-selected number of minutes. The c.m.o.s. decade counters IC_6 and IC_7 have ten decoded outputs allowing pre-selection of a count from 0 to 99. When the pre-selected count is reached, both inputs to $IC_{8(b)}$ are high which resets the D type until the next alarm is detected. A reset may be effected at any time before this by the use of Sw_1. During the alarm period a relay is energized allowing a wide variety of functions to be switched electrically and independently. If a number of circuits need to be automatically switched on and off at different times and for different periods, several alarm circuits can be used in parallel.

Printed circuit boards

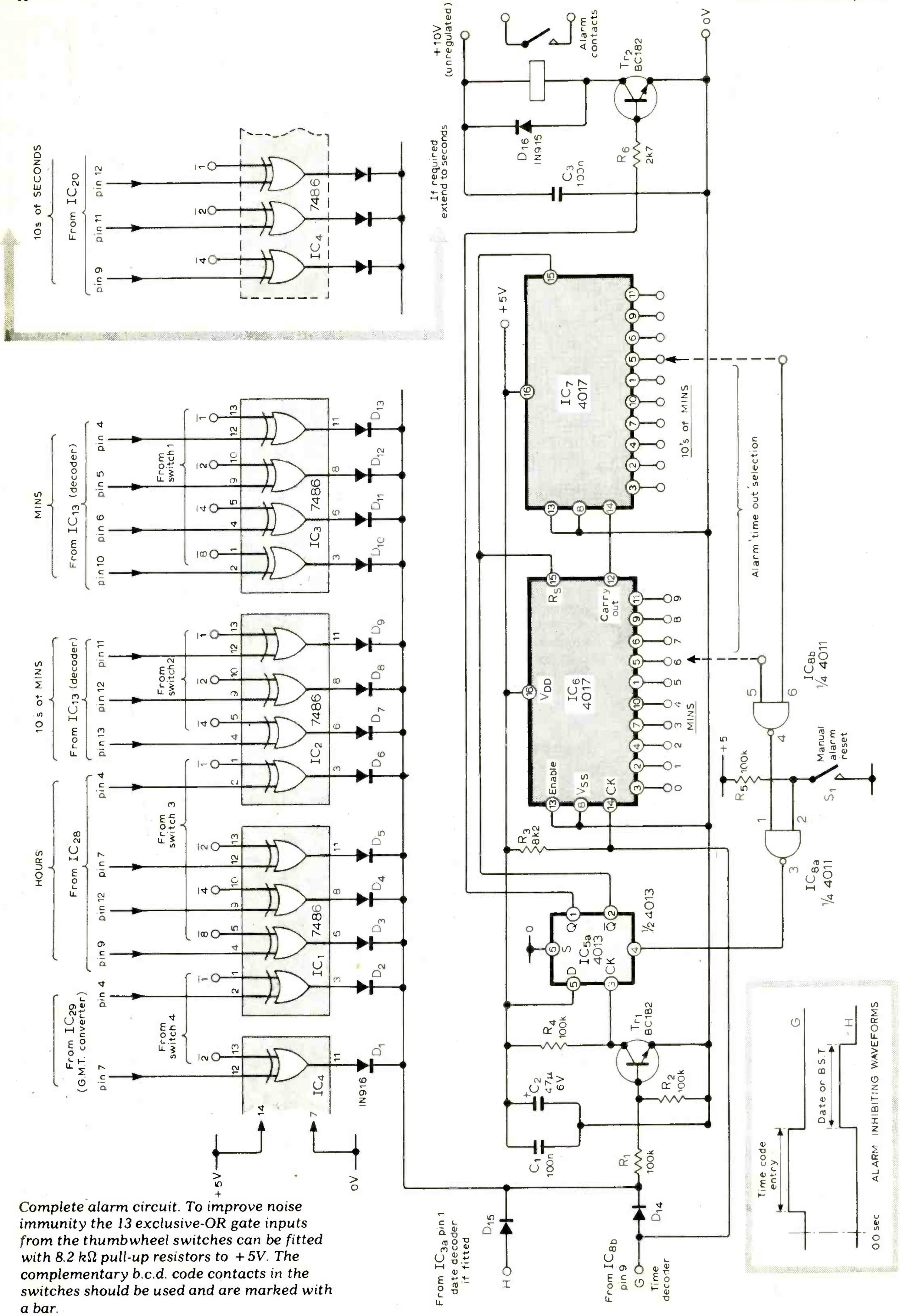
A set comprising two double-sided boards and one single-sided board for the date decoder/BST switch, display, and alarm circuit is available for £8.00 inclusive from M. R. Sagin, at 23 Keyes Road, London N.W.2. The decoder board allows leading zero blanking, and the alarm board offers automatic cancelling after a preselected number of minutes.

A set of five p.c.b.s and special components are still available for the original time code clock as detailed in the August 1976 issue of Wireless World.

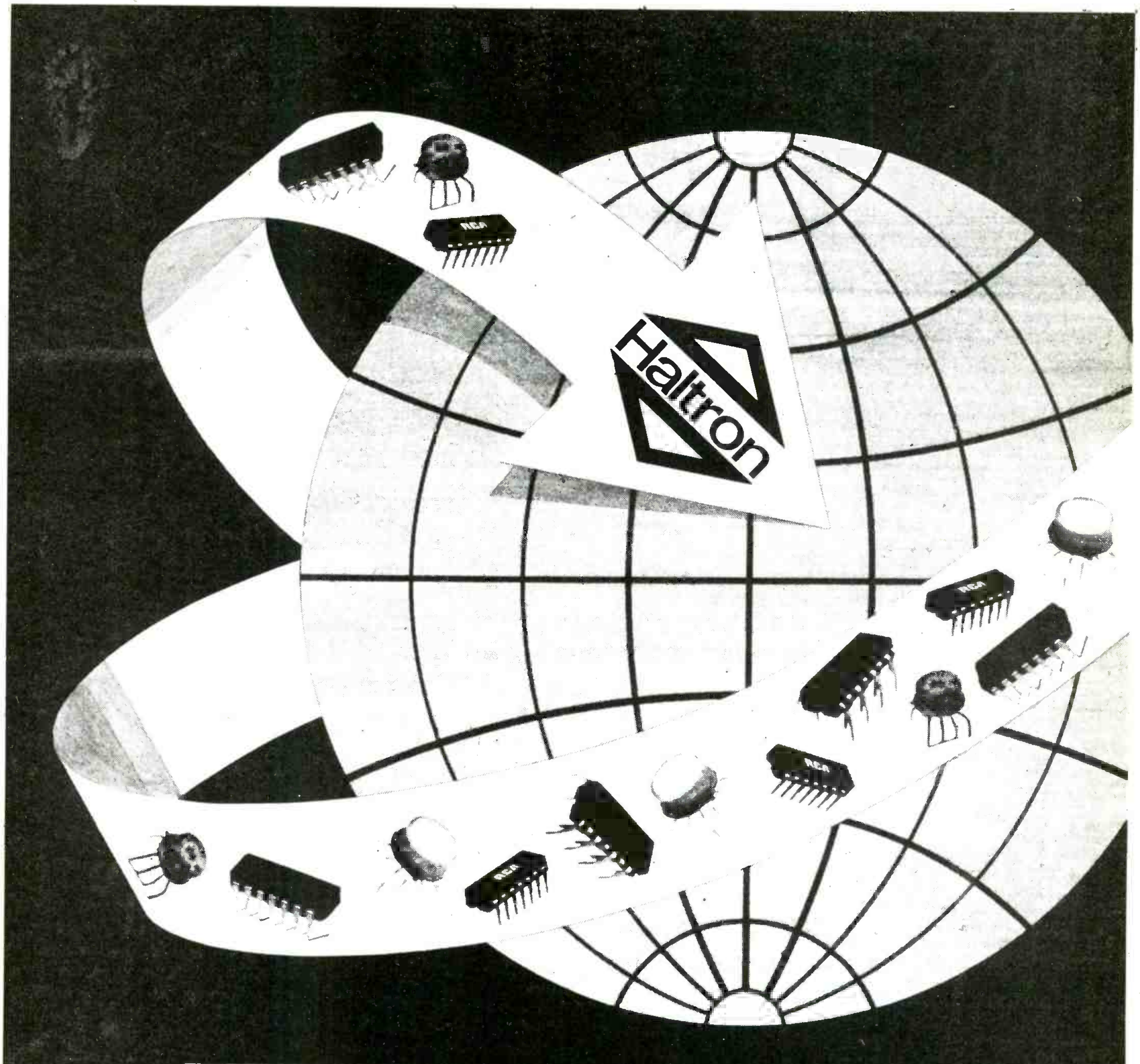
Component list for one alarm circuit (shown overleaf)

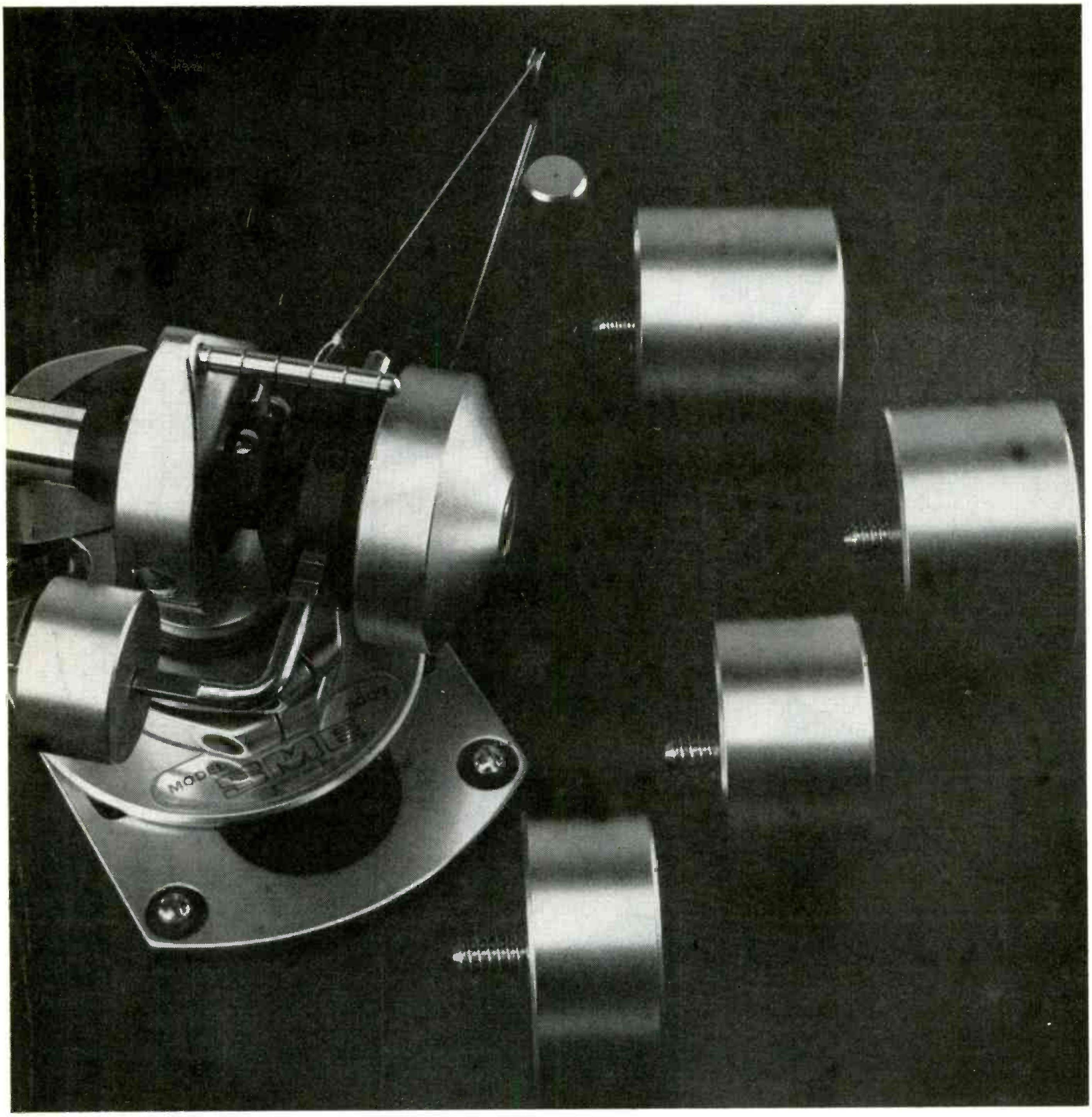
Integrated circuits	
1, 2, 3, 4	7486
5	4013
6, 7	4017
8	4011
Resistors	
1, 2, 4, 5	100k
3	8.2k
6	2.7k
Capacitors	
1, 3	0.1μF disc
2	47μF 6V electrolytic
Misc.	
$Tr_{1,2}$	BC182
$D_{1\text{-}16}$	1N916 or similar
thumbwheel switch sections	Doram 338-399 and 338-406
Sw_1	push to make push button (or use s.p.c.o. switch for possibility of alarm inhibit position)

Correction
IC_3 in Fig. 2 of the June issue should be a 4013 and not a 4015 as shown in the components list.



Complete alarm circuit. To improve noise immunity the 13 exclusive-OR gate inputs from the thumbwheel switches can be fitted with 8.2 kΩ pull-up resistors to +5V. The complementary b.c.d. code contacts in the switches should be used and are marked with a bar.


Haltron



Decoupling

Some circuits and some thoughts on their purpose

by S. W. Amos, B.Sc., M.I.E.E.

Decoupling is usually defined in technical dictionaries as the reduction of unwanted coupling between stages in multi-stage equipment and, in the example usually quoted, the unwanted coupling is caused by an impedance in the common power supply. Such coupling can cause oscillation and the remedy is to include a decoupling network as illustrated in Fig. 1 which shows the essential components of a three-stage RC-coupled amplifier. R_s represents the resistance of the power supply and R_dC_d is the decoupling network. By redrawing the circuit diagram as in Fig. 2 we can see that it has the form of an astable multivibrator circuit. R_s is the effective collector load of Tr_3 and, if large enough, causes the circuit to generate relaxation oscillations at a frequency determined primarily by the capacitors C_2 and C_3 and the associated base resistors. In audio amplifiers the oscillation frequency is usually very low — of the order of 1Hz — and gives rise to an audible effect known as motor boating. The decoupling network is situated between Tr_3 collector and Tr_2 base in one of the cross couplings which gives rise to oscillation and, if it introduces sufficient attenuation at low frequencies, can prevent oscillation.

Fig. 2 is useful in showing, for example, that there is little point in putting a decoupling network in the collector circuit of Tr_2. Such a circuit would appear at the point marked X in Fig. 2: it would smooth the supply to Tr_2 but would do nothing to discourage multivibrator action.

R_d and C_d serve purposes other than the prevention of multivibrator oscillation. For example they act as smoothing components for the supply to Tr_1 and attenuate any 50Hz or 100Hz ripple. Such ripple is applied directly to the base of Tr_2 and is subjected to the gain of this and subsequent stages of the amplifier. For example if R_d = 1 kilohm and C_d = 100μF any 100Hz components present at the output of the power supply are attenuated by a factor of approximately 60 (the reactance of 100μF being 16 ohms at 100Hz).

But possibly the most important effect of a decoupling network is on the transfer of signal-frequency energy from one stage to the next. To illustrate this consider Fig. 3, which shows a common-emitter tuned amplifier. R_4C_2 are collector decoupling components similar to R_dC_d in Fig. 1. But by arranging R_4C_2 as shown in Fig. 3 we can see that C_2 plays an important role in the output circuit of the transistor. The output signal from the transistor is, of course, generated between collector and emitter and, to minimise signal loss, these two electrodes should be connected by low-impedance paths to the output load, i.e. the primary winding of the output transformer T_2. There is a direct connection between the collector and one end of the load: the decoupling capacitors C_2 and C_3, provided they have suitable capacitances, provide a low-reactance path between emitter and the other end of the load.

Similar considerations apply at the input of the amplifier. The input signal should be applied between the base and the emitter of the transistor. The source of input signal is the tuned secondary winding of the transformer T_1 and one end of this is directly connected to the base. A low-impedance path from the other end of the tuned winding to the emitter is provided by the decoupling capacitor C_1 (which effectively short-circuits the lower arm R_2 of the

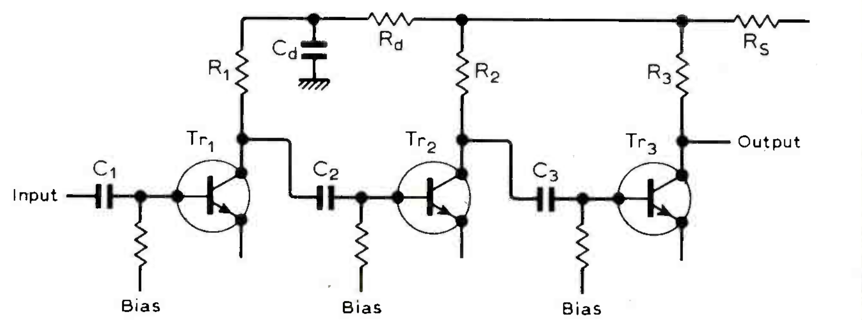
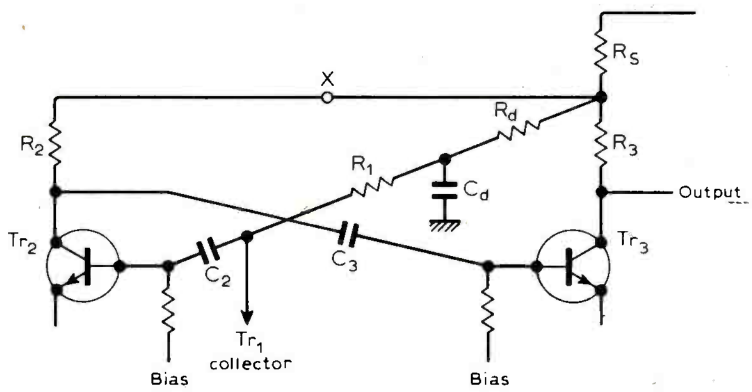


Fig. 1. Essential features of a three-stage RC-coupled amplifier. R_s represents the resistance of the power supply and R_dC_d are decoupling components.

Fig. 2. The circuit of Fig. 1 redrawn to show its similarity to that of an astable multivibrator.



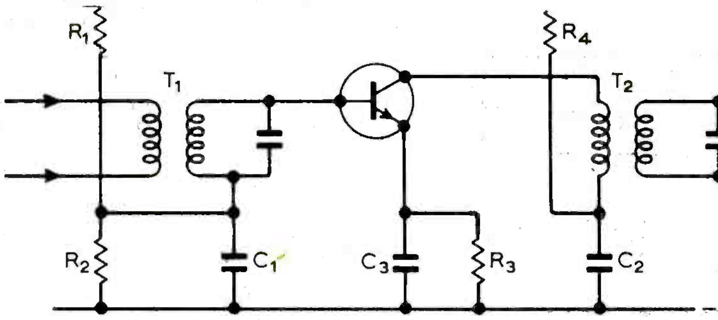


Fig. 3. C_1, C_2 and C_3 are decoupling capacitors providing low-impedance paths for the input and output signals of the transistor.

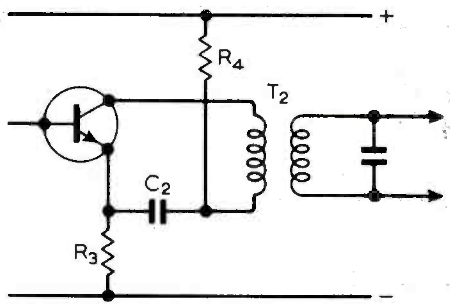


Fig. 4. A simplification of the output-circuit decoupling of Fig. 3.

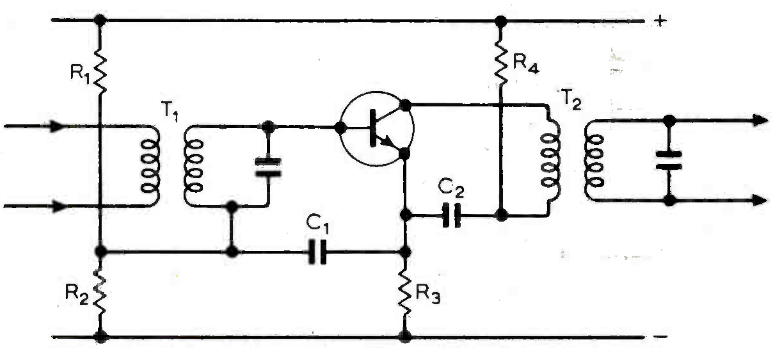


Fig. 5. A simplification of the input- and output-circuit decoupling of Fig. 3.

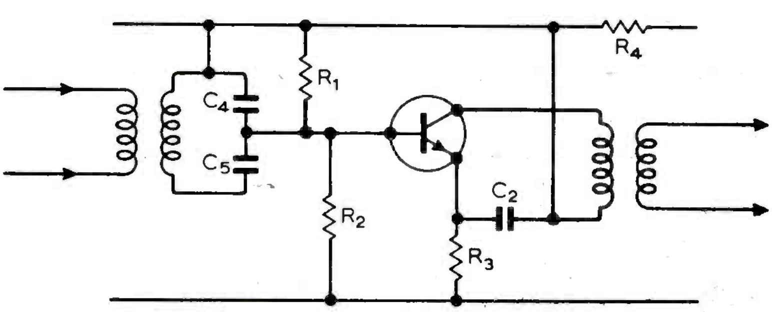


Fig. 6. A circuit in which a single capacitor (C_2) provides input and output decoupling.

potential divider) and C_3 (which similarly short-circuits the emitter resistor R_3).

C_1, C_2 and C_3 in Fig. 3 thus provide examples of an important function of decoupling components: by providing low-impedance paths they confine signals to the areas where they are wanted and, by implication, prevent them from entering areas where they could cause difficulties.

Emitter decoupling

C_3 was introduced in the preceding paragraphs as a means of providing low-impedance paths for the input and output signals of the transistor. It has, however, another function and this is to eliminate the negative feedback introduced by the emitter resistor R_3. This feedback is generally undesirable because it reduces the gain of the transistor and increases the input and output resistances. Increase in the input resistance would be a nuisance if this resistance is used to determine the passband of the tuned input transformer T_1. To be effective in eliminating feedback C_3 must have a low reactance at the operating frequency. Because the reactance of a capacitor is inversely proportional to frequency, feedback elimination becomes less effective as frequency is reduced and the value of C_3 is therefore so chosen that effective elimination is achieved at the lowest frequency of interest: it is then automatically better at higher frequencies. This requirement also ensures that the capacitor is large enough to provide low-impedance paths for the input and output signals. It might be thought that the value of the emitter decoupling capacitor would be determined by R_3 and the operating frequency, the loss due to feedback being 3dB at the frequency for which the reactance of C_3 equals R_3. This is not true, however, because the internal emitter resistance r_e of the transistor is effectively in parallel with R_3 and is normally much smaller than R_3. Thus the true 3dB loss frequency is that for which the reactance of C_3 is equal to the parallel resistance of R_3 and r_e. From this relationship it is possible to deduce the value of the decoupling capacitor to use in a particular circuit. It is given by the following expressions.

For bipolar transistors

$$C = \frac{h_{fe}}{2\pi f_{min}(h_{fe} + R_e)}$$

where R_e is the value of the external emitter resistor.

For field-effect transistors and valves

$$C = \frac{1}{2\pi f_{min}}\left(g_m + \frac{1}{R}\right)$$

where R is the value of the external source or cathode resistor.

The formal deduction of these expressions was given by P. Engstrom in *Wireless World* for December, 1971.

We have so far discussed collector, base and emitter decoupling. In valve technology decoupling is also required for the screen grid of pentodes (still used in high-power equipment such as transmitters). For an a.f. pentode the effect of resistance in the external screen-grid circuit is precisely analogous to that of resistance in the external cathode circuit, i.e. it causes negative feedback and reduced gain. To eliminate this effect an external screen-grid decoupling capacitor is introduced and its value can be calculated from the expression given above by substituting g_s the screen conductance for g_m and R_s, the external screen-grid resistance, for R.

R.f. pentodes also require screen-grid decoupling but here it is necessary for a different reason. As its name suggests the screen grid is required to act as an electrostatic screen between anode and grid circuits and to do this it must be effectively connected to cathode at signal frequencies though at a positive potential to give a reasonable anode current. A capacitor between screen grid and cathode enables this to be done and such a capacitor can legitimately be called a decoupling component because it confines anode and grid signals to their respective areas and prevents leaks between them which could cause r.f. instability.

Decoupling circuits

Examination of Fig. 3 shows that the circuit could be simplified and the impedance of the output signal path further reduced by omitting C_3 and returning C_2 to emitter as shown in Fig. 4. Indeed this arrangement must be adopted in certain circuits where signals are injected into the emitter, e.g. some types of oscillator or frequency-changer circuit. A disadvantage of this circuit is that the smoothing of the collector supply by R_4C_2 is offset by the ripple injected into the emitter circuit via R_3. But possibly a more serious objection to the circuit of Fig. 4 is that R_3 is no longer decoupled and so provides negative feedback. However, this disadvantage can be overcome by applying to the input circuit the same technique used for the output circuit and which led to the circuit diagram of Fig. 4, i.e. by returning C_1 (Fig. 3) to emitter as shown in Fig. 5, which also includes output-circuit decoupling. Although the emitter resistor R_3 is not now shunted by a low-reactance capacitor there is no negative feedback: this is because the input signal is applied directly between base and emitter and the signal generated across R_3 by the collector current is not returned to the base circuit.

In some tuned amplifiers the step-down ratio required in the input transformer is achieved by use of a capacitance potential divider. It is then possible to dispense with capacitor C_1 by returning the potential divider to the positive supply lines as shown in Fig. 6. Here the single decoupling capacitor C_2 provides a low-impedance path for input and output signals. C_4 and C_5 in series tune the secondary winding and C_4 is larger than C_5 to give the required impedance match to the low input resistance of the transistor.

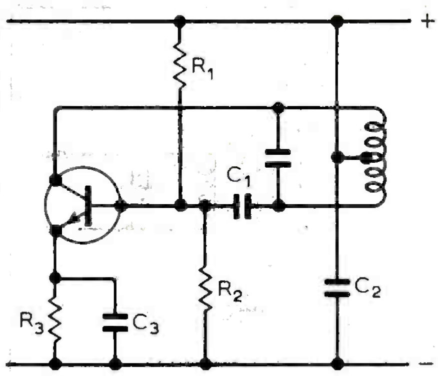


Fig. 7. A Hartley oscillator circuit.

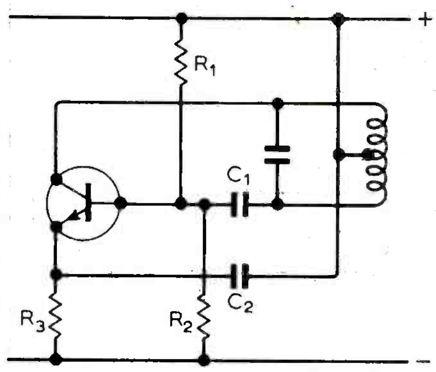


Fig. 8. The circuit of Fig. 7 with simplified decoupling arrangements.

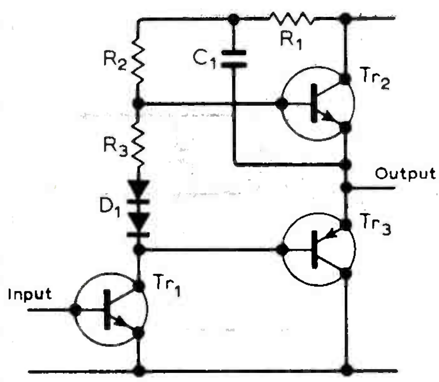


Fig. 9. Essential features of the Tobey-Dinsdale circuit.

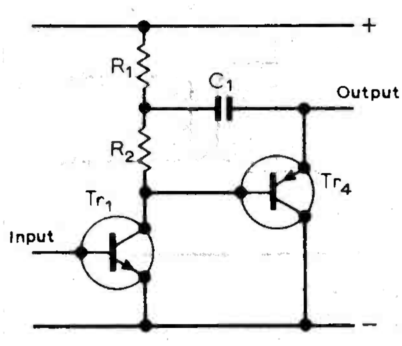


Fig. 10. Simplification of the previous diagram.

Hartley oscillator

Similar decoupling techniques are possible in oscillator circuits. In the Hartley oscillator, for example, one end of the tuned circuit should be connected to collector, the other end to base and the inductor tapping to emitter. Fig. 7 shows a circuit diagram in which stabilisation of the mean collector current is achieved by the potential divider R_1R_2 and the emitter resistor R_3. Such an arrangement is likely to be used if the transistor is required to operate in class A as in oscillators required to give a particularly pure waveform. The required low-impedance connection to the collector is achieved by direct coupling and to the base by the low-reactance capacitor C_1. The connection between tapping and emitter is, however, achieved via the decoupling capacitors C_2 and C_3. C_2 is sometimes a smoothing capacitor in the power supply but to minimise impedance in the tapping-emitter connection C_2 should preferably be a separate local component. As before, C_3 can be dispensed with provided C_2 is returned to emitter as in Fig. 8.

Tobey-Dinsdale circuit

A particularly interesting application of decoupling occurs in the Tobey-Dinsdale amplifier circuit, a development of the Lin circuit. The essential features of the decoupling circuit are shown in Fig. 9. The intention here is to drive the complementary pair Tr_2, Tr_3 as common-emitter amplifiers from the output of Tr_1. The impedance of D_1R_3 is very small and thus Tr_2 and Tr_3 are effectively in parallel although, because they are complementary, their output currents are in push pull. We can thus simplify the circuit by replacing Tr_2 and Tr_3 by a single transistor Tr_4 as in Fig. 10 and the output current from Tr_1 must be directed into the base-emitter junction of Tr_4. There is a direct connection from Tr_1 collector to Tr_4 base and thus a low-impedance connection is required between Tr_4 and Tr_1 emitters. Unfortunately such a connection would short-circuit the output of the amplifier which is taken from Tr_4 emitter. The inclusion of a resistor in Tr_1 emitter circuit would not make the circuit satisfactory because the internal emitter resistance of Tr_1 would still act as a shunt on the amplifier output: moreover the return of the output signal to Tr_1 emitter would give rise to considerable feedback. This problem is solved, as shown in Figs 9 and 10, by providing a low-impedance path between Tr_4 emitter and R_1, R_2 junction. The decoupling capacitor C_1 performs this function so that Tr_4 effectively short-circuits R_2 and thus ensures that most of the signal-frequency output of Tr_1 enters Tr_4. For successful operation R_2 should, of course, be large compared with the input resistance of Tr_4 i.e. of the complementary pair. If C_1 were instead returned to the negative supply rail the base-collector junctions of Tr_2 and Tr_3 would be effectively connected across R_2: the complementary pair would then operate as emitter followers and their high input resistance would make it difficult to drive adequate current into them.

A consequence of returning C_1 to the top end of R_2 is that the decoupling resistor R_1 is effectively in parallel with the output load of the complementary pair: thus R_1 must be large compared with this load resistance.

Inductors in decoupling circuits

Many of the decoupling circuits which have been discussed include a resistor in the supply lead. This reduces the collector supply voltage available to the transistor and the need to retain an adequate collector voltage limits the resistance that can be used for decoupling. This difficulty can be overcome by use of an inductor in place of a resistor, for its reactance then determines the effectiveness of the decoupling circuit while the resistance determines the loss of collector supply voltage. A.f. inductors are, however, bulky and expensive components and this solution is generally reserved for r.f. amplifiers where small and inexpensive inductors can give adequate reactance. At u.h.f. and v.h.f. ferrite beads threaded on supply leads can give adequate reactance and these can be combined with bush capacitors to form particularly compact decoupling networks.

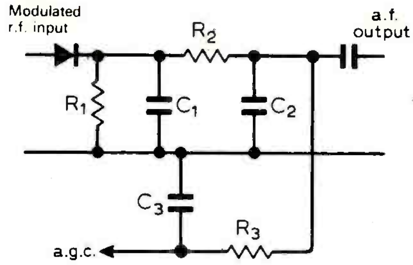


Fig. 11. The diode detector circuit provides two examples of decoupling.

Diode a.m. detectors

In all the examples of decoupling networks so far considered we have concentrated on the provision of low-reactance paths to confine signals to the areas where they are required. We could, however, alternatively regard these networks as examples where the signals are prevented from reaching areas where they are not required. For example in Fig. 3 signals in the output circuit are prevented from entering R_4 by the provision of C_2 and from entering R_3 by the provision of C_3. R_4C_2 and R_3C_3 are both, in fact, current dividers in which the current is mainly confined to the capacitor by making its reactance small compared with the associated resistance. In some decoupling circuits the same end is achieved by the use of potential dividers and the diode a.m. detector circuit of Fig. 11 provides two examples. R_3C_3 is intended to convey direct current to the earlier stages of the receiver to control their gain but it must prevent audio signals from reaching these earlier stages. To be effective therefore the reactance of C_3 must be small compared with R_3 even at the lowest audio frequency of interest, say 50Hz. R_3 is normally given a value large compared with the diode load resistance so that there is no appreciable shunting effect. 50 kilohms might be a suitable value for R_3 and C_3 can then be 1μF which has a reactance of 3 kilohms at 50Hz.

Similarly R_2C_2 is intended to prevent r.f. signals from entering the a.f. amplifier but it should not, of course, attenuate audio signals significantly. Thus the reactance of C_2 should be large compared with R_2 even at the highest audio frequency: it will then be even larger at lower frequencies. It would be satisfactory therefore to make the reactance of C_2 equal to R_2 at, say, 10kHz. The loss will then be 3dB at 10kHz, 1dB at 5kHz and less at lower frequencies. If the reactance of C_2 is equal to R_2 at 10kHz it will be only 1/46th of R_2 at 460kHz, approximately the intermediate frequency of a.m. receivers. This gives a loss of 35dB. If R_2 is 820 ohms C_2 could be 0.02μF which has a reactance of 800 ohms at 10 kHz.

● *continued from p.65*

Design a clock-driven circuit using JK flip-flops and NAND gates that will satisfy the given specification.

(1) **I/O characteristics.** As shown in Fig. 11(a) and 11(b).

(2) **Internal characteristics.** The internal state diagram of the required circuit is shown in Fig. 11(c).

(3) **State reduction.** The state table is shown in Fig. 11(d) and examination of this table shows that no state reduction is possible in this case.

(4) **Primitive circuit.** Binary codes are allocated as shown on the state diagram. By direct reference to this diagram the following equations are obtained.

$$S_A = S_0 + S_2 = \bar{A}\bar{B} + \bar{A}B = \bar{A}$$
Therefore $J_A = 1$

$$R_A = S_1 + S_3 = A\bar{B} + AB = A$$
Therefore $K_A = 1$

$$S_B = S_1 + (S_2) = A\bar{B} + (\bar{A}B) = A\bar{B}$$
Therefore $J_B = A$

$$R_B = S_3 + (S_0) = AB + (\bar{A}\bar{B}) = AB$$
Therefore $K_B = A$

$$Z_1 = S_0X = \bar{A}\bar{B}X$$

$$Z_2 = S_0X + S_1X = \bar{A}\bar{B}X + A\bar{B}X = \bar{B}X$$

$$Z_3 = S_0X + S_1X + S_2X = \bar{S_3}X = \overline{AB}X = (\bar{A} + \bar{B})X$$

The circuit implementation of these equations is shown in Fig. 11(e).

Announcements

Professor D. Zissos will conduct a **five day course** on Logic, Interfaces and Microprocessors from July 4 to 8 at the Southgate Technical College, London N14. Further details from Interprojects Ltd, 29 Church Street, Edmonton, London N9 9DY.

Philips and MCA will present their first UK public demonstration of the optical video disc system at the **Video Disc '77** conference in London, November 8 and 9, say the organisers. The last Video Disc conference was held two years ago, before which similar demonstrations were to be held but the only equipment shown was the now defunct Teldec.

The **World Radio Club** have announced revised times of transmission on the BBC World Service: the Sunday transmission at 0815 GMT will be cancelled. The times from Wednesday, September 7 will be: Wednesday, 0815 to 0830, 1330 to 1345 and 2315 to 2330 GMT, and Friday 2100 to 2115 GMT.

2,000 candidates responded to NASA's invitation to participate in the *Spacelab* experiment in 1980 (See WW May 1977, p66). NASA say they and the European Space Agency have now selected 222 representing the US and 14 other countries: NASA chose 81 from the US and the rest from India, Japan, Canada France and Belgium. The other 136 investigators came from 10 ESA member states, Austria and Norway.

Salon International des Composants Electroniques

New products seen at the Paris show

For one week in April, Paris again became the centre of world electronics. It brought together 1260 exhibitors, of which 534 were French and 726 were from 30 other countries. Entrance passes alone indicated that there were 75,972 visitors, from 87 countries, almost 13% of these being from foreign countries. Although this is 5.1% more than last year, it must be remembered that last year's show did not include a section on test and measuring equipment.

