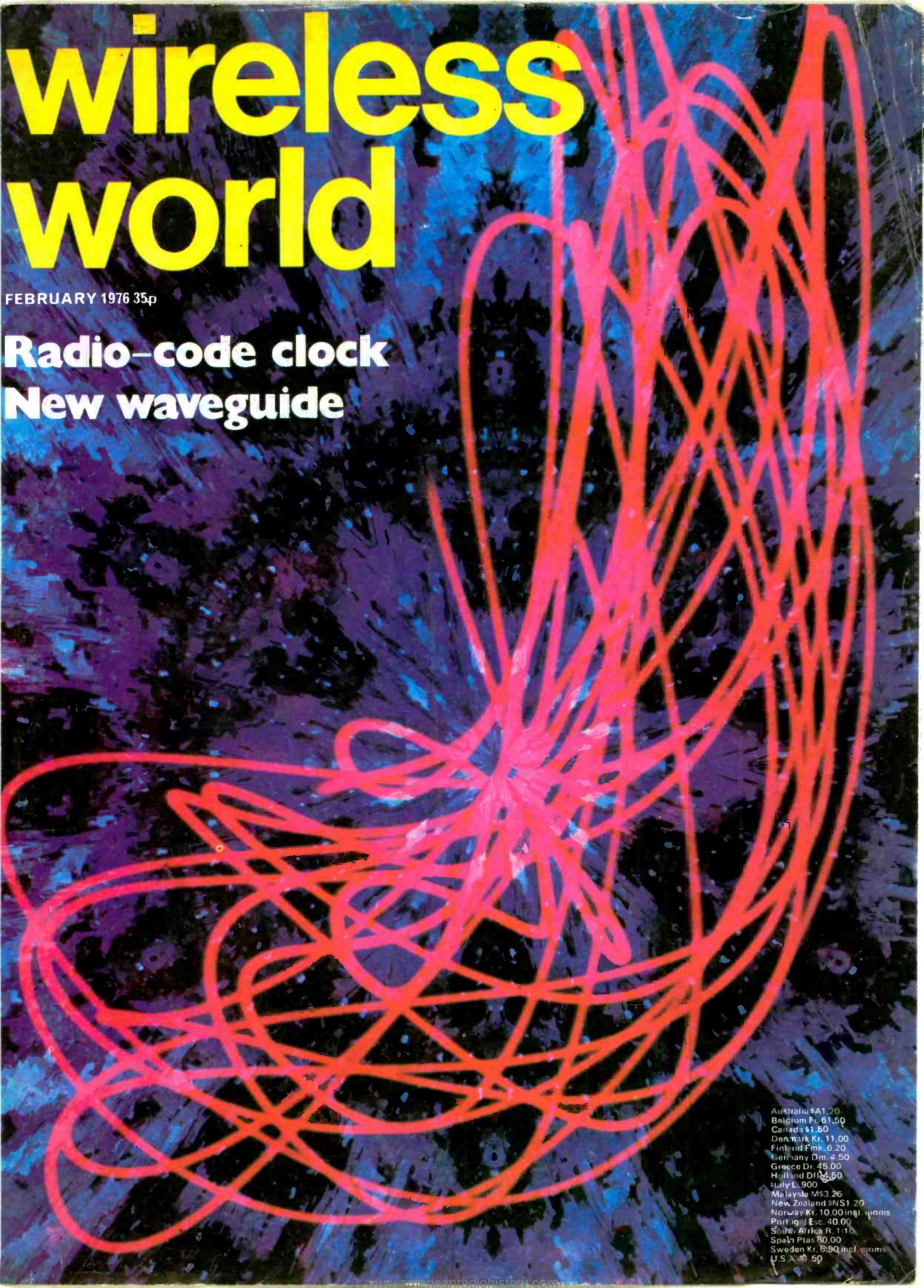
wireless world

FEBRUARY 1976 35p

Radio-code clock
New waveguide



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4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
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FEBRUARY

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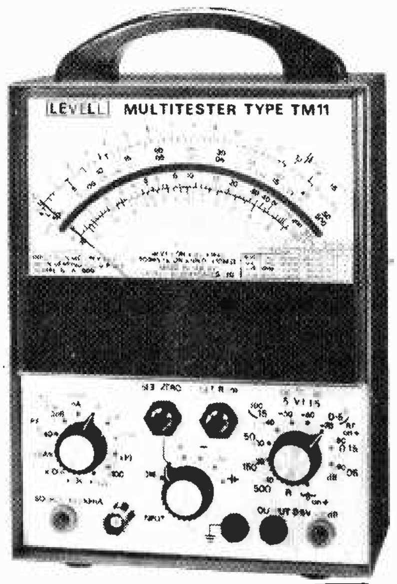
With over 100 basic ranges.



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JUNE

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JULY

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AUGUST

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OCTOBER

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NOVEMBER

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DECEMBER

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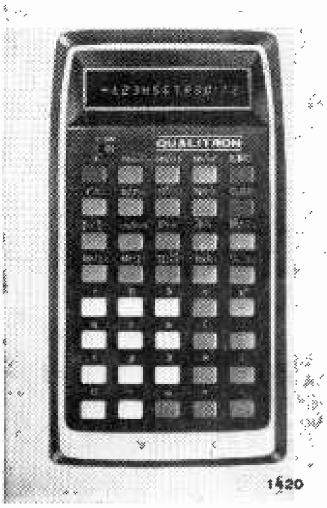
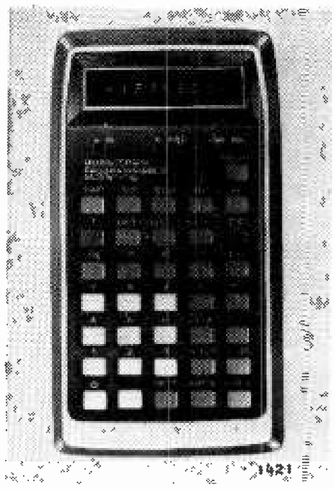
Q1 1420 — SENIOR



- Automatic selection of correct notation for result display (scientific or floating point)
- Dome keyboard for excellent response and preventing double entry input
- Algebraic mode operation
- Chain operations
- Change sign operation
- Three memories
- Display and memory exchangeable
- Trigonometric functions (sin, cos, tan)
- Inverse trigonometric functions ($\sin^{-1}$, $\cos^{-1}$, $\tan^{-1}$)
- Radian or degree selectable
- π constant
- Logarithms (ln, log)
- Anti logarithms (e^x, 10^x)
- Combinatorial functions ($n!$, $\binom{n}{r}$, $(n)_r$)
- Normal distribution function (Pr(x))
- Gamma function ($\Gamma(x)$)
- Group operations ($\Sigma\pm$, σ, $\bar{X}$, $||x||$)
- Group controls (K↑, K↓, Σ↑, Σ↓ CL_{GRP})
- Power function (y^x)
- Reciprocal (1/x)
- Square root ($\sqrt{x}$)
- Square (x^2)
- Sum of squares (Σx^2)
- Summation (ΣX)
- Item count (n)
- Mean value ($\bar{X}$)
- Mixed chain operations with parentheses approach (up to two levels)
- 14-digit LED display
- 10-digit mantissa with sign and 2 digit exponent with sign for data entry or results ($10^{-99} \sim 10^{99}$)

PRICE: £61.55 *(Excluding VAT)*

Q1 1421 — PROGRAMMABLE



- Reverse polish notation
- Display and Y-register exchangeable
- One accumulating memory (Memory store, Memory recall, M + X, M − X and M + X^2)
- Trigonometric functions (sin cos, tan)
- Inverse-trigonometric functions ($\sin^{-1}$, $\cos^{-1}$, $\tan^{-1}$)
- Radians and degrees exchangeable
- π constant
- Logarithms (ln, log)
- Anti-logarithms (e^X)
- Power function (y^X)
- Reciprocal (1/x)
- Square root ($\sqrt{x}$)
- Square (X^2)

IT CAN LOAD ANY 102 STEPS PROGRAM TO HELP YOU SOLVE THE REPEATED, ENORMOUS, COMPLEX PROBLEMS:

The Qualitron Programmable Calculator can be used to memorize any combination of key entrys while in the LOAD mode, then automatically plays back the programmed sequences as often as desired in the RUN mode.

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BESIDES HAVING THE CAPABILITY OF A SCIENTIFIC CALCULATOR:

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- Full floating point
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- Change sign operation

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Q1 1439—FINANCIAL

SPECIFICATION

- 9 digit green tube display
- 8 digits capacity for data entry or results ($10^{-8} \sim 10^8$)
- Fixed point (0 1 2 7 places),or full floating point selectable
- Dome keyboard for excellent response and preventing double entry input

BASIC FUNCTION (+ − × ÷ %) AND MEMORY

- Algebraic mode operation
- Constant operations
- Repeat operations
- Chain operations
- Percentage with automatic add on and discount
- Change sign operation
- Four memories

SPECIAL FUNCTION

- Financial operations
- Cost sell margin operations
- Trend line opeations
- Delta percentage operations
- Item count (n)
- Mean value ($\bar{X}$)
- Square root ($\sqrt{x}$)
- Summation (ΣX)
- Sum of squares (ΣX^2)

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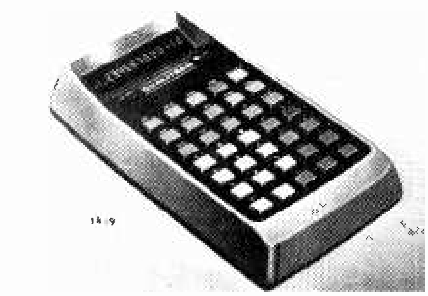
Q1 1419 — ADVANCED



SPECIFICATION

- 14 digit LED display
- 10 digit mantissa with sign and 2 digit exponent with sign for data entry or results ($10^{-99} \sim 10^{99}$)
- Automatic selection of correct notation for result display (scientific or floating point)
- Dome keyboard for excellent response and preventing double entry input

BASIC FUNCTION (+ × − ÷) AND MEMORY

- Algebraic mode operation
- Constant operations
- Repeat operations
- Chain operations
- Change sign operation
- Display and Y register exchangeable
- One accumulating memory
- Display and memory exchangeable

SPECIAL FUNCTION

- Trigonometric functions (sin cos, tan)
- Inverse trigonometric functions ($\sin^{-1}$, $\cos^{-1}$, $\tan^{-1}$)
- Hyperbolic functions (sinh, cosh tanh)
- Inverse hyperbolic functions ($\sinh^{-1}$, $\cosh^{-1}$, $\tanh^{-1}$)
- Radian or degree selectable
- π constant
- Logarithms (ln, log)
- Anti logarithms (e^x, 10^x)
- Power function (y^x)
- Reciprocal (1/x).
- Square root ($\sqrt{x}$)

PRICE: £31.25 *(Excluding VAT)*

Q1 1444 — SLIDE RULE

SPECIFICATION

- 9-digit green tube display
- 8 digits capacity for data entry or results ($10^{-8} \sim 10^8$)
- Full floating point
- Floating negative sign
- Dome keyboard for excellent response and preventing double-entry input
- Automatic display blanking

BASIC FUNCTION (+, x,−,%) AND MEMORY

- Algebraic mode operation
- Constant operations
- Repeat operations
- Chain operations
- Percentage with automatic add-on and discount
- Change sign operation
- Display and Y-register exchangeable
- One accumulating memory

SPECIAL FUNCTION

- Reciprocal (1/x)
- Square root ($\sqrt{x}$)
- Square (x^2)

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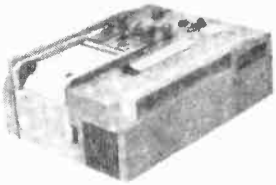
Made in USSR



Type H3020-1
Single pen

Type H3020-3
Three-pen

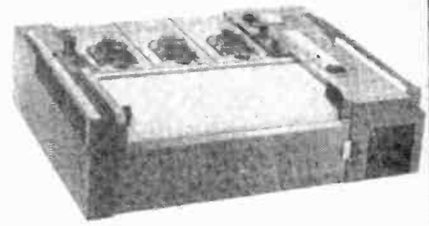


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Chart drive 200-250v 50Hz

Recording: Syphon pen directly attached to moving coil frame, curvilinear co-ordinates

Equipment: Marker pen, Timerpen, Paper footage indicator, 10 rolls of paper, connectors, etc.

Dimensions: H320-1: 285x384x16.5mm
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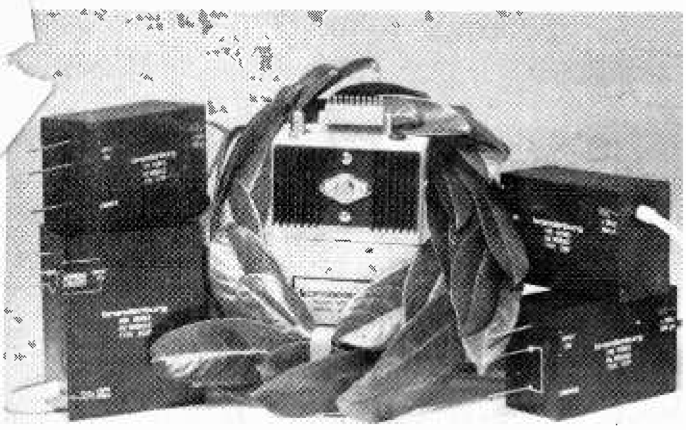
brandenburg's Olympian view.



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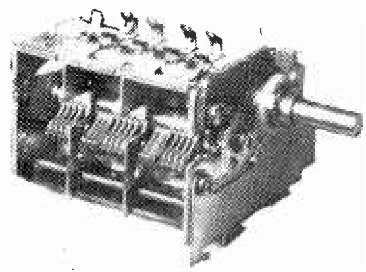
WW—062 FOR FURTHER DETAILS

NT3302 · fet fm tunerhead +AM gang



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* 335pF AM gangs
* AFC facility

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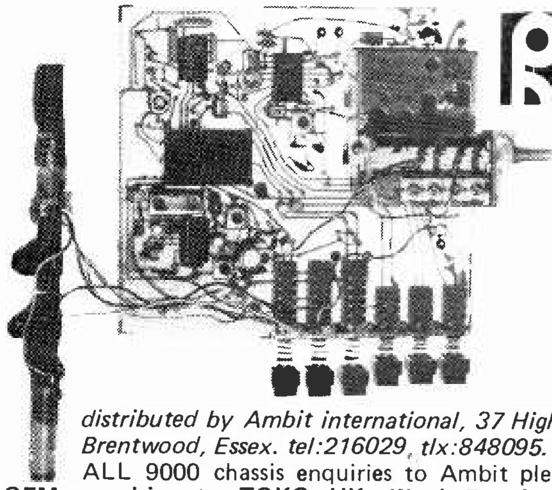

distributed by Ambit international, 37 High St Brentwood, Essex. tel:216029, tlx:848095.

ALL 9000 chassis enquiries to Ambit please.

OEM enquiries to TOKO UK, Ward Royal Parade, Alma Road, Windsor, Berkshire. tel:54057, tlx:848095.

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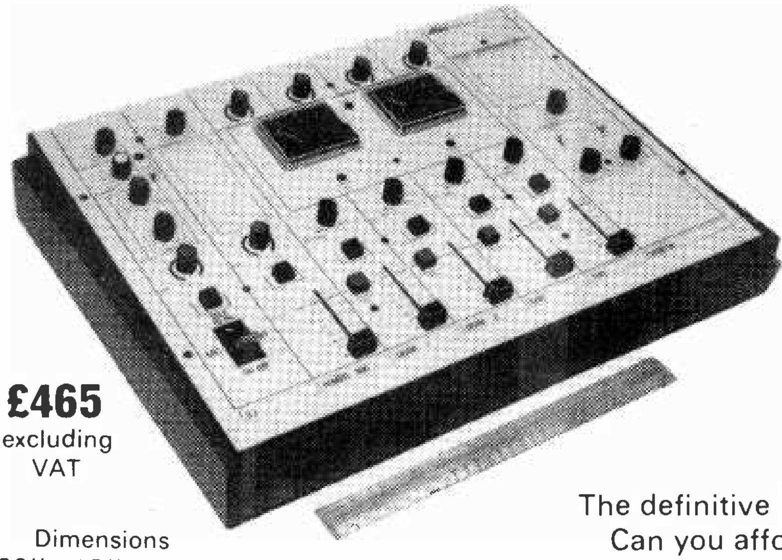
Alice Broadcasting STM6

Six Channel Stereo Transmission Mixer (ALICE'S BABY)



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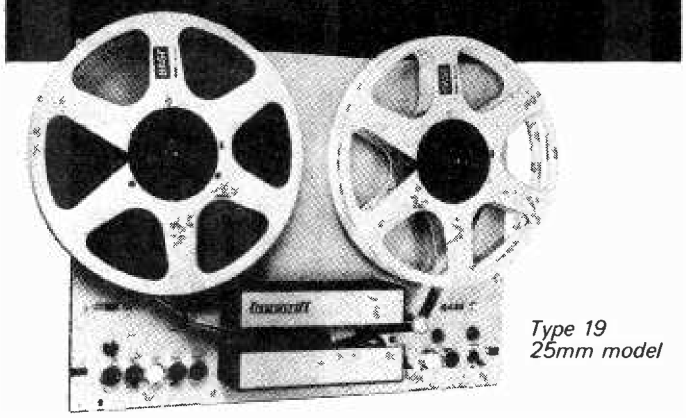
and multi-channel electronics for studio and industrial use



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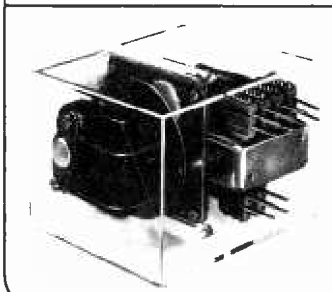

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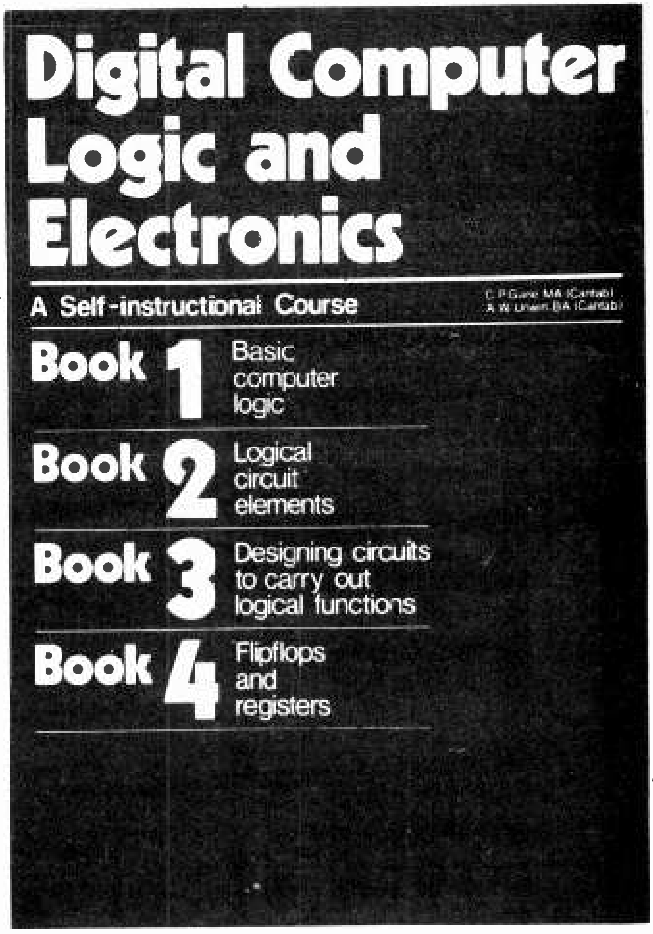
Teach yourself the latest techniques of digital electronics



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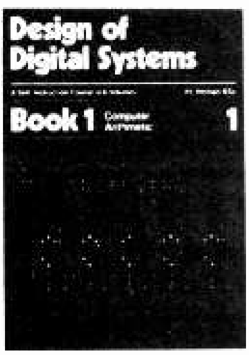

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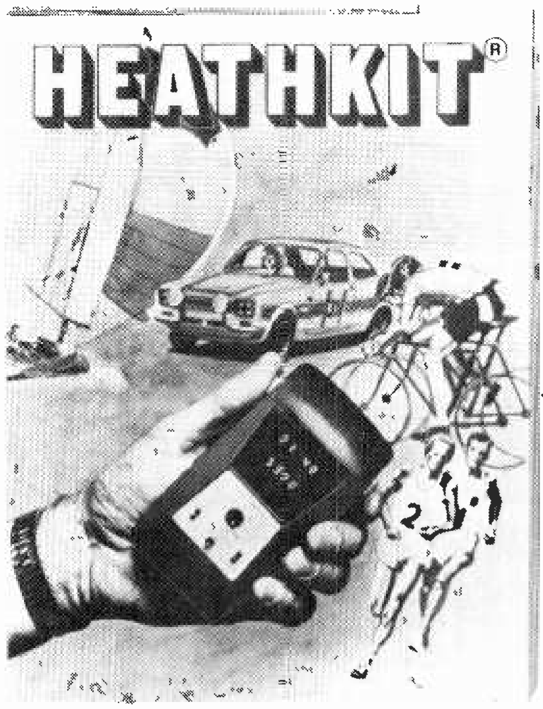

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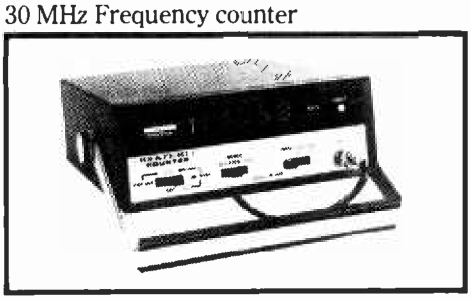
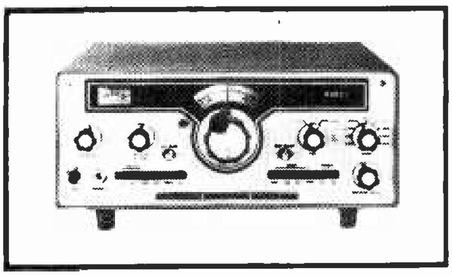
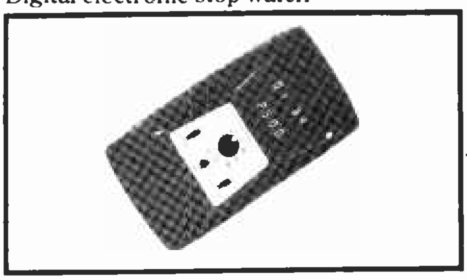


SSB Transceiver



Digital electronic stop watch



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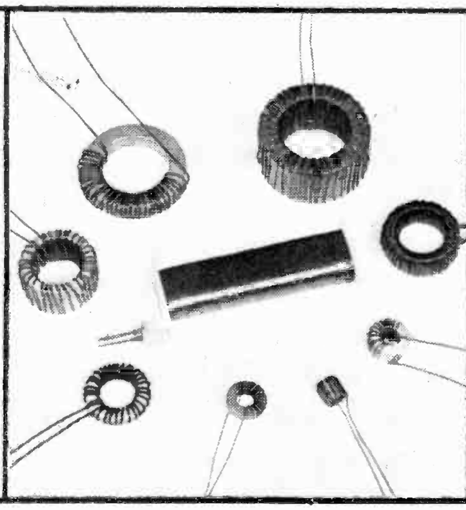

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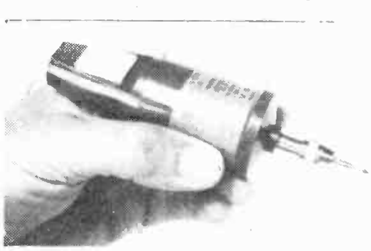

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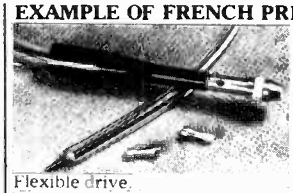

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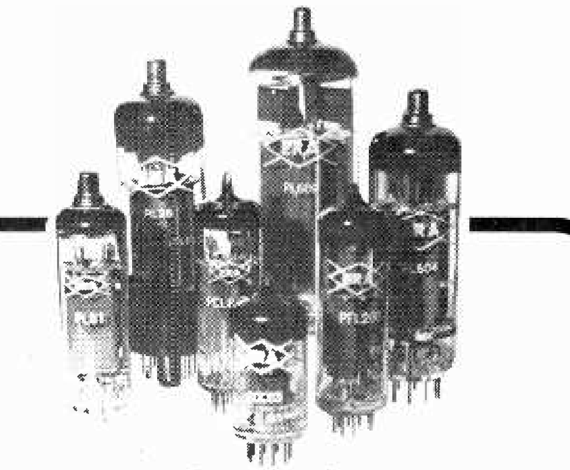

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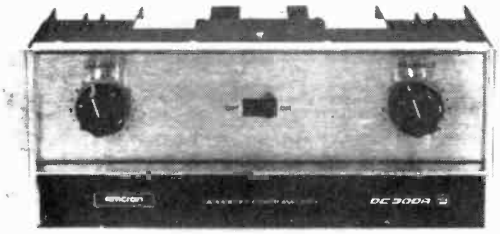

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This tuner is available ready to plug in and use, on a two week money back guarantee for your inspection and test, followed by a FIVE year performance guarantee against failure in normal use.

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SFG10.7MA Filter Unit	£2.95
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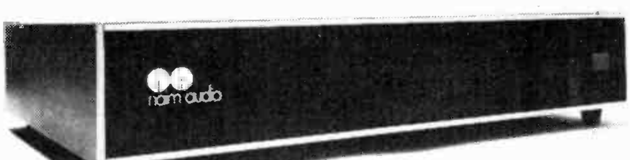

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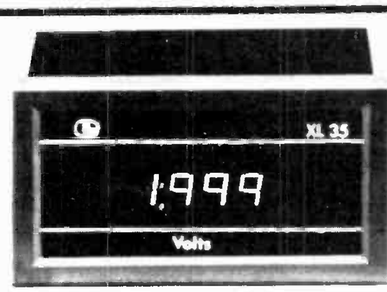

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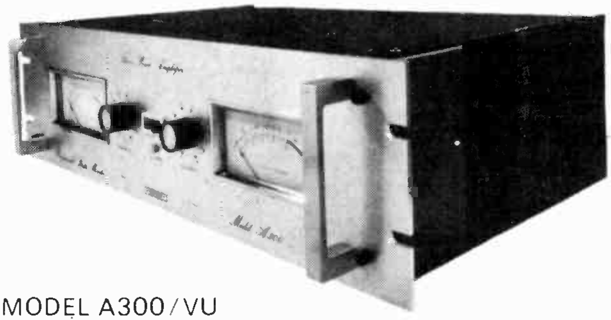
STEREO POWER AMPLIFIERS



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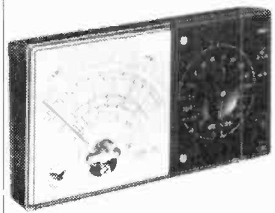
Test Equipment



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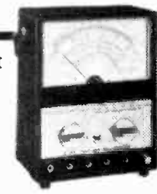

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WW

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AEL 3030

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wireless world

Electronics, Television, Radio, Audio

FEBRUARY 1976 Vol 82 No 1482

Contents

Cover shows trace of laser beam responding to sound waves, made by using mirrors attached to loudspeakers. Photograph, provided by Standard Elektrik Lorenz AG, was taken by Manfred Kage of the Institut für wissenschaftliche Fotografie.

IN OUR NEXT ISSUE

Push-button f.m. tuner design in two versions. Simple version for easy construction and adjustment. Advanced version for higher performance. Extra circuit facilities can be added.

Radar targets — aircraft, motor cars, birds and other things. How various objects appear to "eyes" which respond only to electromagnetic radiation.

Frequency modulation illustrated. Oscillograms obtained with the aid of a Fourier synthesizer show the significance of sidebands in an f.m. signal.