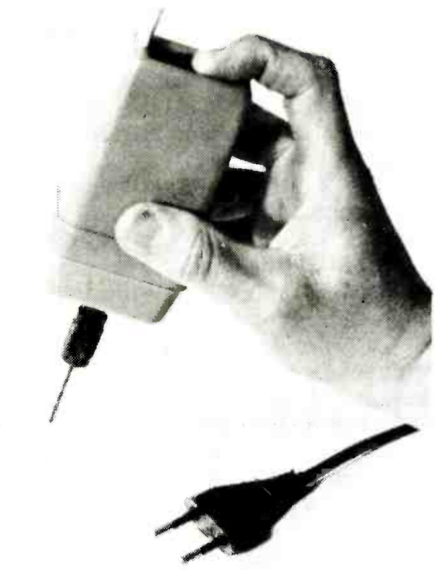
Apart from increases in the number of foreign exhibitors this year – for example, there were about 30% more British and 10% more West German participants – and the introduction of newcomers from countries such as Korea and India, there were also changes in the mixture of activities of the companies exhibiting. Although exhibitors from the USA increased by almost 60%, the number of major American semiconductor companies was less than in 1976.

It is always difficult, at a show of this size, to assess a particular industry, but, if judged solely on the enthusiasm of the exhibitors and visitors at the show, a fair conclusion would be that the European electronics industry is alive and well.

Several families of power semiconductors were launched by RCA Solid State – Europe. Among these developments was a 'quick-connect' package intended for medium- and high-power silicon controlled rectifiers and triacs. The package, which may be fixed on a TO-3 heatsink, uses AMP type connectors. An example device in the new package is the T6260 40A triac. Also being launched by RCA was the Versawatt TO-220 range of silicon controlled rectifiers. These fast-switching devices are designed for reverse-blocking applications and have turn-off times as short as 6µs. The rectifiers are rated at 5A r.m.s. with maximum trigger currents of 50mA. RCA was also showing a new range of epibase power transistors in TO-3 packages, which they claim is the largest range of its kind on the market. This range includes the 2N3055 device, which is also available in hometaxial construction.

Other products launched by the company included a range of medium-power n-p-n transistors, several integrated circuits and a microprocessor aid. The transistors, designated as RCP111/3/5 and /7, are high-voltage, low collector-base capacitance types, especially designed for television applications such as video and audio output stages, regulators and linear amplifiers. The new microprocessor aid is a hand-held data terminal which offers a low-power, soft-copy alternative to conventional printing terminals. It uses a calculator-type keyboard and an eight-digital l.e.d. display. The Cosmac CDP18S021 Micro-terminal, as it is called, is designed to interface with Cosmac hardware support systems to provide control, communications and debugging functions.

On the AEG-Telefunken stand was the TDA1062, an f.m. tuner unit for car radios. The unit consists of a mixer, modulator and phase-sensitive detector suitable for frequencies up to 200MHz. It also has a built-in a.g.c. amplifier for external p-i-n diodes, and is adaptable to capacitance diodes. Variometer or variable capacitor tuning may be used and tuning a voltage of only 2 to 7.5V is necessary. The makers claim that no alignment is needed. Another device was the TDA1068 noise suppressor, which is designed for the a.f. section of car radios. It will work from a supply voltage from 9.5 to 15V and is suitable for mono or stereo operation. Three PAL colour-TV devices, TDA2140/50 and /60, were also shown. Type 2140 is a sub-carrier reference oscillator, type 2150 forms a luminance and chrominance amplifier and type 2160 contains the synchronous modulator and RGB matrix.



The new miniature 220 to 250V Bimrill shown by Boss Industrial Mouldings Limited. The drill is supplied with three collets for accepting twist drills, burrs and mops with shanks up to ⅛ in diameter. Its 7500 rev/min motor is powerful enough to drill through brass and steel.

Of particular interest on the Texas Instruments stand was the TBM0103, a non-volatile, 92,304-bit, magnetic-bubble memory on a single chip. The bubble chip is comprised of a gadolinium-gallium garnet substrate upon which a magnetic epitaxial film is grown. Patterns of permalloy metal are deposited on the film to define the path of bubble domains, which are made to move in a shift-register fashion when in the presence of a rotating magnetic field. The 14-pin d.i.l. module measures 1.0 × 1.1 × 0.4in and is specified for 100kHz operation, with an access time of 4ms for the first bit and a cycle time of 12.8ms for the 144-bit page. Continous-rated power consumption is ½W.

Four differential line-transceiver i.cs, types SN55118, SN55119, SN75118 and SN75119, were also announced by Texas Instruments. These devices are designed for interfacing between t.t.l.-type digital systems and differential data transmission lines. Each circuit combines a three-state driver and a receiver in one package.

A m.o.s.f.e.t. transistor has been developed by Texas Instruments to help manufacturers improve the performance of the r.f. section of Citizen's Band tuners. The TIS148 transistor provides 20dB conversion gain with only a 3.2dB conversion noise figure when used as a mixer for 27MHz. The device also eliminates the need for an r.f. amplifier.

A new 16-bit microprocessor has also been introduced by Texas. It is believed to be the first monolithic central processing unit produced using bipolar integrated injection logic (i²l). The SBP9900 microprocessor uses this technique to provide selection by the user of speed and power and static operation, to enable a single non-critical d.c. power supply to be used and to ensure direct t.t.l.-compatible inputs and outputs.

A digital multimeter was launched at the show by Gould Advance Limited. The new instrument called the Alpha III, is a low cost version of the Beta multimeter launched in 1976. The instrument has a 3½-digit l.e.d. display and is claimed to operate for more than 50h from one set of batteries.

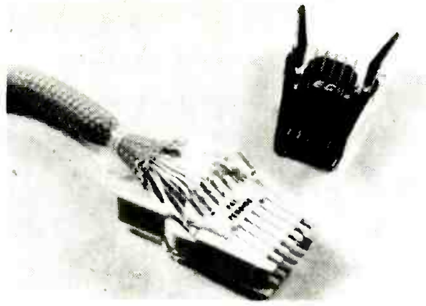
Nippon Electric were showing a microcomputer board teaching kit called the TK-80. The kit, which until the show had not been introduced to the European market, provides all the hardware elements, software tools and information for tutorial introduction to, and advanced details for, the μPD8080A 8-bit microcomputer and its software. The TK-80 is built around NEC's μCOM-8 microcomputer family of l.s.i. devices, including the μPD8080A c.p.u., a clock generator, a r.a.m., a r.o.m., a keyboard and an l.e.d. display.

The largest of all the stands at the show was that representing Thomson-CSF, who had a large array of new products ranging from transistors and capacitors to brushless d.c. motors and cathode-ray tubes. Included in the devices from the Electron Tubes division was the TH5108 electronically-tunable, X-band Gunn diode source. This model delivers more than 30mW over its ±100MHz tuning range and its centre operating frequency can be anywhere in the 9200 to 9300MHz band. The frequency drift for this varactor-tuned source is less than 200kHz/°C.

The THX914, also from Thomson-CSF, is a plasma display panel having a capacity of over 1300 characters (32 lines of 42 characters) with a useful screen area of 163mm square. The THX914, which is t.t.l-compatible, has all the normal functions of an a.c.-driven plasma panel, with a fast access time of 200μs to write a five-by-seven point character.

Another device from the Electron Tubes Division was the THX1107 c.c.d. device which is a development of the THX1105, first introduced in 1976. This analogue delay line has 512 elements, a maximum bandwidth of 5MHz and a distortion figure of 1% for a 500mV output signal.

SGS-Ates have managed to produce i.c. amplifiers capable of handling high currents ($I_{C(max)}$ = 3.5A) and high voltages ($V_{CE(sus)}$ >44V). This has allowed a typical output power of 20W into a 4Ω loudspeaker, with a distortion of less than 1%, using a single and inexpensive integrated audio amplifier, the TDA2020. Output powers of 180W can be achieved using two of these amplifiers. SGS-Ates is also developing a new family of power transistors giving up to 50A current handling capability, high switching speeds of less than 0.5μs, and operating frequencies of 50MHz. Devices in the range also have low leakage currents. The transistors will be manufactured in planar technology, so that they will withstand adverse operating conditions.



A dual-in-line test clip, displayed by UMD Amphenol, is suitable for use on 14 and 16 contact devices. The clip, called the DIP/LOC, is designed to lock on to an i.c. to ensure positive contacts with all leads.

A new surface-acoustic-wave filter designed for PAL television receivers shown by Siemens Electron Tube Division. With this device it is possible to design an i.f. stage that features superior performance and stability characteristics compared to the conventional L-C type. These types of filter are particularly suitable for teletext decoder circuits.

A large selection of new devices was being shown by Siemens. An audio amplifier i.c., in a TO220 case, was developed by the company specifically for use in car radios. With two 4Ω loudspeakers connected in parallel, the TDA 2870 provides 10W from 14.4V, and when used with only one 4Ω loudspeaker the output power is 5W. The device has built-in temperature-sensing overload and short-circuit-current protection. In addition it has a low thermal resistance of 5°C/W maximum.

Among the new power semiconductors from Siemens was a fast silicon diode for TV receivers, a mains thyristor and two fast power diodes. The silicon diode, type BY302, has a soft recovery performance and a reverse recovery time of 250ns. The thyristor, type D10, has a high blocking stability and a mean on-state current of 8A. The power diodes, types SSiN36 and SSiN46, are intended preferably for use in forced-commutated s.c.r. circuits. Model N36 is a screw bolt design having a maximum allowable r.m.s. current rating of 550A and model N46 is of the disc type, rated at 900A. Maximum forward voltage ratings for the devices are 2.05V and 2.00V respectively.

Other power devices were the BStP49 and the BStQ63, both high-speed thyristors, and the BStR68L power thyristor, all in flat-pack ceramic insulated cases. These devices were developed mainly for line-commutated converters. Maximum r.m.s. on-state currents and turn-off times (at the maximum junction voltage) for the P49 and Q63 are 1100A & 10μS and 1000A & 50μs respectively.

Also seen at the show

Continental Device (India) Limited; a solar cell designed to supply transistor radios. The device provides about 6V at 300mW (in India), and is available in different sizes and with various specifications.

Intersil; types 7106 and 7107 c.m.o.s. monolithic a.-d. converters designed for direct drive of 3½-digit l.e.d. displays or equivalent l.-c. displays.

Raytheon; type 2901A, a four-bit microprocessor slice, said to be 30% faster than the 2901. Three quad op-amps; type HA4741, which has no crossover, the pin-compatible LM348 with built-in overload protection, and type RC4156, having an improved noise figure and a 3.5MHz bandwidth.

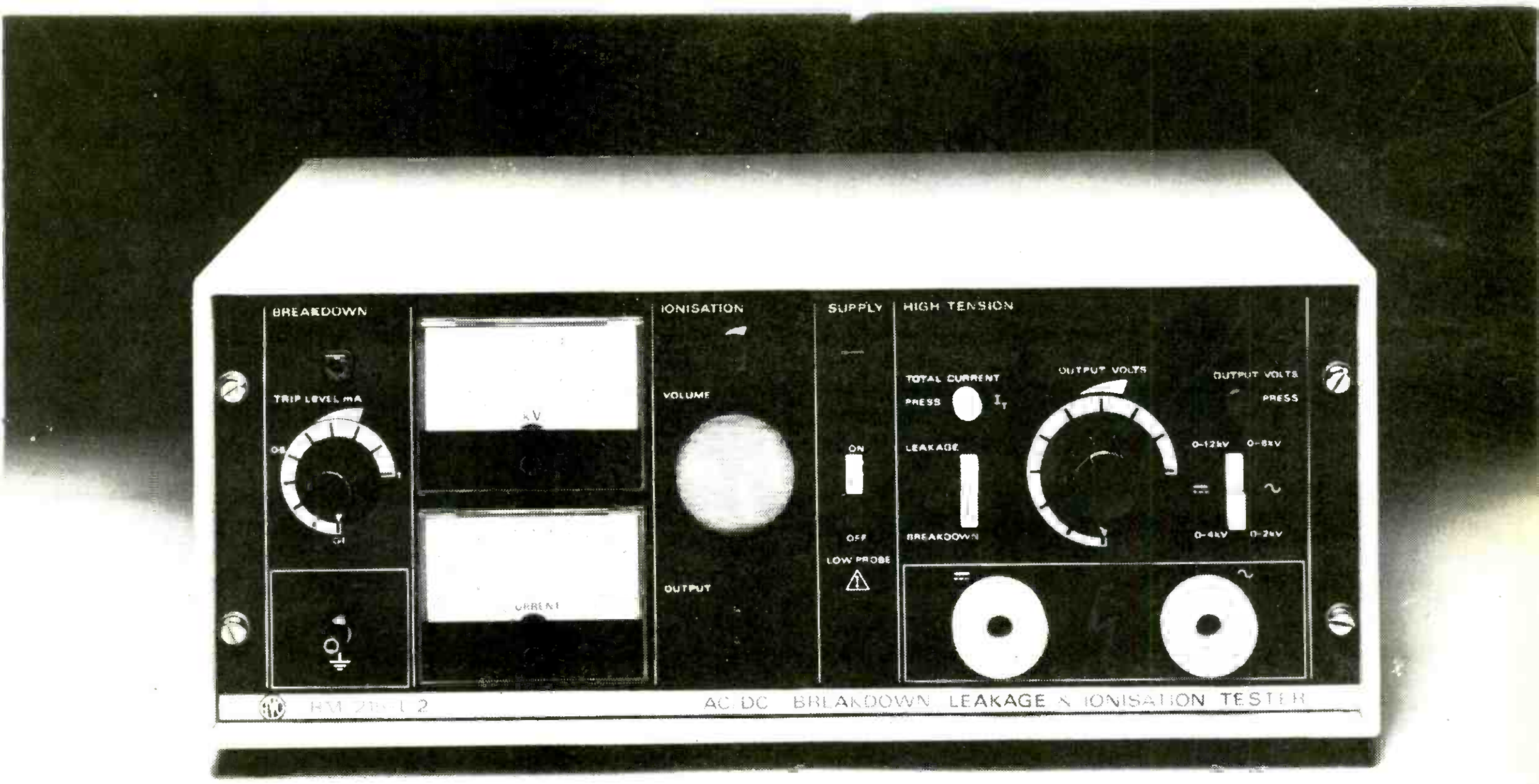
Silicon Transistor Corporation (STC); the model STA9160 switching transistor in a TO-3 can. This device has ratings of 500W and 100A, and a V_{cco} of 120V.

Jaybeam Limited; a 2.5m skeleton parabolic dish antenna having yagi and shrouded feed assemblies. Models available include an 18dBd (w.r.t. a dipole) antenna for the 400MHz band, a 24dBd antenna for u.h.f. TV bands, and a 26dBd antenna for the 900MHz band. In addition there is a 28dBd dish for 1500MHz and a 31dBd dish for 2GHz.

ITT; a battery-operated laser torch designed specifically for use with night vision equipment. The lens system can be adjusted and will provide a spot diameter from 1.5 to 8m at 100m range.

Hewlett Packard; two dual optically-coupled isolators, models HCPL-2730 and 2731. These units have very high transfer ratios (10:1) and low input currents of 500μA and will operate up to 200k-bits/s. Isolation between inputs and outputs is 3000V.

Thomson-CSF; a bipolar power transistor, designed by the Microwave Microelectronics Division, which is claimed to be one of the best r.f. transistors on the market. The 250W p.e.p. device, model TH430, is intended for s.s.b. transmitters in the range 2 to 30MHz. It has a power gain of at least 14dB.



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The AVO Breakdown and Ionisation Tester RM215-L/2 is specifically designed to help solve all manner of quality control problems.

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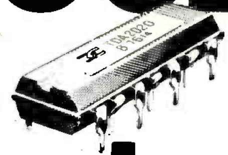
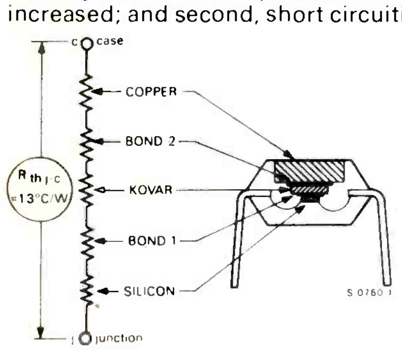


The most powerful Monolithic IC amplifier in the world.

20 watts output (continuous sine wave) . . . Less than 0.2% total harmonic distortion at *all* powers, *all* frequencies . . . And totally electronically indestructible!

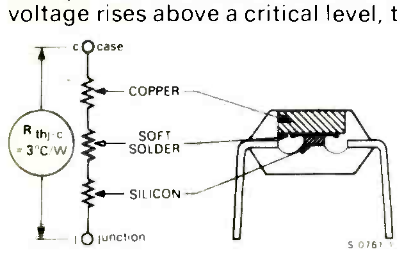
Until recently, all monolithic IC chips suffered from two basic design weaknesses. First, thermal runaway causing heat to build up as current increased; and second, short circuiting.



Standard plastic package with copper slug.

Until the SOC20 IC chip! This extraordinary new power amplifier chip is uniquely designed to improve thermal dissipation. It also has two separate built-in circuits, one of which measures on-chip temperature. If this should rise above 150°C the output transistors are switched off thus preventing thermal runaway.

And short circuits? The other circuit continuously monitors both current and voltage. If the product of current and voltage rises above a critical level, the



SOC20 plastic package with chip directly soft-soldered to copper slug.

drive is adjusted to bring the transistors within safe operating limits.

The amplifier can drive speakers of any impedance – maximum power will only fall outside the recommended 4Ω – 8Ω range.

And *any* pin on the chip may be shorted to *any* voltage in the system for *any* length of time . . . and *no* damage will occur!

Superb quality . . . extraordinary power

The SOC20 isn't only safe . . . it's also extraordinarily sophisticated. Total harmonic distortion is less than 0.2% at all powers and all frequencies – and in normal use is well below 0.1%.

If power is at a premium, use two SOC20 amplifiers in 'Full Bridge' to give over 40 watts continuous into 8Ω speakers.

The SOC20 is naturally guaranteed unconditionally for one year. Although with the SOC20's unique patented design, we think you'll have little cause to make use of any guarantee!

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Maximum supply voltage
±22 V (44 V total)
Output power
20 watts continuous 4Ω or 8Ω
Open loop gain
100 dB
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50 dB
Input noise voltage
4 nV
Number of transistors
18

Supplied with free printed circuit board, heat sink mounting bracket, comprehensive instructions, and suggested applications.

The SOC20 will work on any supply from 12-44 volts and therefore can be used for in-car as well as domestic applications. Apart from its obvious audio uses the fact that it is DC coupled throughout makes it ideally suited for servo systems – in radio-controlled models for example.

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Weather-satellite picture facsimile machine — 5

Modification of the facsimile machine for radio weather charts

by G. R. Kennedy

Parts one to four of this article described a prototype rotating-drum facsimile machine for producing APT, SR and WEFAX transmission pictures. This final part describes modifications to the basic design of the machine so that it may be used specifically for meteorological purposes. The modifications will enable both weather satellite and radio facsimile broadcasts to be printed.

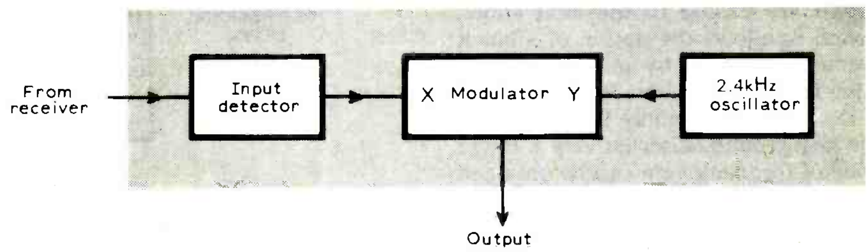
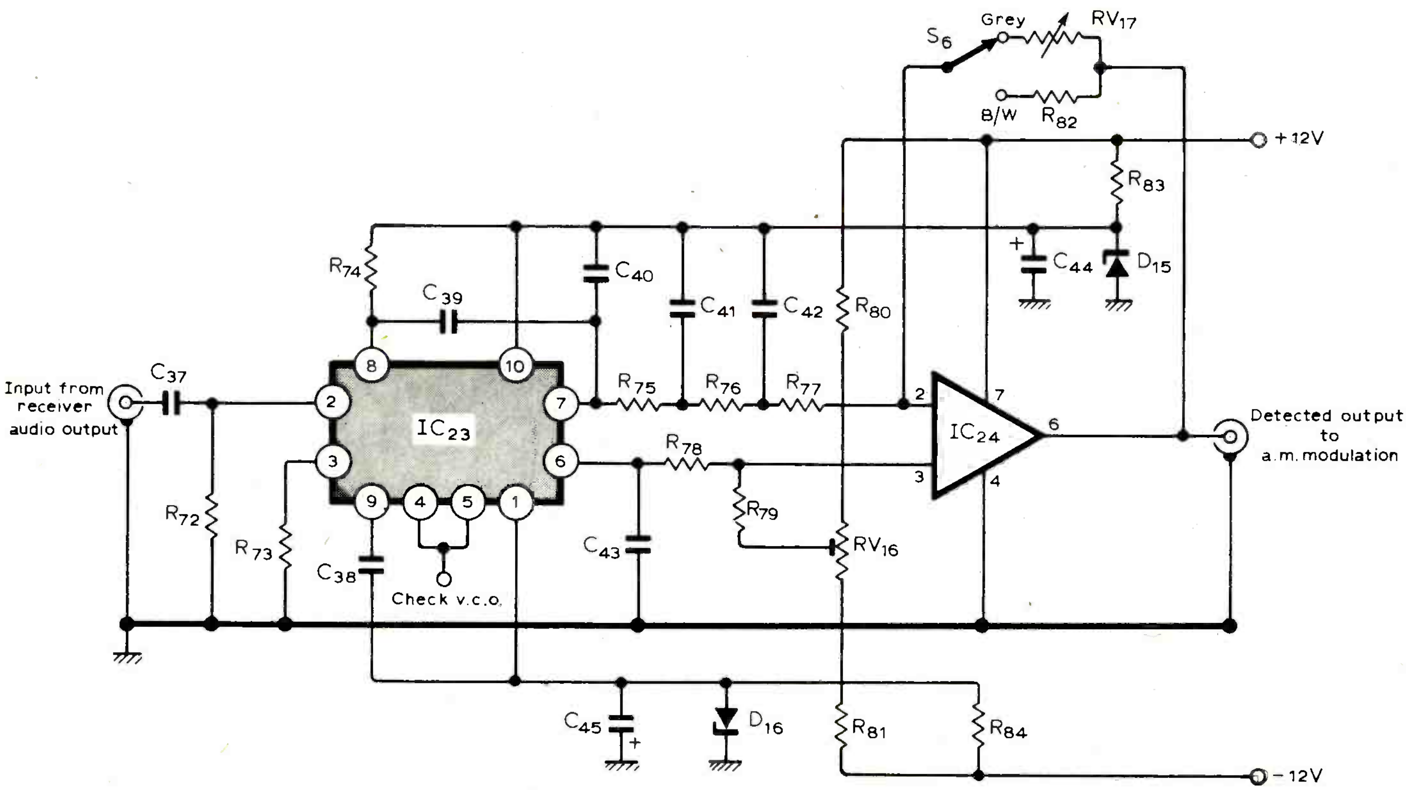


Fig. 16. Frequency-shift keying (f.s.k.) terminal block diagram,

Weather charts, prepared by hand or computer, are transmitted by short-wave and long-wave radio by most national meteorological organisations, (see Ref. 13). The internationally adopted standards for drum rotation speeds and index of co-operation (i,o.c.) are 60, 90 and 120 rev/min and 576 or 288 respectively. The 288 index is sometimes referred to as 'alternate line scanning'. 90 rev/min charts are invariably for aeronautical use. The transmissions are frequency shift keyed ±400Hz on short-wave and ±150 Hz on long wave. Some charts are sent on one sideband of a double side-band transmission, often with teleprinter traffic on the other. Reception requires a good communications receiver with a stable beat frequency oscillator (b.f.o.) and a frequency shift keying (f.s.k.) terminal connected to the receiver audio output (see Fig. 16). This provides a machine-compatible output to the facsimile machine described earlier. The audio signal from the receiver is detected and applied to one input port of an analogue modulator or mixer, an accurate 2.4kHz signal being applied to the other. The output is the product of the two signals. Since most charts are black and white, the detector is arranged to latch between two levels corresponding to black and white; this enhances copy under poor signal conditions. For those cases where greys are required, such as for the Russian composite chart and Meteor satellite transmissions, the detector can be switched to respond to varying levels. The detector and a.m. modulator are powered from a stabi-

Fig. 17. Input detector of f.s.k. terminal circuit.



lized power supply with a very low output ripple.

The circuit details for the input detector are shown in Fig. 17. The receiver audio is applied to one input of the phase-lock loop IC_{23} via C_{37}, while the other input is balanced to ground. The output comprising the f.m. demodulation of the input frequency-shift passes through the low-pass filter R_{75}, R_{76}, R_{77}, C_{41} and C_{42} to operational amplifier IC_{24}. The d.c. level from IC_{23} is maintained by the input to the non-inverting input of the op-amp via R_{78}. C_{43} decouples any residual v.c.o. signal, and together with the low-pass filter removes the loop p.s.d. sum frequency. IC_{24} is run with its negative rail to ground to ensure that only positive signals are passed to the next stage. Switch S_6 allows the option of a black and white picture by placing a large value feedback resistor, R_{82} across IC_{24} so that it latches solidly between positive and ground. Alternatively a lower value of feedback gain can be obtained by selecting RV_{17} which can be preset to give the required grey scale. The grey reference level for half carrier shift is finely set by preset RV_{16}.

The output of the detector is applied to the detector i/p terminal of balanced modulator IC_{25} via RV_{19}, which sets the modulation depth. IC_{25} is a double balanced mixer which is used here to amplitude modulate the detected signal onto a 2.4kHz carrier. This is fed in via RV_{18}, which sets the carrier level, to the carrier input. Input biasing is effected by R_{86}, R_{87}, R_{88} and R_{89}. The residual level of the output carrier is set by RV_{20} so that the carrier is modulated to 75%, the residual 25% being used in the facsimile machine for clocking. The gain is preset by R_{90}, the bias by R_{92}, and R_{93} and R_{94} are the chip output transistor collector loads. The output terminals are at approximately +10V, so the output signal is a.c. coupled by C_{48}. R_{85} and R_{91} set the carrier mean d.c. level. The −5V rail is derived from the −12V supply by R_{95}, D_{17} and C_{49}. (Note: pin assignments are shown in Fig. 18 for the 'L' 14 pin d.i.l. version of the Motorola MC1496. With appropriate pin connections, the Motorola 'G' version or the Signetics NE5596 'A' or 'K' can be used).

With the circuit values given, the v.c.o. frequency of IC_{23} is 5.5kHz. This was found to be a good compromise between the upper frequency limit of the receiver audio amplifier and the lower frequency limit for black to white transitions for fine detail. Tests showed that for a b.f.o. frequency of 3kHz fine lettering was not discernable, and few communication receivers have a good response above 8kHz.

A crystal-controlled 2.4kHz generator is shown in Fig. 19. There are many ways of producing the frequency accurately, but this shows a method using a fairly standard crystal bar. The 144kHz crystal is the feedback element in a simple t.t.l. gate oscillator, IC_{26}. The

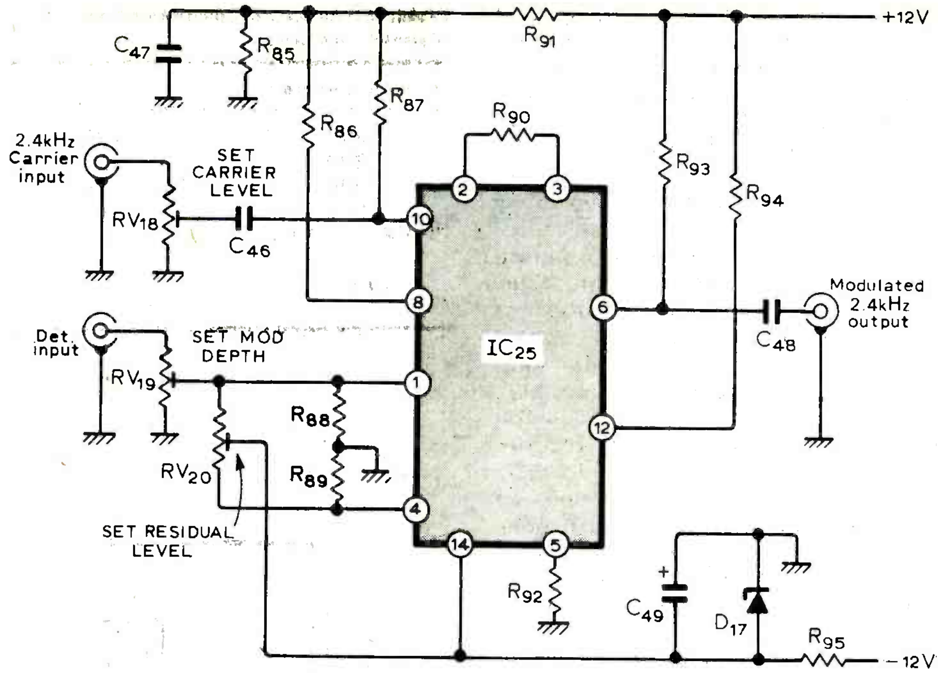
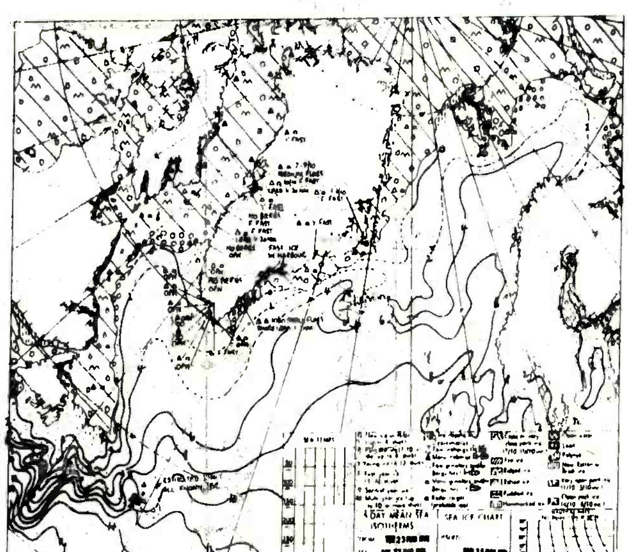
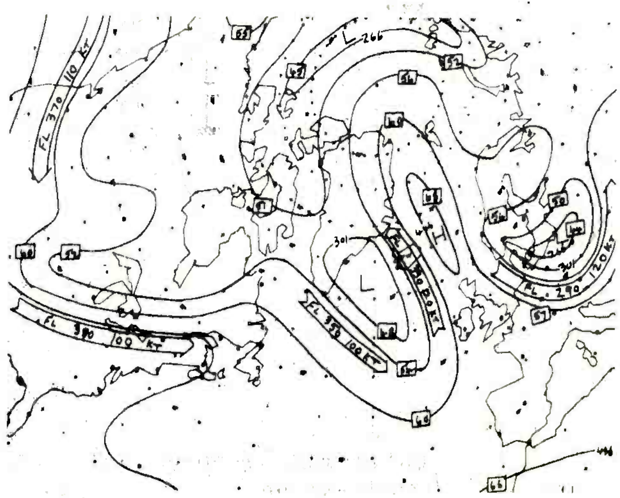


Fig. 18. Amplitude modulator of f.s.k. terminal circuit.



120 rev/min radio weather facsimile chart. *A typical chart for general meteorological use, showing sea ice and 5 day mean sea isotherms.*



90 rev/min radio weather facsimile chart. *Charts sent at 90 rev/min are invariably for aeronautical use. This chart shows upper air wind speed for pilots flying the North Atlantic.*

output is divided by five in IC_{27} and further divided by 12 in IC_{28}. The resultant 2.4kHz is taken directly to the f.s.k. modulator IC_{25} and buffered and inverted in IC_{29}. This output is used in the facsimile machine to drive the motor circuitry and detector. The inversion in IC_{29} partially corrects for phase shift in the f.s.k. input detector and precludes RV_8, the sample pulse delay pot in the facsimile machine having to be adjusted differently for satellite pictures and facsimile charts. The power supply circuit for the f.s.k. terminal, shown in Fig. 20, uses i.c. voltage regulators IC_{30} and IC_{31} with external transistors Tr_{20} and Tr_{21} to increase the regulating sensitivity. This gives no output protection, but gives a very high input rejection and hence extremely low ripple. If a less smoothed supply is used, hum bars are prone to appear on the final print as a regular speckling of the chart lines.

The actual modifications to the facsimile machine itself are straightforward and involve the addition of a phase-locked frequency generator, two binary dividers, and switching to change the motor drive frequencies. Fig. 21a shows the essentials of the basic system before modification. Note that the APT/SR switch S has been added to illustrate the routing of APT or SR line division frequencies — in the basic machine the 1/5 line position of the line division switch S_3 can be used for APT/WEFAX. The modifications to the basic design are shown in Fig. 21b. The line division switch remains, but the APT/SR switch is enlarged to give positions for 60, 90, 120 and 240 drum revolutions per minute, as well as the SR line division rates of 240 rev/min for 1/5 line, 192 rev/min for 1/4 line and 144 rev/min for 1/3 line. For 60, 120 and 240 rev/min the 2.4kHz is divided by 50 and is selected by S_{7b} to pass directly to the motor drive power amplifier, or divided by two, or divided by four, to give 240, 120 or 60 rev/min respectively. For 90 rev/min the path is the same as for 60 rev/min except that the 2.4kHz is increased 1½ times to 3.6kHz to give an output of 60 rev/min times 1½, i.e. 90 rev/min. The 3.6kHz generator is shown in Fig. 22. The 2.4kHz input is applied to phase-lock loop IC_{32}. The output of the 3.6kHz v.c.o. is amplified by Tr_{22} and taken to the drum function switch S_{7a} and to duodecal divider IC_{33} connected as a divide-by-three circuit. The 1200 Hz output from this circuit is returned to IC_{32} in order to phase lock the v.c.o. to the 2.4kHz input. The SR signal path remains the same as in the basic scheme. Since the motor drive circuit is not as efficient at lower frequencies, RV_{11} in the motor drive circuit (Fig. 12) is advanced when the chart modification is carried out. The drive at the higher frequencies is then automatically reduced by S_{7d} switching the RV_{11} wiper to ground via R_{111} for 240 rev/min and R_{112} for the SR frequencies. The motor drive voltage therefore remains

Table 1. Settings for gain potentiometer RV_6 (on a scale of 0-10) as used on the prototype facsimile machine.

Charts (rev/min)	I.o.c.		Setting
120	228	(no expansion, linear)	8.20
120	576	(no expansion, linear)	7.20
90	576	(no expansion, linear)	7.00
60	576	(no expansion, linear)	6.80
NOAAs, Meteor-25		with appropriate log/lin and expander settings)	3.00
ATS-3		with appropriate log/lin and expander settings)	4.50

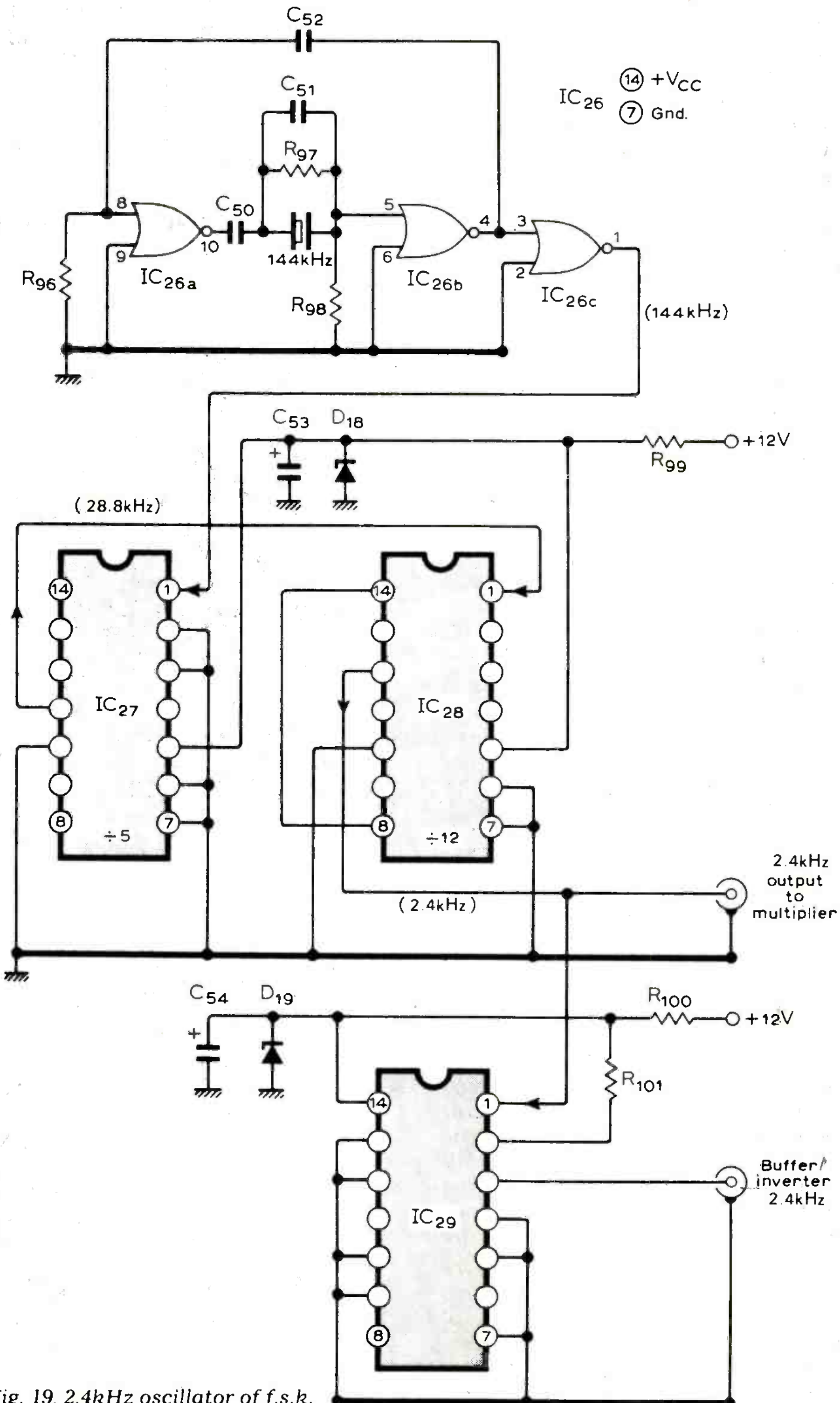


Fig. 19. 2.4kHz oscillator of f.s.k. terminal circuit.

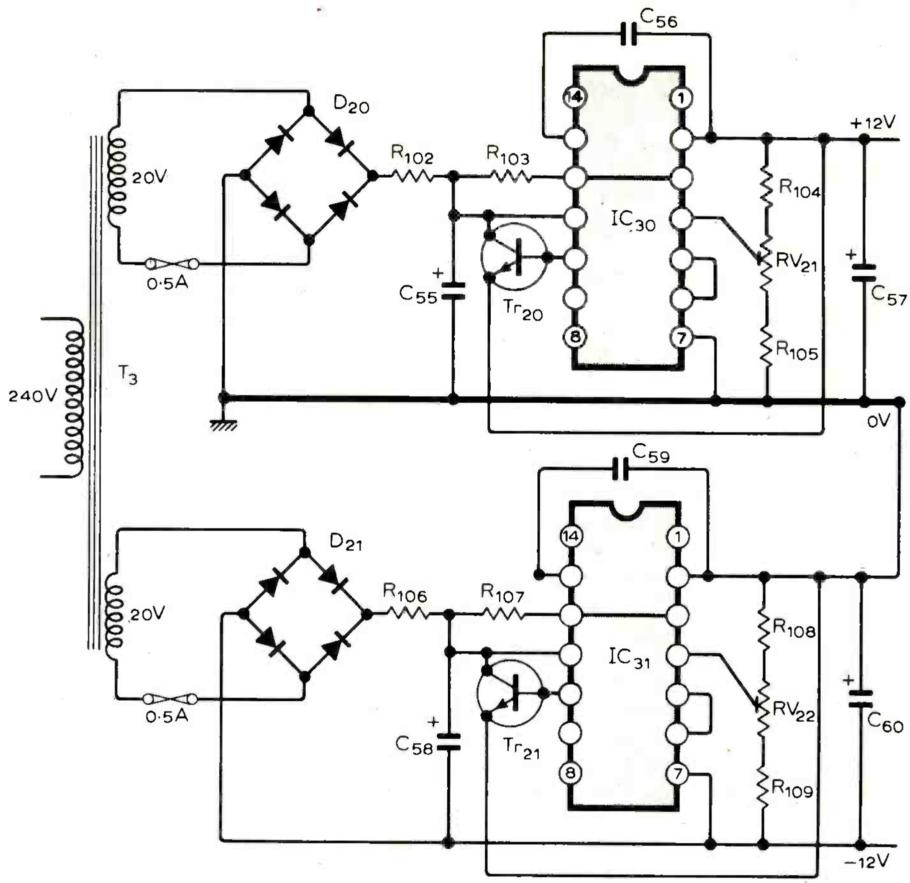


Fig. 20. Low-ripple power supply for f.s.k. terminal circuit.

approximately constant at all drum rates. Depending on the type of transformer used in the motor power amplifier, the values of coupling capacitors C_{24}, C_{25} and of tuning capacitor C_{27} in Fig. 12 may have to be increased, although in the prototype this was not found to be necessary.

The traverse modification concerns the provision of two traverse speeds by switching and an alternative gear train. The same gears are used for SR pictures and 120 rev/min charts, but for 60 rev/min charts the standard synchronous motor used for the traverse would not run on a 12Hz supply in the prototype and simple switching was arranged to apply 50Hz mains to the motor with a replacement gear train to give the correct rate of drive. For 120 rev/min the switching between the synchronous low speed (normal) and the 50Hz rate (fast) gives approximately the correct drive speeds for 576 and 288 i.o.c. respectively. At 60 and 90 rev/min, charts are normally only sent at 576 i.o.c. The gearing has to be changed to a ratio of 7:1, using the motor and roller size described earlier. The situation for printing satellite pictures remains the same, i.e. direct drive (1:1) for ATS-3, 2:1 at "normal" for NOAAs, and 2:1 at "fast" for Meteor-2. (Note: as a guide, in the original machine the 7:1 nominal gearing was 60-107 for motor to shaft, 23-90 for shaft to roller, these representing teeth of diametrical pitch 100).

Operation for radio facsimile charts

The facsimile machine gain pot setting has to allow for the effective writing speed of the crater-tube light beam at different drum and traverse rates. The prototype used an analogue turns counting dial for setting RV_6 (see Fig. 7). The settings used are set out in Table 1.

The output of the f.s.k. terminal is taken to the expander input, with the expander set for a direct signal i.e. no expansion. Phasing is carried out as for satellite pictures. No strobing is used and the monitor oscilloscope is triggered from the sync output socket. The drum edge pulse thus appears every two or four sweeps of the oscilloscope time-base; this is quite adequate for positioning the drum and chart edges. Detector switch S_6 is set to black-and-white, the receiver is tuned to the required signal and the beat frequency oscillator set to give bright/dim keying of the crater tube. This can be done without great precision on short-wave

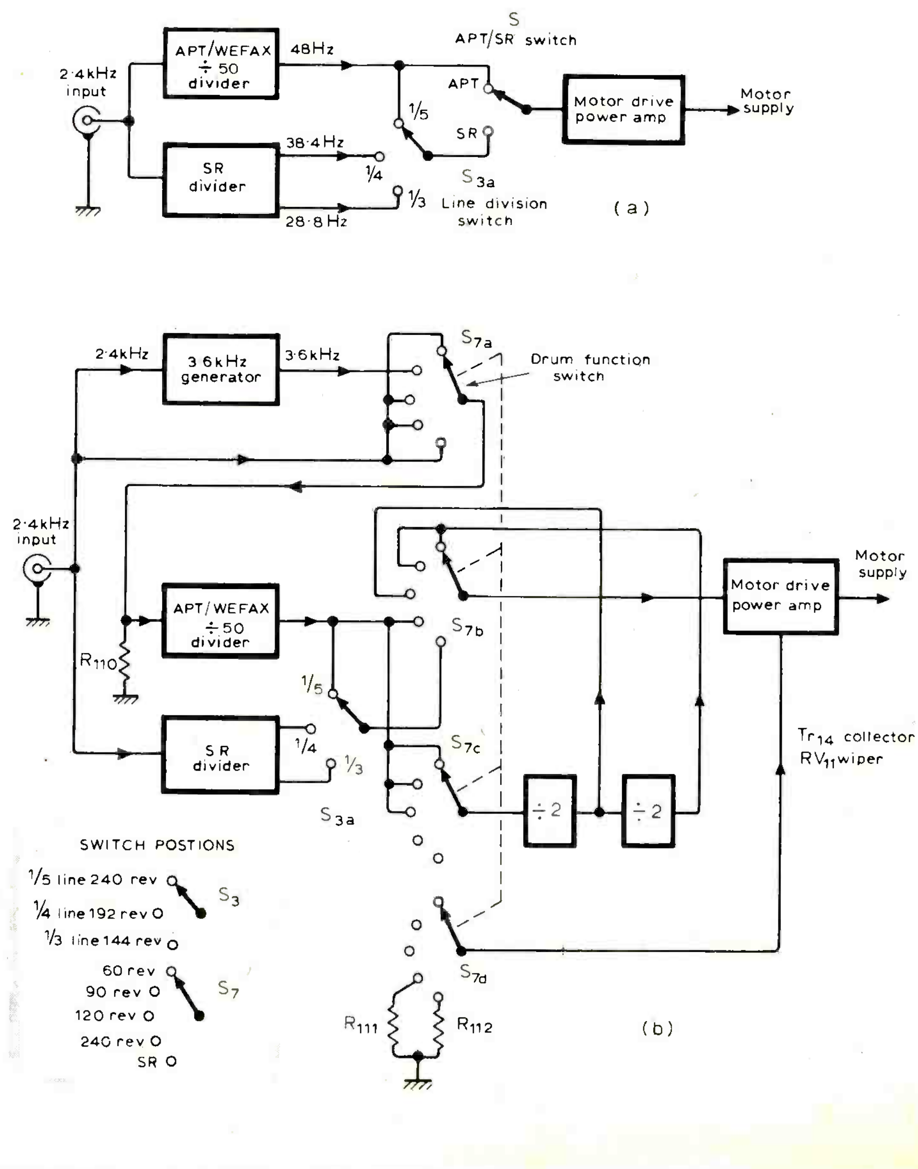


Fig. 21. Essential modifications to the facsimile machine, showing (a) – before modification and (b) – after modification.

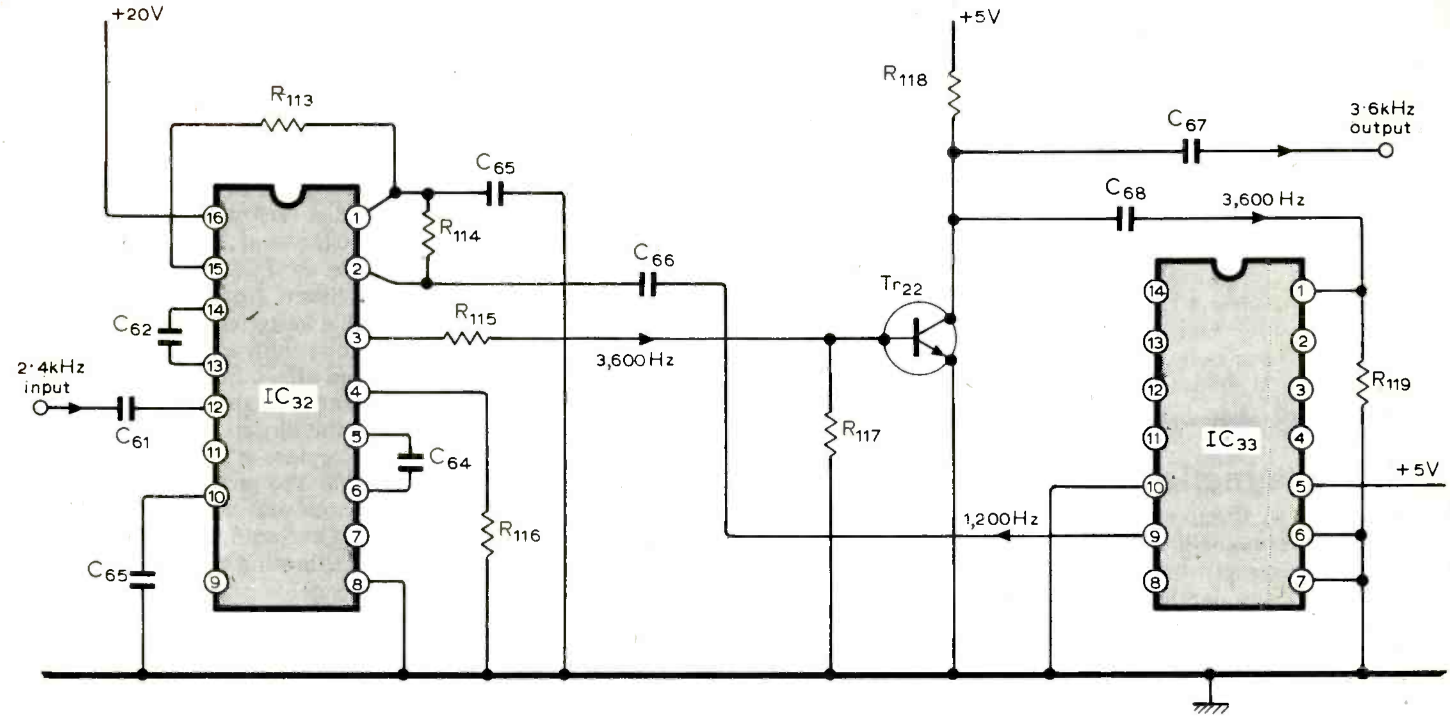


Fig. 22. Phase-locked 3.6kHz generator circuit for "90 rev/min" charts. Correction note! On IC_{32}, the connection shown from pin 10 to ground via C_{65} should be a connection from pin 11 to ground via C_{63}.

but requires more finesse on v.l.f. signals due to the reduced frequency shift. Received chart quality can be improved in the presence of interference by reducing the receiver i.f. bandwidth to just encompass the carrier shift. As a matter of detail, most transmissions have a white inter-chart level and short duration black edge phasing pulses. Those stations of French, or previously French colonial origin, send a black resting level and half-line black/white phasing bars. According to which side of the carrier the b.f.o. is tuned — for double sideband transmissions — the chart may be printed as black lines on white or vice-versa. The option is useful not only for slide production but also to enable a readable copy to be obtained if there is severe interference to one side of the carrier.

The Russian weather charts, that contain strips of computer-processed Meteor satellite pictures, require the detector to be switched to grey on S_6 and RV_{17} adjusted for optimum results, consistent with black lines being printed on the chart.

Photographic materials

The author has found that a most suitable material for all prints, both satellite pictures and radio facsimile charts, is Ilford's Ilfospeed 2.1.M and 3.1.M, a fast-processing resin coated, polyethylene laminated paper. For development an Ilfospeed developer is available, although Kodak D-19 used in its concentrated working solution strength has given excellent results.

It should be noted that this article refers to special radio transmissions and any enquiry concerning reception licencing should be addressed to the relevant licencing authority.

Components list

Resistors (¼W 20% unless otherwise stated)

72	560	96	1.8k
73	560	97	150k
74	4.7k	98	1.8k
75	3.3k	99	120, 1W
76	3.3k	100	270, ½W
77	3.3k	101	470
78	10k	102	10
79	10k	103	2.2k
80	4.7k	104	680
81	4.7k	105	680
82	1.2M	106	10
83	270, 1W	107	2.2k
84	270, 1W	108	680
85	1k	109	680
86	47	110	2.7k
87	47	111	100
88	47	112	330
89	47	113	1k
90	1k	114	1k
91	1k	115	1.5k
92	6.8k	116	1.8k
93	3.9k	117	100
94	3.9k	118	1k
95	330, ½W	119	1k

Transistors

20	BFY51 or similar
21	BFY51 or similar
22	2N3704 or similar

Transformer

3 0-20V @ 1A
0-20V @ 1A
RS Components

Switches

6	SPST toggle
7	4 pole 5 way rotary

Crystal

144kHz quartz bar (Senator Crystals)

Diodes

15-19	5.1V400mW zeners
20	RS REC70 or similar
21	RS REC70 or similar

Integrated circuits

23	NE565	29	SN7437N
24	SN72741N	30	μA723C
25	MC1496L	31	μA723C
26	SN7402N	32	NE562B
27	SN7490N	33	SN7492N
28	SN7492N		

Variable resistors (presets)

16	2.5k 10 turn		
17	0.5M	20	10k
18	10k	21	2k
19	20k	22	2k

Capacitors (μF unless otherwise stated)

37	0.022	53	100/25V
38	0.01+0.0015	54	100/25V
39	0.0012	55	200/35V
40	0.022	56	100p
41	0.047	57	100/35V
42	0.047	58	200/35V
43	0.082	59	100p
44	100/25V	60	100/35V
45	100/25V	61	0.1
46	0.22	62	1.0 Mylar
47	0.33	63	0.068
48	0.10	64	0.068
49	47/12V	65	0.082
50	0.0068	66	0.082
51	560p	67	0.47
52	0.01	68	1.0

New Products

Electromagnetic pump

The Appliance Components Eckerle ETU21 electromagnetic piston pump will handle both corrosive and non-corrosive thin, clean liquids. The latest version is fitted with Delrin inlet and outlet fittings but a more expensive model with stainless steel fittings is available. Measuring 2¼ in × 3¼ in, the pump is self-priming and will handle up to 11 gallons an hour. It may be driven via a silicon semiconductor diode for a 12 to 240V 50Hz a.c. supply, and operates at 25 times a second. Maximum discharge height is 65ft and the maximum vertical lift is 10ft. Apart from non-return valves, the only moving part is the metal piston. Internal metal components, which require no lubrication, are made from corrosion resistant materials. The materials used for the moulded seals and valves can be selected to suit the liquid being handled. Appliance Components Ltd, Cordwallis Street, Maidenhead, Berks SL6 7BQ.
WW 301

I/O ports

Bidirectional, latched input/output ports (interface vector bytes) are announced by the Signetics group of Mullard. The 8-bit ports are intended as interface elements for microprocessors, being compatible with the 8X300 micro. Each i.v. byte contains eight data latches, which can receive data from either a microprocessor port or a user port, the two modes being under separate control. Priority is given to the user port.

The bytes are programmed by the user or manufacturer to recognize an 8-bit address, which opens the port and allows data through when a 'select' signal is applied. Data transfer is stopped when the address no longer matches the programmed, internal address of the byte. Types 8T32 and 8T36 possess three-state outputs, while the 8T33 and 8T35 bytes are open-collector units. 8T32 and '33 are synchronous, '35 and '36 asynchronous. The voltage supply needed is 5V and the modules are in 24-pin packages. Mullard Ltd, Mullard House, Torrington Place, London WC1E 7HD.
WW 302

Component meter

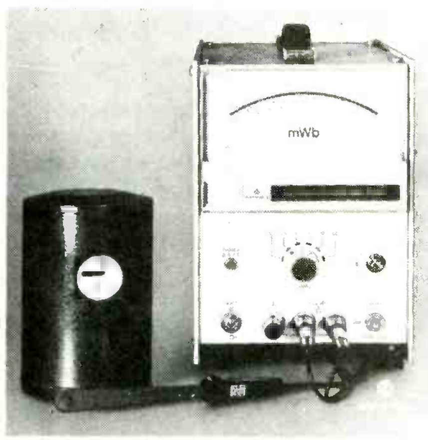
The Wayne Kerr component meter B424 measures resistance, capacitance and inductance on the bridge principle. The display reads up to 1999, and measurements are given up to 20MΩ, 20mF and 2kH. Resolution on the most sensitive ranges is 10mΩ, 0.1pF and 0.1μH. An analogue output is available to feed ancillary equipment. The instrument has an accuracy of 0.25% (± one digit) on all ranges, and is suitable for battery or mains operation. Selection of R, C or L is by push-button, and range-changing by 9-position rotary switch. Illuminated pointers indicate the most appropriate range, and the display also includes decimal points and units. Operating the range switch automatically selects the most suitable test frequency: 1kHz or 100/120Hz. Two test terminals are normally used, but a third is available if required for screened connections. Bias voltage is provided for polarising electrolytics under test. When inductors with high-permeability cores are being measured the test signal level is held below 100mV. Wilmot Breeden Electronics Ltd, 442 Bath Road, Slough, Berks SL1 6BB.
WW 303

Fluxmeter

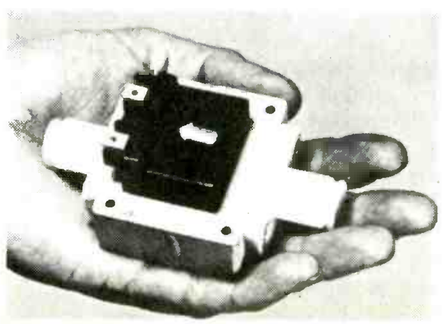
The Austrian made Norma Fluxmeter detects voltage time integrals to measure magnetic flux, flux density and mutual induction. The range is from 0.1 to 50mWb in six ranges with a sensitivity of 1μWb and an accuracy of ± 1% of f.s.d. The instrument has an auto-zero facility and a recorder output, with a source resistance of 2kΩ, on which 1V corresponds to f.s.d. The instrument operates either from the mains or rechargeable batteries. Two probes are available, one with a turns × area of $10^{-2}m^2$, and the other 6× $10^{-4}m^2$. A standard source is also available with a 3.5 × 15.5mm airgap having an induction, say Cropico, of 500 mT[4], accurate to within 1%. The unit measures 160 × 240 × 310mm and weighs 3.8kg. The price is £964 excluding v.a.t. The search coils and calibrating magnet are extra. Cropico say delivery is around three to four weeks. Cropico Ltd, Hampton Road, Croydon CR9 2RU.
WW 304

Microwave power meter

The Sanders Division of Marconi Instruments have introduced a programmable, thin film, thermo-electric (t.f.t.) power meter, type 655oB, for power measurement at microwave frequencies. Replacing the type 655oA, the meter has binary-coded decimal, programmable ranging, automatic range and scale selection and auto-zero



WW 304



WW 301

WW 303

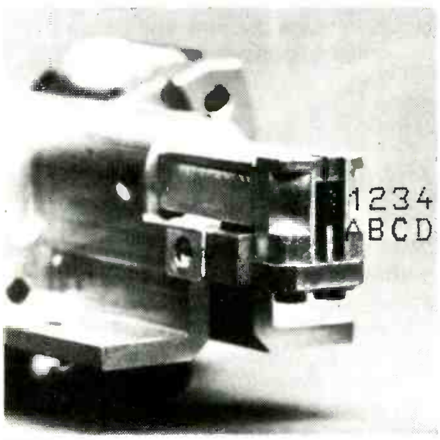
facilities. It can be used with a range of t.f.t. power heads covering frequencies between 10MHz and 40GHz with a power range from 1μW to 3W. The instrument can be used in automatic test systems, but in its manual modes is also suitable for use as a conventional power meter. The t.f.t. power heads available are compatible with all the power meters in the company's range. Marconi Instruments Ltd — Sanders Division, Gunnels Wood Road, Stevenage, Herts, SG1 2AU.
WW 305

Dual-in-line reed relay

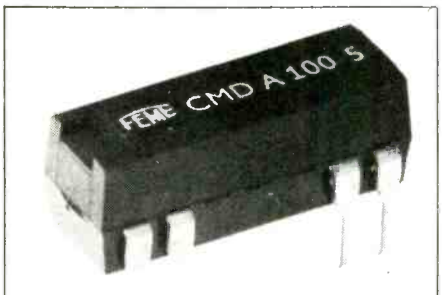
A range of d.i.l. packaged reed relays is now offered by Feme. Single-pole normally-open, double-pole normally-open, and single-pole changeover contact arrangements are available as standard with coil voltage ratings of 5, 6, 12, and 24 volts d.c. Rhodium contacts are used to obtain maximum life at power levels within the ratings of the contacts. Quiller Components Ltd, Cardigan House, Winton, Bournemouth, Dorset, BH9 1AU.
WW 307

Dot matrix printer

A dot matrix serial printer developed by Honeywell Information Systems Italia is controlled by a built-in microprocessor. Its printing head (see photo) has needles operated electromagnetically to a 7 × 7 or 7 × 9 dot matrix and operates at speeds up to 120 characters per second. There are 132 print positions and the character set, which can be changed by replacing a character generating read-only memory, comprises 128 symbols. An original and up to four copies can be printed, and options such as front feed or dual paper movement are available. At every print interruption the print head automatically moves a space to the right to make the printed characters visible. The inked ribbon is contained in a removable cartridge. Honeywell Information Systems Italia, Caluso, Turin, Italy.
WW 309



WW 309



WW 307

25MHz oscilloscope

A range of measuring facilities usually found on wider-band instruments is provided by Philips on the dual-trace PM3214. The delayed timebase, which can be displayed effectively at the same time as the main sweep and strobe, is calibrated and can be made to start immediately after the delay or on receipt of a trigger after the delay. Sensitivity is 2mV per centimetre from 0 to 25MHz and triggering modes include full-range auto, a.c. or d.c. and television line or frame.

For those occasions when signal "low" cannot be earth, the instrument is double-insulated to enable it to be used without an earth connexion. Batteries may alternatively be used and a variety of mains supply voltages can be accommodated. Pye Unicam Ltd, York Street, Cambridge.
WW 311

Television off-air receiver

A crystal controlled mono-channel, mono-standard receiver for off-air professional television applications has been introduced by Barco. Designated VSD2/X, the receiver is supplied for any channel between 47 and 865MHz, including mid-band channels, and for television standards BG, DK, I, and L. The channel selectivity is sufficiently high that the receiver can be used in situations where the field strength of the adjacent (disturbing) channel is several times higher than the strength of the chosen channel. Relative indication of the field strength is presented on a front panel meter. N.V. Cobar Barco Electronic, Video Systems Department, Th. Sevenslaan 106, 8500 Kortrijk, Belgium.
WW 306

1000-watt transceiver

The National Radio transceiver type NCX-1000 has a transmitter power output of 1000 watts p.e.p. on s.s.b.; 1000 watts c.w. (normal c.w. duty cycle); and 500 watts a.m. or f.s.k. Its frequency coverage is 3.5 to 30MHz. Output impedance is 25-100 ohms (minimum tuning range of pi network). Carrier and opposite sideband suppression is greater than 40dB, while receiver sensitivity is better than 0.5μV for 10dB (s + n)/n ratio. Selectivity is 2.7kHz (a crystal lattice filter is used) and the receiver dynamic range is 105dB. Image and i.f. rejection is better than 60dB. Export Division, EMEC Inc., P.O. Box 1285, Hallandale, Florida 33009, USA.
WW 310

Operational amplifier

The 1435/1435-83 is a differential input operational amplifier designed for amplification of wideband complex waveforms with frequency components from d.c. to 1GHz. Gain accuracy is 0.01%. This is reflected in the settling time specification of 70ns to 0.01% for a 10-volt output step. There is a level frequency response beyond 100kHz and smooth 6 dB/octave roll-off beyond 100MHz. When handling complex waveforms such as square pulses, overshoot is less than 1% of output pulse amplitude. Operating temperature is −55°C to +125°C. Teledyne Philbrick, Heathrow House, Bath Road, Cranford, Middlesex TW5 9QQ.
WW 308

WW 305

Sidebands by mixer

Bletherization

The on-going initiation of marketing-oriented buzzwords develops in their enunciator an in-built motivation for the generation of enhanced input/output ratios. When it comes to the crunch, marketing is an aggressively-formulated scenario of both software and hardware-oriented data organization, using sophisticated, number-crunching equipment for the on-line analysis of a cash-flow situation. At the end of the day, the viability of any throughput-motivated validization operation must hopefully depend on the dialogue between personnel engaged in hardware generation and those who basically adjust output-level values to maximize financial advantage, in a committed operation. When intelligence communication is contra-indicated, obscurantization can be generated by sophisticated employment of in-built jargonisation, soonest. Or something.

Update

Some of our readers who have been amateur constructors since capacitance was measured in jars have been baffled by the newer system of component values that are now common. We have explained them before, but we still receive the odd query: if you've been used to dealing with 0.01μF capacitors for fifty years, it comes as a shock to find that you should have been calling the wretched things 10n.

Briefly, it goes something like this. The idea developed from a British Standard designed to avoid decimal points and long strings of noughts on components themselves. On circuit diagrams, the nature of the component can also be omitted — a capacitor is obviously measured in fractions of a farad, so the F is redundant. The decimal point is replaced by the multiplier of the unit (k, M, μ, etc) and the full range of noughts needed is two. For example, 0.0033μF would be written 3n3, meaning 3.3 nanofarads (nano = 10^{-9}). A resistor of 3,300Ω is 3k3 and an inductor of 0.0048 henries becomes 4m8 (4.8mH). A 0.1μF capacitor is 100n, and so on. It's much simpler than the old way and it does avoid decimal points, which can so easily be missed out.

Sounds philological

The sheer labour that engineers go through to bring forth a new device or system fades into insignificance beside the agonies of mind they suffer when they have to think up a name for it. The systems of sound reproduction that use three or more loudspeakers are no exception, in that they have been called everything from quadraphonic to surround-sound, from perisonic to four-channel: and they are just the printable ones. Surely, it's now time to settle down, put away the Latin, Greek and Oxford English dictionaries and come up with a sensible name.

"Quadraphony" is not a good choice. To start with, it's a Graeco-Roman mess, conceived on the wrong side of the blankets, and secondly, the meaning is wrong. It implies a square sound, which is surely not what is intended: a square-sounding punk rock group is not an idea I can easily contemplate. In any case, it should be quadro-, the adjectival form, not quadra-. Or perhaps quadri-, if the number four is intended.

"Surround-sound" has been used rather a lot and has the merit of describing the effect rather than the means of producing it, which could change — it avoids the use of any part of a word meaning "square" or "four". We already have systems, which can use three or six loudspeakers, to which the term quadraphonic is not applicable. My feeling is, though, that the word is too long and is ugly when used adjectivally.

"Ambisonic" is good, but is used almost as a trade-name. For this reason, it is unlikely to be adopted by orgnizations who have their own nominal axes to grind.

Any reference to the number four is not a good idea, even if it were always the right number. It has most relevance to a system using four completely separate channels, but this can't be used for all types of sound reproduction and can't, therefore, be used in an overall description. My own suggestion is to term the reproduced surrounding sound field the phonosphere and to coin the word "phonospheric" to describe such equipment. I shall now sit back and await retribution for my temerity.

2p or not 2p?

Not that tuppence will get you very far in this inflationary age, but it does seem extraordinary that a plain, ordinary (or even coloured ordinary) resistor can cost up to 5p. It seems possible, since the majority of our readers are employed in the electronics industry, that whenever they are seized with the desire to build an amplifier, a commensurate number of relevant components promptly disappears from their labs (a company I know of used to keep small components for engineers to use as they needed them, without having to sign a stores chit, on the basis that each engineer would probably only build one television set and one amplifier and that number of components could be written off).

But that is irrelevant if the prospective builder is not able to liberate components or does not possess the legendary "junk box", beloved of writers of books entitled "The Practical Guide to . . . " So, they are faced with problems of supply and, having located a source, the cost. Time was when you could find a radio shop in any town which sold components, not teak-finished furniture with knobs on, where you could buy everything needed. I remember buying everything I needed for a 12in television set, quite casually, from the local shop. (I won't say how long ago, but Sutton Coldfield and Ally Pally had it all to themselves.)

The only way you can buy stuff now is to send off to a mail order establishment, and very good some of them are, if expensive. I would have thought, and I have no doubt that a great number of component suppliers will put me straight here, that the High Street shops of yore could still perform a very useful function and make a profit doing it. Admittedly, they couldn't stock all the exotic bits and pieces we are now used to, but the ordinary components and materials ought to be no problem. They would be able to buy in bulk from manufacturers who won't deal with the public and, in any case, couldn't handle an order for a few pence. Free of the burden of postage, packing and insurance, they could probably sell components at a lower price, and to boost their sales they could assemble kits of parts for the more popular small designs and sell them both directly and by mail order. Perhaps the new 'byte' shops will do something like that.

Cuckoos

"Nah, well, it's analogue, innit? Wot yer want's a digital readaht." Thus spake a young man of nearly six at the recent RSGB exhibition, as his friend (well turned seven) commented on some frequency-measuring instruments. They caught sight of me and, since it looked as though they might draw me into the discussion, I hurried away before they discovered my relative ignorance of such matters.

But really, haven't these infants more immediately fascinating pursuits to occupy them? Have grass-snakes and guinea-pigs totally disappeared from these islands? Surely not, and yet here were these two, looking as unlike infant prodigies as it is possible to imagine, discussing oscillator stability and instrument design while outside, the toads were toadying and field-mice fielding away like anything.

The sign of a mis-spent youth may no longer be a degree of proficiency at snooker, but deftness with a couple of c.m.o.s. chips and a bit of Veroboard.

Safe, tough, efficient and versatile – that's our new miniature CX iron.

Safe because it is virtually leak-free (leakage current less than 1μA). Earth it if you like – three core lead. It is made to conform with B.S. 3456 and has a breakdown voltage of more than 4000V.

Tough because the handle is almost unbreakable and the ceramic shaft is covered by a stainless steel shaft.

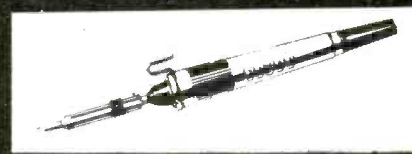
Efficient because the element is situated right inside the soldering bit and the heat generated by its 17 watts is not wasted.

Versatile because the iron can be used for a wide variety of soldering jobs; with six easily interchangeable, slide-on bits, ranging from $\frac{1}{4}$" right down to $\frac{3}{64}$" (1mm). It's suitable for small, miniature and micro miniature joints.

Available for 220-250 volts *or* 100-120 volts. *Weight* – $1\frac{1}{2}$oz (40 gram). *Length* $7\frac{1}{2}$" (19cm). *Price* – **£3.40** fitted with standard bit $\frac{3}{32}$" (2.3mm). *Spare bits* £0.46; £0.72; £0.84 exclusive of VAT.

Stocked by most of the well-known wholesalers and many retailers. Or direct from us if you are desperate.

Model X.25 is a general purpose soldering iron, also with two shafts for toughness and perfect insulation. Available for 220-250 volts *or* 100-120 volts at 25 watts and priced at **£3.40** exclusive of VAT.



Stand model S.T.3 has a chromium plated steel spring, two sponges for cleaning the bits and is priced at **£1.40** exclusive of VAT.

ANTEX

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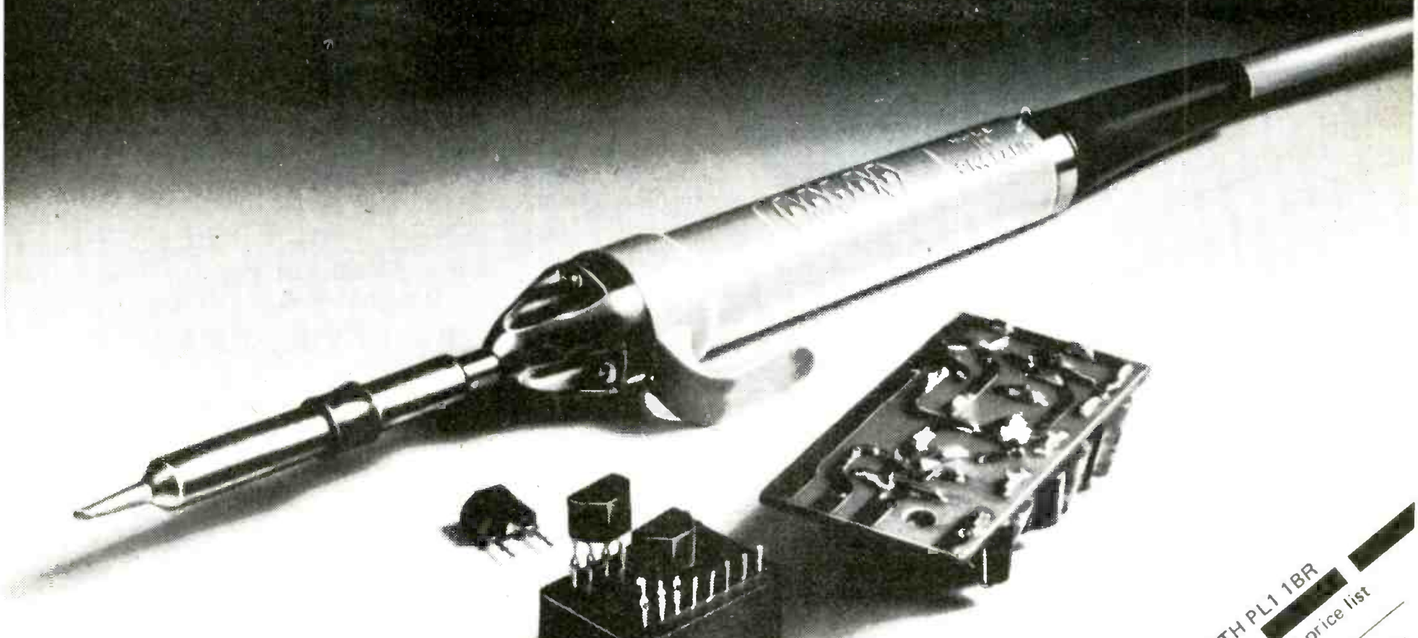
Forget all you've ever read about miniaturised soldering irons. This is the NEW ANTEX CX.