SIXTY-SIXTH YEAR OF PUBLICATION

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wireless world

Deliver us from data

The Government's proposals for safeguarding the privacy of personal information held in electronic computers and data banks are welcome but not before time. In a recent White Paper* they announce their intention to set up a permanent watchdog organization, a Data Protection Authority, to oversee the use of computers and "ensure that they are operated with proper regard for privacy and with the necessary safeguards for the personal information which they contain." One wonders why it has taken so long for the UK to get as far as a mere statement of intent when other countries have already taken the necessary steps to protect their citizens by laws. Sweden introduced a Data Act in 1973, the USA a Privacy Act in 1975, a part of West Germany (Hesse) had a Data Protection Law as early as 1970, and legislation is on the way, in the form of Bills or draft laws, in at least ten other countries.

At least our tardiness in the UK may give us time to consider a wider danger, of which the threat to privacy in data banks is only a part: the extent to which we are in thrall to information. Two ways of getting power over people are to hold information about them and to control the information that is supplied to them. Electronics has enormously increased the capacity to do both these things. For the holding of information (as in data banks) electronics makes possible extensive, cheap storage, quick access and transfer between systems, and easy combination of data from different sources to form "identikit" pictures of individuals. And the information is held in codes which are not intelligible to the individuals themselves. For the controlling of information supplied to people, broadcasting is becoming increasingly powerful. It cannot control what people think but, like other media, it does control by its selection of material what they think about. Whenever there is a revolution or military coup the first thing to be taken over, usually by force, is the radio and television services. But broadcasting is not the end of the matter. Britain, in common with other industrialized nations, is considering the introduction of information services wired to people's homes (e.g. by existing domestic telephone lines or perhaps wideband optical fibres in the future). Already the British Post Office has started trials with its Viewdata system. And, as a correspondent pointed out in the January issue, if people are selecting information via a permanent wired system from an electronic data store held by some organization, it is possible to monitor their choice of information, discover what they are interested in and exploit this knowledge.

In a benign democratic society one may not think there is much to fear. Unfortunately, improved information technology helps benign democracy to become paternalistic bureaucracy. From there to repressive totalitarianism is but a short step.

*"Computers and Privacy" Cmnd. 6353, HMSO, 28p, with a supplement "Computers: safeguards for privacy" Cmnd. 6354, HMSO, 55p.

Time-code receiver clock — 1

An accurate and automatic digital time-piece

by A. F. Cross, B.Sc.
Thames Television Ltd

Last year time code transmissions started from Rugby on 60kHz, offering a new approach to accurate time-keeping in the UK. This article describes a 24-hour digital clock of flexible design, based on the Rugby signal.

Many designs for digital clocks have been published, but generally they have had two drawbacks; they require an accurate internal frequency source and manual setting. While the first problem may be solved, at a price, the second usually involves the GPO speaking-clock. This design was aimed at producing a relatively inexpensive time-piece capable of keeping correct time without regular checking. The usual mains-derived reference, whilst having a low long term frequency error, exhibits a high short term variation, with the result that a clock can be in error by several seconds at any time. On the other hand, a local crystal reference will exhibit an accumulating long term error.

The clock to be described uses a crystal oscillator and divider chain. Checking and setting of the clock is provided automatically by a received time code.

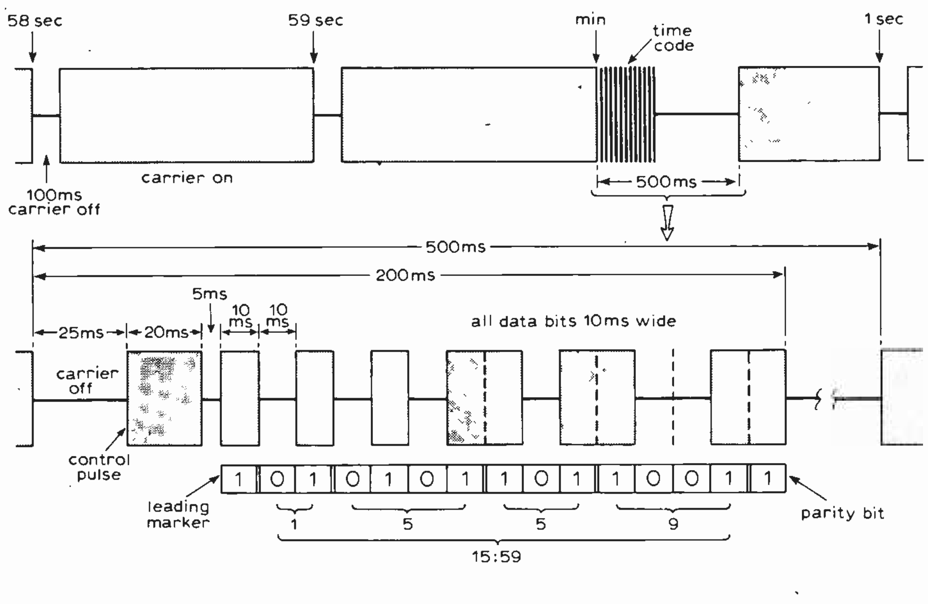
Transmission

The National Physical Laboratory has been controlling the transmission of 1s pulses radiated on 60kHz from the GPO transmitter at Rugby. In 1974 a data code was added to the signal to give the exact time of day. The carrier is on-off modulated, as shown in Fig. 1. The one-second intervals are indicated by the start of a 100ms break in carrier, and the minute by a 500ms break. The data has been added to the 500ms break. The 20ms control pulse indicates that data is to follow, which comprises a leading 1 followed by thirteen data bits for hours and minutes. The data is followed by a parity bit which checks that the data has been correctly received.

The carrier, and hence the pulse timing, is based on a rubidium reference at Rugby, which is compared with a caesium reference at the NPL Teddington; the deviation is usually in the order of 1 in 10^{11}. The clock uses the timing of the code to resynchronize the reference divider, and the data to check and correct the displayed time. Several checks are carried out on the time code before it is allowed to influence either internal timing or displayed time. The transmission is normally maintained twenty four hours a day, except for five or six hours on the first Tuesday of each month to allow for maintenance. The clock will free-run during this period and the accumulated error (a fraction of a second) will be eliminated when the code is again received.

Initially, consideration was given to using the one-second received pulses to clock the seconds display. This method has problems because interference can cause multiple clocking, and other information, which is transmitted during the minute, must be discriminated against. It was decided for overall simplicity to derive the 1Hz signal from the reference divider. Although the transmitted code is always GMT, or more precisely UTC (Universal Co-ordinated Time), the facility for switching the display to BST manually has been provided. A further feature of the clock is that it will follow the internationally agreed time-scale corrections, often referred to as the leap-second. This is a one-second correction which is made to all standard clocks to maintain tracking between the precise atomic standard and the astronomic time scale. The correction is made every 12 or 18 months as required *(Wireless World,* June 1971, p.276). A free-running clock, no matter how accurate, cannot carry out this adjustment automatically.

Fig. 1. On-off modulation of the 60kHz carrier – one-second intervals are indicated by the start of a 100ms break, and the minute by the 500ms break.



System operation

The block diagram in Fig. 2 shows the interconnexion between the circuit functions, each of which may be constructed independently. The circuit may be considered in two sections; a free-running clock, and a receiver plus control logic. The clock comprises the hours, minutes and seconds dividers and displays, the crystal oscillator, and the 5-decade reference divider. These sections together will operate as a normal digital clock, except that no manual setting facility is provided.

The receiver amplifies and demodulates the 60kHz signal which is then passed to the time code register section. When a control pulse has been detected a 100Hz clock loads the serial data into the shift register. When the register is full, clocking ceases and, if parity is correct, a data strobe pulse is generated. The data in the register is applied to the 13-bit comparator, which also receives data from the hours and minutes display-dividers. An output from the comparator to the control logic indicates whether the display-dividers agree with the received data. Upon receiving the data-strobe signal from the time-code register, and a comparison error signal from the comparator, the control logic initially assumes that the error is in the received code. If, however, two consecutive received data words both give an error signal, the control logic acts to correct the display-dividers. This is achieved in less than 15ms by fast-clocking the hours and minutes-dividers at 100kHz until the comparator gives the no-error signal. In normal operation the received code agrees with the contents of the hours and minutes display-dividers. The control logic then resets the seconds-divider, which should be reading zero, and resynchronizes the 5-decade divider, which is normally a correction of less than 1ms. The outputs of the hours-divider pass through the GMT/BST converter before driving the display logic. With the converter set to GMT there is no effect on the hours data; when set to BST, a one hour correction is made to the display.

Clock options

It is possible to simplify the clock by omitting certain functions. The simplest circuit would comprise the receiver, the time-code register and the four-digit display logic. Such a clock would display GMT hours and minutes. A 1kHz signal is required to control the clock generator, but its accuracy need only be about ±1% and a 555 timer would be suitable. Retaining three decades of the divider chain, and improving the accuracy of the 1kHz clock to about ±0.1% would produce a 1Hz signal for clocking a seconds-divider. The 3-decade divider would be resynchronized with the data-strobe signal, which would also reset the seconds count. In the absence of a carrier these simplified clocks would cease to function correctly because there is no display counter. This also means that there is little protection against incorrect data; once a control pulse has been detected the display will show the contents of the shift register, even it it is wrong. The parity signal can, however, light a warning indicator. Also, if a control pulse is not recognised, the display will not update, but continue to show the previous time code. Even with these limitations, a simplified version of the clock can still find useful applications where an occasional time check is required and a continuous reliable readout is not necessary. The GMT/BST converter may be included or omitted as required.

Circuit operation

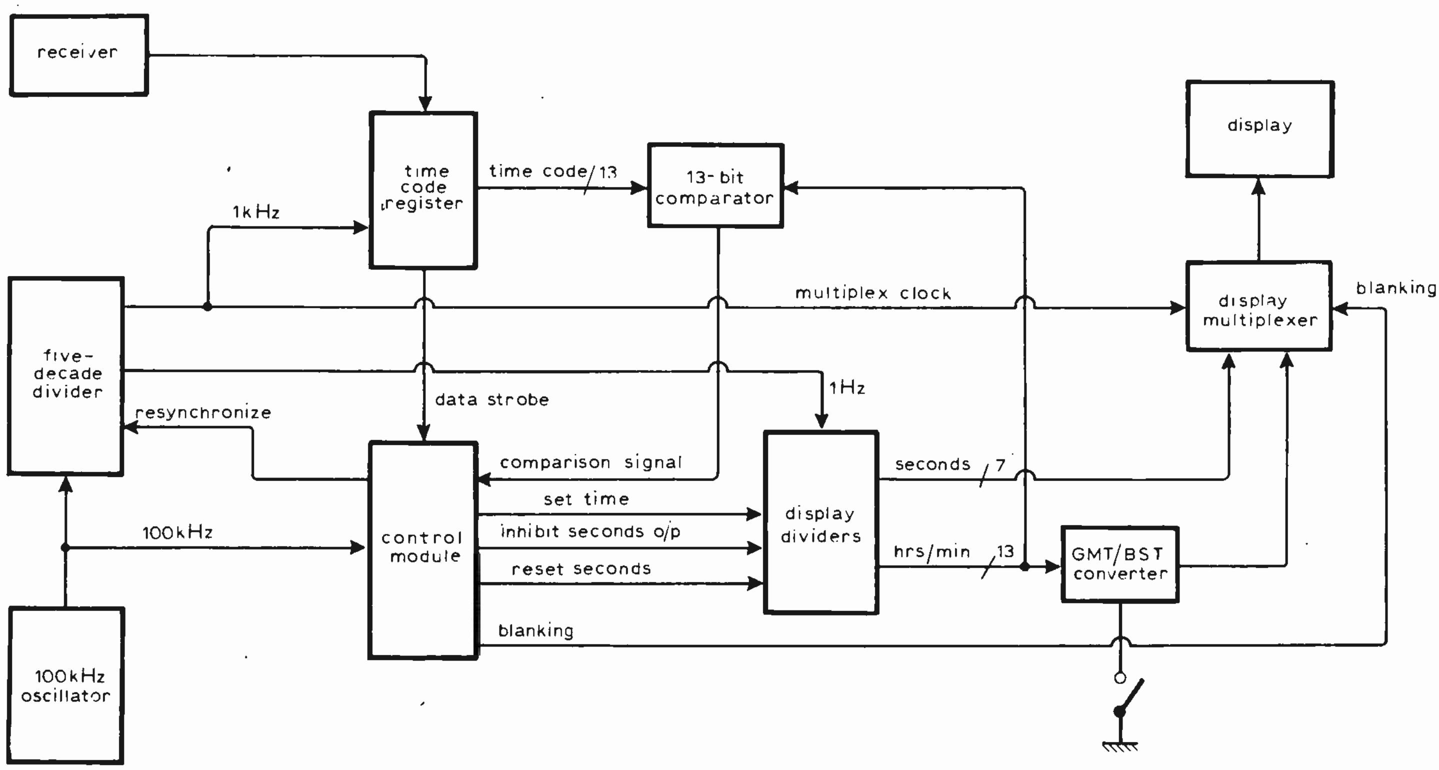
The units of seconds, minutes and hours each use a 7490 decade counter, and the tens-of-seconds and minutes use a 7492 divide-by-12 as shown in Fig. 3. With the most significant bit ignored, (output D) the device divides by 6 in binary sequence. The tens-of-hours divider is provided by a 7473 dual JK flip-flop, and the 24-hour reset is provided by a D-type flip-flop.