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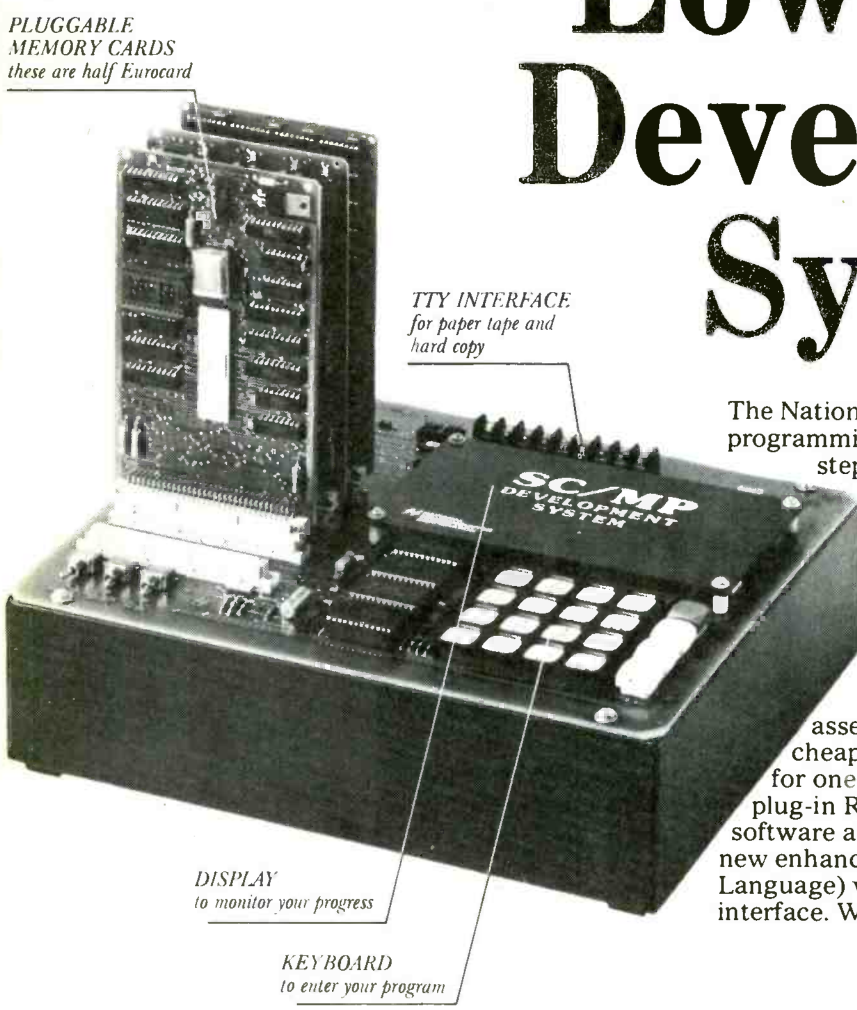
WW7

The SC/MP LCDS that is truly a Low Cost Development System



The National Semiconductor LCDS really does make programming simple. You can develop your own program step-by-step to see how it works and if it works. And with it you can develop the potential of your SC/MP microprocessor.

The simple keyboard and display give you a chance to look at your program as you go—so you can learn programming in your own way. A built-in routine makes software debug so easy.

LCDS is not a kit—it comes fully assembled and tested at less than £350, which is cheaper than the software expert is likely to charge for one program. It is expansible too with additional plug-in RAM, ROM/PROM Eurocards. Available software aids include a Line-by-Line Assembler and a new enhanced language—NIBL (National Industrial BASIC Language) which allows plain English man/machine interface. We make technology work. Every time.

ALSO AVAILABLE
THE FAMOUS
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SC/MP INTROKIT **£68.61** + VAT p&p 75p

CONTAINS ALL YOU NEED TO GET STARTED ON LOW BUDGET MICROPROCESSOR KIT. EUROCARD + CON. SC/MP CHIP. 512 × B PROM. 256 × 8 RAM. VOLTAGE REG, XTAL TTY INTERFACE, ETC. REQUIRES +5 −12 VOLT SUPPLY. IF YOU DON'T HAVE A TTY, THEN OUR KEYBOARD KIT IS WHAT YOU NEED

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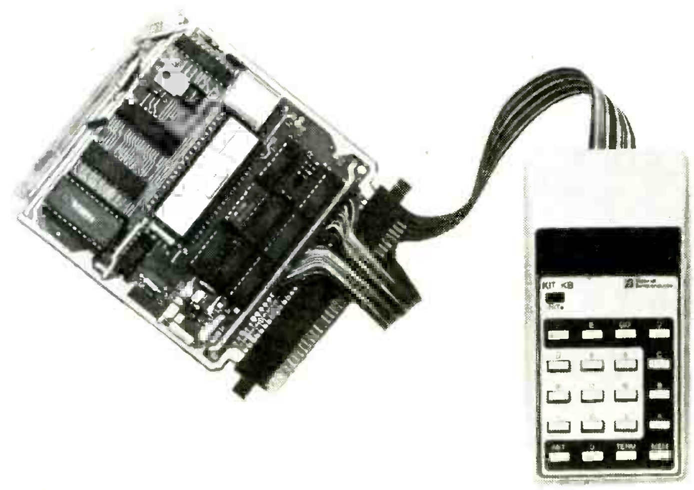

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WW063 FOR FURTHER DETAILS

DIY SPEAKER KITS

15-WATT KIT IN CHASSIS FORM
When you are looking for a good speaker, why not build your own from this kit. It's the unit which we supply with the enclosures illustrated below Size 13" · 8" (approx.) woofer (EMI), tweeter, and matching crossover components. Power handling capacity 15 watts rms. 30 watts peak.

£17.00 PER STEREO PAIR + P & P £3.40

EASY-TO-BUILD WITH ENCLOSURE

Specially designed by RT-VC for cost-conscious hi-fi enthusiasts, these kits incorporate two teak-simulate enclosures, two EMI 13" × 8" (approx.) woofers, two tweeters and a pair of matching crossovers. Easily constructed, using a few basic tools. Supplied complete with an easy-to-follow circuit diagram, and crossover components. Input 15 watts rms. 30 watts peak, each unit. Cabinet size 20" × 11" × 9½" (approx.). £25.50 PER STEREO PAIR + p & p £5.50

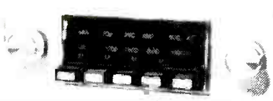
COMPACT' FOR TOP VALUE
How about this for incredible bookshelf value from RT-VC! A pair of high efficiency units for only £7.50 – just what you need for low-power amplifiers. These infinite baffle enclosures come to you ready mitred and professionally finished. Each cabinet measures 12" × 9" × 5" (approx.) deep, and is in wood simulate. Complete with two 8" (approx.) speakers for max. power handling of 7 watts.

per stereo pair £7.50 + p & p £1.70

SPEAKERS Two models – Duo IIb, teak veneer, 12 watts rms, 24 watts peak, 18½" · 13½" · 7¼" (approx.).
★£34 PER PAIR + p & p £6.50
Duo III, 20 watts rms, 40 watts peak, 27" · 13" · 11½" (approx.)
★£52 PER PAIR + p & p £7.50

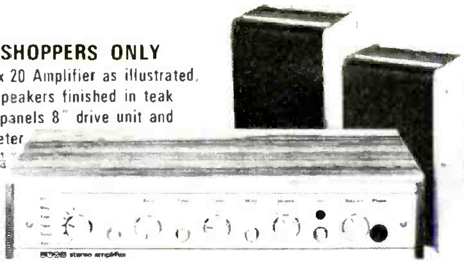
EASY TO BUILD RECORD PLAYER KIT
Ideally suited for the constructor who requires a complete stereo unit at a budget price, comprising ready assembled stereo amp. module, Garrard auto/manual deck with cueing device, pre-cut and finished cabinet work. Output 4 watts per channel, phones socket and record / replay socket £26.95 p & p £4.05

CAR RADIO KIT



Complete with speaker, baffle and fixing strip. The Tourist IV for the experienced constructor only. The Tourist IV has five push buttons, four medium band and one for long wave band. The tuning scale is illuminated and attractive small aluminium control knobs are used for manual tuning and volume control. The modern style fascia has been designed to blend with most car interiors and the finished radio will slot into a standard car radio aperture. Size approx. 7" × 2" × 4¼". Power Supply Nominal 12 volts positive or negative earth (altered internally) Power Output 4 watts into 4 ohms.
MOTOR TOP 10 AWARD
£12.50 + p & p £1.50

PERSONAL SHOPPERS ONLY
Viscount IV 20 x 20 Amplifier as illustrated, plus 1 pair of speakers finished in teak with melamine panels 8" drive unit and 3½" approx tweeter 22" 13" 10½" size approx.
£45.00 SPECIAL OFFER



illustrated above **20 x 20 WATT STEREO AMPLIFIER**
Superb Viscount IV unit in teak-finished cabinet. Silver fascia with alimunium rotary controls and pushbuttons, red mains indicator and stereo jack socket. Function switch for mic, magnetic and crystal pick-ups, tape, tuner, and auxiliary Rear panel features two mains outlets. DIN speaker and input sockets, plus fuse. 20 + 20 watts rms, 40 + 40 watts peak. ★ £29.90 + p & p £2.10

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DEDUCT 10% — Mailorder only (not on postage)
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★ on complete stereo systems using ★ starred Products
For example–
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AM. FM. TUNER P.C.B. with Mullard L.P. 1186, 1185, 1181 modules £9.50
CROWN 5 push button car radio, LW. MW. 12v Pos. neg. earth 5 watts output, tone control complete with speaker and fixing kit, in dash type £15.95
STEREO CASSETTE TAPE PLAYER Negative earth only, 3 watts per channel output £16.50
AM. FM. STEREO MULTIPLEX CAR RADIO/cassette player in dash fixing Negative earth 5 watts output £39.00
SONIX 'TROOPER' Boys Military style mains, battery radio only £6.95

VISCOUNT COMBI £65.00
For personal shoppers only, this unit comprises: The 20 × 20 Viscount amplifier BSR MP60 Type turntable housed in an attractive teak finished console with smoked acrylic cover. Approx. 30¼" × 14½" × 7½" complete ready to connect to the speaker system of your choice.

BSR TURNTABLES
BSR MP60 TYPE
Single play record player (Chassis form) £15.95 less cartridge. P & P £2.00
BSR automatic record player deck (Chassis form) with cueing device and stereo ceramic head. £9.95 P & P £2.00
Cartridges to suit above
ACOS MAGNETIC STEREO £4.95
CERAMIC STEREO £1.95

TURNTABLE illus. Popular BSR MP 60 type, complete with magnetic cartridge, diamond stylus, and de luxe plinth and cover. Ready wired ★ £29 + p & p £4.50

30 x 30 WATT AMPLIFIER KIT
Specially designed by R.T-VC for the experienced constructor, this kit comes complete in every detail. Same facilities as Viscount IV amplifier. Chassis is ready punched, drilled and formed Cabinet is finished in teak veneer. Silver fascia and easy-to-handle aluminium knobs. Output 30 + 30 watts rms, 60+60 peak. £29.00 +p & p £2.10

DECCA 20 WATTS STEREO SPEAKER
This matching loudspeaker system is hand made, kit comprises of two 8" dia meter approx. base drive unit, with heavy die cast chassis laminated cones with rolled P.V.C. surrounds, two 3½" diameter approx. domed tweeters comp with crossover networks £20.00 stereo pair £4.00 p & p

PYE STEREO GRAM CHASSIS
(Complete with circuit-diagrams)
Complete ready to install—Wave bands LM, VHF STEREO, VHF MONO. Controls for tuning volume, balance, bass and treble. Power output 7 watts R.M.S per channel 14 watts peak 8 ohms. 2" · 8" approx chassis speakers and BSR auto record player deck. PERSONAL SHOPPERS ONLY £35.00

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ACTON: Mail Order only No callers

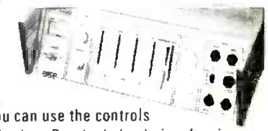
PORTABLE MONO DISCO CONSOLE

with built-in pre-amplifiers
Here's the big-value portable disco console from RT-VC! It features a pair of BSR MP 60 type auto-return, single play professional series record decks. Plus all the controls and features you need to give fabulous disco performances. Simply connects into your existing slave or external amplifier. p & p £6.50 £64.00

35-WATT MONO DISCO AMP
£27.50 + p & p £2.50
Size approx 13⅞" · 5¼" · 6⅜"

Here's the mono unit you need to start off with. Gives you a good solid 35 watts rms, 70 watts peak output. Big features include two disc inputs, both for ceramic cartridges, tape input and microphone input. Level mixing controls fitted with integral push-pull switches. Independent bass and treble controls and master volume.

100 WATT MONO DISCO AMP
Size approx. 14" · 4" · 10½".



Sloping facia, you can use the controls without fuss or bother. Brushed alumimium fascia and rotary controls. Five smooth acting, vertically-mounted slide controls – master volume, tape level, mic level, deck level, PLUS INTER-DECK FADER for perfect graduated change from record deck No. 1 to No. 2, or vice versa. Pre-fade level control (PFL) lets YOU hear next disc before fading it in. VU meter monitors output level. £65.00
Output 100 watts RMS 200 watts peak. p & p £4.00

PRACTICE GUITAR AMPLIFIER WITH BUILT-IN SPEAKER

This budget practice amplifier, has been specially designed for the amateur, who requires a quality self-contained unit with all facilities. 2 inputs – 1 for mic or guitar, the 2nd for record player or cassette deck, it also can be used for cine-sound amplification. 2 volume controls, 1 for each input, also base and treble controls. Power output with internal speaker, 12 watts RMS, with remote speaker (not supplied) 20 watts RMS. Size approx. 17" + 9" · 11". £32.50 + p & p £3.00

HOME 8 TRACK CARTRIDGE PLAYER

Automatically switches programmes monitored by indicators, with manual override track selection. This unit will match with the Unisound modules and is compatable with the Viscount IV amplifier with Sim teak cabinet. approx. 9" · 8" · 3½". p & p £1.50 £14.60

4 x 4 STEREO AMP KIT £14.50 P & P £2.

For the experienced constructor who wants to design his own stereo. Kit includes all necessary components including constructors manual. Plus Pair of easy to build 4 watt speakers in kit form, with teak simulate finish cabinets 12" x 9" x 5" approx.

NEW FANTASTIC SAVING. **sinclair**
I.C 20, 20 WATTS STEREO AMPLIFIER KIT WITH PZ 20 POWER UNIT
A build-it-yourself stereo power amplifier with latest integrated circuitry. 10W RMS per channel output, full short-circuit and overheat protection. Complete with PZ20 Power Supply
OUR PRICE £5.95 + p & p £1
LIST £14.50

BI-PAK

High quality modules for stereo, mono and other audio equipment.

NEW

PUSH-BUTTON STEREO FM TUNER

OUR PRICE ONLY
£20.45

Fitted with Phase Lock-loop Decoder

The 450 Tuner provides instant program selection at the touch of a button ensuring accurate tuning of 4 pre-selected stations, any of which may be altered as often as you choose, by simply changing the settings of the pre-set controls.
Used with your existing audio equipment or with the BI-KITS **STEREO 30** or the **MK60** Kit etc. Alternatively the **PS12** can be used if no suitable supply is available, together with the Transformer **T538.**
The S450 is supplied fully built, tested and aligned. The unit is easily installed using the simple instructions supplied.

★ FET Input Stage
★ VARI-CAP diode tuning
★ Switched AFC
★ Multi turn pre-sets
★ LED Stereo Indicator

Typical Specification:
Sensitivity 3μ volts
Stereo separation 30db
Supply required 20-30v at 90 Ma max.

MPA 30

Enjoy the quality of a magnetic cartridge with your existing ceramic equipment using the new M.P.A. 30, a high quality pre-amplifier enabling magnetic cartridges to be used where facilities exist for the use of ceramic cartridges only.
It is provided with a standard DIN input socket for ease of connection. Full instructions supplied.
£2.85

VAT ADD 12½%

POSTAGE & PACKING
Postage & Packing add 25p unless otherwise shown. Add extra for airmail. Min. £1.00

STEREO PRE-AMPLIFIER

PA 100

OUR PRICE
£13.75

A top quality stereo pre-amplifier and tone control unit. The six push-button selector switch provides a choice of inputs together with two really effective filters for high and low frequencies, plus tape output.

Frequency Response + 1dB 20Hz 20KHz. Sensitivity of inputs
1. Tape Input 100mV into 100K ohms
2. Radio Tuner 100mV into 100K ohms
3. Magnetic P.U. 3mV into 50K ohms

P.U. Input equalises to R1AA curve with 1dB from 20Hz to 20KHz
Supply — 20-35V at 20mA

Dimensions 299mm x 89mm x 35mm

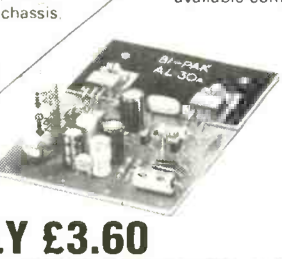
MK. 60 AUDIO KIT: Comprising 2 x AL60's. 1 x SPM80. 1 x BTM80. 1 x PA100. 1 front panel and knobs. 1 Kit of parts to include on/off switch, neon indicator, stereo headphone sockets plus instruction booklet. **COMPLETE PRICE £29.55** plus 85p postage.

TEAK 60 AUDIO KIT:
Comprising Teak veneered cabinet size 16¾"x11½"x3¾", other parts include aluminium chassis, heatsink and front panel bracket plus back panel and appropriate sockets etc. **KIT PRICE £10.70** plus 85p postage.

NEW AL30A

10w R.M.S. AUDIO AMPLIFIER MODULE

The AL30A is a high quality audio amplifier module replacing our AL20 & 30. The versatility of its design makes it ideal for record players, tape recorders, stereo amps, cassette and cartridge players. A power supply is available comprising a PS12 together with a transformer T538, also for stereo, the pre-amp PA12.



SPECIFICATION:
- Output Power 10w. R.M.S.
- Load Impedance 8 to 6ohms.
- Sensitivity 90mv for full output.
- Frequency Response 60Hz to 25KHz ± 2db.
- Supply 22 to 32 volts.
- Input Impedance 50K.
- Total Harmonic Distortion Less than .5% (Typically .3%).
- Max. Heat Sink Temp 80°c.
- Dimensions 90 x 64 x 27mm

ONLY £3.60

STEREO 30

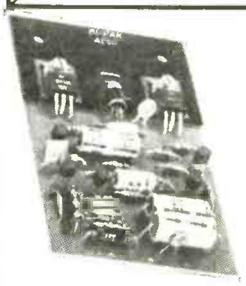
COMPLETE AUDIO

7+7 WATTS R.M.S.

P & P 45p
£16.25

The Stereo 30 comprises a complete stereo pre-amplifier, power amplifiers and power supply. This, with only the addition of a transformer or overwind will produce a high quality audio unit suitable for use with a wide range of inputs i.e. high quality ceramic pick-up, stereo tuner, stereo tape deck etc. Simple to install, capable of producing really first class results, this unit is supplied with full instructions, black front panel knobs, main switch, fuse and fuse holder and universal mounting brackets enabling it to be installed in a record plinth, cabinets of your own construction or the cabinet available. Ideal for the beginner or the advanced constructor who requires Hi-Fi performance with a minimum of installation difficulty (can be installed in 30 mins).

TRANSFORMER £2.45 plus 62p p &p
TEAK CASE £5.25 plus 62p p & p.



AL 60 25 Watts (RMS)

★ Max Heat Sink temp 90C. ★ Frequency response 20Hz to 100KHz ★ Distortion better than 0.1 at 1KHz ★ Supply voltage 15-50v ★ Thermal Feedback ★ Latest Design improvements ★ Load — 3,4,8, or 16 ohms ★ Signal to noise ratio 80db ★ Overall size 63mm. 105mm. 13mm.

Especially designed to a strict specification. Only the finest components have been used and the latest solid-state circuitry incorporated in this powerful little amplifier which should satisfy the most critical A.F. enthusiast.

£4.35

NEW

PA12

NEW PA12 Stereo Pre-Amplifier completely redesigned for use with AL30A Amplifier Modules. Features include on/off volume, Balance, Bass and Treble controls. Complete with tape output.

Frequency Response 20Hz-20KHz (—3dB). Bass and Treble range, 12dB. Input Impedence 1 meg ohm. Input Sensitivity 300mV. Supply requirements 24V .5mA. Size 152mm x 84mm x 33mm.

£6.70

PS12

Power supply for **AL30A, PA12, SA450,** etc.

Input voltage 15-20v A.C. Output voltage 22-30v D.C. Output current 800 mA Max. Size 60mm x 43mm x 26mm.
Transformer T538 £2.30

OUR PRICE £1.30

Stabilised Power Supply Type SPM80

SPM80 is especially designed to power 2 of the AL60 Amplifiers, up to 15 watts (R.M.S.) per channel simultaneously. With the addition of the Mains Transformer **BMT80,** the unit will provide outputs of up to 1.5A at 35V. Size 63mm. 105mm. 30mm. Incorporating short circuit protection.
Transformer BMT80
£2.60 + 62p postage

£3.75

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AAY32	0.15
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AAZ15	0.31
AAZ17	0.25
AC107	0.75
AC125	0.30
AC126	0.25
AC127	0.25
AC128	0.25
AC141	0.20
AC141K	0.30
AC142	0.20
AC142K	0.25
AC176	0.25
AC187	0.25
AC188	0.25
ACY17	0.65
ACY18	0.65
ACY19	0.65
ACY20	0.65
ACY21	0.65
ACY39	1.00
AD149	0.70
AD161	0.75
AD162	0.75
AF106	0.45
AF114	0.25
AF115	0.25
AF116	0.25
AF117	0.25
AF139	0.40
AF186	1.50
AF239	0.45
AFZ11	2.75
AFZ12	2.75
ASY26	0.45
ASY27	0.50

ASZ15	1.25
ASZ16	1.25
ASZ17	1.25
ASZ20	0.75
ASZ21	1.50
AU110	1.70*
AU113	1.70*
AUY10	1.70*
BA145	0.15*
BA148	0.15*
BA154	0.10
BA155	0.12
BA156	0.13
BAW62	0.05
BAX13	0.07
BAX16	0.07
BC107	0.12
BC108	0.12
BC109	0.13
BC113	0.15*
BC114	0.18*
BC115	0.19*
BC116	0.19*
BC117	0.22*
BC118	0.16*
BC125	0.18*
BC126	0.25*
BC135	0.15*
BC136	0.19*
BC137	0.16*
BC147	0.10*
BC148	0.10*
BC149	0.13*
BC157	0.12*
BC158	0.11*
BC159	0.13*
BC167	0.13*
BC170	0.16*
BC171	0.14*

BC172	0.13*
BC173	0.15*
BC177	0.19
BC178	0.18
BC179	0.20
BC182	0.11*
BC183	0.11*
BC184	0.12*
BC212	0.14*
BC213	0.14*
BC214	0.17*
BC237	0.17*
BC238	0.12*
BC301	0.45
BC303	0.60
BC307	0.20*
BC308	0.18*
BC327	0.22*
BC328	0.18*
BC337	0.19*
BC338	0.18*
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BCY31	1.00
BCY32	1.00
BCY33	0.90
BCY34	0.90
BCY39	3.00
BCY40	1.25
BCY42	0.30
BCY43	0.32
BCY58	0.23
BCY70	0.18
BCY71	0.22
BCY72	0.17
BCZ11	1.50
BD115	0.60
BD121	1.50
BD123	1.50
BD124	1.00

BD131	0.51
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BD135	0.35*
BD136	0.36*
BD137	0.37*
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BD139	0.43*
BD140	0.47*
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BD181	1.38
BD182	1.48
BD237	0.80
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BDY60	0.75
BF115	0.39
BF152	0.25
BF153	0.25
BF154	0.25
BF159	0.35
BF160	0.30
BF167	0.39
BF173	0.39
BF177	0.38
BF178	0.45
BF179	0.48
BF180	0.45
BF181	0.45
BF182	0.45
BF183	0.45
BF184	0.39
BF185	0.37
BF194	0.12*
BF195	0.11*
BF196	0.13*
BF197	0.14*
BF200	0.32
BF224	0.20*

BF244	0.35*
BF257	0.37
BF258	0.42
BF259	0.45
BF336	0.50*
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BF338	0.55*
BFS21	2.27
BFS28	1.38
BFS61	0.25*
BFS98	0.25*
BFW10	0.90
BFW11	0.90
BFX84	0.38
BFX85	0.41
BFX87	0.35
BFX88	0.32
BFY50	0.28
BFY51	0.26
BFY52	0.26
BFY64	0.30
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BSX19	0.34
BSX20	0.34
BSX21	0.32
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BTY79/400R	3.19
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BU206	2.25*
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CRS1/05	0.45
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GJ7M	0.75
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MJE370	0.65
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MJE521	0.75
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MPF103	0.30*
MPF104	0.30*
MPF105	0.30*
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MPSU01	0.32*
MPSU06	0.40*
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NKT404	1.73
NE555	0.45
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OA7	0.55
OA10	0.55
OA47	0.14
OA70	0.30
OA79	0.30
OA81	0.30
OA85	0.30
OA90	0.80
OA91	0.08

OA95	0.08
OA200	0.10
OA202	0.11
OA210	0.75
OA211	0.75
OAZ200	0.65
OAZ201	0.65
OAZ206	0.65
OAZ207	0.65
OC16	1.25
OC20	2.00
OC22	2.50
OC23	2.75
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OC25	0.90
OC26	0.90
OC28	2.00
OC29	2.00
OC35	1.50
OC36	1.50
OC41	0.50
OC42	0.50
OC43	1.50
OC44	0.50
OC45	0.50
OC71	0.45
OC72	0.45
OC73	1.00
OC74	0.50
OC75	0.60
OC76	0.50
OC77	1.20
OC81	0.75
OC81Z	1.00
OC82	0.75
OC83	0.55
OC84	0.60
OC122	1.50
OC123	1.55
OC139	1.25

OC140	1.95
OC141	2.25
OC170	0.60
OC171	0.60
OC200	1.00
OC201	1.50
OC202	1.25
OC203	1.25
OC204	1.25
OC205	1.75
OC206	1.75
OC207	1.25
OCP71	1.25
ORP12	0.70
R2008B	2.25*
R2009	2.25*
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TIL209	0.25
TIP29A	0.50*
TIP30A	0.60*
TIP31A	0.62
TIP32A	0.75
TIP33A	1.00
TIP34A	1.20
TIP41A	0.70
TIP42A	0.90
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ZS140	0.25*
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ZS178	0.54*
ZS271	0.22*
ZS278	0.56*
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ZTX108	0.10*
ZTX109	0.12*
ZTX300	0.12*

ZTX301	0.13*
ZTX302	0.17*
ZTX303	0.17*
ZTX304	0.19*
ZTX311	0.12*
ZTX314	0.20*
ZTX500	0.13*
ZTX501	0.14*
ZTX502	0.16*
ZTX503	0.17*
ZTX504	0.20*
ZTX531	0.20*
ZTX550	0.16*
1N914	0.07
1N916	0.07
1N4001	0.06
1N4002	0.07
1N4003	0.08
1N4004	0.09
1N4005	0.13
1N4006	0.15
1N4007	0.15
1N4009	0.15
1N4148	0.07
1N5400	0.14
1N5401	0.16
1S44	0.06
1S920	0.08
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2G301	1.00
2G302	1.00
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2N404	0.60
2N696	0.25
2N697	0.16
2N698	0.30
2N705	0.80
2N706	0.12
2N708	0.21
2N930	0.26

2N1131	0.26
2N1132	0.26
2N1302	0.37
2N1303	0.37
2N1304	0.45
2N1305	0.45
2N1306	0.50
2N1307	0.50
2N1308	0.60
2N1309	0.60
2N1613	0.33
2N1671	1.50
2N1893	0.33
2N2147	1.40
2N2148	1.65
2N2218	0.33
2N2219	0.42
2N2220	0.35
2N2221	0.22
2N2222	0.25
2N2223	2.75
2N2368	0.17
2N2369A	0.21
2N2484	0.21
2N2646	0.50
2N2904	0.35
2N2905	0.35
2N2906	0.25
2N2907	0.21
2N2924	0.15*
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2N2926	0.13*
2N3053	0.25
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2N3440	0.60
2N3441	0.80
2N3442	1.20
2N3525	0.90
2N3614	1.20

2N3702	0.15*
2N3703	0.15*
2N3704	0.15*
2N3705	0.15*
2N3706	0.14*
2N3707	0.18*
2N3708	0.14*
2N3709	0.15*
2N3710	0.14*
2N3711	0.15*
2N3771	1.60
2N3772	1.70
2N3773	2.65
2N3819	0.36*
2N3820	0.46*
2N3823	0.60*
2N3866	1.00
2N3904	0.21*
2N3905	0.22*
2N3906	0.22*
2N4058	0.20*
2N4059	0.15*
2N4060	0.20*
2N4061	0.17*
2N4062	0.18*
2N4124	0.17*
2N4126	0.17*
2N4286	0.20*
2N4288	0.25*
2N4289	0.25*
2N5457	0.35*
2N5458	0.35*
2N5459	0.35*
3N125	1.75
3N141	0.85

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BT17	55.64
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C3JA	10.00
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DAF96	1.00*
DET22	15.12
DET24	41.00
DF91†	0.40*

DF96	1.00*
DK91†	0.55*
DK92	1.25*
DK96	1.10*
DL92	0.75*
DL94	1.20*
DL96	1.10*
DLS10	8.25
DLS15	8.25
DLS16	8.25
DLS19	8.25
DM70	1.25
DM71	1.25
DM160	1.50
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E55L	21.89
E80CC	4.86
E80CF	6.23
E80F	5.57
E80L	5.34
E81CC	5.76
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E92CC	4.86
E99F	5.38
E130L	16.85
E180CC	5.23
E180F	5.64

E182CC	5.72
E186F	7.68
E188CC	4.92
E280F	12.95
E283CC	7.85
E288CC	12.22
EA52	12.92
EA76	1.50
EABC80	0.40*
EAF42	1.25*
EAF801	1.75*
EB41	1.75*
EB91†	0.30*
EBC33	1.75*
EBC41	1.25*
EBC81	1.10*
EBC90†	0.65*
EBC91†	0.50*
EBF80	0.45*
EBF83	1.25*
EBF89†	0.40*
EBL31	2.50*
EC90†	0.40*
EC91†	2.80*
EC92	1.25*
EC157	190.00
ECC33	3.50*
ECC35	3.50*
ECC40	1.25*
ECC81†	0.45*
ECC82†	0.45*
ECC83†	0.45*
ECC84†	0.50*
ECC85†	0.55*
ECC86	2.00*
ECC88†	0.60*
ECC89	0.75*

ECC91†	0.35*
ECC189	1.00*
ECC807	1.75
ECC808	2.25*
ECF80†	0.60*
ECF82†	0.60*
ECF86	0.75*
ECH35	2.00*
ECH42	1.15*
ECH81†	0.50*
ECH83	0.85*
ECH84†	0.85*
ECL80†	0.60*
ECL81	0.75*
ECL82†	0.55*
ECL83	1.50*
ECL84	0.90*
ECL85	0.85*
ECL86†	0.65*
ECLL800	7.00*
EF37A†	1.60*
EF39†	1.60*
EF40	1.15*
EF41	1.20*
EF42	2.00*
EF50†	0.60*
EF54	5.00*
EF55	2.50*
EF80†	0.45*
EF83	1.75*
EF85†	0.50*
EF86†	0.45*
EF89	0.60*
EF91†	0.65*
EF92†	0.75*
EF93†	0.50*
EF94†	0.55*

EF95†	0.30*
EF98	1.25*
EF183†	0.50*
EF184†	0.50*
EF804S	6.50
EF805S	7.00
EH90	0.75*
EK90†	0.65*
EL32	1.50*
EL33	3.50*
EL34†	0.85*
EL36	0.75*
EL41	1.25*
EL42	1.75*
EL81	1.10*
EL83	1.25*
EL84†	0.35*
EL86†	0.50*
EL95†	0.80*
EL90†	0.75*
EL91	3.76*
EL156	16.25
EL360	2.25*
EL500/504	1.50*
EL509	2.16*
EL821	4.32*
EL822	4.65*
EM80	1.10*
EM81	1.00*
EM84	1.00*
EM85	1.25*
EM87	1.50*
EN32	5.50
EN91†	0.55

EN92	1.94
EY51†	0.75*
EY81	1.65*
EY83	1.75*
EY84	3.86*
EY86†	0.50*
EY88	1.75*
EY500A	1.36*
EY802	0.82*
EZ35	0.55*
EZ40	1.25*
EZ41	1.25*
EZ80†	0.30*
EZ81†	0.35*
EZ90†	0.45*
FN4-500	2.50*
FN4-800	2.50*
G1-371K	15.00
G55-1K	9.50
G180-2M	12.90
G240-20	11.75
G400-1K	13.50
GN4	2.50
GN4A	2.50
GS16	9.00
GT1C	6.95
GU50	9.66
GU51	9.80
GXU1	10.43
GXU2	17.20
GXU3	21.42
GXU4	21.94
GY501	1.32*
GZ32	0.75*

GZ33	4.00*
GZ34†	1.24*
GZ37	4.00*
KT61	3.50*
KT66	4.00*
KT88	4.75*
KTW61	1.75*
KTW62	1.75*
KTW63	1.75*
M8079	8.38
M8080	3.80
M8081	6.16
M8082	4.65
M8083	5.60
M8091	7.70
M8096	3.75
M8097	3.56
M8098	3.20
M8099	5.20
M8100	5.90
M8136	5.95
M8137	6.08
M8140	4.50
M8141	4.85
M8142	4.00
M8144	3.75
M8149	5.10
M8161	5.62
M8162	5.76
M8163	4.50
M8190	4.60
1	3.70
M8196	3.40
M8204	3.50

M8212	8.62
M8223	2.30
M8224	2.80
M8225	2.60
M8248	6.54
MU14	1.00*
MX119	17.49
MX123	32.07
MX145	25.25
MX151	11.69
MX152	61.65
MX161	66.60
MX163	11.69
MX164	12.56
MX166	59.40
MX168	22.28
N78	7.50*
OA2†	0.45
OA3	1.10
OA4	1.10
OB2†	0.45
OB3	0.75
OC2	2.30
OC3†	0.45
OD3†	0.45
OZ4	0.75*
PC86†	0.85*
PC88†	0.85*
PC95	0.70*
PC97	0.88*
PC900†	0.75*
PCC84†	0.45*
PCC85	0.45*
PCC88	0.65*

PCC89†	1.05*
PCC189†	0.65*
PCC805†	0.95*
PCC806†	0.95*
PCE82†	1.05*
PCF80	0.72*
PCF82†	0.50*
PCF86†	0.65*
PCF87†	1.00*
PCF200†	1.05*
PCF201†	1.05*
PCF801†	0.55*
PCF802†	0.72*
PCF805	1.28*
PCF806	0.80*
PCF808	1.28*
PCL82†	0.50*
PCL83†	0.92*
PCL84†	0.50*
PCL85†	0.80*
PCL86†	0.65*
PCL805/85†	0.80*
PD500	3.00*
PE66-40N	27.30
PFL200	0.88*
PL36†	0.92*
PL81	0.55*
PL81A†	1.00*
PL82	0.60*
PL83†	0.55*
PL84†	0.60*
PL504/500†	0.96*
PL508†	1.32*

PL509†	2.16*
PL519†	2.96*
PL801	1.10*
PL802†	1.80*
PY33	0.68*
PY81†	0.72*
PY82	0.45*
PY83	0.60*
PY88†	0.68*
PY500A†	1.36*
PY800/81†	0.72*
PY801	0.72*
QQV02-6	9.00
QQV03-10†	1.60
QQV03-20A†	8.50*
QQV06-40A†	8.50*
QQV07-50	34.80
QQZ03-20A	27.50
QQZ06-40A	38.80
QU37	11.00
QV03-12	3.00
QV04-7	2.50
QV08-100	82.40
QY3-65	40.40
QY3-125†	10.00
QY4-250	51.30
QY4-400	55.50
QY5-500	118.50
QY5-3000A	170.00

QZ06-20	18.95
R10	5.00
R17	1.65*
R18	3.86*
R19	1.00*
R20	1.00*
RG3-250	8.85
RG3-250A	8.85
RG3-1250	20.95
RG4-1250	27.50
RG4-3000	53.45
RR3-250	9.55
RR3-1250	22.00
S11E12	18.00
S130	2.00
S130P	2.50
STV280-40	10.00
STV280-80	20.00
SU41	2.50
SU42	9.00
TD03-10	15.00
TD03-10E	17.50
TD03-10F	17.50
TT15	22.00
TT21	7.00
TT22	7.00
TT100	37.50
TY2-125	40.20
TY4-400	54.00
TY4-500	68.40
TY5-500	160.00
TY6-800	145.00
TY6-5000A	188.00

BASES

B7G unskirted	0.15
B7G skirted	0.30
B9A unskirted	0.15
B9A skirted	0.30
Int Octal	0.20
Mazda Octal	0.20
Nuvistor	0.25
Loctal	0.55
8 pin	0.15
14 pin	0.15
16 pin	0.17
Valve screening cans all sizes	0.30

CRT'S

2AP1	8.50*
2BP1	9.00*
3BP1	6.00
3DP1	5.00*
3EG1	7.00*
3FP7	3.00*
3GP1	6.00
3JP1	8.00*
3JP2	8.00*
3JP7	10.00*
3KP1	15.00*
3RP1	35.00*
4EP1	25.00

4EP7	25.00
4EP11	25.00
5ADP1	35.00
5BP1	5.00*
5CP1	5.00*
5CP1A	40.00
5FP15A	5.00
5FP7	5.00*
5UP7	5.00*
DG7-5	25.00
DG7-32	36.00
DH3-91	31.00
DH7-11	68.00
VCR97	5.00*
VCR138	10.00*

VCR138A	12.50*
VCR139A	8.00*
VCR517A	3.00*
VCR517B	3.00*
VCR517C	3.00*

= Surplus

3" MU metal screens	1.50
5" MU metal screens	2.50
Tube Bases	0.75

INTEGRATED CIRCUITS

7400	0.20
7401	0.20
7402	0.20
7403	0.20
7404	0.26
7405	0.23
7406	0.55
7407	0.55
7408	0.28
7409	0.28
7410	0.20
7412	0.26
7413	0.45
7416	0.40
7417	0.40
7420	0.20

7422	0.25
7423	0.35
7425	0.35
7427	0.35
7428	0.50
7430	0.20
7432	0.36
7433	0.37
7437	0.42
7438	0.37
7440	0.22
7441AN	0.92
7442	0.78
7447AN	1.20
7450	0.20
7451	0.20

7453	0.20
7454	0.20
7460	0.20
7470	0.35
7472	0.36
7473	0.36
7474	0.40
7475	0.59
7476	0.42
7480	0.60
7482	0.85
7483	1.00
7484	1.00
7486	0.40
7490	0.52
7491AN	0.85

7492	0.60
7493	0.70
7494	0.80
7495	0.80
7496	0.90
7497	3.67
74100	1.75
74107	0.45
74109	0.86
74110	0.57
74111	0.86
74116	1.89
74118	0.95
74119	2.00
74120	1.10
74121	0.45
74122	0.60
74123	1.00

74125	0.80
74126	0.80
74128	0.80
74132	0.80
74136	0.68
74141	0.85
74142	3.00
74143	3.00
74144	3.00
74145	1.00
74147	2.45
74148	2.00
74150	1.75
74151	0.90
74154	2.00
74155	0.90
74156	0.90
74157	0.90

74159	2.50
74170	2.60
74172	5.00
74173	1.75
74174	1.57
74175	1.00
74176	1.10
74178	1.65
74179	1.65
74180	1.65
74190	1.48
74191	1.48
74192	1.25
74193	1.25
74194	1.25
74195	1.10
74196	1.20
74197	1.00

74198	2.25
74199	2.25
76013N	1.75*
TAA570	2.30*
TAA630S	3.50*
TBA480Q	1.84*
TBA520Q	2.30*
TBA530	1.98*
TBA540Q	2.30*
TBA550Q	3.22*
TBA560CQ	3.22*
TBA673	2.19*
TBA700	1.52*
TBA720Q	2.30*
TBA750Q	2.99*
TBA990Q	2.99*
TCA270Q	2.99*
TCA760A	1.38*

Terms of business: C.W.O. postage and packing valves and semiconductors 25p per order. CRTs 75p. Items marked * add 12½% VAT. Others 8%
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ASTRA-PAK

92 GODSTONE ROAD
WHYTELEAFE SURREY CR3 0EB

★ NEW ★ FULLY GUARANTEED COMPONENTS ★ FULL SPEC SEMICONDUCTORS ★ QUANTITY DISCOUNTS ★

BEAD TANTALUM

1 22 33 47 68 luf 35v all values	.11
2 2 3.3 4 7 6.8uf 35v all values	.12
10uf 25v	.13
22uf 16v	.13
33uf 10v	.14
47uf 6 3v	.15
68 100uf 3v both values	.15

CARBON FILM RESISTORS

¼ watt — 10Ω — 1MΩ — E12 Series .01 each, .09 for 10 of any one value, .75 for 100 of any one value.

I.C. SOCKETS

8 pin	.11
14 pin	.12
16 pin	.13
24 pin	.48

LEDS

	125"	2"
Red	09"	09"
Green	25"	25"
Amber	25"	25"

400mW ZENER DIODES

2 7v-33v .09 each, .80 for 10, 3.50 for 50, 6.25 for 100 — Any Mix

S.C.R's

7 amp 100v	.50
7 amp 400v	.72
16amp 100v	.75

DIAC

BR100	.26

150 amp 100v stud rectifier — stud anode 1.00

ELECTROLYTICS

uf	16v	25v	40v	63v
1	.045	.05	.055	.06
1 5	.045	.05	.055	.06
2 2	.045	.05	.055	.06
3 3	.045	.05	.055	.06
4 7	.045	.05	.055	.06
6 8	.05	.055	.06	.07
10	.05	.06	.07	.09
22	.06	.07	.09	.13
33	.07	.085	.10	.15
47	.08	.10	.12	.19
100	.10	.13	.18	.26
150	.11	.15	.20	.28
220	.12	.16	.22	.32
330	.14	.18	.26	.36
470	.16	.20	.29	.40
680	.18	.24	.35	.48
1000	.20	.29	.41	
2200	.24	.38	.60	
4700	.39	.52	.85	

BAX16	.05	BC158	.11
BC107	.085	BC159	.11
BC108	.085	BC182	.11
BC109	.09	BC182L	.11
BC147	.09	BC183	.11
BC148	.09	BC183L	.11
BC149	.09	BC184	.11
BC157	.10	BC184L	.11

BC212	.12	MPSA56	.22	IN914	.06	2N3702	.08
BC212L	.12	MPSU01	.35	IN4001	.05	2N3704	.07
BC213	.11	MPSU51	.38	IN4002	.055	2N3705	.07
BC213L	.11	OA47	.08	IN4003	.06	2N3707	.08
BC214	.13	OA79	.08	IN4004	.075	2N3710	.07
BC214L	.13	OA90	.07	IN4005	.09	2N3819	.22
BCY70	.17	OA91	.075	IN4006	.10	2N3904	.12
BCY71	.18	OC20	.98	IN4007	.11	2N3906	.12
BCY72	.15	OC28	.78	IN4148	.05	2N4058	.12
BD131	.40	OC35	.78	IN5402	.16	2N4062	.12
BD132	.41	OC36	.78	IS44	.05	CMOS	
BFX85	.25	TIP29A	.46	IS920	.06	4000	.18
BFX87	.24	TIP29B	.55	2N696	.15	4001	.20
BFX88	.24	TIP30A	.52	2N706	.20	4002	.20
BFY50	.16	TIP30B	.62	2N1306	.35	4011	.20
BFY51	.16	TIP31A	.54	2N1307	.35	4012	.20
BFY52	.16	TIP31B	.65	2N2219	.20	4013	.50
BSX19	.20	TIP32A	.62	2N2222	.20	4016	.50
BSX21	.25	TIP32B	.75	2N2222A	.20	4017	.95
MJE340	.66	TIP41A	.67	2N2368	.20	4020	1.05
MJE371	.66	TIP41B	.70	2N2646	.42	4024	.75
MJE521	.60	TIP42A	.75	2N2904	.20	4025	.20
MJE2955	.92	TIP42B	.80	2N3053	.17	4027	.60
MJE3055	.65	TIP3055	.50	2N3054	.42	4030	.55
MPSA06	.22	ZTX107	.10	2N3055	.42	4033	1.50
MPSA13	.24	ZTX304	.20	2N3440	.50	4040	1.00

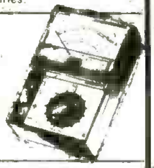
4042	.80	LINEAR		7410	.16	7473	.35
4044	.99	380-14	1.05	7411	.25	7474	.35
4049	.55	555-8	.36	7412	.24	7475	.46
4054	1.10	710-14	.32	7413	.28	7476	.37
4060	1.10	711-14	.32	7414	.60	7483	.92
4066	.50	3045	.45	7416	.30	7485	1.25
4069	.40	VOLTAGE REGS		7417	.30	7486	.34
4071	.26	300	1.25	7420	.16	7489	2.80
4081	.20	723-14	.46	7425	.20	7490	.42
4093	.80	7805TO220	1.30	7426	.26	7492	.48
4501	.20	7812TO220	1.30	7427	.30	7493	.42
4502	1.00	7815TO220	1.30	7430	.16	7495	.74
4507	.60	7905TO220	1.95	7432	.30	7496	.80
4511	1.50	7912TO220	1.95	7437	.33	74121	.32
4528	1.05	7915TO220	1.95	7440	.16	74123	.70
4556	.98	7400 TTL		7441	.68	74132	.75
4583	.80	7400	.16	7442	.60	74141	.80
		7401	.16	7445	.96	74145	.75
OP AMPS		7402	.16	7447	.76	74147	1.40
301A-8	.35	7403	.16	7450	.16	74150	1.45
709-14	.46	7404	.16	7451	.16	74151	.75
741-8	.22	7405	.16	7453	.16	74153	.85
741-14	.20	7406	.32	7454	.16	74154	1.37
741 TO99	.48	7407	.32	7460	.16	74157	.70
747-14	.70	7408	.16	7470	.30	74161	1.00
3900	.50	7409	.16	7472	.32	74173	1.50

SERVICE TRADING CO

RELAYS

Wide range of AC and DC relays available from stock. Phone or write in your enquiries.

WHY PAY MORE?!



MULTI RANGE METER. A.C. volts 2.5-500 D.C. volts 2.5-500 (Sensitivity 2000Ω/V D.C. & A.C.) D.C. current 0/1/10/100 mA. Ohms range. Sturdy compact moving coil instrument with 21 ranges, dimensions 120 × 80 × 44mm. Weight 0.32 kg. SERVICE TRADING CO. Price **£5.50.** Incl. leads and battery. Post 50p (Total price inc VAT & Post **£6.48.**)

TRIAC. Raytheon tag symmetrical Triac. Type Tag 250/500v 10 amp 500 piv. Glass passivated plastic triac. Swiss precision product for long term reliability **£1.25.** P&P 10p (inclusive of date and application sheet). Suitable Diac **20p.**

0 to 60 MINUTES CLOCKWORK TIMER.

Double pole 15 amp 230AC. Contacts (no dial) **£1.50.** P&P 30p.

GALVANOMETER.

50 micro mirror galvo. Calibrated 50-0-50 and 0-100. Mfg. by Griffin & George Ltd. Offered at fraction of maker's price, in original ministry packing **£12.00,** p&p 60p.

CONTACTOR

Mfg. by Hendrey Relays, type C2839 220/250 AC ops. Contact 4C/0 at 20 amp at 440 volts AC, price **£6.00.** P&P 75p.

CITENCO

FHP motor type C7333/15 220/240 volts AC. 19 rpm reversible motor, torque 14.5kg, gear ratio 144:1. Brand new incl. compasitors, our price **£14.25.** P&P £1.25.

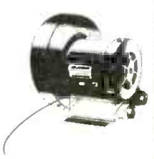
230 VOLT AC FAN ASSEMBLY

Powerful continuously rated AC motor complete with 5 blade 6" aluminium fan. Price **£3.95.** P&P 65p.

21-WAY SELECTOR SWITCH with reset coil

The ingenious electro mechanical device can be switched up to 21 positions and can be reset from any position by energising the reset coil. 230/240v. A.C. operation. Unit is mounted on strong chassis. Complete with cover. Price **£5.50.** P&P 75p.

VORTEX BLOWER AND VACUUM UNIT

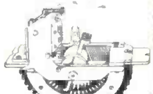


Dynamically balanced totally enclosed 9" rotor with max. air delivery of 1.5 cubic metres per min. Max. static pressure 600mm W.G. Suction or blow from 2 side-by-side 37mm I.D. circular apertures fitted to base of unit. Powerful continuously rated 115v a.c. motor mounted on alloy base with fixing facilities. Dimensions: Length 22cm x width 25cm x height 25cm. These units are ex equipment but have had minimum use. Fully tested prior to despatch. Price **£12** + £1.50 P&P. Suitable transformer for 230/240v a.c. **£6** + £1 P&P.

NI-CAD BATTERIES

	Height (mm)	Width (mm)	Length (mm)
1b AH 1.2 Metal 3	163	55	27
23 AH 1.2v Plastic Case 4	214	79	27
15 AH 1.2v Metal 6.50	219	75	29
40 AH 1.2 Plastic Case £8	275	80	35

UNISELECTOR SWITCH



4 bank, 25 way 75 ohm coil 36-48v D.C. operation. Ex **new** equipment **£4.25.** P&P 75p. Total price inc. VAT **£5.40.**

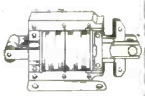
MINIATURE UNISELECTOR

12v 11 way 4 bank (3 non-bridging, 1 homing) **£2.50.** P&P 35p.

MICRO SWITCHES

Omron roller micro switch Type V15 FL 22-1C. 10 for **£2.00** post 50p (Min. order 10).
Sub-miniature Burgess type V 4T 1. 10 for **£2.50.** 50 for **£10.00,** post paid.
Sub-miniature Honeywell roller M/S Type 3 115M 906T 10 for **£2.50,** post paid.
LEVER OPERATED 20 amp c/o. Mfg. by Unimax USA. 10 for **£4.00** plus 50p P&P (min. order 10).

NEW HEAVY DUTY SOLENOID



Mfg. by Magnetic Devices. 240v. A.C. operation approx. 20lb pull at 1.25". Price **£7.00.** P&P 75p.
Similar to above approx. 10lb pull **£3.50.** P&P 60p.

230-250 VOLT A.C. SOLENOID

Similar in appearance to illustration. Approximately 1½lb pull. Size of feet 1⅜" × 13/16". Price **£1.00.** Post 25p.

24 VOLT D.C. SOLENOIDS

UNIT containing: **1 heavy duty solenoid approx. 25 lb. pull** at 1 in. travel. 2 solenoids of approx. 1 lb. pull at ½ in. travel. 6 solenoids of approx. 4 oz. pull at ½ in. travel. Plus 1 24V D.C. 1 heavy duty 1 make relay. Price **£3.00.** Post £1.00. **ABSOLUTE BARGAIN.**

240 A.C. SOLENOID OPERATED FLUID VALVE

Rated 1 p.s.i. will handle up to 7 p.s.i. Forged brass body, stainless steel core and spring. ½ in. b.s.p. inlet outlet. Precision made British mfg. PRICE **£2.75.** Post 50p, new original packing.

VARIABLE VOLTAGE TRANSFORMERS

Carriage extra

INPUT 230 v. A.C. 50/60

OUTPUT VARIABLE 0/260v. A.C.

BRAND NEW. All types.

200W (1 Amp) fitted A/C volt meter	**£11.50**
0.5 KVA (Max. 2½ Amp)	**£14.00**
1 KVA (Max. 5 Amp)	**£18.00**
2 KVA (Max. 10 Amp)	**£30.00**
3 KVA (Max. 15 Amp)	**£38.00**
4 KVA (Max. 20 Amp)	**£60.00**

LT TRANSFORMERS

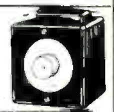
0-12v/24v at 1 amp	£2.50	p&p 50p
0-15v at 1 amp. + 0-15v at 1 amp (30v 1 amp.)	£2.50	p&p 50p
25-0-25v at 2½ amp.	£4.50	p&p 75p
0-12v/24v. 10 amp	£12.35	p&p £1.50
0-4v/6v/24v/32v at 12 amp.	£13.00	p&p £1.50
0-12v at 20 amp or 0-24v at 10 amp	£12.40	p&p £1.50
0-6v/12v/17v/18v/20v at 20 amp	£14.00	p&p £1.50
0-6v/12v at 20 amp.	£11.85	p&p £1.00

Other types in stock, phone in enquiries.

300 V.A. ISOLATING TRANSFORMER

115/230 screened primary, two separate or 115v for 115 or 230v. Secondary two 115v at 150 V.A. each for 115 or 230v output. Can be used in series or parallel connections. Fully tropicalised. Length 13.5cm, width 11cm, weight 15lbs. Special price **£6.00,** carr. £1.00.

RODENE UNISET TYPE 71 TIMER



0-60 sec. 230v AC operation. Incorporating a lapsed time indicator and repeat facilities. A precision motorised timer ideal for process timing, photography, welding, mixing etc. Price **£6.00** p&p 60p.

STROBE! STROBE! STROBE!

HY-LIGHT STROBE KIT Mk. IV

Latest type Xenon white light tube. Solid state timing and triggering circuit. 230/240 volt A.C. operation. Speed adjustable 1-20 f.p.s. Designed for large rooms, halls, etc. Light output greater than many (so called 4 Joule) strobes. Price **£18.00.** Post 75p. Specially designed case and reflector for Hy-Light **£8.25.** Post £1.00.

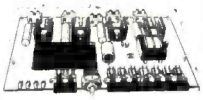
ULTRA VIOLET BLACK LIGHT FLUORESCENT TUBES

4ft. 40 watt £7.00 (callers only). **2ft. 20 watt £5.00.** Post 60p. (For use in stan bi-pin fittings). MINI **12in. 8 watt £1.75.** Post 25p. **9in. 6 watt £1.40. 6in. 4 watt £1.40.** Post 25p. Complete ballast unit. Either 6", 9" or 12" tube 230V. A.C. op. **£3.50** plus p&p 40p. Also available for 12V. D.C. op. **£3.50** plus p&p 40p.

XENON FLASH GUN TUBES

Range of Xenon tubes available from stock. S.A.E. for full details.

SQUAD LIGHT

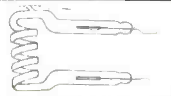


A new conception in light control. Four channels each capable of handling 750 watts of spotlights, floodlights or dozens of small mains lamps. Seven programs all speed controlled plus flash modulation, effectively giving 14 different displays. Makes sound-to-light obsolete. Completely electrically and mechanically noise free. Price only **£60.00**. Post 75p. S.A.E. (Foolscap) for further details.

RELAYS

Wide range of AC and DC relays available from stock. Phone or write in your enquiries.

FT3

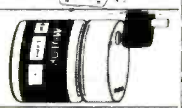


High intensity multi turn voltage, neon glow, discharge flash tube. Design for ignition timing, etc. **£1.50** P&P 25p. 3 for **£3.00** P&P 50p.

RESET COUNTER

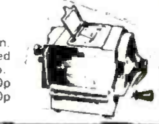
230 volts AC 3 digits mfg. Veeder Root type LL 14:1 **£1.75** p&p 25p. 7 fig. 24v non set **£1.50** p&p 25p.

BIG INCH



Tiny precision built 3 rpm USA motor size only 1 × 1 100 volt AC op. supplied with resistor for 230 volt AC price **£2.00** P&P 20p. 4 for **£5.00** post paid.

INSULATION TESTERS (NEW)



Test to I.E.E. spec. Rugged metal construction, suitable for bench or field work constant speed clutch. Size L 8 in. W 4 in. H 6 in., weight 6 lb.
500 VOLTS 500 megohms **£40.00** Post 80p
1000 VOLTS 1000 megohms **£46.00** Post 80p
SAE for leaflet

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ACCOUNT CUSTOMERS MIN. ORDER £10.00

GEARED MOTORS

100 R.P.M. 115 lbs. ins.!!

115 lb. ins. 110 volt, 50Hz, 2.8 amp, single phase, split capacitor motor. Immense power. Continuously rated. Totally enclosed. Fan cooled. In-line gearbox. Length 250mm. Dia. 135mm. Spindle Dia. 15.5mm. Length 145mm, ex-equipment tested **£12.00.** Post £1.50. Suitable transformer 230/240 volt **£8.00.** Post 75p.

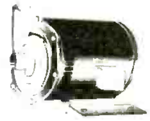
15 R.P.M.

Type SD48 15 r.p.m. 80 lb. ins. Input 100/120 volt A.C. Length incl. gearbox 270mm. Height 135mm. Width 150mm. Shaft drive 16mm. Weight 8.5 Kilos. BRAND NEW. Price **£10.00,** carr. £1.00. Suitable transformer for use on 220/240 volt A.C. **£6.00.** Post 50p.

BODINE TYPE N.C.I. GEARED MOTOR

(Type 1) 71 r.p.m. torque 10 lb. in. **Reversible** 1/70th h.p. cycle .38 amp. This U.S.A. motor is offered in as new condition. Input voltage of motor 115v **A.C.** Supplied complete with transformer for **230/240v A.C. input.**
Price type **£6.25.** Post 75p or less transformer **£3.75.** Post 65p.
(Type 3) 71 r.p.m. 230 Volt A.C. Continuously rated. Non reversible **£6.50** Post 75p.

A.E.G. WATER PUMP



200-240v a.c. motor 2850 rpm 480w approx. 1/3 hp driving a centrifugal pump with 1½" inlet and outlet delivering approx. 40 galls per min. at 10ft head. Ideal for pumping or circulating any non corrosive light viscosity liquid. Dozens of uses in industrial labs etc. Note this pump is not self-priming. Price **£15** + 75p p&p.

CITENCO

FHP motor type C 7333/15 220/240v a.c. 19 rpm reversible motor torque 14.5 kg. Gear ratio 144:1. Brand new incl. capacitor our price **£14.25** + £1.25 p&p.

REVERSIBLE MOTOR 230V A.C.

General Electric 230v A.C., 1,600 r.p.m. 0.25 amp. Complete with anti-vibration mounting bracket and capacitor. O/A size 110mm x 95mm. Spindle 5/16" dia. 20mm long. Ex-equipment tested **£3.00.** Post 50p.

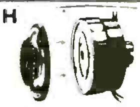
REVERSIBLE MOTOR

AEI 1/12 hp continuous rated, reversible motor. 100/120v A.C. 50/60 cycle 2850 r.p.m. Flange fixing dia 4", length 4½", shaft 1" × 5/16". Price **£3.25.** P&P 75p.

METERS NEW 90mm Diameter

Type: 65CS D.C. mc. 2, 5, 10, 20, 50 amp **£3.00.** 100 amp **£3.25. Type: 62T2 A.C.** M/I. 1, 10, 50 amp **£3.00.** 0-150 Volt A.C. M/I **£3.25** and 300 Volt A.C. R/M/C **£3.00** P&P 30p.

BENDIX MAGNETIC CLUTCH



Superb example of electro-mechanics. Main body in two sections. Coil section is fixed and has ⅜" sleeve. The drive section rotating on the outer perimeter. When engaged the transmission is extremely powerful. Diameter 1½". Total width 1¾". 24V D.C. op. Price **£3.50** plus p&p 45p.

TIME SWITCH

Horstmann Type V Mk II Time Switch. 200/250 volt A.C. Two on/two off every 24 hours at any manually pre-set time 30 amp contacts. 36-hour spring reserve in case of power failure. Day omitting device. Fitted in heavy high impact case with glass observation window. Built to highest Electricity Board spec. individually tested. Price **£7.75.** Post 50p (Total inc VAT £8.91).

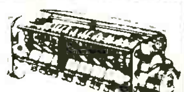
A.C. MAINS TIMER UNIT

Based on an electric clock, with 25 amp single-pole switch, which can be preset for any period up to 12 hrs. ahead to switch on for any length of time from 10 mins. to 6 hrs. then switch off. An additional 60 min. audible timer is also incorporated. Ideal for Tape Recorders, Lights, Electric Blankets etc. Attractive satin copper finish. Size 135 mm x 130 mm x 60 mm. Price **£2.25.** Post 40p (Total inc VAT & Post **£2.87**).

POWER RHEOSTATS

New ceramic construction, vitreous enamel embedded winding, heavy duty brush assembly, continuously rated.
25 WATT 10, 25, 100, 150, 250, 500, 1k, 1.5k ohm **£1.90.** Post 20p. **50 WATT** 100, 500 ... **£2.40.** Post 25p. **100 WATT** 1, 5, 10, 25, 50, 100, 250, 500, 1k, 1.5k, 2.5k, 5k ohm **£3.70.** Post 35p.
Black Silver Skirted knob calibrated in Nos. 1-9 ... dia brass bush ... above Rheostats **22p ea.**

PROGRAMME TIMERS



230 Volt AC Operation. 15 or 20 r.p.m. Each cam operates a c/o micro switch. Ideal for lighting effects, displays, etc. Ex equip. tested. Similar to illustration.
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... **£7.50**
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600V AC range: 15,000 Ω/V
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AC/DC current ranges: 60-120-600μA-3-12-300mA-1.2-6A
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Accuracy: 1.5% DC; 2.5% AC (of full scale deflection)

Mirror scale and knife edge pointer. Taut suspension of movement. Transistor amplifier is used for all AC ranges thus achieving a common linear scale for both AC and DC ranges.

Meter is protected by a transistorised cut-out relay circuit. Range selection is achieved by clearly marked piano keys. Power source: 5 1.5V dry cells. Dimensions: 95 x 225 x 120mm.

PRICE £39.50 plus VAT
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OSCILLOSCOPE CI-5
Made in USSR

Extremely simple and easy to use single beam oscilloscope. Well proved design based on standard octal valves makes servicing and maintenance straightforward and inexpensive. Because of its bandwidth of 10 MHz the instrument is suitable for general electronic applications and educational purposes where a sophisticated instrument would be both too expensive and delicate. 3in. tube giving a 50 x 50mm clear display. Amplitude and time base calibrations. Sensitivity 30mm/v max. Triggered and free-running time base, suitable for displaying pulses from 0.1 μ sec. to 3 m sec. A.C. mains operation.

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6AT6	0.60	35B5	0.70
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6BJ6	0.75	EAC91	0.55
6BN6	0.80	EAF42	0.70
6BZ6	0.55	EAF801	0.65
6BZ7	0.70	EBC41	0.75
6C4	0.40	EBC81	0.50
6CB6	0.50	EBF80	0.50
6EA8	0.75	EBF83	0.50
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6J4	0.75	EC86	0.75
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6J6	0.35	EC91	2.80
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6SN7GT	0.55	ECC83	0.38

ECC84	0.35	ECL85	0.65
ECC85	0.45	ECL86	0.55
ECC86	1.25	EF80	0.35
ECC88	0.60	EF85	0.45
ECC89	0.60	EF86	0.40
ECC189	0.80	EF183	0.35
ECF80	0.45	EF184	0.40
ECF82	0.45	EFL200	0.75
ECF86	0.75	EL34	0.70
ECF801	0.75	EL36	0.60
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ECH42	0.85	EL82	0.60
ECH81	0.50	EL83	0.60
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ECH84	0.50	EL95	0.70
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ECL84	0.60	EY81	0.45

All prices are exclusive of VAT

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PCC85	0.45	TT22	6.30
PCC88	0.65	UABC80	0.50
PCC89	0.55	UAF42	0.70
PCC189	0.65	UBC41	0.50
PCF80	0.40	UBC81	0.50
PCF82	0.40	UBF80	0.50
PCF86	0.65	UBF89	0.50
PCF200	0.80	UCC84	0.75
PCF201	0.85	UCC85	0.50
PCF802	0.55	UCF80	0.75
PCH200	0.75	UCH42	0.80
PCL81	0.55	UCH81	0.50
PCL82	0.40	UCL82	0.40
PCL84	0.50	UCL83	0.70
PCL85	0.60	UF41	0.75
PCL86	0.60	UF42	0.75
PCL200	0.75	UF80	0.40
PL33	0.40	UF85	0.50
PL36	0.60	UF89	0.50
PL38	0.65	UL41	0.70
PL81	0.55	UL84	0.50
PL82	0.50	UY41	0.55
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AC188	20
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AF115	24
AF116	24
AF117	24
AF118	70
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AF125	30
AF126	28
AF127	28
AF139	34
AF178	1 20
AF179	1 20
AF180	1 20
AF181	1 20
AF186	1 20
AF239	37
ASY26	40
ASY27	45
ASY28	40
ASY29	45
ASY67	1 40
ASZ21	2 00
†BA145	15
†BA148	15
BA154	10
BA155	12
BA156	13
BAX12	11
BAX13	07
BAX16	07
BC107	12
BC107A	12
BC107B	15
BC108	11
BC108A	11

BC108B	12
BC108C	13
BC109	13
BC109B	13
BC109C	14
†BC113	12
†BC114	15
†BC115	15
†BC116	15
†BC116A	15
†BC117	18
†BC118	10
BC119	28
†BC125	16
†BC126	20
†BC128	25
†BC132	14
†BC134	14
†BC135	14
†BC136	16
†BC137	16
BC138	28
BC139	35
BC140	32
BC141	32
BC142	22
BC143	28
†BC147	10
†BC147A	11
†BC147B	11
†BC148	08
†BC148A	09
†BC148B	09
†BC148C	09
†BC149	10
†BC149B	12
†BC149C	12
†BC153	18
†BC154	18
†BC157	11
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†BC171B	15
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BC177	17
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BC178C	18
BC179	18
BC179B	19
BC179C	19
†BC182	12
†BC182A	12
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†BC182LB	11
†BC183	10
†BC183A	10
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†BC183L	10
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†BC183LB	10
†BC183LC	10
†BC184	11
†BC184B	12
†BC184C	13
†BC184L	11
†BC184LB	12
†BC184LC	13
BC186	25
BC187	26
†BC204	15
†BC204A	16
†BC204B	16
†BC205	14
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†BC205B	15
†BC205	15
†BC206A	15
†BC206B	15
†BC207	10
†BC207A	11
†BC207B	13
†BC208	10
†BC208A	11
†BC208B	11
†BC208C	11
†BC209	12
†BC209B	13
†BC209C	13
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†BC212B	13

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†BC212LA	13
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†BC213LB	15
†BC213LC	15
†BC214	15
†BC214B	14
†BC214C	20
†BC214L	18
†BC214LA	15
†BC214LB	16
†BC214LC	20
†BC237	15
†BC237A	16
†BC237B	16
†BC238	14
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4027	60
4028	90
4029	1 30
4030	65
4031	2 40
4032	1 00
4033	1 60
4034	5 00

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BSR HI-FI AUTOCHANGER
STEREO AND MONO £11.95 Post 75p

Plays 12", 10" or 7" records. Auto or Manual. A high quality unit backed by BSR reliability with 12 months guarantee. A.C. 200/250V. Size 13½-11¼in. 3 speeds. Above motor board 3¾in. Below motor board 2½in. with STEREO and MONO CARTRIDGE

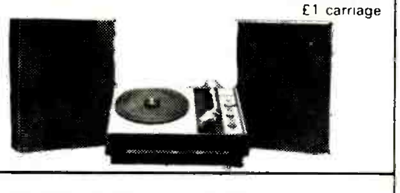
B.S.R. SINGLE PLAYER similar to above with stereo cartridge and cueing device, large turntable **£13.50**

B.S.R. P128 with magnetic cartridge. Balanced arm cueing device **£24.50.** Post £1.

PORTABLE PLAYER CABINET
Modern design. Rexine covered. Vynair front grille. Chrome fittings. Size 17 x 15 x 8in. approx. **£4.50** Post 75p
Motor board cut for BSR or Garrard deck

HEAVY METAL PLINTHS
With P.V.C. Cover. Cut out for most B.S.R. or Garrard decks. Silver grey finish. **£6.50** Post £1.50
Model "A" Size 12½ x 14¾ x 7½in.
Model "B" Size 16 x 13¾ x 7in. **£7.50.**
Extra large plinth & cover, teak wood base. Size 20"x17½"x9" **£19.50.** Callers only

COMPLETE STEREO SYSTEM
Two full size loudspeakers 13¾ x 10 x 3¾in. Player unit clips to loudspeakers making it extremely compact, overall size only 13¾ x 10 x 8½in., 3 watts per channel, plays all records 33 r.p.m., 45 r.p.m. Separate volume and tone controls Attractive Teak finish 240V a.c. mains **£22.50** £1 carriage



SMITH'S CLOCKWORK 15 AMP TIME SWITCH
0—6 HOURS £3.30 Post 35p

Single pole two-way. Surface mounting with fixing screws. Will replace existing wall switch to give light for return home, garage, automatic anti-burglar lights, etc. Variable knob. Turn on or off at full or intermediate settings. Brand new and fully guaranteed.

TEAKWOOD LOUDSPEAKER GRILLES will easily fit to baffle board. Size 10½ x 7⅞in—**45p.**

R.C.S. "MINOR" 10 watt AMPLIFIER KIT
This kit is suitable for record players, guitars, tape playback, electronic instruments or small P.A. systems. Two versions available Mono. **£11.25;** Stereo. **£18.** Post 45p. Specification 10W per channel, input 100mV, size 9½ x 3 x 2in. approx. S.A.E. details. Full instructions supplied. AC mains powered.

VOLUME CONTROLS
5k. to 2M. LOG or LIN L/S **35p.** D P **60p.** STEREO L/S **85p.** D P **£1.** Edge 5K S P Transistor **45p.**

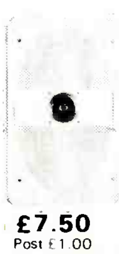
80 Ohm Coax 8p yd.
STANDARD TYPE VHF FRINGE LOW LOSS **15p yd.** Ideal 625 and colour
PLUGS **10p.** SOCKETS **10p.** LINE SOCKETS **18p.** OUTLET BOXES **50p.**

DRILL SPEED CONTROLLER/LIGHT DIMMER KIT. Easy to build kit. Will control up to 500 watts AC mains **£3.25** Post 35p

STEREO PRE-AMP KIT. All parts to build this pre-amp 3 inputs for high, medium or low gain per channel, with volume control and P.C. Board. Can be ganged to make multi-way stereo mixers. **£2.95** Post 35p

E.M.I. 13½ x 8in. SPEAKER SALE!
With tweeter and crossover 10 watt State 3 or 8 ohm As illustrated. **£5.95** Post 45p

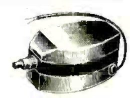
Ditto 15 watts, 8 ohm **£8.50** Post 65p



With tweeter and crossover 20 watt Bass res 25 c.p.s. Flux=11 000 gauss 4 or 8 or 15 ohm 20 to 20,000 c.p.s. **£9.50** Post 75p

Bookshelf Cabinet Teak finish. For EMI 13 x 8 speakers. **£7.50** Post £1.00

THE "INSTANT" BULK TAPE ERASER AND HEAD DEMAGNETISER. Suitable for cassettes, and all sizes of tape reels. A.C. mains 200/250V. Leaflet S.A.E. Will also demagnetise small tools. **£4.50** Post 50p



BLANK ALUMINIUM CHASSIS. 6 x 4—**70p;** 8 x 6—**90p;** 10 x 7—**£1.15;** 12 x 8—**£1.35;** 14 x 9—**£1.50;** 16 x 6—**£1.45;** 16 x 10—**£1.70. ANGLE ALI.** 6 x ¾ x ¾in—**15p.**
ALUMINIUM PANELS. 6 x 4—**17p;** 8 x 6—**24p;** 14 x 3—**25p;** 10 x 7—**35p;** 12 x 8—**43p;** 12 x 5—**30p;** 16 x 6—**43p;** 14 x 9—**52p;** 12 x 12—**68p;** 16 x 10—**75p.**
MANY ALI BOXES IN STOCK. MANY SIZES

ELAC 9 x 5in HI-FI SPEAKER TYPE 59RM
£3.45 Post 35p
This famous unit now available. 10 watts. 8 ohm.