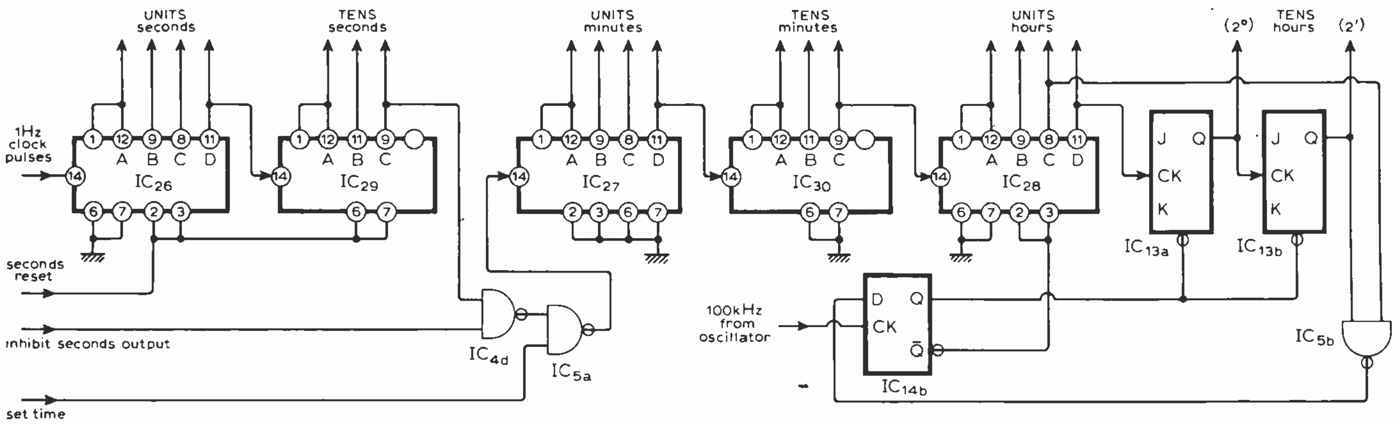
When a count of 24 exists in the hour-dividers a logic 0 is applied to the flip-flop via NAND gate IC_{5b} which is connected to the appropriate divider outputs. Because the D-type is clocked at 100kHz, the 0 on the D input will be clocked within 10μs, which sets the Q output to 0 and the $\bar{Q}$ output to 1. The Q output provides a low reset to the JK flip-flops for tens-of-hours; the logic 1 on the $\bar{Q}$ output provides the required high reset on the hours-units-divider. The D input now changes back to a 1, but the D-type does not change until the next clock pulse. Thus a 10μs reset pulse to the hours-divider is ensured.

The NAND gates IC_{4d} and IC_{5a} between the seconds and minutes-dividers provide the facility for injecting fast clocking pulses into the minutes and hours-dividers for time setting. In normal operation these gates have no effect, and the output pulses from the tens-seconds divider pass to the clock input of the units-minutes divider. When the fast-set condition is operating, the inhibit-seconds ouput signal goes low, thereby forcing the output of gate IC_{4d} to logic 1. Pulses at 100kHz appear on the set-time input of gate IC_{5a} which are then inverted. Thus the hours and minutes count is advanced at 100,000 steps per second. The maximum setting time is determined from the time taken to clock the dividers through 24 hours i.e. 14 4ms.

Fig. 2. Block diagram which may be considered as two sections – a free running clock, and a receiver plus control logic.

The 5-decade divider is shown in Fig. 4 and comprises five 7490 i.cs. Besides





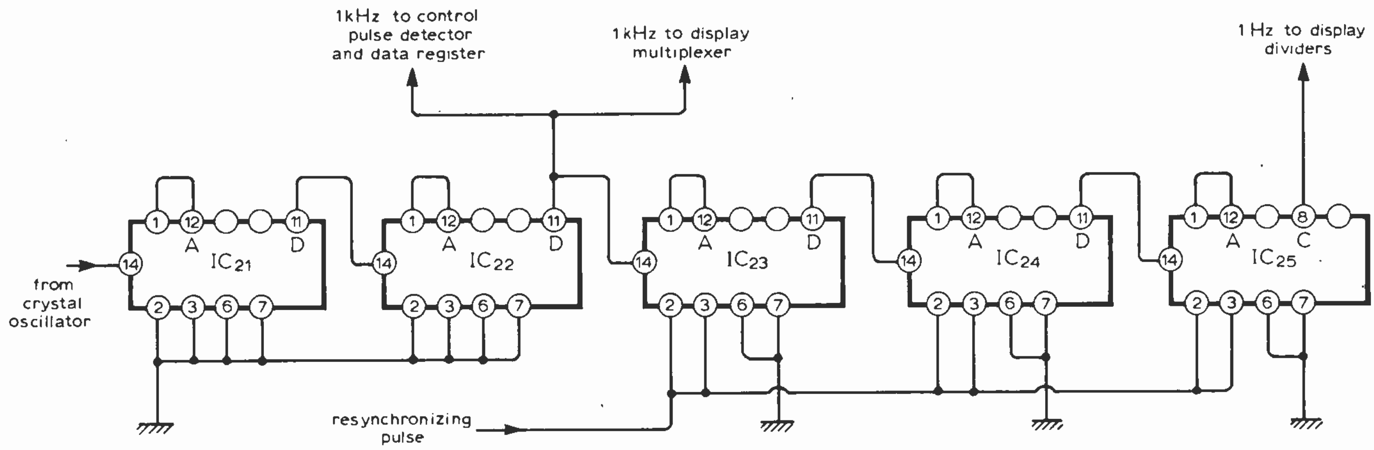


Fig. 3. (top) Display dividers – seconds, minutes and hours each use decade counters and the tens of seconds and minutes use divide-by-12s.

Fig. 4. (above) Five-decade divider. Besides providing the 1Hz output for clocking the display dividers, it also provides 1kHz for the time-code register.

Fig. 5. (right) Oscillator circuit incorporating a two transistor buffer to produce a t.t.l. compatible output at 100kHz.

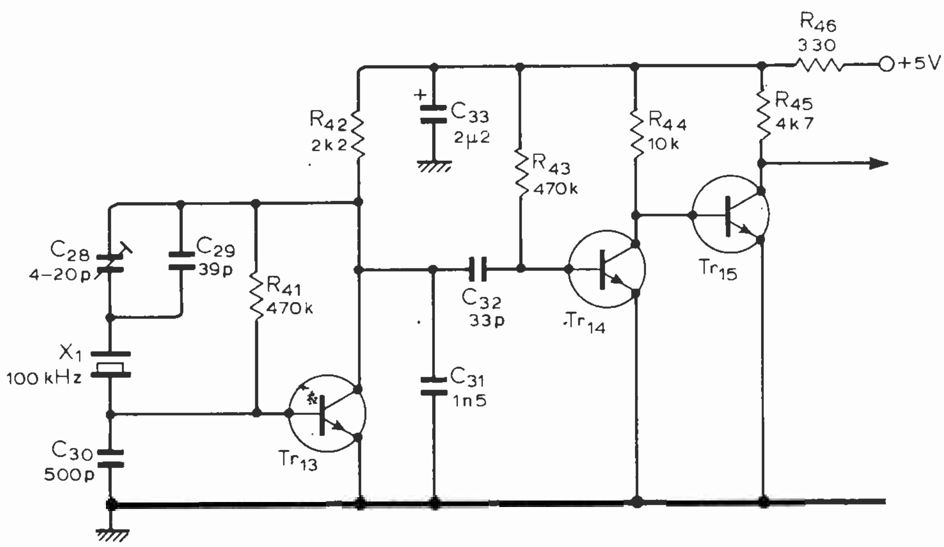
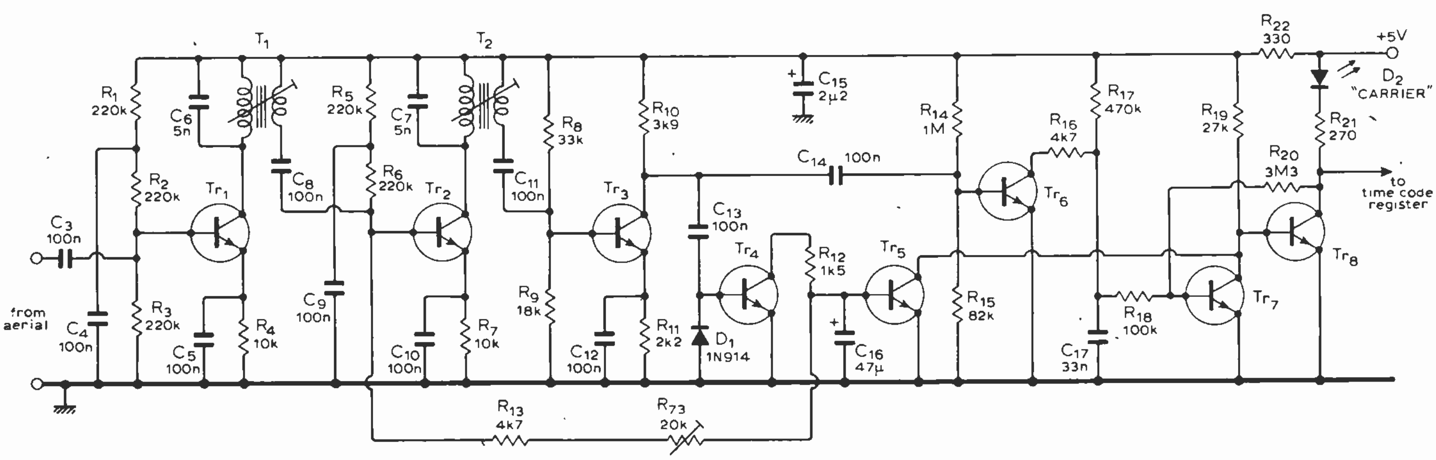
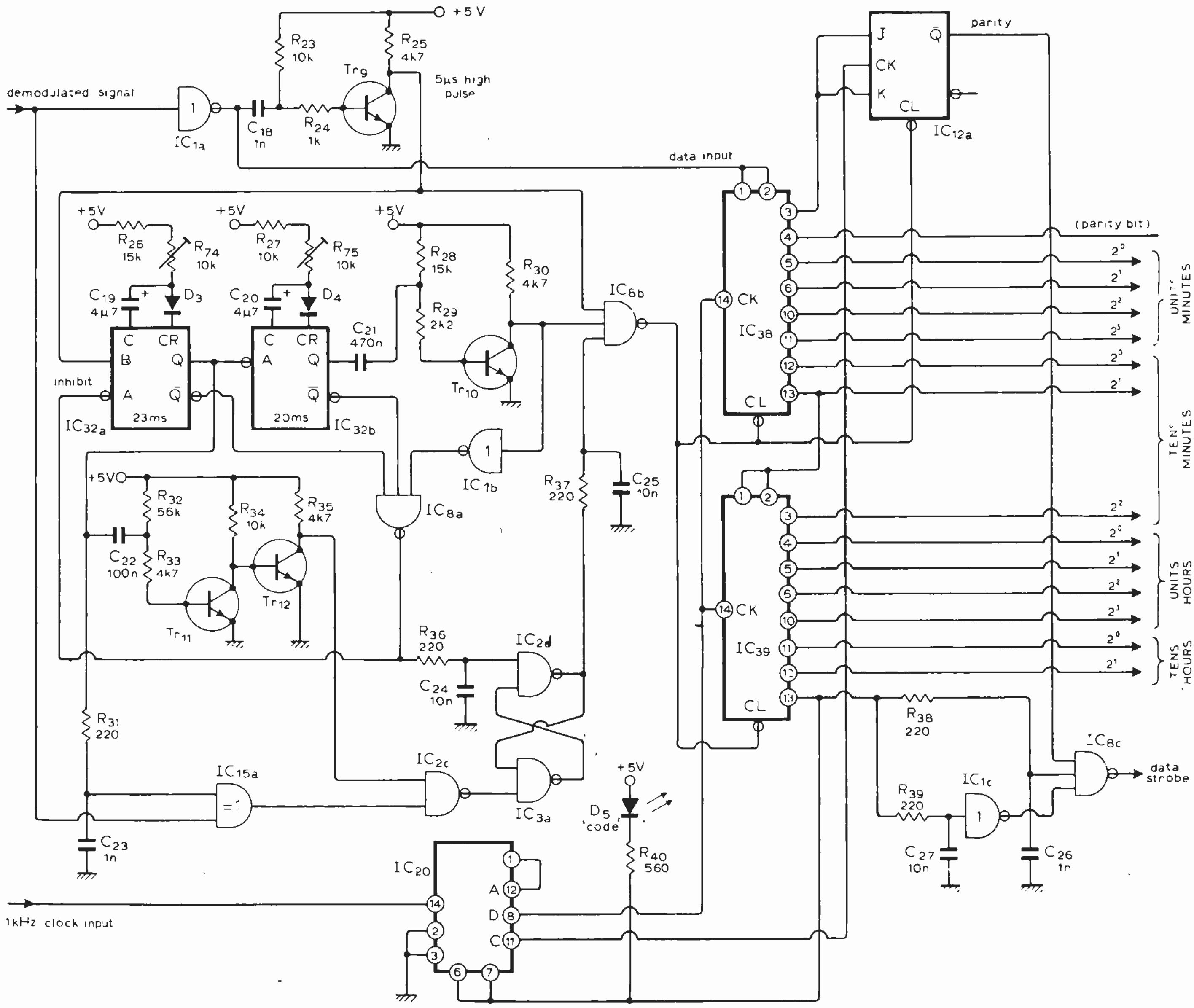


Fig. 6. (below) Receiver and demodulator circuit. A.g.c. is applied over the second and third stages.





Truth table for decade counter

	D	C	B	A
Reset at 0.2s	0	0	0	0
State at 0.3s	0	0	0	1
State at 0.4s	0	0	1	0
State at 0.5s	0	0	1	1
State at 0.6s	0	1	0	0
State at 0.7s	0	1	0	1
State at 0.8s	0	1	1	0
State at 0.9s	0	1	1	1
State at 1.0s	1	0	0	0
State at 1.1s	1	0	0	1
State at 1.2s	0	0	0	0

Box: 1-0 transition provides clocking output at end of second.

providing the 1Hz output for clocking the display-dividers, it also provides 1kHz for the time-code register, which in turn derives the 100Hz data clocking pulses. The 5-decade divider is resynchronized by resetting the last three dividers. The resetting pulse from the control logic appears at the end of the received data word, which is about 200ms after the beginning of a second as shown in Fig. 1. Conventional setting to zero would therefore result in the clock being permanently 0.2s slow. However, Truth Table 1 for the decade divider reveals that, although the D output goes

Fig. 7. Time-code register – takes in the demodulated signal, detects the control pulse and stores the incoming time code.

low one second after the zeros reset, the C output does so after 0.8s. If, therefore, the C output is used to clock the seconds-display dividers, the indicated time will be correct to within about 5ms.

The oscillator circuit in Fig. 5 is quite conventional. A two transistor buffer is added to produce a t.t.l. compatible output which operates at 100kHz. When the Rugby transmitter is switched off for maintenance, the crystal oscillator is required to hold the correct time to an accuracy of about 5 parts per million. This can be achieved by a simple oscillator, over a restricted temperature range but, if greater accuracy is required, a temperature-compensated oscillator should be considered.

The receiver, see Fig. 6, uses a ferrite rod aerial, followed by three stages at r.f., the first two being tuned. Automatic gain control is applied over the second and third stages and a simple transistor demodulator is employed followed by d.c. amplification to provide a t.t.l. compatible output. At low signal levels a muting circuit inhibits the demodulator output. The r.f. stages are conventional and require little explanation. The tuned transformers are not critical and the originals were handwound. Transistor Tr_4 is the level detector for the a.g.c. circuit. Signal peaks exceeding the base-emitter threshold voltage will result in Tr_4 discharging the a.g.c. reservoir capacitor C_{16}. This reduces the base bias voltage to Tr_2 which reduces the gain of the second stage. With a.g.c. operating, the signal at the collector of Tr_3 is between 600mV and 800mV peak-to-peak. The a.g.c. voltage is detected by Tr_5 and no-signal or a weak signal will result in an increase in a.g.c. voltage. When this voltage turns Tr_5 on the output of the demodulator is inhibited. To allow for differing transfer characteristics and variations in signal strength, a potentiometer (R_{73}) in the a.g.c. feedback line may be used to vary the level of signal at

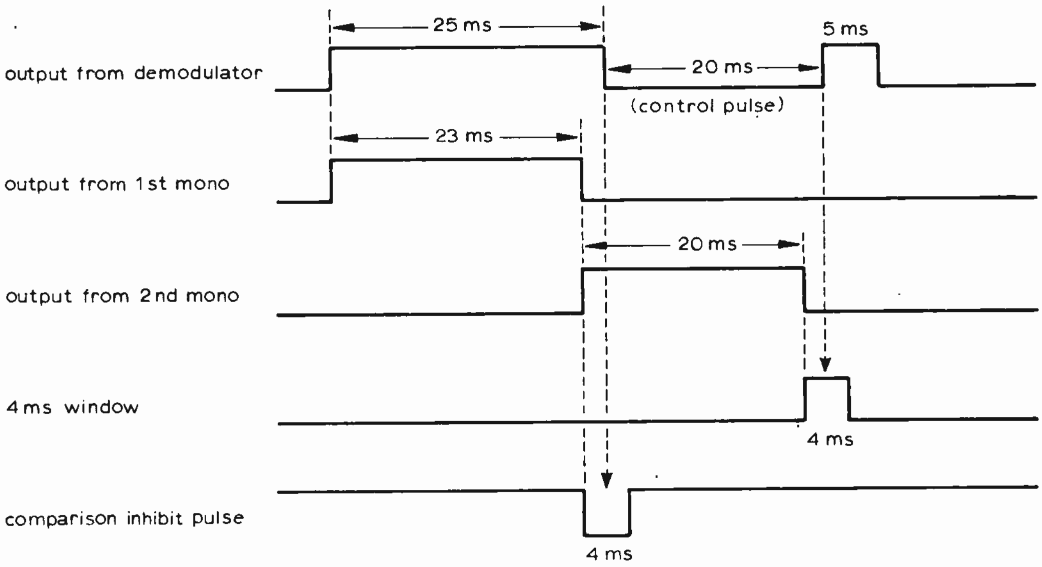


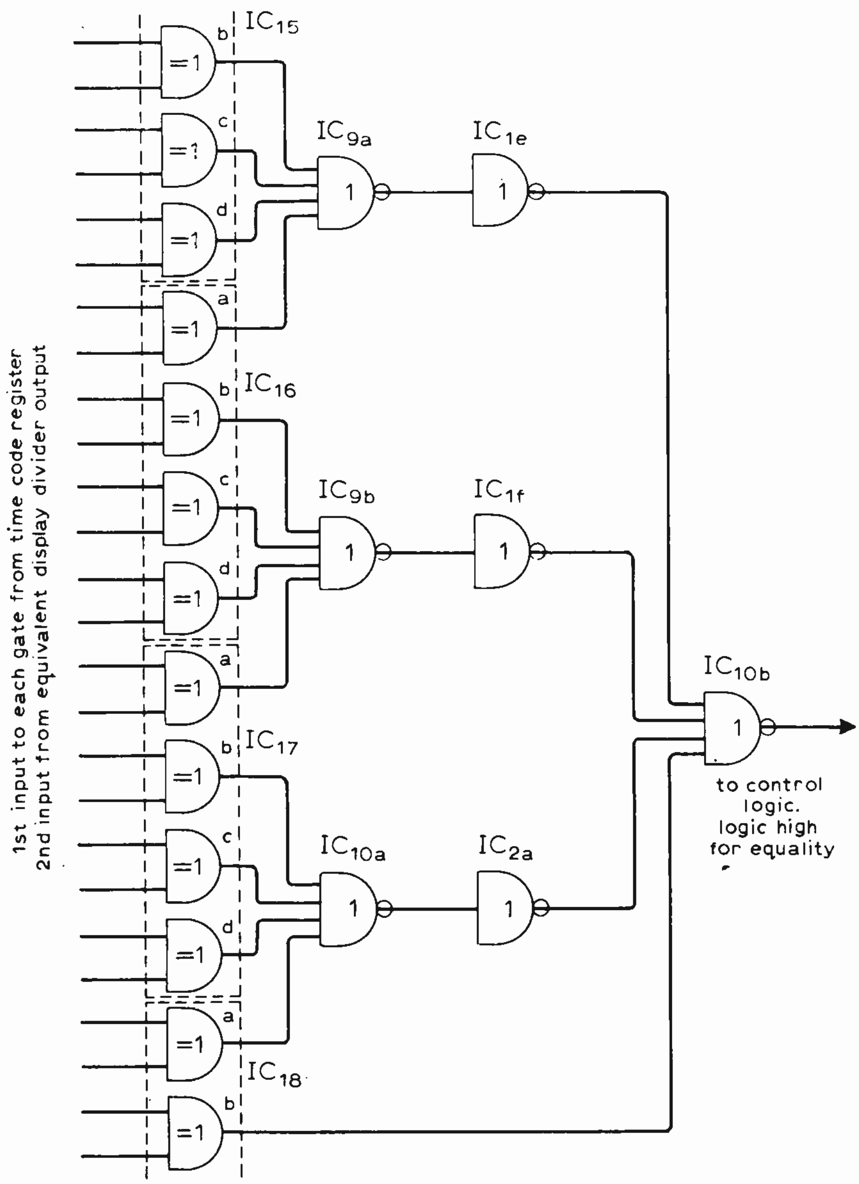
Fig. 8. Timing diagram for control pulse detection.

which the muting circuit operates. In areas of high signal strength, the muting circuit can operate at a higher signal level, thereby improving the interference rejection when the carrier is not present. With a weaker signal, the muting circuit must be set to operate at a lower level. Transistor Tr_6 is the demodulator and, with no signal present, is biased off. With a carrier signal, the positive peaks turn Tr_6 on which discharges C_{17}. The potential on C_{17} is detected by Tr_7 which, with Tr_8, produces a 5V demodulated signal. Resistor R_{20} provides a small measure of positive feedback to assist clean switching. The output from Tr_8 is fed to the time-code-register logic, and also drives a l.e.d. indicator (carrier).

The time-code-register, Fig. 7, takes in the demodulated signal, detects the control pulse and stores the incoming time code. It also checks the parity of the detached signal and generates a data-strobe pulse when the register is full. Transistor Tr_9 produces a 5μs pulse for every carrier-off transition. This pulse is used to trigger monostable IC_{32a} (23ms), whose trailing edge triggers monostable IC_{32b} (20mS). The differentiated trailing edge of the second monostable pulses the transistor Tr_{10} which delivers an output of about 4ms. The output of gate IC_{8a} inhibits retriggering of the monostable chain during its active period, i.e. for 47ms. Gate IC_{8a} also applies a reset level to the cross-coupled NAND-gate bistable IC_{2b}/IC_{3a}, which is removed for the 47ms period. The timing of the internally generated pulses in relation to the demodulator output is shown in Fig. 8. The action of the detector is best explained if monostable IC_{32a} is imagined to have a period of 25ms, and monostable IC_{32b} a period of 18ms; the reason for modifying these periods will be explained later.

The detector attempts to mimic the expected incoming waveform of the control pulse. The Q output of the first monostable, once it has been triggered,

Fig. 9. Comparator circuit which compares 13 inputs from the time-code register with the hours and minute-divider output.



goes high for 25ms, and then low. This is exactly the signal out of the demodulator when a control pulse is received. The two signals are compared and any difference results in the output of exclusive -OR gate IC_{15a} going high, and the cross-coupled NAND-gate bistable becoming set (output of IC_{2d} low). Because it is impossible to mimic exactly the 25ms off-period, a degree of tolerance is allowed by shortening the monostable period to 23ms and producing at the end of the period, a 4ms inhibit pulse (Tr_{11}, Tr_{12}) which prevents the setting of the bistable around the time of the carrier-on transition. The timing allows a total error of up to 2ms either way. The 4ms pulse from Tr_{10} generates a gating window for the period 43ms to 47ms after the initial triggering of the 23ms monostable. Its output is applied to the 3-input NAND gate (IC_{8b}). For a low pulse on the output of the gate, three input conditions must apply; the 4ms window must be open, the bistable must not have been set, and an off-transition pulse must appear on the collector of Tr_9. The low output pulse represents the end of the control pulse.

To summarise; after receipt of an off-transition, a continuous high for 23ms is sought, followed by a continuous low from 27ms to 43ms, again followed by an off-transition between 43ms and 47ms. The signal will be ignored if there is any deviation from these conditions. This detection technique has been found to give extremely good immunity against false triggering due to noise. The low pulse generated on the output of IC_{8b} resets the two 8-bit serial-in shift registers ($IC_{38\ \&\ 39}$). All outputs go low. When pin 13 of the second register goes low it removes the reset-to-nine signal from the clock generator IC_{20} which is a divide-by-10, clocked by a continuous 1kHz signal from the 5-decade divider chain. Upon removal of the reset, it starts to generate a 100Hz signal on its D output, the first positive transition occurring between 8ms and 9ms after the removal of the reset, and thereafter at 10ms intervals. This signal is applied to the clock input of the shift registers, thereby clocking in the time code applied to the input of the first register.

The first data bit in the time code is always a 1; after 16 clock pulses this 1 will have reached the last bistable in the second shift register (pin 13). This output restores the reset to the clock generator which stops the clock pulses. The register now contains the complete time code, including leading marker bit and parity bit. The parity is checked by using a JK flip-flop (IC_{12a}) to count the number of 1's appearing at the first shift register output as the data is clocked through. For every 1 clocked into the register, the J and K inputs become logic 1; when clocked, the JK flip-flop inverts its previous state. For a 0 on the J and K inputs, the output state does not change when the flip-flop is clocked. Thus the final state of the JK flip-flop is determined by whether an even or odd number of 1's have been clocked into the register. The flip-flop starts in the reset state, Q = 0; if received parity is correct the final state is Q = 1. Gate IC_{8c} generates the data-strobe pulse of 2μs about 200ns after the full signal is received from the shift register, and in the presence of correct parity. The data-strobe pulse is passed to the control logic. The data-clock enabling signal is used to drive the code indicator D_5, which will light for about 150ms upon recognition of a control pulse.

Thirteen inputs from the time-code register are compared with the hours and minutes divider outputs — Fig. 9. Thirteen exclusive -OR gates ($IC_{15,\ 16\ \&\ 17}$) each compare one bit, giving a logic 0 output for input identity and a 1 for disparity. The first twelve outputs are OR-ed via inverted NOR gates, and these outputs are again OR-ed, along with the thirteenth bit comparison, by NOR gate IC_{10b}, producing a logic high for no comparison error.

(To be continued)

Sixty Years Ago

The principle of redundancy, or the "belt and braces" approach to the achievement of reliability, is common enough, but for those who imagined it to be a modern, money-no-object attitude, the following piece from our issue of February, 1915, is some indication to the contrary. It rather reminds one of the writers who advocate the use of electronic ignition devices, but recommend the use of a changeover switch for instant reversion to the mechanical system.

"Every means of long-distance communication has been used in this war, and although the carrier pigeons' loft in the South of England, long utilised by the British Admiralty, was dismantled a few years ago on account of the introduction of wireless telegraphy, we know that pigeons are still being used by the British for war purposes. Only quite recently the War Office authorities issued instructions to the effect that it was hoped that British sportsmen who were not able to distinguish between ordinary wood pigeons and carrier pigeons would abstain from pigeon shooting altogether. The reason for this appears to have been that some of our own sportsmen were destroying British flying dispatch bearers. The fact of the matter with regard to all these things is that the latest method may for all ordinary purposes supersede its predecessors; but in times of strain and stress it is wise to have as many strings to one's bow as possible."

Literature Received

Magnifiers for desk use, quality control and inspection, including the illuminated variety, spectacle types and eye magnifiers are described in an illustrated brochure from Combined Optical Industries Ltd, 200 Bath Road, Slough, SL1 4DW WW407

A seven-volume collection of data on Motorola semiconductor devices is now available. Devices from other manufacturers are covered in broad outline. Four of the books, the index and three volumes of discrete devices, are available at £10.50, while those concerned with emitter-coupled logic, complementary m.o.s. and linear i.cs are priced at £6. The complete set costs £15. Motorola Ltd, Semiconductor Division, York House, Empire Way, Wembley, Middlesex HA9 0PR.

Plessey have produced an illustrated brochure on its range of resistors of various kinds, including faders, cermet power resistors, potentiometers and trimmers. R.f. chokes are included. Plessey Resistors, Cheney Manor, Swindon, Wilts SN2 2PZ WW408

A complete catalogue of the prolific Foulsham range of books on hobbies and technical subjects, including electronics, is obtainable from Foulsham-Tab Ltd, Yeovil Road, Slough SL1 4JH WW409

A comprehensive listing of all known professional resistors in Western Europe has been compiled by the European Space Agency as an introductory volume in a series covering all components. The lists will be published annually. The Resistance Reference Book is obtainable free from ESRIN/SDS, Electronic Components Databank, Casella Postale 64, I-00044 Frascati (Roma) WW410

Aerialite have sent us the first two leaflets in their new series, which describe and illustrate u.h.f. aerials and a range of coax. plugs and sockets, diplexers and a masthead amplifier. Aerialite Aerials Ltd, Whitegate, Broadway, Chadderton, Oldham, Lancs OL9 9QG WW411

A shortform catalogue is obtainable from AMI Microsystems, which lists current and future projects in the field of microprocessors, memories, communication modules, watch and clock circuits, calculator chips and displays. AMI Microsystems Ltd, 108A Commercial Road, Swindon, Wilts WW412

We have received a data sheet from ITT, which gives constructional and application details on their transformers and coils. It can be obtained from ITT Components Group Europe, Electrical Products Division, Edinburgh Way, Harlow, Essex WW413

British Standard BS 1597 "Radio interference suppression on marine installations" is now revised. Copies are available at £3.50 from BSI Sales Department, 101 Pentonville Road, London N19ND.