R.C.S. LOW VOLTAGE STABILISED POWER PACK KITS
All parts and instructions with Zener diode, printed circuit rectifiers and double wound mains transformer. Input 200/240V a.c. Output voltages available, 6 or 7.5 or 9 or 12V d.c. up to 100mA or less. Size 3 x 2½ x 1½in. Please state voltage required. **£2.95** Post 45p

R.C.S. POWER PACK KIT
12 VOLT, 750mA. Complete with printed circuit board and assembly instructions. **£3.35** Post 30p
12 VOLT 300mA KIT, **£3.15.** 9 VOLT 1 AMP KIT, **£3.35.**

R.C.S. GENERAL PURPOSE TRANSISTOR PRE-AMPLIFIER — BRITISH MADE
Ideal for Mike, Tape, P.U., Guitar, etc. Can be used with battery 9-12V or H.T. line 200-300V d.c. operation. Size 1¾ x 1¼ x ¾in. Response 25 c/s to 25 kc/s. 26 dB gain. For use with valve or transistor equipment. Full instructions supplied. Details S.A.E. **£1.45** Post 30p

ELECTRO MAGNETIC PENDULUM MECHANISM
1.5V d.c. operation over 300 hours continuous on SP2 battery, fully adjustable swing and speed. Ideal displays, teaching electro magnetism or for metronome, strobe, etc. **95p** Post 30p

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ALL POST 50p

250-0-250V 70mA, 6.5V, 2A	**£3.45**
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300-0-300V 120mA, 2 x 6.3V 2A C.T., 6.3V 2A	**£7.00**
220V 45mA, 6.3V 2A	**£1.75**
HEATED TRANS. 6.3V ½ amp **£1;** 3 amp	**£1.40**

GENERAL PURPOSE LOW VOLTAGE. Tapped outputs at 2 amp. 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 25 and 30V **£4.60.** 1 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60 **£4.60.** 2 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60 **£7.** 3 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60 **£8.70.** 5 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60 **£11.25.** 6.06V 500mA **£1,** 9V 1 amp **£1,** 12V 300mA, **£1,** 12V 500mA, **£1,** 12V 750mA, **£1,** 10V, 30V, 40V 2 amp. **£2.75,** 20V, 3 amp. **£2.45,** 40V, 2 amp. **£2.95,** 30V 5A and 34V 2ACT **£3.45,** 0, 5, 8, 10, 16V, ½ amp. **£1.95,** 20V ½ amp. **£1.75,** 20V, 1 amp. **£2.20,** 20V 3 amp. **£2.50,** 20-0-20V 1 amp. **£2.95,** 30V 1½ amp. **£2.75;** 20V, 40V, 60V or 20-0-20V, 1 amp. **£3.50.** 30-0-30V 3 Amp **£7.**
AUTO TRANSFORMERS, 115V to 230V or 230V to 115V 150W **£5;** 250W **£6;** 400W **£7;** 500W **£8.**
FULL WAVE BRIDGE CHARGER RECTIFIERS 6 or 12V outputs, 1½ amp **40p;** 2 amp **55p;** 4 amp **85p.**
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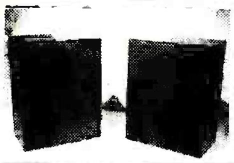
12V. 1½A HALF WAVE Selenium Rectifier. **25p.**

R.C.S. BOOKSHELF SPEAKERS
13 x 10 x 6in. 50 to 14,000 cps 8 watts rms. 8 ohms
£16 pair Post £1.30



KUBA-KOPENHAGEN STEREO

TUNER-AMPLIFIER CHASSIS AM-FM 5+5 WATT
This Continental 4-band radiogram chassis uses first class quality components throughout. Features: Large facia panel with 7 push buttons for medium, long, short, VHF-FM, AFC, phono, mains on-off. 4-rotary controls, tuning, volume, tone, balance. Facia size 17 x 4½ inches. Chassis size 17 x 4½ x 5½ inches. DIN-connector sockets for tape record/playback, loudspeakers, phono pick-up, external FM-AM aerials. Automatic stereo beacon light. Built-in ferrite rod aerial for medium/longwave. A.C. 240V mains. Circuit supplied. Above speakers are suitable. **£33.50** Post £1.50

LOW VOLTAGE ELECTROLYTICS
1, 2, 4, 5, 8, 16, 25, 30, 50, 100, 200mF 15V **10p.**
500mF 12V **15p;** 25V **20p;** 50V **30p;** 420/500V **£1.30**
1000mF 12V **17p;** 25V **35p;** 50V **47p;** 100V **70p.**
2000mF 6V **25p;** 25V **42p;** 420/500V **£1.30.**
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3900mF 100V **£1.60.** 4700mF 63V **£1.20.**
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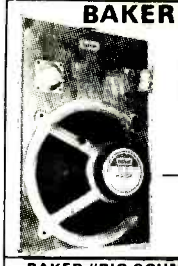
MANY OTHER ELECTROLYTICS IN STOCK
SHORT WAVE 100pF air spaced gangable tuner. **95p.**
TRIMMERS 10pF, 30pF, 50pF **5p.** 100pF, 150pF **15p.**
CERAMIC, 1pF to 0.01mF, **5p.** Silver Mica 2 to 5000pF **5p.**
PAPER 350V-0.1 **7p;** 0.5 **13p;** 1mF 150V **20p;** 2mF 150V **20p;** 500V-0.001 to 0.05 **5p;** 0.1 **10p;** 0.25 **13p;** 0.47 **25p.**
MICRO SWITCH SINGLE POLE CHANGEOVER 20p.
SUB-MIN MICRO SWITCH, 25p. Single pole change over.
TWIN GANG, 385 + 385pF **50p;** 500pF standard **75p;** 365 + 365 + 25 + 25pF, Slow motion drive **65p.**
120pF **TWIN GANG, 50p;** 365pF **TWIN GANG, 50p.**
NEON PANEL INDICATORS 250V. Amber or red **30p.**
RESISTORS. ¼W, ½W, 1W, 20% **2p;** 2W, **10p.** 10Ω to 10M
HIGH STABILITY. ½W 2% 10 ohms to 6 meg., **12p.**
Ditto 5%. Preferred values 10 ohms to 10 meg., **5p.**
WIRE-WOUND RESISTORS 5 watt, 10 watt, 15 watt. 10 ohms to 100K **12p** each
TAG STRIP 28-way **12p.**
TAPE OSCILLATOR COIL. Valve type. **35p.**
BRIDGE RECTIFIER 200V PIV ½ amp **50p.**
TOGGLE SWITCHES S.P. **20p.** D.P.S.T. **25p.** D.P.D.T. **30p.**
MANY OTHER TOGGLES IN STOCK
PICK-UP CARTRIDGES ACOS GP91 **£1.50.** GP93 **£2.50.**
SONOTONE stereo **£2.00.** SHURE M75 ECS **£8.**

BAKER MAJOR 12" £14.95
Post £1.00



30-14,500 c/s, 12in. double cone, woofer and tweeter cone together with a BAKER ceramic magnet assembly having a flux density of 14,000 gauss and a total flux of 145,000 Maxwells. Bass resonance 40 c/s. Rated 25W. NOTE: 4 or 8 or 16 ohms must be stated.

Module kit, 30-17,000 c/s with tweeter, crossover, baffle and instructions. **£18.95** Post £1.60p each
Please state 3 or 8 or 15 ohms.

BAKER "BIG-SOUND" SPEAKERS. Post £1.00 each.

'Group 25'	'Group 35'	'Group 50/15'
12in 30W **£11.95**	12in. 40W **£13.95**	15in. 75W **£24.95**
4 or 8 or 16 ohm	4 or 8 or 16 ohm	8 or 16 ohm

BAKER LOUDSPEAKER, 12 INCH, 60 WATT. GROUP 50/12, 8 OR 15 OHM HIGH POWER. FULL RANGE PROFESSIONAL QUALITY. RESPONSE 30-16,000 CPS. MASSIVE CERAMIC MAGNET WITH ALUMINIUM PRESENCE CENTRE DOME. **£20.95** Post £1.60

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For 12in. or 10in. speaker 20x13x12in **£14.50** Post £2.
For 13x8in. or 8in. speaker **8.50** Post £1.
For 6½in. speaker and tweeter 12x8x6in **£5.80** Post 75p
Many other cabinets in stock. Phone your requirements

R.C.S. 100 watt VALVE AMPLIFIER CHASSIS

Four inputs. Four way mixing, master volume, treble and bass controls. Suits all speakers. This professional quality amplifier chassis is suitable for all groups, disco, P.A., where high quality power is required. 5 speaker outputs. A/C mains operated. Slave output socket. Produced by demand for a quality valve amplifier. 100V line output to order. Send for leaflet. Suitable carrying cab **£14.** Price **£85** carr. £2.50

SPEAKER COVERING MATERIALS. Samples Large S.A.E.
LOUDSPEAKER CABINET WADDING 18in. wide **20p** ft.
Horn Tweeters 2-16kc/s, 10W 8 ohm or 15 ohm **£3.60**
De Luxe Horn Tweeters 3-18kc/s, 30W, 8 ohm, **£7.50.**
CROSSOVERS. TWO-WAY 3000 c/s 3 or 8 or 15 ohm **£1.90.** 3-way 950 cps/3000 cps, **£2.20.**
LOUDSPEAKERS P.M. 3 OHM 7x4in. **£1.50;** 6½in., **£1.80;** 8x5in., **£1.90;** 8in., **£1.95.**
SPECIAL OFFER: 80 ohm, 2¼in., 2¾in., 35 ohm, 3in., 25 ohm, 2½in., 3in., 5x3in., 7x4in., 8 ohm, 2½in., 3in., 3½in., 5in., 15 ohm, 3½in. dia. 6x4in., 7x4in., 5x3in., 3 ohm., 2½in., 2¾in., 3½in., 5in. dia. **£1.25 each.**
PHILIPS LOUDSPEAKER, 8in., 4 ohms, 4 watts, **£1.95**
RICHARD ALLAN TWIN CONE LOUDSPEAKERS 8in. diameter 4W **£2.50.** 10in. diameter 5W **£2.95;** 12in. diameter 6W **£3.50.** 3/8/15 ohms, please state.
PIEZO ELECTRIC HORN TWEETER. Handles up to 100 watts. No crossover required **£9.95.**

Tweeter Volume Control 15 ohms 10W with one inch long threaded bush for wood panel mounting. ¼in. spindle. **65p.**

BAKER 150 WATT PROFESSIONAL MIXER AMPLIFIER

All purpose transistorised. Ideal for Groups, Disco and P.A. 4 inputs speech and music 4 way mixing. Output 4 8/16 ohms a.c. Mains. Separate treble and bass controls. Master volume control. Guaranteed. Details S.A.E. **£68** £1.50 carr.
NEW MODEL MAJOR—50 watt, 4 input, 2 vol. Treble and bass. Ideal disco amplifier **£49** Carr. £1

100 WATT DISCO AMPLIFIER
volume, treble, bass controls. 500 M.V. or 1 volt input. Four loudspeaker outputs 4 to 16 ohm. All transistor **£59**

BARGAIN 4 CHANNEL TRANSISTOR MONO MIXER
Add musical highlights and sound effects to recordings. Will mix Microphone, records, tape and tuner with separate controls into single output. 9V. **£6.95**
TWO STEREO CHANNEL VERSION £8.95
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ALUMINIUM HEAT SINKS. FINNED TYPE.
Sizes 6½" x 4½" x 2¼" **95p.** 6½" x 2" x 2¼" **65p.**
BALANCED TWIN RIBBON FEEDER 300 ohms. 5p yd.
JACK SOCKET Std. open-circuit 20p, closed circuit 25p;
Chrome Lead-Socket 45p. Mono or Stereo.
Phono Plugs 8p. Phono Socket 8p.
JACK PLUGS Std. Chrome 30p; Plastic 25p; 3.5mm 15p.
STEREO JACK PLUG 30p. SOCKET 25p.
DIN SOCKETS Chassis 3-pin 10p. 5-pin 10p.
DIN SOCKETS FREE 3-pin 25p; 5-pin 25p. DIN PLUGS 3-pin 25p; 5-pin 25p. VALVE HOLDERS, 10p; CANS 10p.
TV CONVERGENCE POTS **15p Each**
Valves = 5, 7, 10, 20, 50, 100, 200, 250, 470, 2000 ohms.

R.C.S. SOUND TO LIGHT KIT
Kit of parts to build a 3 channel sound to light unit 1,000 watts per channel. **£14.** Post 35p
Easy to build. Full instructions supplied. Cabinet **£3.**

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DIGITAL FREQUENCY METER YOURS FOR ONLY £54.50+ £4.36 VAT

The DFM you must have at a price that could save you up to £25. It's easy to see how accurate this new Doram meter is thanks to 4 digit display with extra shift left to check 5 digits for even greater accuracy!

You can see the well-designed shatterproof case with its built-in handle/display tilt-foot looks so much more expensive than many a kit product.

But Doram kits always give you the best for less. This complete kit with case, printed circuit boards, all components and instructions is yours for only £54.50 + £4.36 VAT.

The meter covers 20Hz to 50MHz with prescaler (additional purchase) provision allowing you to measure up to 500MHz. Input impedance and sensitivity are very high with read-out accurate to ± 0.01%!

So the message comes through loud and clear – don't miss this latest Doram digital bargain.

KEY DATA

Frequency range	20Hz to 50MHz in 3 steps
Sensitivity	20mV r.m.s.
Input Impedance	1MΩ in parallel with 30pF
Input Coupling	AC
Maximum Input	10V r.m.s
Frequency Standard	1MHz .001% calibration tolerance
Display	4 Digit LED display with shift left for 5 digit readout
Accuracy	± 1 digit (.01%)
Supply Voltage	220-240V ac with 12V dc 100mA output for prescaler supply

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Doram Electronics Ltd, PO Box TR8, Wellington Road Industrial Estate, Wellington Bridge, Leeds, West Yorkshire LS12 2UF.

Registered in London No. 1155856. Directors: R. A. Marler, D. I. Turner, F. Chable.

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Demodulator TDM29
A new JVC design with improved muting.

Type A Variomatrix
Decoder Synthesizer (with or without SQ Option).

Decoder
Type 3A
Type 5A

PRICE LIST (VAT in brackets: overseas customers neglect)

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QS	Variomatrix Decoder Kit	£32.00+	(£4.00)
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SQ	Type L3A Kit	£26.50+	(£3.31)
	Type L5A Kit	£31.50+	(£3.94)
	PCBs (for both types)	£6.90+	(£0.86)
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(Overseas Airmail £4 per kit)

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9 DELL WAY, LONDON W13 8JH. Telephone 01-998 8221

WW—041 FOR FURTHER DETAILS

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SIZES	BOX ALONE	WITH ADDITION★
8"x5½"x5"	£1.94	£2.71
9"x4"x3"	£1.30	£2.07
6"x4"x4"	£1.10	£1.96
5"x3"x1½"	£0.51	
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Plus VAT and carriage

★WITH FRONT PANEL, INSIDE PANEL (BOTH ALUMINIUM) AND 4 RUBBER FEET

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TRANSFORMERS

ALL EX-STOCK — SAME-DAY DESPATCH

MAINS ISOLATING VAT 8%

PRI 120/240V SEC 120/240V
Centre Tapped and Screened

Ref.	VA (Watts)	£	P&P
07★	20	4.40	.79
149	60	6.20	.96
150	100	7.13	1.14
151	200	11.16	1.50
152	250	12.79	1.84
153	350	16.28	1.84
154	500	19.15	2.15
155	750	29.06	OA
156	1000	37.20	OA
157	1500	45.60	OA
158	2000	54.80	OA
159	3000	79.05	OA

★115 or 240 sec only

12 and/or 24-VOLT

Separate 12v windings
Primary 220-240 Volts

Ref	Amps 12v	Amps 24v	£	P&P
111	0.5	0.25	2.20	.43
213	1.0	0.5	2.64	.78
71	2	1	3.41	.78
18	4	2	4.03	.96
70	6	3	5.35	.96
108	8	4	6.98	1.14
72	10	5	7.67	1.14
116	12	6	8.99	1.32
17	16	8	10.38	1.32
115	20	10	13.18	2.08
187	30	15	17.05	2.08
226	60	30	26.82	OA

50 VOLT RANGE

Primary 220-240V
SEC. TAPS 0-19-25-33-40-50V

Ref.	Amps	£	P&P
102	0.5	3.41	.78
103	1.0	4.57	.96
104	2.0	6.98	1.14
105	3.0	8.45	1.32
106	4.0	10.70	1.50
107	6.0	14.62	1.64
118	8.0	17.05	2.08
119	10.0	21.70	OA

30 VOLT RANGE

Primary 220-240V
SEC. TAPS 0-12-15-20-25-30V

Ref.	Amps	£	P&P
112	0.5	2.64	.78
79	1.0	3.57	.96
3	2.0	5.27	.96
20	3.0	6.20	1.14
21	4.0	7.44	1.14
51	5.0	8.37	1.32
117	6.0	9.92	1.45
88	8.0	11.73	1.64
89	10.0	13.33	1.84

60 VOLT RANGE

Primary 220-240V
SEC TAPS 0-24-30-40-48-60V

Ref.	Amps	£	P&P
124	0.5	3.88	.96
126	1.0	5.58	.96
127	2.0	7.60	1.14
125	3.0	10.54	1.32
123	4.0	12.23	1.84
40	5.0	13.95	1.64
120	6.0	15.66	1.84
121	8.0	20.15	OA
122	10.0	24.03	OA
189	12.0	27.13	OA

AUTO TRANSFORMERS

Ref.	VA Watts	TAPS	£	P&P
113	20	0-115-210-240v	2.48	.71
64	75	0-115-210-240v	3.95	.96
4	150	0-115-210-220-240v	5.35	.96
66	300	" "	7.75	1.14
67	500	" "	10.99	1.64
84	1000	" "	18.76	2.08
93	1500	" "	23.28	OA
95	2000	" "	34.82	OA
73	3000	" "	48.00	OA

HIGH VOLTAGE

MAINS ISOLATING
Pri 200/220 or 400/440
Sec 100/120 or 200/240

VA	Ref.	£	P&P
60	243	5.89	1.32
350	247	14.11	1.84
1000	250	35.65	OA
2000	252	54.25	OA

SCREENED MINIATURES Primary 240V

Ref.	mA	Volts	£	P&P
238	200	3-0-3	1.99	.55
212	1A, 1A	0-6, 0-6	2.85	.78
13	100	9-0-9	2.14	.38
235	330, 330	0-9, 0-9	1.99	.38
207	500, 500	0-8-9, 0-8-9	2.59	.71
208	1A, 1A	0-8-9, 0-8-9	3.53	.78
236	200, 200	0-15, 0-15	1.99	.38
214	300, 300	0-20, 0-20	2.56	.78
221	700 (DC)	20-12-0-12-20	3.41	.78
206	1A, 1A	0-15-20, 0-15-20	4.63	.96
203	500, 500	0-15-27, 0-15-27	3.99	.96
204	1A, 1A	0-15-27, 0-15-27	5.39	.96
S112	500	0-12-15-20-24-30	2.64	.78

DECS SOLDERLESS BREADBOARDING

S Dec 70 contacts	£1.98
T Dec 208 contacts	£3.38
U Dec 'A' IC's etc.	£3.99
U Dec 'B' IC's etc.	£6.99

VAT 8% P&P 40p

CASED AUTO. TRANSFORMERS

240V cable input. USA 2-pin outlets

20VA	£4.96.	P&P .96	Ref. 113W
75VA	£6.03.	P&P 1.14	Ref. 64W
150VA	£8.48.	P&P 1.14	Ref. 4W
300VA	£12.53.	P&P 1.45	Ref. 66W
500VA	£15.73.	P&P 1.64	Ref. 67W
750VA	£18.55.	P&P 1.76	Ref. 83W
1000VA	£22.68.	OA	Ref. 84W
2000VA	£37.65.	OA	Ref. 95W

BRIDGE RECTIFIERS

200v	2A	45p
400v	2A	55p
200v	4A	65p
400v	4A	80p
400v	6A	£1.00
500v	10A★	£2.35

P&P 29p. VAT 12½%
★VAT 8%

HIGH QUALITY MODULES VAT 12½%

10 watt RMS Amplifier	£3.66
25 watt RMS Amplifier	£4.57
Pre-Amp for 3-5-10w	£6.95
Pre-Amp for 25w	£13.88
Power Supplies for 3-5-10w	£1.35
Power Supplies for 25w	£3.76
Transformer for 5-10w	£2.41
Transformer for 25w (one module)	£4.79
P&P Amps/Pre-Amps/Power Supplies	40p
P&P Transformers	96p

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AVO8	£68.95
AVO71	£28.00
AVO73	£37.80
AVOMM5	£21.94
WEE MEGGER	£55.05
AVO TT169	£26.00
U4315	£14.95

Includes steel carry case in-circuits transistor tester
Avo Cases and Accessories
P&P £1.50. VAT 8%

STEREO 30

Complete chassis, inc 7+7w r.m.s. amps, pre-amp, power supply, front panel, knobs (needs mains trans.), **£19.05.** Mains trans. **£2.45.** Teak veneered cab. **£5.25.** P&P £1.02. VAT 12½%.

TI MINI-MULTIMETER

DC-1000V. AC-1000V
AC/DC-1000Ω/V
DC-100mA. Res — 150K
Bargain at **£5.30**
VAT 8% P&P 62p

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CC12-05. 3, 4.5, 7.5, 9, 12v 500mA. **£5.29**
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P&P 70p. VAT 12½%.

STEREO F.M. TUNER

4 Pre-selected stations
Switched AFC
Supply 20-35v 90Ma Max.
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15W **£3.46.** 18W **£3.46.** 25W **£3.20**
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Operating Voltage 20/45v
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WW-076 FOR FURTHER DETAILS

NEW PRODUCTS!

NRDC-AMBISONIC 45J

SURROUND SOUND DECODER

The **first ever** kit specially produced by Integrex for this British NRDC backed surround sound system which is the result of 7 years' research by the Ambisonic team. W.W. July, Aug. and Sept. '77.
The unit is designed to decode not only 45J but virtually all other 'quadrophonic' systems (Not CD4), including the new BBC Matrix H 10 input selections.
The decoder is linear throughout and does not rely on listener fatiguing logic enhancement techniques. Both 2 or 3 input signals and 4 or 6 output signals are provided in this most versatile unit.

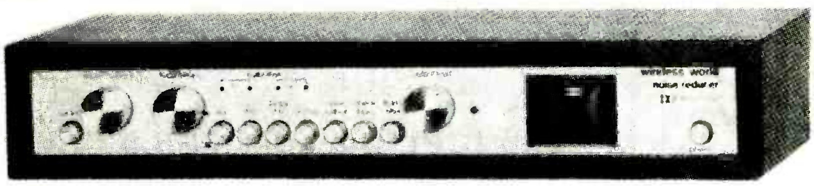
Complete kit, including licence fee £45.00 + VAT

INTRUDER 1 RADAR ALARM

With Home Office Type approval.
As in this issue of "Wireless World", designed by Mike Hosking, 240V ac mains operated and disguised as a hardbacked book. Detection range up to 30 feet. Complete kit. Exclusive designer approved kit £46.00 + VAT.

Wireless World Dolby(TM) noise reducer

Trademark of Dolby Laboratories Inc.



Typical performance

Noise reduction better than 9dB weighted.
Clipping level 16.5dB above Dolby level (measured at 1% third harmonic content)

Harmonic distortion 0.1% at Dolby level typically 0.05% over most of band, rising to a maximum of 0.12%

Signal-to-noise ratio: 75dB (20Hz to 20kHz, signal at Dolby level) at Monitor output

Dynamic Range >90db

30mV sensitivity.

Featuring

- switching for both encoding (low-level h.f. compression) and decoding
- a switchable f.m. stereo multiplex and bias filter
- provision for decoding Dolby f.m. radio transmissions (as in USA)
- no equipment needed for alignment
- suitability for both open-reel and cassette tape machines
- check tape switch for encoded monitoring in three-head machines

Complete Kit **PRICE: £39.90** + VAT

Also available ready built and tested . . . . **Price £54.00** + VAT

Calibration tapes are available for open-reel use and for cassette (specify which) . . . . **Price £2.20** + VAT *

Single channel plug-in Dolby(TM) PROCESSOR BOARDS (92 x 87mm) with gold plated contacts are available with all components . . . . **Price £8.20** + VAT

Single channel board with selected fet . . . . **Price £2.50** + VAT

Gold Plated edge connector . . . . **Price £1.50** + VAT*

Selected FETs **60p** each + VAT, **100p** + VAT for two, **£1.90** + VAT for four

Please add VAT @ 12½% unless marked thus*, when 8% applies (or current rates)

Buy it with Access · EUROCARD · BARCLAYCARD · master charge

We guarantee full after-sales technical and servicing facilities on all our kits, have you checked that these services are available from other suppliers?

Please send SAE for complete lists and specifications

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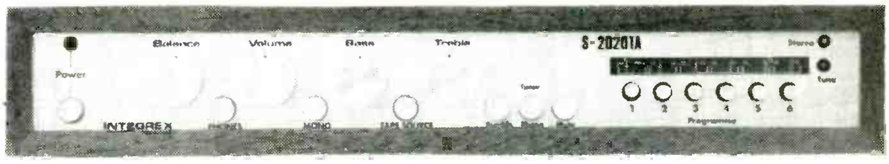
INTEGREX

S-2020TA STEREO TUNER/AMPLIFIER KIT

SOLID MAHOGANY CABINET



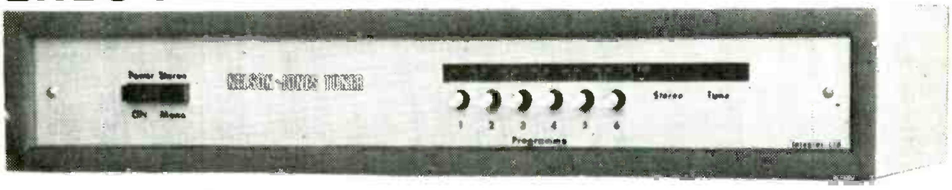
A high-quality push-button FM Varicap Stereo Tuner combined with a 24W r.m.s. per channel Stereo Amplifier.

Brief Spec. Amplifier Low field Toroidal transformer, Mag, input, Tape In/Out facility (for noise reduction unit, etc.), THD less than 0.1% at 20W into 8 ohms. Power on/off FET transient protection. All sockets, fuses, etc., are PC mounted for ease of assembly. Tuner section uses 3302 FET module requiring no RF alignment, ceramic IF, INTERSTATION MUTE, and phase-locked IC stereo decoder. LED tuning and stereo indicators. Tuning range 88—104MHz. 30dB mono S/N @ 1.2μV. THD 0.3%. Pre-decoder 'birdy' filter.

PRICE: £58.95+VAT

NELSON-JONES STEREO FM TUNER KIT

A very high performance tuner with dual gate MOSFET RF and Mixer front end, triple gang varicap tuning, and dual ceramic filter/dual IC IF amp.



Brief Spec. Tuning range 88—104MHz. 20dB mono quieting @ 0.75μV. Image rejection — 70dB. IF rejection — 85dB. THD typically 0.4%.
IC stabilized PSU and LED tuning indicators. Push-button tuning and AFC unit. Choice of either mono or stereo with a choice of stereo decoders.

Compare this spec. with tuners costing twice the price.

Mono £32.40+VAT

With ICPL Decoder £36.67+VAT

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STEREO MODULE TUNER KIT

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7427	37p
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7430	18p
7432	36p
7437	36p
7438	36p
7440	19p
7441	75p
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7448	80p
7450	18p
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7454	18p
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7474	34p
7475	45p
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74145	90p
74147	190p
74148	160p
74150	140p
74151	72p
74153	85p
74154	150p
74155	90p
74156	90p
74157	90p
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74192	120p
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CD4040AE	120p
CD4042AE	90p
CD4043AE	100p
CD4046AE	140p
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3900	Quad. Op. Amp.	14 pin DIL	70p
709	Ext. Comp	8/14 pin OIL	30p
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CA3080E	Op Transcond Amp.	8 pin DIL	90p
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★TBA820	2W Audio Amp	QIL	80p
★TDA2020	20W Audio Amp	QIL DIL	325p
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1A 50V	TO5	60p
1A100V	TO5	70p
1A400V	TO5	80p
3A400V	Stud	90p
7A100V	TO5+HS	84p
7A400V	TO5+HS	90p
8A 50V	Plastic	130p
12A400V	Plastic	160p
16A100V	Plastic	160p
16A400V	Plastic	180p
16A600V	Plastic	220p
BT106 1A 700V	Stud	110p

C106D 4A/400V	Plastic	63p
★MCR101 0.5A/15V	TO-92	25p
2N3525 5A/400V	TO-66	120p
2N4444 8A/600V	Plastic	185p
★2N5060 0.8A/30V	TO-92	34p
★2N5062 0.8A/100V	TO-92	37p
★2N5064 0.8A/200V	TO-92	40p

TRANSISTORS

AC125	25p
AC126	20p
AC127	20p
AC128	18p
AC141	20p
AC142	20p
AC176	20p
AC187	20p
AC187K	25p
AC188	20p
AC188K	25p
AD149	49p
AD161	45p
AD162	45p
AF114	20p
AF115	20p
AF116	20p
AF117	20p
AF127	25p
AF139	43p
AF239	48p
BC107 B	9p
BC108 B	9p
BC109 B	10p
BC109C	12p
★BC117	22p
★BC147	9p
★BC148	9p
★BC149C	10p
★BC157	11p
★BC158	10p
★BC159	11p
★BC169C	12p
★BC172	11p
BC177	18p
BC178	17p
BC179	18p
★BC182	12p
★BC183	12p
★BC184	13p
BC187	30p
★BC212	11p
★BC213	10p
★BC214	14p
BC461	36p
BC478	30p
BCY70	18p
BCY71	22p
BD124	130p
BD131	63p
BD132	65p
★BD135	48p
★BD136	50p
★BD139	52p
★BD140	58p
BDY20	125p
BDY56	200p
BF115	22p
BF167	23p
BF170	23p
BF173	25p
BF177	26p
BF178	28p
BF179	33p
BF180	33p
BF184	22p
★BF194	10p
★BF195	9p
★BF196	14p
★BF197	15p
BF200	32p
BF257	32p
BF258	36p
BF259	38p
BF337	30p
★BFR39	30p
★BFR40	30p
★BFR41	30p
★BFR79	30p
★BFR80	30p
BFR81	30p
★BFR88	30p
BFX30	34p
BFX84	30p
BFX85	30p

BFX86	30p
BFX87	30p
BFX88	30p
BFY50	22p
BFY51	22p
BFY52	22p
BFY90	120p
BRY39	45p
BSX19	20p
BSX20	20p
★BU105	140p
BU108	250p
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MJ491	200p
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MJE3055	70p
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★MPSA56	32p
★MPSU06	62p
★MPSU56	78p
OC28	120p
OC35	90p
OC36	90p
★OC71	20p
★R2008B	200p
★R2010B	200p
★TIP29A	40p
★TIP29C	55p
★TIP30A	48p
★TIP30C	60p
TIP31A	52p
TIP31C	52p
TIP32A	58p
TIP32C	82p
TIP33A	90p
TIP33C	115p
TIP34A	115p
TIP34C	160p
TIP35A	225p
TIP35C	290p
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TIP36C	340p
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TIP41C	78p
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2N1305	65p
2N1306	75p
2N1307	75p
2N1308	50p
2N1309	50p
2N1613	25p
2N1711	25p
2N1893	30p
2N2102	55p
2N2219	20p
2N2222	20p
2N2369	14p
2N2484	30p
2N2904 A	25p
2N2905 A	25p
2N2906 A	24p

★2N2926R	7p
★2N2926B	7p
★2N2926O	10p
★2N2926Y	12p
★2N2926G	12p
2N3053	22p
2N3054	65p
2N3055	65p
2N3439	67p
2N3442	140p
★2N3565	30p
★2N3702	12p
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★2N3704	12p
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★2N4124	22p
★2N4125	22p
★2N4126	22p
★2N4289	20p
★2N4401	27p
★2N4403	27p
2N4427	90p
★2N5089	27p
2N5296	55p
★2N5401	50p
2N6034	160p
2N6107	55p
2N6247	190p
(Comp to 2N3055)	
2N6254	130p
2N6292	65p
40360	40p
40361	45p
40362	45p
40364	120p
40409	65p
40410	65p
40411	300p
40636	130p
40594	88p
40595	97p

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★BF256B	70p
MPF102	40p
★MPF103	40p
★MPF104	40p
★MPF105	40p
★2N3819	25p
★2N3820	50p
2N3823	57p
★2N5457	40p
★2N5458	40p
★2N5459	40p
★2N5485	40p

MOSFETs

3N128	96p
3N140	95p
3N141	95p
3N187	180p
40603	63p
40673	63p

UJTs

★TIS43	34p
2N2160	95p
2N2646	45p
★2N4871	54p

PUJT

★2N6027	48p

DIODES

★SIGNAL

OA47	9p
OA81	20p
OA85	20p
OA90	7p
OA91	7p
OA95	7p
OA200	8p
OA202	10p
IN914	4p
IN916	9p
IN4148	4p

RECTIFIER

★BY100	25p
★BY126	12p
★BY127	10p
IN4001	5p
IN4002	5p
IN4004	6p
IN4005	6p
IN4007	7p
IN5401	13p
IN5404	18p
IN5407	23p

ZENER

2.7V to 33V★	
★400mW	9p
★1W	18p

NOISE

★Z5J	110p

BRIDGE RECTIFIERS

★1A 50V	22p
★1A 100V	24p
★1A 200V	28p
★1A 400V	30p
★1A 600V	36p
★2A 50V	30p
★2A 100V	35p
★2A 200V	40p
★2A 400V	45p
★3A 200V	60p
★3A 600V	72p
★4A 100V	84p
★4A 400V	90p
6A 50V	90p
6A 100V	96p
6A 200V	108p
6A 400V	120p
10A 400V	270p
25A 400V	400p

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6	400	99p
6	500	107p
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15	500	180p
40430		130p
40669		130p
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18V	7818	140p	18V	7918	200p
24V	7824	140p	24V	7924	200p

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6BW7	0.65
6BX6	0.29
6BY7	0.36
6BZ6	0.60
6C4	0.50
6C5G	0.60
6C6	0.45
6C9	2.00
6C10	0.71
6CB6A	0.50
6C12	0.40
6CD6G	1.60
6CG8A	0.90
6CL6	0.75
6CL8A	0.95
6CM7	1.00
6CS6	0.45
6CU5	0.90
6D3	0.75
6DE7	0.90
6DT6A	0.85
6EW6	0.85
6E5	1.00
6F1	0.80
6F6G	0.60
6F12	0.50
6F14	0.90
6F15	0.85
6F16	0.75
6F18	0.60
6F23	0.65
6F24	0.80
6F25	1.00
6F26	0.36
6F28	0.74
6F32	0.70
6G6G	0.60
6GH8A	0.80
6GK5	0.75
6GU7	0.90
6H6GT	0.30
6J5GT	0.65
6J6	0.35
6J7G	0.35
6J7M	0.65
6JU8A	0.90
6K7G	0.35
6K8G	0.50
6K8GT	0.55

6L1	2.50
6L6GC	0.85
6L7(M)	1.50
6L12	0.39
6L18	0.60
6L19	2.00
6LD12	0.40
6LD20	0.80
6N7GT	0.70
6PL12	0.40
6P15	0.35
6Q7G	0.50
6Q7GT	0.50
6Q7M	0.65
6R7G	0.70
6R7(M)	1.00
6SA7	0.55
6SC7GT	0.75
6SG7	0.55
6SH7	0.55
6SJ7	0.60
6SK7GT	0.55
6SQ7	0.60
6U4GT	0.80
6U7G	0.55
6U8	0.50
6V6G	0.30
6V6GT	1.00
6X4	0.45
6X5GT	0.45
6Y6G	0.95
6Y7G	1.25
7A7	1.00
7B6	0.80
7B7	0.80
7D6	2.00
7F8	2.00
7H7	0.80
7R7	2.00
7V7	2.00
7Y4	0.80
7Z4	0.80
8D2	0.50
8D8	0.50
9BW6	0.90
9D7	0.70
9U8	0.45
10C2	0.70
10C14	0.50
10D1	0.85
10DE7	0.80
10F1	0.67
10F9	0.65
10F18	0.65
10L14	0.45
10LD11	0.75
10LD12	0.45
10PL12	0.55
10P13	0.80
10P14	2.50
10P18	0.54
12A6	0.65
12AC6	0.80
12AD6	0.80
12AE6	0.80

12AT6	0.45
12AT7	0.34
12AU6	0.50
12AU7	0.34
12AV6	0.60
12AX7	0.34
12AY7	1.00
12BA6	0.50
12BE6	0.55
12BH7	0.55
12BY7	0.85
12E1	3.50
12J5GT	0.40
12J7GT	0.70
12K5	1.50
12K7GT	0.50
12K8	0.75
12Q7GT	0.50
12SA7GT	0.75
12SC7	0.50
12SG7	0.55
12SH7	0.50
12SJ7	0.60
12SK7	0.60
12SN7GT	0.75
12SQ7	0.80
12SQ7GT	0.80
12SR7	0.75
14H7	0.75
14S7	1.00
18	1.25
19AQ5	0.65
19BG6G	1.00
19G6	6.50
19H1	4.00
19Y3	0.40
20D1	0.70
20D4	2.50
20F2	0.85
20L1	1.20
20P1	1.00
20P3	1.00
20P4	0.84
20P5	1.50
25A6G	0.70
25L6G	0.70
25Y5	0.80
25Z4G	0.50
25Z5	0.75
25Z6G	0.80
28D7	2.00
30A5	0.75
30C1	0.40
30C15	0.77
30C17	0.77
30F5	0.70
30L1	0.39
30L15	0.75
30L17	0.70
30P4MR	0.98
30P12	0.74
30P19/	
30P4	0.90
30P16	0.37
30P18	0.50

30PL1	1.00
30PL12	0.54
30PL13	1.00
30PL14	1.29
30PL15	1.00
35A3	0.75
35C5	0.80
35D5	0.90
35L6GT	0.80
35W4	0.55
35Z3	0.80
35Z4GT	0.70
35Z5GT	0.80
50B5	0.95
50C5	0.70
50CD6G	1.20
50EH5	0.85
50L6GT	1.00
66KU	0.52
72	0.70
77	0.45
85A2	0.75
85A3	0.75
90CV	2.80
108C1	0.40
150B2	1.00
150C2	0.85
215SG	0.60
302	1.20
303	1.20
305	1.20
807	1.10
956	0.50
1625	2.50
1821	1.00
5702	1.20
5763	1.65
6057	1.00
6060	1.00
6067	1.00
6146	4.70
6463	2.00
7025	1.50
7193	0.60
7475	1.20
9002	0.55
9006	0.45
A1834	1.00
A3042	6.00
AC2PEN	1.00
AC2PENDD	1.00
AC6/PEN	0.60
AC P4	1.50
AC PEN(7)	1.20
AC THI	1.00
AL60	1.20
ARP3	0.60
ATP4	0.50
AZ1	0.50
AZ31	0.60
AZ41	0.50
B36	0.75
B719	0.39

B729	0.79
BL63	2.00
CL33	1.75
CV6	0.60
CV63	1.00
CV988	0.25
CY1C	1.00
CY31	0.70
D1	0.50
D63	0.30
DAC32	0.80
DAF91	0.35
DAF96	0.60
DC90	0.70
DD4	0.80
DF33	0.75
DF91	0.30
DF96	0.60
DH63	0.50
DH76	0.50
DH77	0.50
DH81	0.80
DK32	0.60
DK40	0.70
DK91	0.50
DK92	1.00
DK96	0.70
DL63	0.70
DL82	0.80
DL92	0.45
DL94	0.80
DL96	0.60
DM70	0.80
DM71	1.75
DW4/350	1.15
DY51	2.00
DY87/6	0.35
DY802	0.50
E80CC	2.50
E80CF	5.00
E80F	2.20
E83F	1.60
E88CC	1.20
E92CC	0.70
E180CC	0.80
E180F	1.15
E182CC	3.00
E188CC	2.50
E280F	5.00
E1148	0.60
EA50	0.40
EA76	1.30
EABC80	0.40
EAC91	0.55
EAF42	0.70
EAF801	0.75
EB34	0.30
EB91	0.20
EBC41	0.75
EBC81	0.45
EBC90	0.50
EBC91	0.50
EBF80	0.40
EBF83	0.45
EBF89	0.40