A brochure is available on the ELLM earth line and leakage monitor which prevents the connexion of a piece of equipment to the mains via a circuit breaker if a leakage of over 30mA exists or if a sufficiently good earth is not provided. Commercial and Industrial Electrical Services Ltd, 73-75 Shawhill Road, Birmingham B8 3LJ WW414

Correction

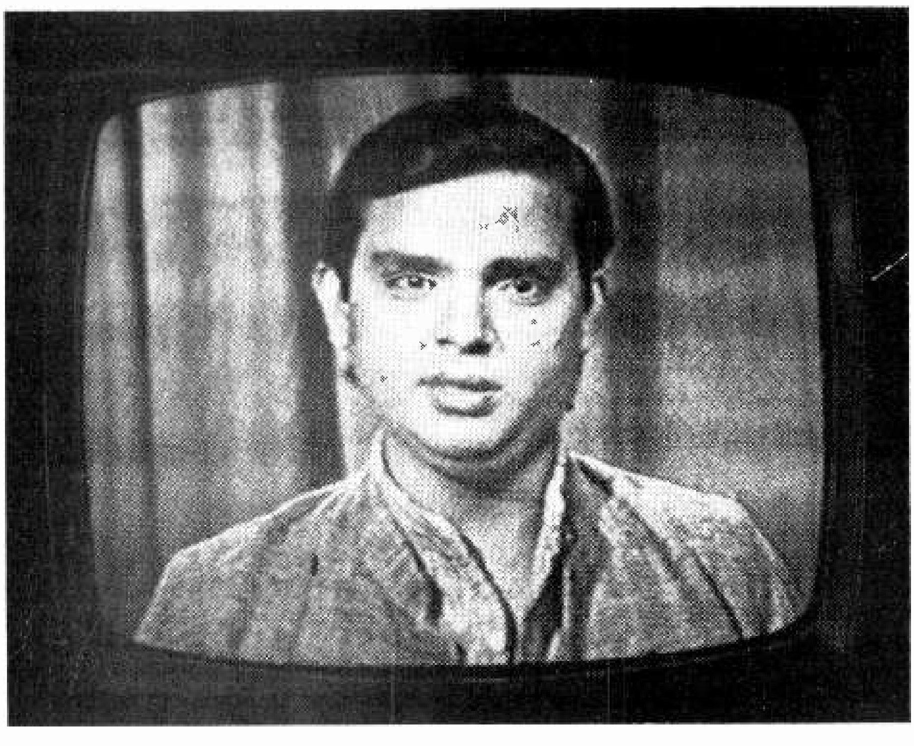
In the November issue we stated that Custom Transformers offered only the mechanical components for transformers. This was wrong — a winding service is provided. We apologize for the error. The catalogue is obtainable from Custom Transformers Ltd, Bristol Road, Malmesbury, Wilts SN16 0DU, and covers units from 5 to 1500VA WW415

News of the Month

Dublin, Sheffield receive Indian TV

Broadcasts from the ATS-6 satellite now transmitting educational television programmes over the sub-continent of India (see "A star for India", p.549 December 1975 issue) have been received successfully by workers at University College, Dublin and by Steve Birkill of Sheffield. Special receivers have been built for the frequency modulated 625-line transmissions. The accompanying photograph was taken from the receiver at Dublin and *Wireless World* will be publishing further details of this installation in the next issue. The Sheffield installation consists of a 5ft aluminium mesh paraboloid (pictures were noisier than those received in Dublin where a 20ft diameter parabolic dish was used) with dipole disc feed and transistor head amplifier, a 5MHz bandpass filter centred on 860MHz, and a standard u.h.f. TV tuner feeding an NE561B integrated phase-lock demodulator at an i.f. of 35MHz. From Britain the geostationary satellite over East Africa appears at about 20° elevation, bearing 135°. Signal strength is reported to be fairly constant with little or no variation from day to day. Polarization appears to be in a vertical plane and constant. It is estimated that from the direction of Sheffield the e.r.p. is approximately 30dB below that of the main lobe.

Received from the ATS-6 satellite broadcasting eductional TV programmes over India, this 625-line picture was photographed in Dublin (see news item).



Audio Fair under new management

A new management team recruited by the Audio Fair's owners, Iliffe Promotions Ltd, will be responsible for the 1976 show, replacing the previous organizers Industrial and Trade Fairs Ltd. The 21st International Audio Festival and Fair will be held at London's Olympia from September 13 to 19, 1976. Improved facilities for trade visitors will include a day and a half reserved for trade only, and the organizers claim that there will be major innovations designed to make the event the best in its history. Backing for the Fair has been confirmed by the IPC Business Press journals *Wireless World, Melody Maker, Electrical & Radio Trading, Black Music* and *Electrical and Electronic Trader*. The new management team includes Cyril Rex-Hassan, Don Quillen and Geoffrey Tomkins, all well known in the running of audio events.

Jersey 'phones computerized

The States of Jersey Telecommunications Board has opened its first computer controlled telephone exchange system at Jersey Central. Initially the equipment will serve 2,500 lines in the island's capital, St. Helier, but to cope with growth in the tourist trade an extension to provide a further 2,500 lines is already in production.

By the use of stored programme control techniques (see July 1974 issue, p.241) the Board will be able to introduce new facilities in the future as and when required, often by quite simple changes in the computer programme and without the need for additional equipment. The system already provides for such facilities as automatic print-out of data for subscribers' accounts and print-out of the calling subscriber's identity on emergency 999 calls. In addition, by dialling a special digit recipients of malicious calls can cause a print-out of the telephone number of the originating caller, and the time and date, to be recorded on a teleprinter located at the exchange. Subscriber controlled call transfer will also be introduced on a limited basis to enable the Board to guage the demand for such a facility. Subscribers who use this service will be able to have their calls automatically re-routed when they are away from their normal line. A second, similar installation designed by Pye TMC in association with Philips Telecommunicatie Industrie BV is to be brought into service early in the New Year at Jersey West Exchange.

Colour television sent by p.c.m.

After pilot field trials in April 1975, the BBC and Post Office have carried out a successful major field trial at Portsmouth of equipment for digitally multiplexing two colour television and twelve high quality sound signals to form a 120Mbit/s p.c.m. signal. This was transmitted over a new Post Office coaxial cable system (see "High capacity p.c.m. system", February 1975, p.92). Each video channel employed sub-Nyquist sampling at a rate equal to twice the colour subcarrier frequency of the PAL signal (i.e. about 8.9MHz). After quantizing with eight bits per sample, the bit rate was reduced to optionally five or six bits per sample, using a form of differential pulse code modulation. The resultant bit-rate was 53.2Mbit/s.

The multiplex 120Mbit/s input signal was generated in experimental equipment built in the BBC Research Department. It was formed by interleaving two similar 60Mbit/s "pack-

'ages", each consisting of a combination of one digital PAL colour video signal with a nominal bit rate of optionally 44.3 or 53.2Mbit/s and one 2048kbit/s signal for sound channels. The four signals in the 120Mbit/s multiplex were not synchronized, i.e. their precise bit-rates were independent of each other and also of the resultant 120Mbit/s bit-rate. Engineers of the Independent Broadcasting Authority's Experimental Development Department have also completed field trials of digitally encoded 120Mbit/s colour TV over the same route. The IBA's terminal equipment samples the TV waveform at three times the colour sub-carrier frequency, a rate just over 13.3MHz.

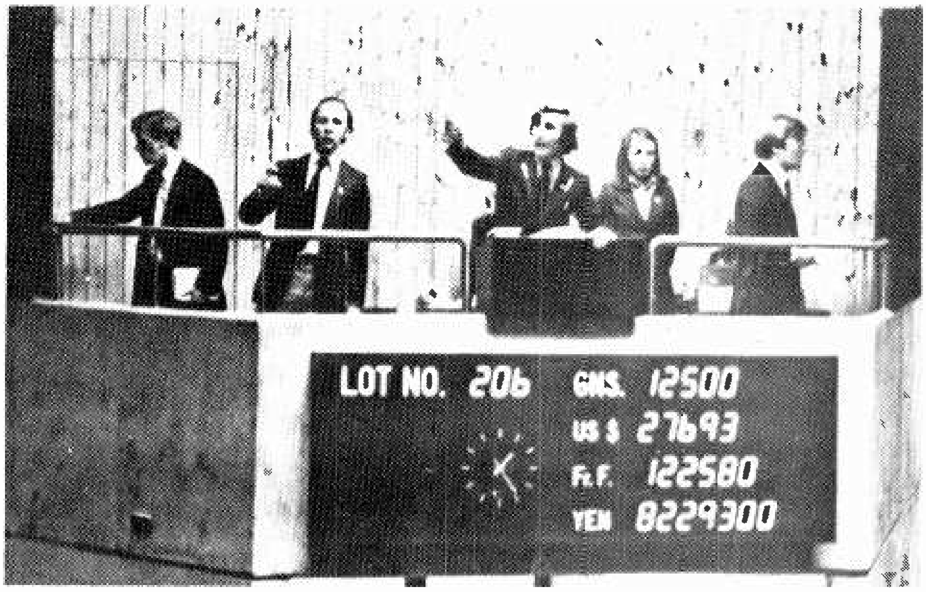
No noise is good noise

An agreement signed recently in Montebello, California between DBX Inc and the Teac Corporation will provide for the inclusion in certain Teac tape recorders of the DBX noise reduction system.

DBX will continue to produce their current range of tape noise reduction products for professional and semi-professional accessory use while Teac will incorporate the system within selected models of their tape recorder range and offer it as an optional extra for other models. The Tascam series 80-8 compact ½in eight track recorder will be the first to incorporate the system. Teac will shortly offer cassette machines equipped with the DBX type II system recently developed specifically for this format. The inclusion within tape recorders of the 2:1 double ended compression/expansion noise reduction system brings a number of claimed operating improvements, signal-to-noise ratio being increased by approximately 30dB and dynamic range headroom being improved by 10-12dB.

Orkneys in colour

The Independent Broadcasting Authority's new high-power u.h.f. television station on Keelylang Hill, Orkney, the first ITV station built in The Orkneys, began transmissions on December 12. It will provide Grampian Television programmes from Aberdeen on channel 43. The station, about four miles west of Kirkwall, will provide 625-line colour and black-and-white pictures for about 15,000 people in most of the group of islands from Papa Westray and North Ronaldsay in the north to Hoy and South Ronaldsay in the south. There will be a few places in The Orkneys screened by local hills where reception is unlikely to be satisfactory. To receive Keelylang Hill, viewers should use Group B aerials with the aerial rods horizontal, carefully positioned and directed towards the transmitter. These aerials should prove equally suitable for the reception of BBC transmissions from this station.



Multicurrency electronic bidding system shown in operation at Goff's new Bloodstock Sales Complex at Kill, near Dublin. The system was designed by CTH Electronics.

Expansion in electronics forecast

The major European electronics markets are expected to expand in 1976 after two years of low growth, although 1973 output levels are unlikely to be repeated before 1977, according to the Mackintosh Electronics Yearbook 1975/76. In its analysis of the west European electronics industry, the yearbook forecasts a 50% growth from 1975 to 1979. General growth rates forecast are: Spain 5-6%; Norway 5.5%; France 4.5%; Belgium 3-4%; Austria and West Germany 4%. At the bottom of the scale are Switzerland and the UK at 1%; Sweden 1.3% and Finland 2%. In the UK a gradual recovery is expected from the 25% fall in the consumer sector during 1975. Telecommunications output has been reduced but the industrial and communications areas could benefit from North Sea oil investment and higher overseas demand in 1976, which in turn should lead to an upturn in the components market.

Microwave c.a.t.v. begins

A cable television network receiving signals by microwave from a Swiss mountain is bringing clear pictures of foreign TV programmes to 35,000 Swiss families for the first time. The Weissenstein c.a.t.v. network, named after the 4,000ft Swiss mountain on which the station is built, is the forerunner of similar systems being developed throughout Europe. In Belgium, a system at Kontrijk will serve a wide area of West Flanders. Special interest is also being shown in Sweden, Denmark, Finland, Austria and the Netherlands, which have the same type of problem as Switzerland.

The microwave system has been introduced into Switzerland by Theta-Com, a subsidiary of the Hughes Aircraft Company. The advantage of using microwaves is that relatively long distances can be covered and natural barriers overcome without laying cables.

BBC equipment designs

New equipment designs by the BBC are being offered for commercial exploitation. Latest developments include a u.h.f. amplifier design for use as a low-power transposer or for transmitter driving (type AM14/550) with intermodulation products at —60dB; an a.m. crystal-controlled monitor receiver, RC3/10, for medium- and long-wave bands incorporating a d.s.b.-synchronous demodulator (i.f. and image rejection < 80dB); an m.f./v.h.f. diplexer; and a directional aerial covering medium- and long-wave bands.

WW noise reducer

As a result of the success of the *Wireless World* Dolby B noise reducer project, our suppliers have successfully applied for a Dolby licence. Components and kits are now available directly from Integrex Ltd (see advertisement) and not from our General Sales Department.

New forms of waveguide

Novel structures for guiding waves offer a three-times improvement over conventional guides, measured on an attenuation x sectional area basis

by H. M. Barlow, Ph.D., D.Sc., Fel.I.E.E.E., F.I.Mech.E., F.I.E.R.E., F.I.E.E., F.R.S. and M. Nouri, Ph.D., *both of University College, London*

For many years electrical engineers have dealt with transmission lines and cables in terms of transverse electromagnetic (t.e.m.) wave propagation. The approach has developed logically and consistently from low-frequency circuit concepts, starting with lumped resistance, inductance and capacitance elements, progressively translated to distributed parameters of the same kind as frequency rises. In the process consideration has been given to the need for components of electric field in the direction of propagation, but we have continued to describe the wave concerned as t.e.m. although in truth it cannot strictly maintain that configuration. The fact is that in practical arrangements using good conductors to carry the longitudinal current at frequencies up to the v.h.f. part of the spectrum, any departure from a pure t.e.m. field has always been minimal and represented, at most, a perturbation easily provided for within the treatment.