EBL21	2.00
EC52	1.00
EC53	1.00
EC54	1.00
EC86	0.84
EC88	0.84
EC92	0.55
EC97	0.75
ECC32	1.00
ECC33	2.00
ECC35	2.00
ECC40	0.90
ECC81	0.34
ECC82	0.34
ECC83	0.34
ECC84	0.35
ECC85	0.39
ECC86	1.25
ECC88	0.72
ECC91	0.35
ECC189	0.80
ECC804	0.79
ECC807	2.80
ECF80	0.60
ECF82	0.50
ECF86	0.80
ECH21	2.00
ECH35	1.60
ECH42	0.71
ECH81	0.40
ECH83	0.50
ECH84	0.50
ECL80	0.45
ECL82	0.50
ECL83	0.74
ECL84	0.65
ECL85	0.70
ECL86	0.64
EF22	1.00
EF40	0.78
EF41	0.75
EF73	1.75
EF80	0.29
EF83	1.25
EF85	0.36
EF86	0.50
EF89	0.42
EF91	0.50
EF92	0.50
EF93	0.40
EF94	0.40
EF95	0.45
EF97	0.90
EF98	0.90
EF183	0.42
EF184	0.42
EF804	1.75
EH90	0.45
EK90	0.40
EL32	0.60
EL34	1.00
EL35	3.00
EL37	3.00
EL41	0.57
EL81	0.65

EL83	0.70
EL84	0.35
EL86	0.60
EL90	0.68
EL95	0.67
EL360	1.80
EL506	1.20
EL509	2.50
EM80	0.55
EM81	0.60
EM83	0.60
EM84	0.45
EM85	1.20
EM87	1.10
EMM803	2.50
EY51	0.45
EY81	0.45
EY83	0.60
EY86/7	0.37
EY88	0.55
EY91	0.50
EY500A	1.45
EZ35	0.45
EZ40	0.52
EZ41	0.52
EZ80	0.35
EZ81	0.40
EZ90	0.45
FC4	1.00
FW4/500	1.80
FW4 800	1.80
GY501	0.95
GZ30	0.48
GZ32	0.60
GZ33	1.80
GZ34	0.75
GZ37	1.60
HABC80	0.80
HL13C	0.60
HL23	0.70
HL23DD	0.68
HL41	1.00
HL41DD	1.00
HL42DD	1.00
HN309	1.70
HVR2	1.00
HVR2A	1.00
HY90	0.55
KT2	0.90
KT8	3.00
KT32	1.00
KT41	1.00
KT44	1.00
KT63	0.60
KT66	3.00
KT71	1.00
KT81	2.00
KT88	6.75
KTW61	1.50
KTW62	1.50
KTW63	1.20
L63	0.65
LN119	0.55
LN152	0.45
LN309	0.49
LZ319	0.40
LZ329	0.40
M8162	1.00
MHL4	1.00
MHLD6	0.99
MKT4	1.20
MU12/14	1.15
MX40	1.00
N150	0.57
N308	0.98

N339	1.25
N379	0.50
N709	0.35
P61	0.60
PABC80	0.45
PC86	0.62
PC88	0.62
PC92	0.55
PC95	1.00
PC97	0.75
PC900	0.40
PCC84	0.39
PCC85	0.47
PCC88	0.61
PCC89	0.49
PCC189	0.52
PCC805	0.75
PCC806	0.70
PCF80	0.40
PCF82	0.45
PCF84	0.70
PCF86	0.57
PCF87	0.77
PCF200	1.20
PCF201	1.00
PCF800	0.77
PCF801	0.49
PCF802	0.54
PCF806	0.53
PCH200	1.00
PCL82	0.54
PCL83	0.49
PCL84	0.46
PCL86	0.65
PCL88	1.29
PCL800	1.00
PCL801	1.00
PCL805/85	0.60
PEN4DD	2.00
PEN25	1.00
PEN45	1.00
PEN45DD	1.00
PEN46	0.60
PEN453DD	2.00
PENA4	1.00
PENDD 4020	1.00
PFL200	0.70
PL33	1.00
PL36	0.60
PL81	0.49
PL81A	0.53
PL82	0.37
PL83	0.45
PL84	0.50
PL302	0.90
PL504 500	0.90
PL505	2.00
PL508	1.30
PL509	2.20
PL519	2.80
PL801	0.74
PM84	0.75
PY31	0.50

PY33 2	0.50
PY80	0.50
PY81	0.50
PY82	0.40
PY83	0.50
PY88	0.60
PY301	0.50
PY500	1.35
PY500A	1.35
PY800	0.50
PY801	0.50
PZ30	0.50
QP21	1.10
QQV03 10	2.00
QS75 20	1.00
QS95/10	1.00
QS150 15	1.80
QV03 12	1.65
QV04 7	3.00
QV06/20	4.70
R10	6.50
R11	1.00
R16	2.00
R17	1.00
R19	0.75
R20	0.60
R52	0.48
RK34	1.00
SP4	1.50
SP13C	0.75
TH4B	1.00
TH233	1.00
TP2620	1.00
TP22	1.00
TP25	1.00
UABC80	0.45
UAF42	0.70
UBC41	0.50
UBC81	0.55
UBF80	0.50
UBF89	0.39
UBL21	2.00
UC92	0.50
UCC84	0.90
UCC85	0.45
UCF80	0.80
UCH21	2.00
UCH42	0.71
UCH81	0.50
UCL82	0.55
UCL83	0.57
UF41	0.70
UF42	0.80
UF80	0.40
UF85	0.50
UF89	0.45
UL41	0.70
UL46	0.70
UL84	0.54
UM80	0.60
URIC	1.00
UU5	1.15
UU9	0.52
UU12	0.40
UY41	0.50
UY42	0.50

UY85	0.35
U10	1.00
U12 14	1.15
U16	1.00
U17	1.00
U18 20	1.80
U19	4.00
U22	0.85
U25	0.71
U26	0.60
U31	0.50
U33	1.75
U35	1.75
U37	2.00
U45	1.20
U47	0.71
U49	0.60
U50	0.55
U52	0.60
U76	0.70
U78	0.45
U81	0.80
U150	0.52
U153	0.50
U191	0.50
U192	0.40
U193	0.50
U251	1.00
U281	0.75
U282	0.70
U291	0.50
U301	0.55
U329	1.00
U339	0.50
U381	0.35
U403	0.90
U404	0.75
U709	0.40
U801	0.80
U4020	0.75
VLS492	9.50
VP2	1.50
VP4(5)	2.00
VP13C	0.60
VP23	0.65
VP41	0.90
VR105	0.50
VR150	0.75
VT61A	0.75
VU111	1.00
VU120	1.00
VU120A	1.00
VU133	1.00
W76	0.50
W81M	1.20
W107	0.75
W719	0.36
W729	1.20
WD709	0.40
XE3	0.60
XFY12	0.60
XH15	0.60
XSG15	1.20
X41	1.00
X61	1.60
X63	1.40
X65	1.60

X66	1.60
X76M	0.75
X119	0.50
X142	0.71
X150	0.71
X719	0.40
Z145	0.67
Z152	0.29
Z329	0.70
Z719	0.29
Z729	0.50
Z749	0.65
Z759	5.85
Transistors and Diodes	
1N1124A	0.61
1N4744A	0.16
1N4952	0.58
2N404	0.21
2N966	0.61
2N1756	0.58
2N2147	0.99
2N2297	0.26
2N2369	0.16
2N2613	0.45
2N3053	0.38
2N3121	2.90
2N3703	0.23
2N3709	0.23
2N3866	1.16
2N3988	0.58
2S323	0.58
AA119	0.18
AA120	0.18
AA129	0.18
AAZ13	0.21
AC107	0.18
AC113	0.30
AC114	0.47
AC126	0.14
AC127	0.20
AC128	0.23
AC132	0.23
AC154	0.30
AC156	0.23
AC157	0.30
AC165	0.30
AC166	0.30
AC167	0.69
AC168	0.44
AC169	0.38
AC176	0.64
AC177	0.32
ACY17	0.30
ACY18	0.23
ACY19	0.23
ACY20	0.30
ACY21	0.30
ACY22	0.18

ACY28	0.21
AD140	0.50
AD161	0.53
AD162	0.53
AF102	1.04
AF106	0.58
AF114	0.30
AF115	0.30
AF117	0.23
AF121	0.35
AF124	0.36
AF125	0.50
AF139	0.76
AF178	0.79
AF180	0.56
AF186	0.64
AF239	0.44
ASY27	0.50
ASY28	0.38
ASY29	0.58
BA102	0.53
BA115	0.16
BA116	0.21
BA129	0.14
BA130	0.12
BA148	0.20
BA153	0.18
BCY10	0.53
BCY12	0.58
BCY33	0.23
BCY34	0.26
BCY38	0.26
BC107	0.14
BC108	0.14
BC109	0.14
BC113	0.30
BC115	0.18
BC116	0.30
BC118	0.26
BF154	0.30
BF158	0.21
BF159	0.30
BF163	0.23
BF173	0.44
BF180	0.35
BF181	0.47
BF185	0.47
BFY50	0.26
BFY51	0.23
BFY52	0.23
BTX34/400	2.31
BY100	0.21
BY101	0.18
BY105	0.21
BY114	0.21
BY126	0.18
BY127	0.21
BYY23	1.16

BYZ10	0.30
BYZ11	0.30
BYZ12	0.30
BYZ13	0.30
BYZ15	2.03
CG12E	0.23
CG64H	0.23
FSY11A	0.26
FSY41A	0.26
GD4	0.38
GD5	0.32
GD6	0.32
GD8	0.23
GD9	0.23
GD11	0.23
GD12	0.23
GD14	0.58
GD15	0.47
GD16	0.23
GET113	0.23
GET118	0.23
GET119	0.30
GET573	0.44
GET587	0.50
GET872	1.11
GET873	0.18
GET882	0.58
GET887	0.26
GET889	0.26
GET896	0.26
GET897	0.26
GET898	0.26
GEX113	0.21
GEX36	0.58
GEX45	0.38
GEX55	0.87
GT3	0.30
M1	0.18
MAT100	0.45
MAT101	0.50
MAT120	0.45
OA9	0.14
OA47	0.12
OA70	0.18
OA73	0.18
OA79	0.11
OA81	0.11
OA85	0.11
OA86	0.23
OA90	0.14
OA91	0.11
OA95	0.11
OA200	0.11
OA202	0.12
OC19	1.46
OC22	0.44
OC23	0.44
OC24	0.44
OC25	0.44

OC28	0.69
OC29	0.73
OC36	0.50
OC38	0.50
OC41	0.58
OC42	0.73
OC43	1.37
OC44	0.12
OC45	0.13
OC46	0.18
OC65	1.31
OC70	0.14
OC71	0.13
OC72	0.13
OC74	0.26
OC75	0.13
OC76	0.18
OC77	0.32
OC78	0.18
OC78D	0.18
OC79	0.47
OC81	0.13
OC81D	0.13
OC82	0.13
OC82D	0.13
OC83	0.23
OC84	0.28
OC123	0.26
OC140	1.11
OC169	0.50
OC171	0.40
OC172	0.41
OC200	0.55
OC201	0.53
OC204	0.50
OC205	0.50
OC206	1.05
ORP12	0.61
SFT237	0.50
SM1036	0.58
ST1276	0.58
SX1/6	0.21
U14706	0.30
XZ30	0.30
Y543	0.21
Y728	0.21

ALL PRICES INCLUDE V.A.T NOTHING EXTRA TO PAY

MATCHED TRANSISTOR SETS
LP15 (AC113, AC154, AC157, AA120), 61p per pack.
1/OC81D and 2/OC81, 50p.
1/OC44 and 2/OC45, 50p.
1/OC82D and 2/OC82, 56p. Set of 3/OC83, 76p.
1 watt Zenners, 2.4v, 2.7v, 3v, 3.6v, 4.3v, 4.7v, 5.1v, 13v, 15v, 16v, 18v, 20v, 24v, 30v, 12p each.

All goods are unused and subject to the manufacturers' guarantee.
Terms of business. Cash or cheque with order. Despatch charges: — Orders below £15 in value, add 25p for post and packing. Orders over £15 post and packing free of charge. All orders cleared same day. Any parcel insured against damage in transit for 5p extra per parcel. Conditions of sale available on request. Many others in stock too numerous to list. Please enclose S.A.E. for reply to any enquiries.

Special offer of EF50 valves, soiled but new and tested, £1 each.

Strobes, Tachos, Meters, Generators and Telecommunications Test Equipment

NEW FUNCTION GENERATORS!

G432 is a source of sine, square and triangle signals, 1Hz to 1.1MHz 2.5V into 50Ω, via attenuator.

£115 Also independently 5V into 600Ω fixed level. Variable d.c. off-set.

G430 (illustrated) provides Sine-wave (0-10Vrms) and Square-wave (0-20V p-p) from 600Ω, continuously variable, via 0-60dB step attenuator. Frequency range 1Hz to 1MHz.

£95 **Send for details of our complete range**

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Model PG312 'Hercules'

(illustrated above)

This high-power (180 watts, max) bench p.s.v. features dual protection — a current-limiter PLUS an electronic cut-out proof against persistent short circuits.

★ 10 to 15 Volts, variable, at 12 Amps, maximum ★ Ripple less than 10mV at full-load ★ Stability 0.3%

£65

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Available Soon!

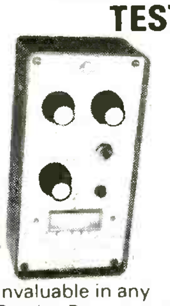
NEW Dynamco 7500 40MHz dual-trace oscilloscope.
Check these star features:

- ★ D.C. to 40MHz, 10mV/div. (1mV to 5MHz on x10)
- ★ 6 input operating modes
- ★ Dual-Time base, 200nSec to 2 Sec/div, with 4 sweep modes
- ★ Excellent trigger facilities

£595

NEW TRANSISTOR TESTERS!

KDP Model TT1



This compact unit facilitates the rapid checking of junction transistors (NPN or PNP), indicating a fault in either junction, excess leakage current PLUS a spot-check of d.c. current-gain.

Invaluable in any Service Department or Development Laboratory.

£23

See inside back cover for details of ICE Super range of multi-meters!

Add 8% VAT to all prices shown. Carriage extra details on request

ELECTRONIC BROKERS LIMITED (New Products Division)
49-53 Pancras Road, London NW1 2QB. Tel: 01-837 7781

Callers welcome—Monday to Friday 9 a.m. to 5 p.m.

MICRO AMPLIFIER

Ex behind the ear hearing aids complete with volume control **£2.16.**

VEEDER-ROOT COUNTER

6 Digit 230-250v cycle operated, not resettable also needs perspex or similar panel over the wheels **£1.62.**

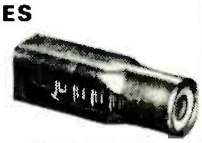
PP3/PP9 REPLACEMENT MAINS UNIT

Japanese made in plastic container with leads size 2" x 1½" x 1½", this is ideal to power a calculator or radio, it has a full wave rectified and smoothed output of 9 volts suitable for a loading of up to 100mA **£2.53.**

DIGITAL DISPLAY UNIT (DIGIVISOR)

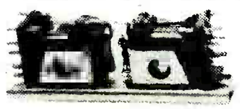
A precision made instrument which is basically a moving coil voltmeter. Instead of having a pointer, however, the scale is punched out with numerals, 0, 1, 2, 3, 4 and so on. When you apply a voltage for instance 8 volts — fig 8 comes in front of a lamp and is focused on to the front screen. This device which must have cost a small fortune to develop and make can also be used for a variety of other purposes. Voltage regulation for instance by making beam of light trigger a photocell, etc **£5.40.**

MERCURY BATTERIES



Bank of 7 Mercury cells type 625 which are approx. ⅝" diameter by ⅞" thick in plastic tube giving a total of 10 7 volts. Being in a plastic tube it is very easy to break up the battery into separate cells and use these for radio control and similar equipment. Carton of 25 batteries **£1.60.**

LATCHING RELAY

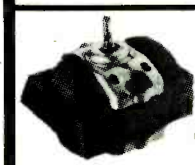


by Guardian Electric, mains operated it is in fact two relays mounted on a metal base plate. The relays being mounted in such a way to ensure that when one closes the other opens and vice versa thus when closed relay A would remain locked until manually released or electrically released by energising relay B. Each relay has 2 sets of 10 amp changeover contacts. Should be ideal for burglar alarms and similar applications **£2.11.**

24 HOUR MOTOR

beautifully made by Sangamo. This is 200-240v mains driven motor with gear box together in one housing, size approx 1¾" dia by 1¾" deep. It you are contemplating making a 24 hour switch with a lot of on offs then this is obviously the motor **Price £1.89.**

4 POLE MOTOR

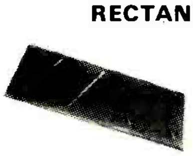


Carefully balanced fitted with belt drive pulley for tape recorders, etc. Normal mains working, speed 1,250 rmp. **£2.12.**

HUMIDITY SWITCH

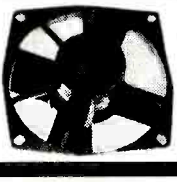
American made by Ranco, their type No J11. The action of this device depends upon the dampness causing a membrane to stretch and trigger a sensitive microswitch adjustable by a screw. Quite sensitive — breathing on it for instance will switch it on. Micro 3 amp at 250v AC. Overall size of the device approx 3⅜" long, 1" wide and 1⅜" deep **65p.**

RECTANGULAR HOT PLATE



Aluminium panel with ridged top and angled underneath to strengthen it. This is approx 10" x 4½" of flat plate. Beneath please is 100w element and sensor switch which will maintain the surface of the plate just too hot to touch. With leads and tags. This is ideal if you are making up a food warmer or for an airing cupboard etc **Price £1.03.**

EXTRACTOR FAN



Ex computers — made by Woods of Colchester ideal for fixing through panel — reasonably quiet running — very powerful 2500 rpm. Choice of two sizes 5" or 6½" dia **£4.43.**

ROTARY WAFER SWITCH

—wiper contacts 3 way 8 poles, 5 amp rating, break before make — ¼" diameter 1" long spindle, slotted for knob screw, made by Plessey. **Price £1.08.**

PERSPEX ENCLOSED 12 VOLT RELAY

with 10 amp changeover contacts, size approx 2" x 1" x 2½" in case **£1.08.**

PAPST MOTORS

West German make, these fine motors are noted for their performance and reliability. Special features are the rotating heavy outer which acts as a flywheel to eliminate wow and flutter and switchable reversing. We have four types in stock, all 1350 revs., including starting capacitor

(1) Ref. No. KLZ 20.50-4, 230 volts 50HZ. **£6.30.**
(2) Ref. No. KLZ 32.50-4, 230 volts 50HZ. **£7.28.**
(3) Ref. same as above, 115 volts 50HZ. **£3.30.**
(4) Ref. same as above, 110 volts 60HZ. **£3.30.**

HONEYWELL P.B. MICROSWITCH

1-2 or 3 10 amp 250v change over microswitch thro panel mounting by cock nuts. 1" dia black knob 1 switch **40p**, 2 switch **55p**, 3 switch **70p.**

INSULATED TERMINALS

Well made with metal panel insulators — screw down to trap wire or insert 4mm plug into top — **15p** each, following colours available

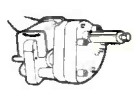
EDGE MOUNTING MOVING COIL METER

100VA fsd. Size 3" x 2". Sealed D.B. made for G.P.O. new and unused **£3.60.**

50 VA MOVING COIL PANEL METER

Large 4½ square flush mounting — mirrored scale for accurate reading scaled DB — beautiful instrument made for G.P.O. new and unused **£4.50.**

SPIT MOTOR WITH CARTER GEAR BOX



Probably one of the best spit motors made. Originally intended to be used in very high priced cookers, however this can be put to plenty of other uses, for instance your garden barbeque or to drive a tumbler for stone polishing; in fact, there are no ends to its uses. Normal mains operation **£3.25** including POST & VAT

ELECTRO MAGNETIC MECHANISMS

4v-8v AC operated the electro mag easily removable from mechanism **50p each** — two types available

TERMS

Cash with order — delivery same day as order received. Prices includes VAT and carriage unless stated but orders under £6 must add 50p to off-set packing etc
BULK ENQUIRIES WELCOMED

J. BULL (ELECTRICAL) LTD.

(Dept. WW)
103 TAMWORTH ROAD
CROYDON CR9 1SG

IT'S FREE!

Our monthly Advance Advertising Bargains List gives details of bargains arriving or just arrived — often bargains which sell out before our advertisement can appear — It's an interesting list and it's free—just send S.A.E. Below are a few of the Bargains still available from previous lines.

Digital Thumbwheel Switch. Black face flush panel mounting, face size approx 3¾" x ¼". White digits 10 positions 0-9. These can be stacked edgewise to any quantity. The right hand and left hand ends have projections for 6BA fixing to the panel. Price left-hand and right hand end switches £1.50 each + 12p. Intermediate switches £1.25 + 10p.

Mains Transformer upright mounting with top tagboard, primary 0-115, 210, 240, two secondaries 115 vots 5mA and 8.5 volt 1.25A. Note this transformer is ex-new equipment. Price £2.00 + 16p. Post 30p + 2p

Mains Transformer, primary 0-110, 127, 150, 180, 220. Secondaries (1) 3.15-0-3.15 (2) 2.5v, (3) 0-220v. Fitted primary screen. This is a 30w transformer, ex equipment £2.50 + 20p. Post 40p + 3p

Relay 6-12 volt. Single 2 amp changeover contacts, open miniature type, size approx 1" cube P.C. mounting ex new equipment 30p + 2p

Relay Miniature 6-12 volt plastic covered plug in type 4 changeover, gold plated contacts 52 ohm coil, size approx 1¼" high, 1" wide, ¾" thick, ex new equipment with base 75p + 6p.

Miniature Relay 6-12 volt plastic covered plug in type 200 ohm coil. Two changeover gold plated contacts ex new equipment with base 75p + 6p.

Three Digit Counter, resettable 12 volt coil, flush panel mounting, black with white digits, ex new equipment £1.75 + 14p.

Reed relay with double wound coil 12 volts one coil will close the read switch, 12 volts on the other coil will open the contact or still further close it depending upon whether the current is opposing or assisting. Price £1.50 + 12p. Post 20p + 2p.

Push on Push off Panel Mounting Switch. 3 amps, 250 volts metal plunger similar to and mounted light toggle switch made by Arrow, 50p + 4p

Push to make Switch 250v 1 amp similar to and mounted like a toggle made by Arco Electronic. Price 35p + 3p.

Panel Mounting Neon Lamp. Compact type with bright chrome type mounting clip, these will flash from voltages of 100 upwards but need a series resistor of about 250k, higher or lower depending upon how bright you want them. Price 30p + 2p, these are red but we also have another slightly larger in natural colour, same price.

Relay, Clare Elliott 670 ohm. Coil sealed in metal can size approx. ¾" by ⅞" x ⅜", two pairs of changeover contacts. This type of relay is mounted by its own leads. £1.00 + 8p.

Desk Instrument Case with sloping front, overall size of sloping front is 4" wide and 5" long. Mounted on a heavy base for stability base size 4½" × 4" with flex lock. The heavy base is easily removed if not required. The average depth below sloping panel 3" approx. Price £1.50 + 12p. Post 50p + 4p. Note the sloping front will be supplied with each of these cases but this already has quite a lot of holes in it, however it is a simple matter to cut and bend new aluminium front if you use this as a pattern

Multicore flex lead. 25 coloured coded cores in PVC outer, length approx 3 metres 50p + 4p

Combined flex lock and cable bush. Self adjusts for most sizes of circular mains lead. This is a two part device held to the back panel by means of a screw, the tightening of which firmly locks the cable which prevents it being pulled to the detriment of the internal connections. Price 25p + 2p.

Voltage or current selector, comprises a 9 pin valve holder and an insulated plug with a shorting link which can be made to short together any pair of the valve holder contacts. Price 30p + 2p.

This Month's Special Bargain Offer consists fluorescent chokes and if you take advantage of it you will be buying at approx one half of the manufacturer's quantity prices. Three popular sizes, type (a) 2ft 20w size 4½" x 1¾" x 1¾" price 50p + 4p, type (b) 4ft 40w or 1 metre 40w size 6½" x 1¾" x 1½" 70p + 6p. Type (c) 5ft 65w size 6½" x 2¼" x 1¾" price 90p + 8p. These prices are cut so keen that we cannot give our normal quantity discounts but if you purchase a minimum of 100 — can be mixed over 3 types — then we will give a special 10% discount

Rigonda 6" Mains Battery TV's for spares, these are less tubes and less knobs and will have one or two other parts missing but in the main are complete and worth having if you have one of these televisions or if you do repairs to them. Price £3.50 + 44p. Post £1.00 + 12½p.

25 Way Plug & Socket by McMurdo. The socket is panel mounting and the plug has a metal shield and cable clamp. Ex unused equipment 60p + 4p a pair.

12 Way Plug & Socket, ditto. Price 50p + 4p a pair.

Remember 7029. We are rapidly running out of this and if you have not put any into stock then this could well be your last chance. The price for 100 metre coil £9.50 + 76p. Carriage £2.50 + 20p.

Engine Revolution Counter. This is ex-Air Ministry item, beautifully made. As a revolution counter it is driven by a flexible shaft and having a permanent magnet field the voltage output would be dependent upon the speed. Of course it will also run as a low voltage D.C. motor and its speed will be dependent upon the applied voltage. This is dustproof and almost waterproof so it will still run in adverse conditions. One point, however, is there are no brushes fitted to these motors, these are special and as yet we have not been able to find a supplier, so you will buy without brushes. The Air Ministry ref. number of the motor is 6A/7A2. We would like to hear from any customer who met this during his service career and who knows of a possible source of brushes. Price £2.00 + 16p. Post 40p + 4p

Miniature Sealed Thermostat. German made, these are about the size of early power transistors, have 4" wire ends and are sealed, so suitable for immersion in many liquids. Operating temperature 90 C plus or minus 3%. We were not sure of the operating voltage and current but we tested one with 100w lamp off the mains and it worked perfectly o.k. Price 50p + 4p

Gooseneck as used on adjustable table lamps, microphone stands, etc. Normal brass ½" thread each end length 18" chrome plated. Price 75p + 6p. Post 30p + 2p

Nicad Battery Charger in neat plastic case size 4¾" x 3¼" x 2¾" approx. with mains input lead and charging output lead terminated with din plug. This is a dual output charger but contains useful mains transformer which makes it easily adaptable for many voltage cells. If not wanted as a charger, could very easily be rebuilt as a power unit for receiver or other device. The plastic case has a neon indicator. Price £2.50 + 20p. Post 40p + 4p.

Panel Meter. 2½" made for Air Ministry, unused but storage soiled. 30mA moving coil offered at a low price but these have loose glasses which will want reglueing. Price £1.50 + 12p. Post 20p + 2p.

Papst Motor, ref. KLZ 20.50-4-540D. This is normal mains working motor, capacitor run so easily reversible. May be a little storage soiled but these are unused and fully guaranteed by us. Price £5.00 + 40p. Post 30p + 2p

Garrard 4 Pole Motor, probably made for record player or tape recorder, this is 140v, 40-60 cycle. We do not know the Garrard ref. no. but the figure 12 is pressed on the bottom bearing cover. Price £2.00 + 25p. Post 30p + 4p

Simmerstat by Sunvic for 2500 watts. Sunvic ref. 230707/10776. This is a larger than usual simmerstat, dimensions approx 2¼" square by 2½" deep. Price £1.50 + 12p. Post 20p + 2p

Smiths Time and Set Switch. 15 amp normal mains operated device intended for use with cookers, etc. which could be set to be switched on up to 14 hours in advance and for and up to one period of 4 hours. A very neat glass fronted instrument with centre control knob size approximately 4½" x 3½" x 2" deep. The Smiths ref. No. CS7400. One obvious use is for switching on your heating an hour or so before you come home so you come home to a warm house. Price £2.50 + 20p. Post 30p + 3p.

10 Amp 12 Way Connector Block, black PVC 30p each, £24 for 100

Fluorescent Choke, polyester filled compact size 5" x 1¾" x 1¾" for 4ft 40w tube. We are selling these in minimum quantity of 100 at a time, price 60p each + VAT @ 8%, carriage at cost.

Appointments

BRUNEL UNIVERSITY
DEPARTMENT OF EDUCATION

TECHNICIAN

required to supervise three others in a Visual Aids and Reprographics workshop and a Physical Sciences Laboratory. The successful applicant will be required to diagnose faults and, if appropriate, repair a wide range of electro-mechanical and electronic equipment. Applicants should be educated to H.N.C. level or equivalent, and a knowledge of photographic techniques is desirable, as is experience of simple TV production techniques.

Salary within the grade 6 scale £3328-£3964 plus £275 London Weighting Supplement. Four weeks annual leave (plus Easter and Christmas weeks). Good conditions of service, sports and social facilities etc.

Write for application form to Assistant Secretary (Establishement), Brunel University, Uxbridge, Middlesex UB8 3PH or telephone Uxbridge 37188 extension 49. Closing date: 8 July, 1977.

7302

The Media Department of the British Council has two vacancies for

Television Engineers

to operate and maintain their studios, situated in Tavistock Square, London

The studios are used to train personnel from countries overseas in broadcasting and closed circuit television techniques in support of developmental broadcasting and education. As well as for the regular training courses, the studios are used to produce videotapes, films and other audiovisual programmes.

Some of the training activity takes place in institutions situated overseas and there may be opportunities for the successful applicants to work and travel abroad.

An essential qualification is the City and Guilds Telecommunications Certificate or HNC or equivalent or broadcast engineering training. Candidates should also have practical experience in studio operations including vision control, lighting, sound and videotape. One of the posts includes responsibility for the supervision of a small team of operational and maintenance engineers; for this post experience of managing staff would be an advantage.

The salary scales, including London Weighting and pay supplements, range from around £4760 to around £5880. There is a non-contributory pension scheme.

For further details and an application form to be returned by 4 July telephone 01-499 8011 extension 3041 or write to Staff Recruitment Department, The British Council, 65 Davies Street, London W1Y 2AA, quoting reference G/5.

7309

CHELSEA COLLEGE
University of London

ELECTRONICS TECHNICIAN GRADE 2B

required for the construction and maintenance of equipment and apparatus and to assist in the running of Electronics and Physics Undergraduate Teaching Laboratories. Day release available for approved courses. Salary in range £2,769 to £3,112 per annum (inclusive). 37½-hour week. Further details and application form from:
Mr. M. E. Cane (2B.ET)
Chelsea College
Pulton Place, Fulham
London SW6 5PR

(7267)

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101 Design/Development and Test Jobs.
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FURTHER APPOINTMENTS CONTINUED ON PAGE 122

HART ELECTRONICS

The *Only* Firm for *Quality* Audio Kits

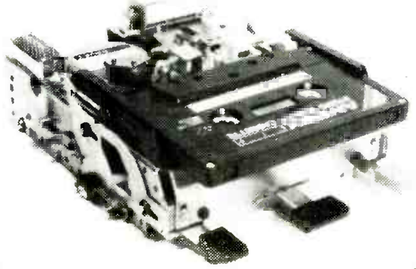
Are proud to offer the only DESIGNER APPROVED kit for the

J. L. Linsley-Hood High Quality Cassette Recorder

As these circuits are capable of such an excellent performance we feel that it is not sensible to sacrifice this potential by designing a kit down to a price. We have therefore spent a little more on professional hardware allowing us to design a very advanced modular system. This enables a more satisfactory electrical layout to be achieved, particularly around the very critical input areas of the replay preamps. These are totally stable with this layout and require no extra stabilising components. Many other advantages also come from this system which has separate record and replay amps for each channel plugging in to a master board with gold-plated sockets. The most obvious is the reduction of crosstalk and interaction which could cause trouble on a single plane board, with our modular system the layout is compact but there is no component crowding. Testing is very easy with separate identical modules and building with the aid of our component-by-component instructions is childishly simple, but the finished result is a unit designed not to normal domestic standards but to the best professional practice.

All printed circuits are of glassfibre material, fully drilled with a tinned finish for easy and reliable soldering. Component locations are printed on the reverse side of the board and are arranged so that all identification numbers are still visible after assembly.

- 71x Complete set of parts for Master Board, includes bias oscillator, relay, controls, etc. £9.83 + £1.23 VAT.
- 72x Parts for Motor Speed and Solenoid Control for Lenco CRV deck. This is the proper board layout as given in the articles. £3.52 + 44p VAT.
- 73x Complete set of parts for stereo Replay Amps. and VU Meter drive £8.12 + £1.02 VAT.
- 74x Complete set for stereo Record Amps. £6.74 + 84p VAT.
- 75x Complete set of parts for Stabilised Power Supply to circuit given in Article. This uses a special low hum field transformer with better characteristics than the commonly used toroid. £8.79 + £1.10 VAT.
- 700M2 Individual High Quality VU Meters with excellent ballistics. £8.48 + £1.06 VAT. Per Pair.
- 700C/2 High Quality Custom built steel Case. Complete with Brushed aluminium front plate, mains switch, record microswitch, turned record level knob, plastic cabinet feet, all bolts, nuts and mounting hardware. All necessary holes are punched and all surfaces are electroplated. Complete step-by-step assembly instructions are included. The cover is finished in an attractive black crackle surface. £16.50 + £2.06 VAT.



LENCO CRV CASSETTE MECHANISM

High Quality, robust cassette transport for Linsley-Hood recorder. Features fast forward, fast rewind, record, pause and full auto stop and cassette ejection facilities. Fitted with Record/play and erase heads and supplied complete with Data and extra cassette ejection spring for above horizontal use. Price £21.60 + £2.70 VAT.

Total cost of all parts £83.58.
Special offer for Complete Kits £81.50 + £10.19 VAT.
Optional extra solid teak end cheeks, £3 pair + 38p VAT.

Reprint of 3 Linsley-Hood Cassette Recorder articles, 45p post and VAT free.

MATRIX 'H' QUADRAPHONIC DECODER

Printed circuit boards and kits to our usual quality are being prepared for this design. Send for list.

We also supply complete kits to make a fully integrated 30 watt stereo amplifier using the Bailey Power Amplifier circuit and the Bailey/Burrows Pre-amplifier with the Quilter Tone control modification.

Printed circuits and components are available for the Stuart tape circuits. These articles described a high quality tape link circuit for use with a reel-to-reel deck. Reprints of the three articles are available from us price 40p. Post Free (No VAT).

ALL PARTS ARE POST FREE

Please send 9 X 4 SAE for lists giving fuller details and Price breakdowns

Penylan Mill, Oswestry, Salop

Personal callers are always welcome, but please note we are closed all day Saturday

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RELAYS—UNISELECTORS—SWITCHES

MINIATURE PLUG-IN RELAYS (Siemans/Varley) with perspex dust cover and base.
6-12-24-48v D.C. In Stock
2 c/o **50p**; 6 make **60p**
4 c/o **75p**; P & P **10p**

S.T.C. MINIATURE (P.C. Mounting) with dust cover
2 c/o (18/24v) **45p** P.P. **10p**
4 c/o (24/36v) **50p** P.P. **10p**
6 c/o (36/48v) **75p** P.P. **10p**

I.T.T. 240v A.C. Plug-In RELAYS (with perspex cover) 10 amp contacts
3 c/o **75p** P.P. **10p**

H.D. TIME SWITCHES (100 amp contacts) 1 on/off in 24 hrs. Excellent condition. 240v-50 hz **£6.50** P.P. **£1.00**

UNISELECTORS 25 WAY
5 Bank Full Wipe 75 ohm **£5.50** P.P. **50p**
6 Bank Full Wipe 75 ohm **£6.25** P.P. **50p**
8 Bank Full Wipe 75 ohm **£7.50** P.P. **50p**
12 Bank Half Wipe 68 ohm **£6.50** P.P. **60p**

SMALL 12V UNISELECTORS 4 Bank 11 way **£2.50** P.P. **50p**

D.C. SOLENOIDS 24v (Cont. Rated) 10lb Pull. 20 mm Stroke. Size 50 x 48 x 42 mm **75p** P.P. **15p**

TELEPHONE HANDSET with Press-to-Speak Switch. **£1.50** P.P. 40p

CITENCO GEARED MOTORS, 240v 50hz, 19 r.p.m. torque 14.5 kg/cm. **£6.75** (new) P.P. 50p

DECADE INDICATOR SWITCHES with plus & minus Push Buttons. 6 mm digits **75p** each P.P. **10p**

KEY SWITCHES '1000' TYPE
4 c/o each way locking **60p** P.P. **10p**
6 make each way locking **60p** P.P. **10p**
Bank of 4. 4 c/o each way. 1 biased **£1.25** P.P. **15p**

MAGNETIC COUNTERS
3 DIGIT RESET COUNTERS (12v D.C.) **£1.50** (Ex Equip.) P.P. **20p**
3 DIGIT RESET COUNTERS (240v 50 hz) **£1.75** (new) P.P. **25p**
6 DIGIT RESET COUNTERS (24v D.C.) **£4** (new) P.P. **25p**
4 DIGIT NON-RESET (24v D.C.) **£1** (New) P.P. **20p**
5 DIGIT NON-RESET (24v D.C.) **£1** (Ex Equip.) P.P. **20p**
6 DIGIT NON-RESET (48v D.C.) **£1.50** (New) P.P. **20p**

MULTICORE CABLES

4 CORE RIBBON (RAINBOW) CABLE 4 x 10/2m.m. forming ¼in. wide strip 10m—**75p**; 50m—**£3**; 100m—**£6**. P.P. **1p** per metre

8 CORE RIBBON (RAINBOW) CABLE 8 x 14/76 Forming ½in wide strip 10m—**£1.50**; 50m—**£6.50**; 100m—**£12.00** P.P. 1p per metre

5 CORE H.D. CABLE 5 x 70/76 P.V.C. Black Outer P.V.C. O.D. ½ in 10m—**£2.50**; 50m—**£12**; 100m—**£22.50** P.P. 2p per metre

10 CORE CABLE 10 x 7/76 (10 colours) P.V.C. O.D. 7m.m. 10m—**£2**; 50m—**£8.50**; 100m—**£16.** P.P. **2p** per metre

16 PAIR RIBBON CABLE 16 x 2 core P.V.C. double sheathed forming 55 m.m. wide strip 10m—**£3**; 50m—**£25**; 100m—**£40.** P.P. **2p** per metre

EQUIPMENT COOLING FANS (100 C.F.M.)
PAPST-LUFTER 120x120x38 m.m. 115v 50hz **£5.75** (New) P.P. **50p**
PAPST 112x112x55 m.m. 220v 50 hz **£3.50** (Ex. Equip.) P.P. **50p**
MUFFIN TYPE 120x120x38 m.m. **£3** (Ex. Equip.) P.P. **50p**

SMALL TRANSFORMERS 240/115v **40p** each

WOODS EXTRACTOR 130x130x80 m.m. 240v. 50 hz **£3.50** (Ex. Equip.) P.P. **75p**

PAPST (SQUIRREL CAGE) 9 Blade. Less Mounting. **£3.50** (new) 240v 50hz P.P. **50p**

VARIOUS

AIR PRESSURE SWITCHES 0-10 lb variable switch contacts 15 amp change-over (a quality unit in turned plated brass) **£1.50** P.P. 25p

E.H.T. MODULES. Input 190-260v 50 HZ. Output 13.7Kv. PK @ 0.50 m/a. (150 x 95 x 70mm) £12. P.P. £1.

MYRIA MEGOHMMETER TYPE 35A. 20-200K MEG/OHMS 500v test. Excellent condition. **£45,** carr. £2.50

SYNCHRONOUS GEARED MOTORS (Smiths) 2 r.p.m. 3 r.p.m. 30 r.p.h. 20 r.p.h. 6 r.p.h. 2 r.p.h. all 240v **£1.50** ea P.P. **25p**

P.C. EDGE CONNECTORS
32 way (.1 pitch) finished ends **45p** P.P. **10p**
56 way (.1 pitch) cuttable **65p** P.P. **10p**
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4 in. Dome (Ext. Gong) 4½/6v D.C. **£2.50** P.P. **£1.00**
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D.C. POWER SUPPLIES Input 240v A.C. TYPE 1 20v D.C. at 1 amp. Fully regulated 155 x 155 x 75 mm totally enclosed **£5** P.P. **75p**

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ROMFORD 44473

Appointments

Advertisements accepted up to 12 noon Monday, June 27, for the August issue, subject to space being available.

DISPLAYED APPOINTMENTS VACANT: £7.50 per single col. centimetre (min. 3cm).
LINE advertisements (run on): £1.10 per line, minimum three lines.
BOX NUMBERS: 50p extra. (Replies should be addressed to the Box Number in the advertisement, c/o Wireless World, Dorset House, Stamford Street, London SE1 9LU.)
PHONE: Eddie Farrell on 01-261 8508
Classified Advertisement Rates are currently zero rated for the purpose of V.A.T.

Radio Frequency Spectrum Engineering

An influential role £7265–£8435

These senior positions within the Directorate of Radio Technology, London, present Electrical Engineers with an outstanding opportunity to help shape future usage and considerable scope for exercising their individual initiative.

The Directorate provides the technical expertise and engineering support so necessary in forming and implementing management policy. It is concerned with all aspects of spectrum engineering — the forward planning, management and regulation of civil frequency bands; radio propagation over the whole frequency spectrum; specifications and equipment type approval for fixed and mobile services, including microwave links; the application of computer techniques to frequency management problems; the nationwide radio interference service; the provision of technical advice on radio services, licensing; and the operation of an international radio monitoring service. It is also very much involved in the technical preparations for the 1979 World Administrative Radio Conference.

The successful candidates will lead specialised teams responsible for key areas within the Directorate's activities. The work should appeal to those engineers who enjoy applying imagination and new ideas to problem solving.

For further information about the work, telephone Mr. R. A. Bedford on 01-275 3381.

Candidates must have a degree or equivalent qualification in electrical engineering and should be Chartered Engineers. In-depth knowledge and experience of spectrum engineering is essential together with a sound appreciation of allied disciplines. Candidates must also have managerial ability and be able to deploy and stimulate staff of different skills. Working knowledge of French an advantage.

Starting salary within the quoted range. Promotion prospects to £10,000 and above. Non-contributory pension scheme.

For an application form (to be returned by 8 July, 1977) write to Civil Service Commission, Alencon Link, Basingstoke, Hants RG21 1JB, or telephone Basingstoke (0256) 68551 (answering service operates outside office hours). Please quote T/9536/2.

(7324)

HOME OFFICE

DESIGN TEST FIELD SERVICE

Immediate vacancies exist in most areas for engineers qualified to BSc/HNC/C&G with analogue, digital or R.F. experience.

Phone or write

APEX PERSONNEL
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LONDON S.W.6

01-731 4353

(7155)

ELECTRONICS ENGINEER (Audio)

needed urgently by lively young West London Company.
Write/ring:
INTEGRATED MUSIC LIMITED
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01-602 2302

(7288)

AVIONIC TECHNICIANS

required

Interesting and varied work on Navigation and Communication Equipment including VHF, VOR, ADF, HF, RADAR, TRANSPONDER / DME & CABIN ADDRESS SYSTEMS.

- ★ Salary from £3,750 to £4,100 according to experience, reasonable overtime opportunities could raise this to £5,000 if desired.
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7 WILLOW ROAD, COLNBROOK, SLOUGH, BERKS.
Telephone Colnbrook 2654

(7268)

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FREE JOBS LIST
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FIELD SERVICE ENGINEERS
BASIC SALARIES TO £5,000 + CAR

7316

34 Percy Street, London, W1
01-637 5551

SUNNY SOUTH COAST

Expansion on the South Coast in the Electronics Industry now demands urgently the following personnel: **Electronic Engineers (R&D), Design Engineers, Software Programmers, Systems Engineers, Development Engineers, Sales Engineers, Trials Engineers, QA Engineers, Test Engineers, Production Engineers, design Draughtsmen, Inspectors, Buyers.**
All these positions offer excellent salaries and prospects and in most cases relocation expenses. Ring or write: C.B.S. Appointments, 224 Old Christchurch Road, Bournemouth, 292155 or Wimbourne 4891 evenings.

(7319)

Electronics Engineer today?

You could be the Computer Engineer of tomorrow!

ICL, Europe's leading computer manufacturer, supplies systems to governments, universities, research, industry and commerce. ICL is renowned for its efficient customer service, and each of our customers relies on a team of Systems Engineers – which is where you come in.

We're building up our intake of Electronics Engineers who will undergo a thorough initial training over 18 weeks at our Training Centre in Letchworth, Hertfordshire – the largest of its kind in Europe, with accommodation provided. You will then work at one of three locations which you choose at interview, from the large number we have throughout the country. Within 18 months you will be a fully trained Systems Engineer with a career rich in opportunity ahead of you, and you will have the satisfaction of using all your technical expertise, tact and personality as a representative of ICL.

You could be just the person we're looking for if you're 20-35 and have any one of the following qualifications plus two years' practical electronics experience:

- City & Guilds Full Electronics Certificate.
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Why hesitate when one of the world's top technologies is there for the taking? Phone David Reeves on 01-788 7272 extension 4150 for an application form, or send the coupon.

To: David Reeves, ICL, 85/91 Upper Richmond Road, Putney, London SW15 2TE. WW1389

I would like to find out more about becoming a Computer Engineer with ICL. Please send me details.

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International Computers

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7299

ELECTRONIC CIRCUIT DESIGN
PHGY 5182

Do you enjoy the challenge of using advanced technology to solve complex interdisciplinary problems. Are you thoroughly conversant with the use of discrete components, microcircuit amplifiers, function generators, TTL and C.mos techniques? Can you design both analogue and digital circuits? We have one vacancy for a senior technician in a small team providing a comprehensive design, construction and maintenance service for teaching and research.

Candidates must have at least 9 years relevant experience including 2 years design work. HNC standard is required and the ability to supervise other staff is essential. Familiarity with medical electronics an advantage.

Salary on University Technical Scale Grade 6 £3315 x 7 — £3950.

Letters of application stating age, qualifications, experience and the names of 2 referees to: Administrator, University of Oxford, Department of Physiology, Parks Road, Oxford OX1 3PT.

Further details from Wilf Laycock, Supervisor, Electronics Group, Oxford 57451.

7310

APPOINTMENTS IN ELECTRONICS

Take your pick of the permanent posts in:

MISSILES — MEDICAL
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MICROWAVE — MARINE
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For expert advice and immediate action on career improvement, 'phone, or write to, Mike Gernat BSc

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Engineering and Technical Recruitment
11 Westbourne Grove
London W2. 01-229 9239.

7098

UNIVERSITY OF STRATHCLYDE
CENTRE FOR EDUCATIONAL PRACTICE (AUDIO VISUAL UNIT)

TELEVISION ENGINEER
Grade 3

required with experience in the maintenance of electronic equipment. The work includes the repair and operation of a wide range of audio visual equipment. The Engineer will also become a member of the studio crew as a Television Cameraman. Applicants should hold an O.N.C., O.N.D. or City and Guilds Certificate and have 3-5 years' relevant experience.

Salary Scale (including all supplements): £2455-£2788 per annum, dependent on experience and qualifications.

Applications in writing, QUOTING REFERENCE CEP. 13/WW, giving details of age, experience and qualifications, should be made to The Personnel Officer, University of Strathclyde, Royal College Building, 204 George Street, Glasgow G1 1XW.

7298

Hoggett Bowers
Executive Selection Consultants

Trade Magazine Editor

Hong Kong — Attractive salary negotiable

Our client, a major South East Asia publishing group, requires an editor for a growing consumer electronics trade magazine. The successful candidate will initially assist the Group Managing Editor, who is currently editing this magazine, and will assume full editorial control as soon as he has gained sufficient knowledge of the trade in the region. He will then be expected to develop the magazine further and increase the coverage into new countries.

Applicants must have had at least five years experience in journalism with at least three in electronics, and will have gained some knowledge of the technical, as well as marketing aspects of the industry. Taxation in Hong Kong is very low and the package will include excellent fringe benefits.

H.W. FitzHugh, Ref: 20053/WW

Male or female candidates should telephone in confidence for a Personal History Form to:
LONDON: 01-734 6852,
Sutherland House, 5/6 Argyll Street, WIE 6EZ.
Offices also in Birmingham, Glasgow, Leeds, Manchester, Newcastle and Sheffield.

7323

You listen to Radio? You watch Television? You're a qualified electronic engineer and yet you've never considered working in broadcasting?

Then perhaps you need to know a little more about some of the opportunities available with the BBC.

Studio Capital Projects
Engineering staff are based in central London, but will travel to various studio centres to assist in the design, installation and commissioning of radio and television studio equipment.

Transmitter Capital Projects
Again based in central London, engineers are required to travel to studios all over the U.K. to assist with the design and commissioning of radio and television transmitters and their associated aerial systems.

Candidates for both these departments should either possess a British university or polytechnic degree in electronic engineering or physics.

Television
Working in the Television Service, based in West London, engineers are involved in the maintenance and operation of the equipment used in the origination and distribution of television programmes.

Transmitters
Engineers are allocated to the major stations in various parts of the country and are responsible for both the maintenance and operation of radio and television transmitter plant. For these positions a current driving licence would be an advantage.

BBC Receiving Station
This station, based at Caversham, Berkshire, requires engineers to operate and maintain the elaborate receiving terminal equipment to enable foreign broadcasts to be monitored.

For these three departments candidates should possess either a City and Guilds full Technological Certificate in Telecommunications (course No. 271) or an HNC in Electronic Engineering. Shift working will normally be involved, for which generous extra payments are made.

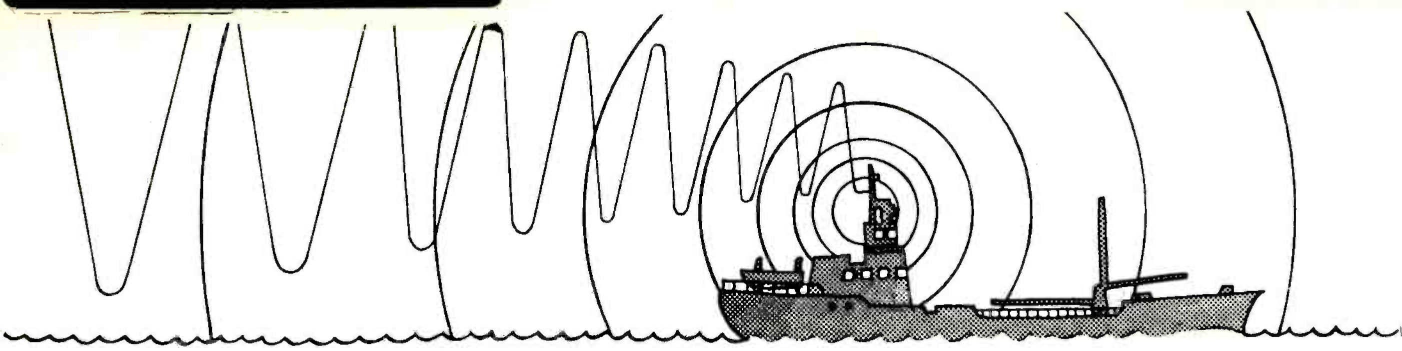
Candidates for all positions must have normal colour vision and hearing.

For further information and an application form, write stating which type of engineering you are interested in to the **Engineering Recruitment Officer, Broadcasting House, London W1A 1AA,** quoting reference No. 77.E.4034/WW and enclosing a self addressed foolscap envelope.

Closing date for completed application forms is 14 days after publication.

BBC

7289



Radio Officers–now you can enjoy the comforts of home.

Working for the Post Office Maritime Services really makes sense. You still do the work that interests you, but with all the advantages of a shore-based job: more time to enjoy home life, job security and good money. To qualify, you need a United Kingdom Maritime Radiocommunication Operator's General Certificate or First Class Certificate of competence in Radiotelegraphy, or an equivalent certificate issued by a Commonwealth Administration or the Irish Republic.

Starting salaries, at 25 or over, are £2905 rising to £3704 after three years service. Between 19 and 24, the starting salary varies from £2234 to £2627 according to age. In addition, a supplement of £312 p.a. is payable. You'll also receive an allowance for shift duties which at the maximum of the scale averages £900 a year and there are opportunities to earn overtime. There's a good pension scheme, sick pay benefits and prospects of promotion to senior management.

Right now we have a few vacancies at some of our coastal radio stations, so if you're 19 or over, preferably with sea-going experience, write to:
ETE Maritime Radio Services Division (L690),
ET 17.1.1.2., Room 643, Union House,
St. Martins-le-Grand, London EC1A 1AR.

Post Office Telecommunications

RADIO TECHNICIANS

Government Communications Headquarters has vacancies for Radio Technicians. Applicants should be 19 or over.

Standards required call for a sound knowledge of the principles of electricity and radio, together with 2 years experience of using and maintaining radio and electronic test gear.

Duties cover highly skilled Telecommunications/electronic work, indluding the construction, installation, maintenance and testing of radio and radar telecommunications equipment and advanced computer an analytic machinery.

Qualifications: Candidates must hold either the City and Guilds Telecommunications Part I (Intermediate) Certificate or equivalent HM Forces qualification.

Salary scale from £2,230 at 19 to £2,905 at 25 (highest pay on entry), rising to £3,385 with opportunity for advancement to higher grades up to £3,780 with a few posts carrying still higher salaries. Pay supplement of £313.20 per annum.

Annual Leave allowance is 4 weeks rising to 6 weeks after 27 years' service.

Opportunities for service overseas.

Candidates must be UK residents.

Further particulars and Application forms available from

Recruitment Officer
Government Communications Headquarters
Oakley, Priors Road
CHELTENHAM, Glos GL52 5AJ
Tel. Cheltenham 21491 Ext. 2270
(STD 0242-21401)

(7219)

ilea

Learning Materials Service

Television Centre, Thackeray Road, SW8

Maintenance Engineer

The Television Centre of the ILEA Learning Materials Service, situated at Battersea, has a vacancy for a maintenance engineer with specialist knowledge of professional studio and film sound equipment. The Centre, which produces programmes for over one thousand educational establishments, is provided with television and film production facilities at broadcast level, which are shortly to be converted to colour.

The successful candidate will join the maintenance section (four in number) and, with other members, will be responsible for maintaining a very wide range of vision and sound equipment which includes helical scan VTR's and cassette machines. He or she will be expected to be the department's expert in sound with particular knowledge of professional mixing desks, tape recorders and 16mm magnetic film recorders and reproducers (some involving digital techniques) and must have a number of years experience in this work. An HNC, the final City and Guilds certificate or a similar qualification in relevant subjects is desirable.

Salary within the scale £4,864-£5,191 (Studio Technician 3).

Application forms, returnable within 14 days of the publication of this advertisement, from the Education Officer, Estab 2A/2, Room 4A, Addington St. Annexe, County Hall, London SE1 7UY. Tel: 01-633 7456.

(7290)

Just a tick, that's all it will take you.

	Yes	No
1. Can you fault find Electronic Circuits?		
2. Do you know how to use an Oscilloscope?		
3. Are you able to read circuit diagrams?		
4. Can you use a Spectrum Analyser?		
5. Do you understand the meaning of GHz?		
6. Does V.S.W.R. mean anything to you?		
7. Do you know how many "ohms" in a village?		

If you score five or more "Yes" answers, then you could qualify for a really interesting career as a Test Technician with Marconi-Elliott Avionic Systems.

In our Mobile Radar Division at Borehamwood in Hertfordshire we're looking for men and women with a good basic electronics background to join teams working on the development, test and manufacture of a wide range of radar equipment and electronic surveillance and alarm systems.

It's challenging work and our Laboratories employ the most advanced techniques. Your experience, plus some training from us, will enable you to enjoy a satisfying future with a top company in the field of electronics development.

If you would like more details, get in touch now with G. Cock at Marconi-Elliott Avionic Systems Limited, Elstree Way, Borehamwood, Herts. Tel: 01-953 2030, Ext.3195.

MARCONI ELLIOTT AVIONICS

A GEC-Marconi Electronics Company

(7320)

COMMUNICATIONS ENGINEER

Newcastle upon Tyne up to £4131

The Engineering Research Station at Killingworth is looking for a Communications Engineer to be involved in developing techniques which will increase the capacity of the Corporation's mobile radio channels. Work may be broadly split into two areas:

(i) investigation of the performance and implementation restrictions of wide area-coverage schemes.

(ii) investigations leading to more effective use of spectrum including problems associated with the transmission of digital information to mobile receivers.

A considerable involvement in discussions with user departments will be needed to ensure feasible integration of new techniques with existing systems.

Candidates should have a degree in Electronics, preferably with a specialisation towards communications.

Starting salary will be within an incremental scale rising from £2361 to £3819 plus a flat rate supplement of £312 p.a., with initial placing according to age, qualifications and experience.

Application forms may be obtained from the
Manager/Management Services, British Gas
Engineering Research Station
Killingworth, Newcastle-upon-Tyne
NE99 1LH
quoting reference
RD/539656/ERS (656) WW

BRITISH GAS

(7325)

TECHNICAL ASSISTANTS

Communications Department

Vacancies will exist for Technical Assistants in the Summer 1977 to work in the Communications Departments of the BBC based in Central London.

Technical Assistants will work under supervision on the maintenance and in some cases the operation of electronic equipment used in the distribution of radio and television programmes.

Duties

Technical Assistants will be concerned with the switching and routing of both television and radio programmes and in the provision and maintenance of all communication systems.

Training

Technical Assistants receive full-time training, which if successful should enable them to qualify internally as BBC Engineers in something over two years.

Qualifications

Applicants, who must be between the ages of 18 and 26 and have normal colour vision and hearing, should have had a good general education and be able to offer G.C.E. 'O' levels in English, Maths and Physics, or the equivalent, and have read up to 'A' level in Maths and Physics. Alternatively an ONC or Part I of the City & Guilds Telecommunications Technicians Course (No. 271) would be acceptable. In addition it is essential that they can demonstrate the ability to apply their knowledge of electricity and magnetism to related practical applications in the fields of communications, radio and television.

Salary

Depending upon experience the starting salary on appointment will be in the range £2514 to £2706 p.a. Additional payments will be made for those Technical Assistants who are required to work shift rotas or irregular hours. In addition a monthly pay supplement depending on total earnings of between £10.86 and £17.38 is payable under the current Incomes Policy.

For further details and application form please write to **The Engineering Recruitment Officer, BBC, Broadcasting House, London W1A 1AA** quoting reference number 77.E.(R) 4036/WW and enclosing an addressed envelope at least 9" x 4". Closing date for completed application forms is 14 days after publication.

BBC

7266

TELEVISION ENGINEERS

EXPORT OPERATIONS

Rediffusion Consumer Electronics is expanding its engineering team to give greater technical support to its customers with particular emphasis on export markets.

If you are a qualified television engineer with current experience in at least some of the following disciplines we should like to hear from you:

★ Design and development of colour TV receivers.
★ Safety engineering, radiation measurements and test house submissions.
★ Quality Assurance in a modern factory environment.
★ Customer service with particular emphasis on export markets.
★ Assessment of audio products from world wide sources.

The team is based at our engineering centre at Chessington, Surrey, but occasional visits to our factories in the North East of England and to our customers, home and abroad, will be required.
Salaries are attractive and assistance with relocation expenses will be offered if appropriate. If you feel you can make a real contribution towards the further success of our operation please write to:

Mr. H. Brearley
Head of Technical Services
REDIFFUSION CONSUMER ELECTRONICS LTD.
Fullers Way South
Chessington
Surrey, KT9 1HJ
or phone 01-397 5411

7301

GRAMPIAN TELEVISION LIMITED

ENGINEERS/TECHNICIANS

The Independent Television Company for North and East Scotland seeks electronic engineers or technicians for duties at its Studio Centre in Aberdeen.

The successful candidates will be employed in the operation and maintenance of modern electronic broadcast equipment.

Experience in this field is desirable but candidates without this experience, having a sound technical training, will be considered.

Salary is in the range £2689 to £4887, dependent on experience, with the prospects of later promotion through competitive interview to more senior posts.

Applications, in writing, to:

Mrs. E. A. Gray
Personnel Officer
Grampian Television Limited
Queen's Cross
Aberdeen AB9 2XJ

(7328)

GRAMPIAN

'SERVING THE OIL COUNTRY'

SALES ENGINEERS

If you are looking for a stimulating and demanding job with the prospect of regular overseas travel on a world wide basis, why not join Pye TVT, one of the world's leaders in the design and manufacture of broadcasting equipment?

Continuing expansion has led to the need within the Technical Sales Department for Sales Engineers in the following fields:

1. Video Tape Recording.
2. Video Mixing, Switching and Assignment, including Station Automation and Computer Editing Systems.
3. Colour Cameras and Telecine.

In each case the successful candidate will be required to discuss advanced and sophisticated equipment at a high engineering level and to assist the regional and area managers in the marketing of these products.

A degree or equivalent qualification is desirable, but several years experience in the relevant field is more important.

These are very responsible posts and salaries will reflect the importance we attach to these appointments. Relocation expenses to this pleasant part of East Anglia will be given in approved cases.

Please write or telephone: Dave Barnicoat, Pye TVT Limited, PO Box 41, Coldhams Lane, Cambridge CB1 3JU.
Telephone: Cambridge 45115

(7291)

Pye TVT Limited
The Broadcast Company of Philips

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WIRELESS TECHNICIANS

There are vacancies at Home Office Wireless Depots throughout England and Wales for Wireless Technicians to assist with the installation and maintenance of VHF and UHF Systems etc.

Applicants must be able to drive a car and be in possession of a current United Kingdom driving Licence.

Salary

is £2010 (at 17), £2450 (at 21) and £2905 (at 25) rising to £3385, plus a 1976 pay supplement of £313.20 a year and a 1977 pay supplement of 5% of total earnings, subject to a minimum of £101.79 a year and a maximum of £208.80 a year.

A Secure Future

with a non-contributory pension scheme, good prospects of promotion and a generous leave allowance. There are opportunities for day release to gain higher qualifications

Qualifications

Candidates, male or female, must hold a City and Guilds Intermediate Telecommunications Certificate or equivalent qualification and have had good experience in Telecommunications.

Interested?

Then write or telephone for further details and an application form to:- Mr C B Constable, Directorate of Telecommunications, Home Office, 60 Rochester Row, London SW1P 1JX. Telephone: 01-211 6420.

(7315)

Home Office

ELECTRONICS ENGINEERS

Are you a young flexible, electronics engineer preferably with HNC and some experience in design/development, able to analyse circuitry and modify existing equipment as well as creating original equipment?

Does the opportunity of joining a small Company in the forefront of scientific instrumentation where hard work and initiative are well rewarded appeal to you?

The job involves the on-site installation, commissioning and after-sales servicing of our range of complex instrumentation and requires a high degree of technical skill, initiative and responsibility.

In return we offer plenty of interest and travel (sometimes international) coupled with first-class working conditions. Salary is by negotiation and all travelling expenses are reimbursed.

Please apply in writing to:

BRUKER

R. F. LADBURY
BRUKER SPECTROSPIN LIMITED
UNIT 3, 209 TORRINGTON AVENUE
COVENTRY, CV4 9HN

7297

SITUATIONS VACANT

Botswana
Telecomms Engineer

For varied engineering and administrative duties to ensure the efficient functioning of telex, telephone, telegraph, and broadcast services for the Botswana Ministry of Posts and Telecommunications.

Candidates, under 55, must be MIEE or MIERE, preferably with a degree. 15 years' experience in telecomms operations is required, including responsibility for maintenance of telex, radio relay and multiplex systems, automatic exchanges, subscribers' equipment and distribution networks. A knowledge of electronic exchange working, exchange signalling systems, and broadcast transmitters is desirable.

Starting salary is equivalent to £6145–£7680 pa and includes a substantial tax-free allowance paid under Britain's overseas aid programme. Basic salary attracts a 25% tax-free gratuity.

Benefits include free passages, generous paid leave, children's holiday visit passages and education allowances, subsidised housing, appointment grant and interest-free car loan.

For full details and application form write quoting MX/1202/WD to

Crown Agents

The Crown Agents for Oversea Governments and Administrations, Appointments Division, 4 Millbank, London SW1P 3JD 7296

RADIO ENGINEER/TECHNICIAN FOR THE CARIBBEAN

Needed to work as technical adviser to the Radio Schools in Haiti, a non-governmental literacy development programme. Responsibility for the training of local counterparts.

A British Volunteer Programme Post: volunteer terms of service include free accommodation, living and other allowances, return air travel, language and orientation courses.

CIIR OVERSEAS VOLUNTEERS

Write with details of curriculum vitae to **CIIR Overseas Volunteers, 1 Cambridge Terrace, London, NW1 4JL.** 7277

ITN
SENIOR ENGINEER
VTR OPERATIONS

Independent Television News Ltd. has a vacancy for a Senior Engineer in the ITN Facilities Centre in Central London, able to operate and maintain a tape transfer area of, at present, 18 Helical Scan Video recorders.

Candidates should have several years' experience with such equipment, and experience of broadcast 2'' quad recorders would be an advantage.

Salary £5712 per annum.
Contributory Pension Scheme and free Life Insurance.

Please telephone the Personnel Officer on 01-637 3144 for an application form, quoting reference 8312. 7294

ASSISTANT ELECTRONICS ENGINEER

required for a Research and Development company in West London.

A vacancy exists for a young engineer educated to HND standard to join a design and development section working on the control of vehicle engines. Experience in industry is desirable but not essential as the applicant would be at a junior level in the first instance.

Please apply, giving details of age, qualifications and experience to:

The Development Manager, SGRD Limited
Concord Road, LONDON W3 0SE (7286)

ARTICLES FOR SALE

MTV

Best choice for used TV

- Largest stock and selection of colour and mono TV in Britain.
- 1976 exports exceeded 250,000 sets.

Trade enquiries to:
Midland TV Trade Services,
Worcester Road, Kidderminster DY10 1HY, England. Tel. Kidderminster 61907 or 67390. Telex 337993 (7130)

MAGNETIC MICROPHONE SPEAKERS

4T Inserts. ideal for all sound speaking and listening applications. Very rugged. DC res. 20 ohms.
Size: 1⅞'' dia. ⅝'' deep.
40p ea + 10p P&P
6 for **£2.20** + 20p P&P.
12 for **£4.50.** P&P free.
S.A.E. for list. Many other items. Trade enquiries welcome.

B.B. SUPPLIES, 141 Shalmsford Street
Nr. CANTERBURY, Kent CT4 7QZ (6/92)

ARTICLES FOR SALE

VHF Rx ass for use on 121.5Mc/s but can be moded to any freq 100/150Mc/s as 9 min. valves, O/P for phones, crystal controlled HC6/u type not supplied, new cond. with circ. £6.50. **ISOLATING TRANS** pria 230v sec 26v at 13 amp with c.t. fitted in case with ammeter new £17.80. I.F.F. **TRANSPONDER** for use in range 950/1100Mc/s with tunable Tx and Rx cavities, 60Mc/s I.F. strip, pulse modulator circs, 115 400C/s I/P, plus large number of misc parts with circ, note these are supplied less valves and ext store soiled otherwise complete £10.80. **INFRA RED TEST SETS** contain mains p.u. giving 24v. d.c. infra red source, ent unit giving 12Kv from 24v, meter, test jig cables, etc., all in neat case transistorised used to test image convertor tubes, good cond. £15. **BATTERIES.** Dryfit sealed lead acid two types 1.8 A/hr. size, 2¾x2x2'' £5.40 and 2.6 A/hr size 5¼x1½x2¼'' £6.50, both new. **KEYBOARDS** for telephone 0 to 9 digits size 4x3'' new £1.50. **PLUG & SK** min. 12-way req ¾'' fix hole new £2 per pair. C.R.T.s all new electrostatic CV2184 2¾'' P7 £4.50. CV1746 6½'' P.1 ordf. tube £6. CV1534 11'' P11 orange £10.80. **SELSYNS** mains power type 230v £25 per pair. **RADAR SCANNER** by Decca 24v drive X band with qty of w.g. £54. **TIMBERS** will measure up to 60 secs in 1/100ths of a sec 24v new £15. **TAPE RECORDER** airport type audio 10 track with rec and playback amps (no erase) for 230v 19'' rack with handbook one only £108. **U.H.F. GROUND** Tx/Rx inst comprise Tx, Md & Rx covers 225/400Mc/s single channel, O/P 100 watts a.m. I/P 115v 50c/s units are for 19'' rack mt, American surplus £173. The following for callers: Marconi h.f. spec analysers 3/30Mc/s £45. P.A. Amps 100watt valve type with c.u. etc. mains £27. P.A. speaker outdoor type 15'' £8 ea. **TANNOY** 200 watt transis amps with control gear also high power p.a. speakers. **SCOPES.** Solartron CD643 DC to 15Mc/s large 5'' single beam scopes £30. Prices inc. VAT and Carr. Goods ex. equip. unless stated new. Carr. applies mainland only.

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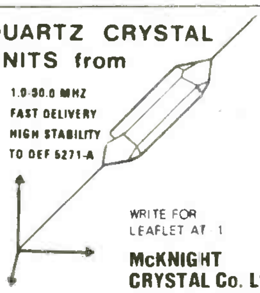

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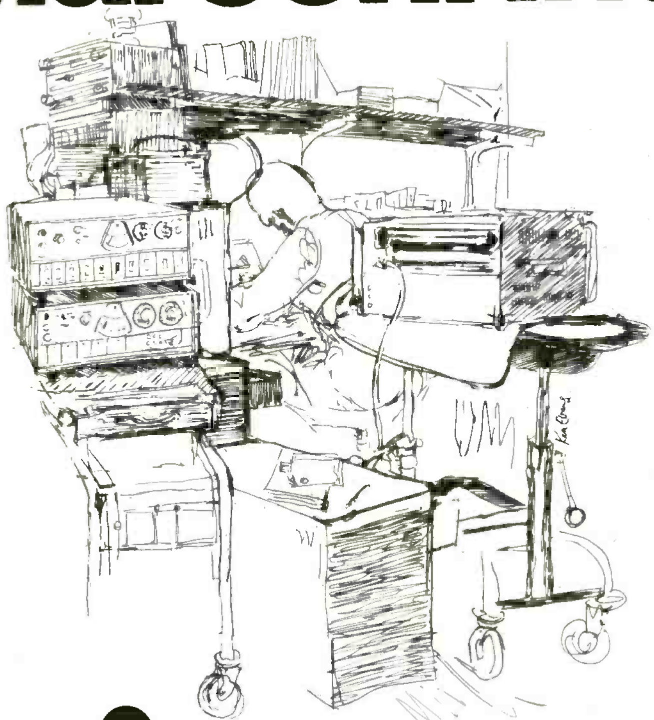

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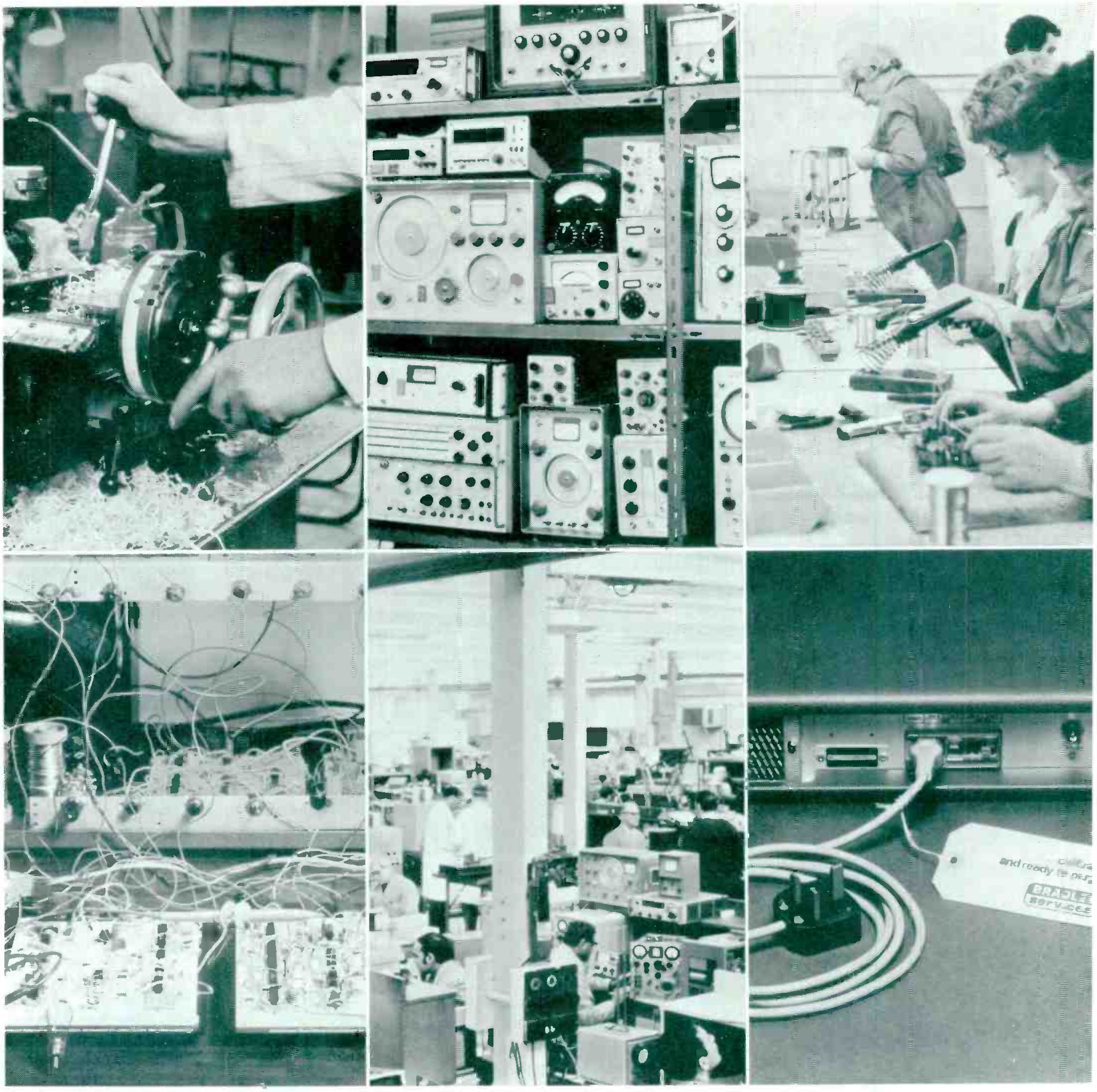

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