Closer examination of the situation, however, identifies a form of surface-wave, sometimes of only slight significance, associated with each surface acting as a field boundary. Thus the familiar t.e.m. wave so-called in a coaxial cable can be depicted, perhaps with some exaggeration of axial electric field, as shown in Fig. 1 (b) and it can conveniently be described as embracing a dual surface-wave of circularly symmetrical variety. Metal surfaces coated with a thin layer of dielectric of higher permittivity than the surrounding medium exhibit enhanced reactance at high frequency and this accentuates the axial component of electric field, leading to a larger content of surface-wave within the total field.

One can also think of a coaxial line in which the outer surface has been removed to an infinite radius, operating in effect as a single-wire transmission line with a circularly symmetrical surface-wave of the Goubau type on the outside, progressively decaying in amplitude with distance from the surface. Fig. 1 (a). When the coaxial metal outer is brought to a finite radius to form a cable, a counterpart field is set up on its inside, satisfying the boundary conditions and forming the dual surface-wave configuration, Fig. 1 (b).

It should be borne in mind that surface-waves propagate freely at any frequency; they are slow-waves not subject to cut-off. This is always a feature of waves that are evanescent in the transverse plane. Cut-off behaviour only arises when waves are reflected backwards and forwards across the guide, as part of the mechanism of forward travel.

Dipole-mode propagation

It happens that in a coaxial line, too small to accept waveguide modes susceptible to frequency cut-off, the usual circularly symmetrical field is not the only one possible. A field of dipole configuration can also exist when the surface impedances are anisotropic, that is to say when they are resistive and inductive to axial current while being resistive and capacitive to circumferential current. This dipole-mode is also a surface-wave and it is best known in its simplest form when propagating along the outside of an isolated dielectric rod, Fig. 2 (a). Such a guide presents to the field concerned an anisotropic surface-impedance of the kind described, but since there is only one surface at finite radius the field extends outside it to infinity, but decaying quite rapidly.

As in the case of the circularly symmetrical wave, a second surface placed coaxially can be made to satisfy the boundary conditions. An anisotro-

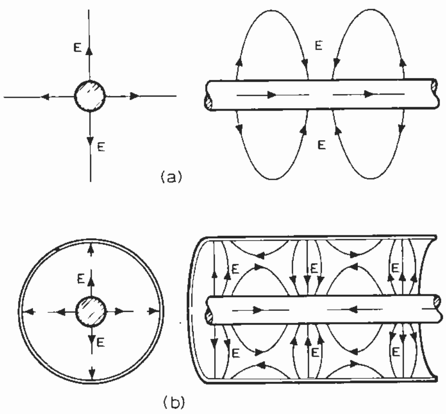
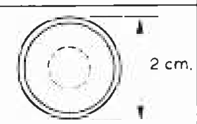
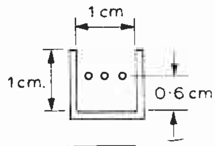
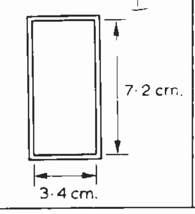


Fig. 1 Circularly symmetrical E_0 waves (a) E_0 surface-wave supported by a single conductor isolated in space. This is a slow-wave. (b) E_0 wave between coaxial metal surfaces. This is also a slow-wave and can be regarded as a form of dual surface-wave.

Comparison between performance of different waveguides operating at 3GHz.

Type of waveguide	Cross-section shown in relative sizes	Electrical features	Relative areas of cross-section	Relative Attenuation	Attenuation multiplied by cross-section
Rectangular half-dipole-mode waveguide		**Wide-band Slow wave**	**1.0**	**1.0**	**1.0**
Rectangular S-band waveguide Dominant H_{01} mode		**Narrow band. Fast wave**	**24.5**	**0.14**	**3.42**
Rigid coaxial line. Circularly symmetrical mode		**Wide-band Slow wave**	**3.2**	**1.0**	**3.2**

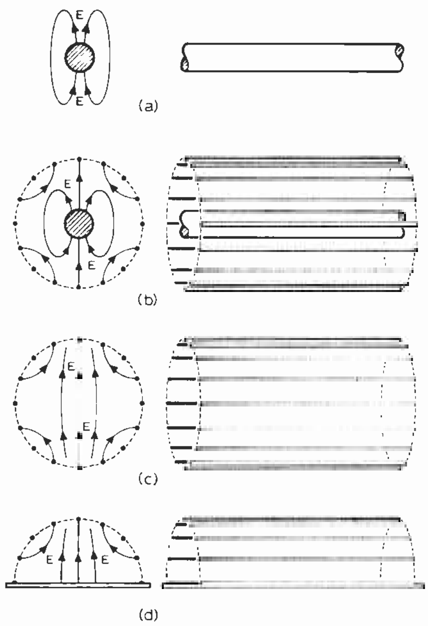
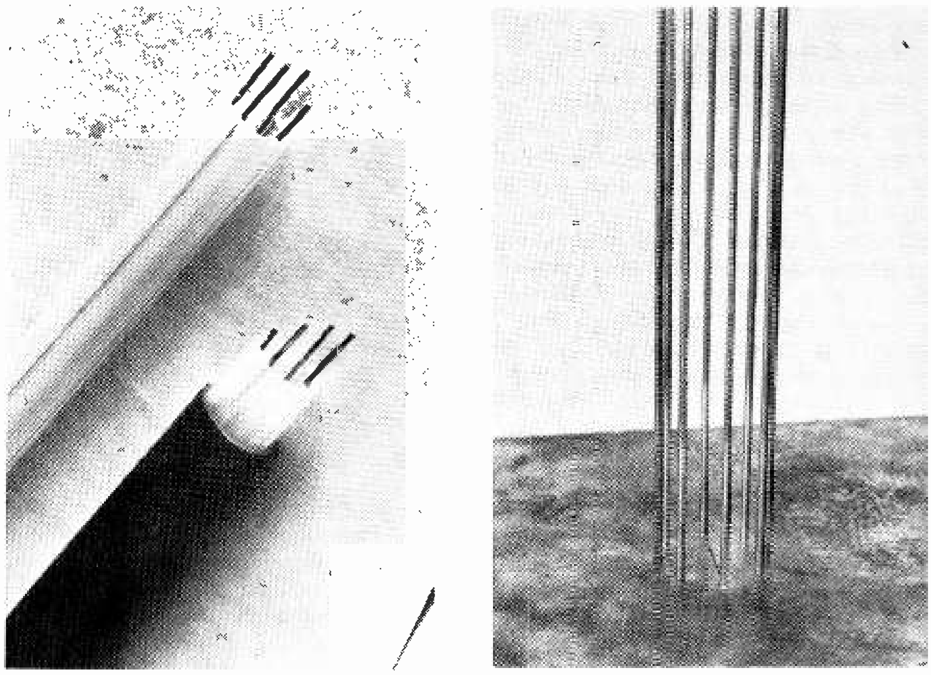
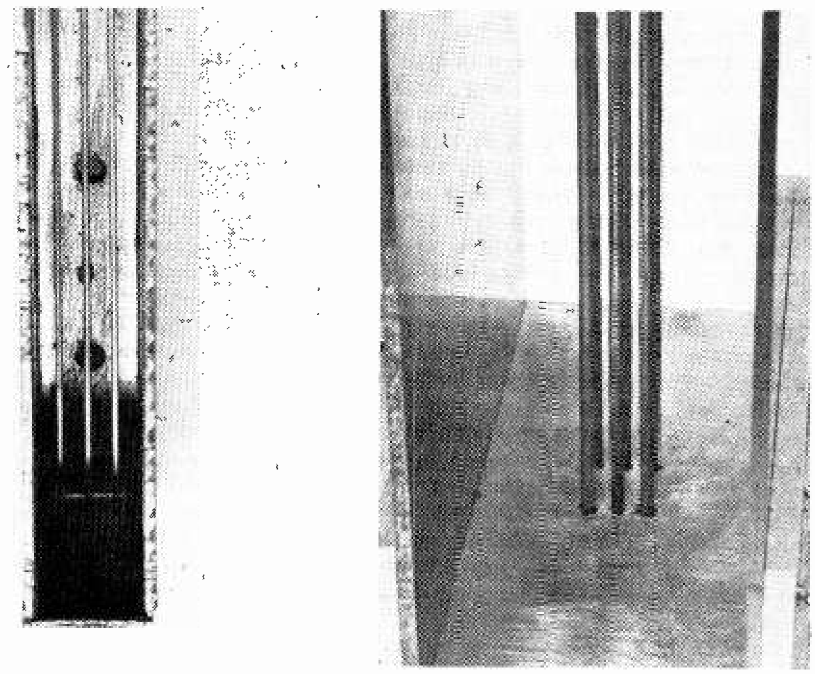


Fig. 2. Cylindrical forms of dipole-mode transmission line (a) Dipole-mode supported by a dielectric rod isolated in space. This is a surface-wave and the dielectric rod exhibits an anisotropic surface impedance. (b) Dual dipole-mode between coaxial surfaces, the inner comprising a dielectric rod and the outer a wire grid of cylindrical form. (c) Dipole-mode within an empty circular-section guide comprising a wire grid. (d) Half dipole-mode in hollow semi-cylindrical guide comprising a wire grid.



Dipole-mode multiwire waveguide of the circular kind (top) and of the rectangular kind (bottom).



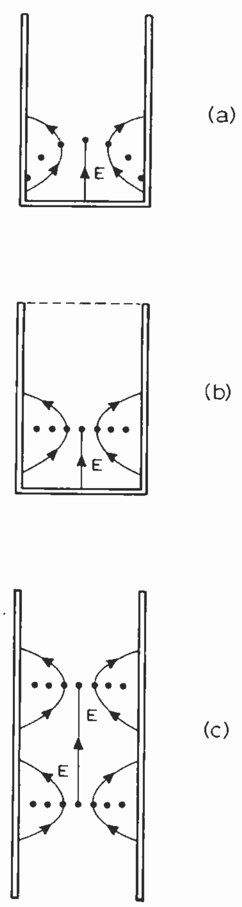


Fig. 3. Half and full-dipole waves in rectangular guide. (a) Half dipole-mode within a rectangular metal channel closed by a semi-circular wire-grid surface. Here parallel metal walls are added to the guide shown in Fig. 2 (d). (b) Half dipole-mode within a rectangular metal channel closed by a plane wire-grid surface. (c) Full dipole-mode in rectangular guide with two plane wire-grid surfaces.

pic surface-impedance, similar to that of the dielectric rod, is required and this can be conveniently provided by a cylindrical grid of wires running parallel along the length, Fig. 2(b). A counter-part dipole field is then established on the inside of the outer surface to form a dual dipole wave.

Having provided for such a wave in this structure, it is apparent that the inner dielectric rod may be removed to leave a hollow cylindrical guide of wire-grid formation supporting a dipole-type field on its inside, Fig. 2 (c). Incidentally, the inner of a coaxial line supporting a circularly symmetrical surface-wave cannot be removed without destroying the whole wave mode.

In the illustrations the field distributions for the dipole-mode are shown pictorially; no attempt is made to include axial components of field which also exist.

The hollow cylindrical structure

supports a dipole field symmetrical about a diameter at right-angles to the direction of polarisation and consequently the image-line technique can be used, comprising the introduction of a metal plate normal to the electric field so as to give a half dipole-mode, Fig. 2 (d).

The evanescence of the field can then be accentuated by placing two parallel metal plates one on each side of the semi-cylindrical surface and perpendicular to the ground plane, Fig. 3 (a). A simple adjustment is to make the wire grid flat and thus provide for the half dipole-mode in a rectangular guide, Fig. 3 (b). The open side of the guide can be closed in most cases by a metal surface, because the field outside the grid is very highly evanescent and has no significant value at the opening.

The corresponding full dipole-mode in rectangular guide requires two grids, as shown in Fig. 3 (c).

Practical applications

A number of different waveguide structures capable of supporting variants of the dipole-mode of propagation have been constructed and measurements are in progress on their attenuation and phase-change characteristics. There are many variables in the design of these waveguides and efforts are being made to optimize performance in a practical structure, hopefully leading to significantly reduced losses and smaller dispersion when compared with conventional transmission lines.

Valuable features of dipole-mode propagation are that the wave is not subject to frequency cut-off and there is a distinct prospect of making better use of the cross-sectional area of the guide by achieving a more uniform energy-density over it. Preliminary results at 3GHz taking as a basis of comparison the product *(attentuation) (sectional area)* are most encouraging and the table shows that dipole-mode rectangular guide is, on this basis, about three times better than both the corresponding conventional rectangular guide and coaxial line.

Apart from the application of dipole-mode lines to a wide range of transmission circuits, there could be development as a leaky-waveguide for communications in tunnels or for coupling to moving vehicles on a railway track.

It is still early days in the development of this novel form of wave transmission but sufficient work has been done to establish firm belief in its future.

It seems that so-called t.e.m. propagation applied at high frequencies without too much regard for the precise nature of the field associated with a given practical structure, has very definite limitations and the time has come to apply more finesse in the approach to some of our problems. By this means new avenues of engineering development are likely to appear on the horizon.

Microcomputer development system

Programme proving and fault finding

The design and development of microprocessor-based equipment usually follows a fairly standard pattern. Once a microprocessor has been chosen, and the proposed system has been planned in some detail, hardware and software development will proceed separately. The programmer will employ what is called a development system, such as the Intellec from Intel or the Exorciser from Motorola, to develop, correct and run his programmes.

Development systems such as these provide the programmer with a good deal of assistance in that they contain "firmware"* designed to speed the operation. For example, they allow the programmer to insert a software "break-point". This means the microprocessor will stop programme execution when the break-point is reached so that the programmer can examine and analyse the state of the various registers within the system at the break-point. This is the equivalent to dividing a complex circuit into smaller units for fault diagnosis by isolating all but the section of interest.

At some stage in the proceedings the user's hardware and software will be combined and comprehensive system tests will be carried out. Fault finding can be difficult, as either the hardware or the software may be responsible for malfunctions.

To alleviate this problem, Intel have introduced a microprocessor development system which they call MDS. This is used in conjunction with a unit called ICE (in-circuit emulator) to provide a flexible microprocessor development and fault finding tool.

In its basic form, MDS comprises a complete 8080 eight-bit microprocessor system with 16kbytes of random-access memory (r.a.m.), 2kbytes of read-only memory (r.o.m.) which holds various programmes for system control and monitoring, 256 bytes of erasable, programmable, read-only memory (e.p.r.o.m.) and interface circuits for a teletype, video display unit, line printer, high-speed tape reader, high-speed tape punch and a universal e.p.r.o.m. programmer.

With an MDS and ICE combination, the hardware and software engineers are able to come together earlier in the development cycle. The c.p.u. chip is unplugged from the user's prototype microprocessor system and the ICE unit, which is connected to the MDS, is plugged in in its place. This configuration allows components and software in the MDS unit to be substituted for components and software in the user's system.

For example, if the system being developed is a machine tool, the user's circuit card is coupled, through its interfaces, to the machine tool and the MDS and ICE units are connected as described above. Initially, the machine tool control programme will be loaded in the MDS and the microprocessor within the MDS will control the machine tool via the interfaces in the user's system. If there is a programme fault, the full facilities of the MDS are available to "de-bug" the programme in real time. Hardware break-points can be set. If, for example, the machine tool performs a faulty operation, a signal from the tool can be picked up and can be used to halt programme execution when the fault occurs. The programmer can then instruct the MDS to print out all the changes which occurred during the 44 steps which were executed just before the fault occurred, so that the sequence of events that led up to the faulty action can be studied.

Stage-by-stage control of the machine tool can be passed from the MDS to the user's system and, section by section, the correct operation of the user's system can be verified.

At the end of this process, the MDS and ICE units will only be performing the task of the c.p.u. chip in the user's system. The ICE unit is then unplugged, the c.p.u. is replaced and the user's system is ready to go into production. At this stage the MDS/ICE combination takes on a different role. It can be taken to the end of the production line and used for final system testing and trouble shooting.

Most of the peripheral units for the MDS mentioned earlier are supplied by Intel. The basic MDS can be expanded by plugging in extra cards to provide extra input/output ports and up to 64kbytes of memory.

*Firmware. A programme that is permanently stored in a read-only memory.

Letters to the Editor

AUDIO AMPLIFIER LOAD SPECIFICATION

Like Mr Stuart, I go along with the principle of Mr Walker's proposal in the December issue but would like to reconsider the load values. Consider a simple case – that of a single-unit loudspeaker. This will have a rated impedance, *R*, stated by the manufacturer and subject to a manufacturing tolerance. Part of this will be due to variations in voice-coil resistance and part due to motional impedance effects which show up as a shallow minimum in the impedance curve, usually at around 400Hz. At low and high frequencies the reactive component will dominate and the impedance will be much higher than the rated value, falling to the d.c. resistance as zero frequency is approached.

The worst-case condition from the point of view in question, that of spurious operation of protection circuits, will be around that minimum of the impedance curve. Here Mr Stuart's $jXR / (R+jX)$ is a somewhat severe but fairly reasonable value.

The famous DIN 45500 gives a lower limit for the magnitude of the impedance of a domestic hi-fi loudspeaker of 0.8 times the rated value (although it is delightfully coy about the phase angle), and this applies to multi-way systems with dividing networks as well as to single units. It seems reasonable that monitor loudspeakers should be able to meet this standard (in the form $1.13\ jXR/(R+jX)$, that is) as well. After all, the BBC designs show very little impedance variation over the whole frequency range.

On examining typical loudspeaker impedance curves there seems to be little justification, however, for *R*/2, still less for Mr Stuart's $jXR/(R+jX)$ for *values of X between 0 and R*, and the demands made on heat sinks and power supply are considerably increased. An amplifier designed to drive the former load will, in fact, be capable of delivering twice its rated output power, which appears ultra-conservative. (For the latter case, no overload protection would seem possible.) Be sure that foreign competitors will not de-rate their products in that way – and it is likely to be economically better to improve the loudspeaker impedance curve anyway.

As to Mr Stuart's final query, the process is already under way. This subject is on the agenda to be discussed by Working Group 10 of IEC SC29B at Gaithersburg, USA, in March 1976. Opinions expressed through the columns of *WW* will be available to the members of WG10 by that time (or before, if they subscribe!). Furthermore, members of the Audio Engineering Society, British Section, will soon be advised of a new venture by which proposals like that of Mr Walker can reach, more quickly, a wide audience of informed opinion and progress to adoption as effective standards quite quickly.

J. M. Woodgate,
Hastings,
Sussex.

Peter Walker raises a very valid point in his reference to the reactive loading of amplifiers (December issue). We have tried to subject our amplifiers to such loads but have found difficulty in defining a "standard load". Our first attempt was to use an R50 crossover network (four section circuit) loaded by resistors. This load did not seem to be difficult enough. We then tried a Spendor BC3, perhaps the most difficult load currently on sale. The Spendor couldn't handle steady tones without (quite naturally) burning out. We were faced with designing an equivalent circuit of the BC3. We have not to date been successful.

To illustrate the problem we compared a P40 amplifier (well respected in its day) with a Classic Two amplifier. The amplifiers were alternatively loaded with an 8 ohm non-inductive load and an R50 loudspeaker. With the gains set for 10 watts into 8 ohms the results were:

	P40 8 ohms	R50
400Hz	0.035%	0.13%
1kHz	0.016%	0.062%
10kHz	0.022%	0.084%
20kHz	0.047%	0.15%
	Classic Two	
400Hz	0.0018%	0.0034%
1kHz	0.0027%	0.0073%
10kHz	0.0051%	0.015%
20kHz	0.018%	0.017%

The figures were measured on a Sound Technology 1700A analyser. The results achieved using the R50 as a load are as expected from its impedance curve. Equally with the Classic Two there was no disturbance on a 10kHz square wave of 12 volt peak-to-peak amplitude. Thus any measurable effects of the loading are probably only apparent at much higher levels, by which time the colourations of the speaker mask any amplifier colourations. Yet my ears tell me differently!

Stan Curtis,
Cambridge Audio,
Huntingdon.

I would like to add my voice to that of Mr Walker (December issue) in saying that a power amplifier must have a reasonable capability to drive reactive loads, if it is to truly called a high-fidelity amplifier.

His criteria seem reasonable to me (i.e. $R = \pm jX$), and indeed coincide with the often quoted load of 2μF // 8 ohms at 10 kHz. All too often one sees an oscillogram published in an amplifier review, of the square wave response of an amplifier at 10kHz, which shows very severe slew rate limitation with an 8ohm/2μF load, but not without the capacitor.

I have recently been doing a good deal of work on class B amplifiers, and the requirement to deal with reactive loads has been well to the fore in my mind. The result of the work so far bears out Mr Walker's assertion that his criteria are no hardship to the designer.

I am frequently surprised at the relatively complex overload protection applied to amplifiers today, and especially that they often make no attempt to look at the mean rather than the instantaneous current. In my present class B design a simple fast-acting fuse is all that is used and this provides quite adequate protection from overload. I would add that the use of just a fuse means the use of transistors with a good safe operating area, and also the use of adequate heat sinks. To me, however, these two requirements are normal good design practice, which should be followed in any case.

Although the use of fast output transistors would seem to give a better output stage on paper, I have been able to get the necessary high performance I sought using 2N3055 (n-p-n) and 2N2955 (p-n-p) devices in the higher power versions of the amplifier, and owing to the use of a simple fuse the amplifier easily meets Mr Walker's requirements.

L. Nelson-Jones,
Bournemouth.

MICROPROCESSORS

Mr Waddington's article on microprocessors in the December issue stated that writing machine code by hand is not recommended for more than about 20 commands. Being an Open University student who used OPUS, a demonstration 8-bit computer with 128 by 8-bit bytes of memory, I feel that this figure is a little low. I was one of a number of students who wrote programmes for this of 70-80 instructions — limited only

by the memory size and the input/output facilities. I feel confident of being able to write and code programmes up to maybe a few hundred commands. However, one needs a machine on which to try out one's programmes and if this includes an assembler this will save a lot of time. Manufacturers' development systems cost from £2000 with necessary peripherals. The computer I am building will cost around £100. However, I am not denying that to write a complex programme involving many thousands of instructions the only reasonable way is to use a high level language like PL/M. This reduces the number of lines of programme that the programmer has to think about by a factor of ten, Intel claim. However, one has to buy time on a large computer to convert from PL/M to machine code and this will probably be beyond the pockets of amateurs like myself.
J. O. Owen, GW8JZB,
Pendine,
Dyfed.

I cannot agree with D. E. O'N. Waddington ("Microprocessors", December issue) that interpreters are only suitable for very large computers. Interpreters are easy to implement, and may save memory space if the interpreter's code can be designed so that it represents the problem more compactly than the host machine's instruction set. They are useful on computers of all sizes.

At Strathclyde we have an interpreter for a high-level language running in about 1k bytes of memory on an Intel 8080 microprocessor, providing immediate portability of programmes from several other ranges of computers. A student is now implementing a similar interpreter for the Motorola M6800 series of computers — hardly very large machines.
Eric C. Sprigg,
Department of Computer Science,
University of Strathclyde,
Glasgow.

Mr Waddington replies:
While I concede that it is quite feasible to write machine code programmes for more than 20 commands (I have done so myself) I do not recommend it as normal practice. The longer the programme, the more likelihood of error and, as Mr Owen says, it is desirable to have some means of trying out programmes before committing them to r.o.m. or p.r.o.m. Computer simulation provides a very powerful method if you can afford it.

Some figures on the cost of using a Time Sharing computer to assemble and simulate programmes, although very approximate, may be of interest.

The initial cost of obtaining a user account number is £5. The average user would spend at the rate of about £14 per hour although the actual cost would, of course, depend on the skill of the programmer. The more skilful will spend at a faster rate but for a shorter time so that it would cost less. If you have no access to a teletypewriter, two courses are open: hire one by the month, only worthwhile if there is a lot of programming to be done, or use one at a computer bureau – Time Sharing charge about £5 a day. However, before embarking on such a course it is as well to realise that mistakes are expensive, particularly when simulating programmes. It is very difficult to estimate how much it will cost to debug a programme. My experience so far suggests that one can easily be out by a factor of two or three times!

With regard to interpreters, obviously Mr Sprigg is better qualified to discuss this subject than I, and I bow to his superior knowledge.

"THE CONSULTANTS"

I must congratulate Mr Dwyer on his review of the activities of consultants (November issue), though Raymond Cooke gave us all a devastating introductory blow. He must have met one of the many people who become acoustical consultants by buying a cheap sound level meter and a text book, having spent their previous twenty years repairing air compressors. There are a lot of these around.

Consultants are a private enterprise and they can only continue in practice as long as they are found to be worth their fees. We are clearly successful in this for we currently have over fifty active commissions ranging from the laboratory measurement of the impact insulation of a sample floor covering, through the design of a loudspeaker system to reproduce the level and spatial characteristics of truck noise, to the acoustic design of a quiet steam power station costing around £300 million. Business has never been so active.

The consultant provides the specialist expertise that is required when people meet a problem well outside their own experience. KEF do not need any advice on how to design loudspeakers but I am sure that if Raymond Cooke needed a spectrographic analysis of a loudspeaker magnet material he would find a consultant with the necessary equipment and specialist expertise in that field. He would never consider the alternative solution, spending £35,000 on the equipment and hiring a man to operate it at a salary of £4,000 a year, and then use the equipment and expertise two or three times a year.

Our clients include one of the big four car manufacturers, several other consulting engineers, some government departments and a large number of very well known architectural practices. They continue to bring their electro-acoustical problems to us, many of them having been with us for fifteen years, so I can safely assume that we are giving good value for the fees we have to charge. KEF experience cannot be typical.
James Moir
James Moir & Associates,
Chipperfield,
Herts.

We found John Dwyer's report on consultants in the November issue to be very fair and objective and were surprised at the response of Mr Faulkner in December Letters.

Unfortunately the rate of progress is such that £10,000 does not buy much equipment. To equip just one of our test benches with: Sound Technology analyzer; Crown IMA analyzer; H-P function generator; H-P a.c. millivoltmeter; H-P oscilloscope; 1% precision loads; and a couple of AVOs sets us back around £4,500. When you start to add up the equipment needed in an R&D lab the figure really starts to climb. And that's just for amplifiers, before we consider f.m. tuners where the real money is.

We have come across consultants who do have their role in evaluating equipment for those (importers?) who do not possess laboratory facilities, but we do not feel they have proved themselves in the field of original product design. We employ a team of development engineers and production engineers in very close contact with our production staff, and despite this we have made mistakes in putting a product into production. Many competent engineers can design a good amplifier, but can they guarantee an outstanding performance on every unit when:
1. Batches of components come from a variety of suppliers with characteristics across the full band of their tolerances.
2. Equipment is made up by different girls with varying degrees of ability.
3. Equipment has to be tested by test engineers lacking the skills and abilities of their R&D counterparts?
When things do go wrong at the production stage it is prohibitively expensive to have a consultant virtually living on site to solve the daily problems.

Consultants do have a role to fulfil as long as they don't get carried away and set themselves up as demigods.
Stan Curtis,
Cambridge Audio,
Huntingdon.

VANISHING COMPONENTS SHOPS

I read with interest Mr Pethers's letter in the November issue. Perhaps it would be fair to show the other side of the counter.

As a small electronic component stockist, I do not wonder that the "big boys" have elected to sell higher value items such as hi-fi rather than components. The time taken to sell one or two resistors at say £0.10 could well result in 10^3 times this small amount for the same staff serving time.

It is not that I decry small value sales: it is just that no-one can exist with the vanished profit on small components. London rents, rates, insurances, and all the other multiplicity of outgoings which come under the generic term "overheads", have escalated enormously. In reference to staff, perhaps Mr Pethers has not experienced the peculiar situation where, although there are N number unemployed, it is very difficult to find reliable people at non-ransom salary levels.

In many sales areas customers pay a minimum order charge. To make the component area viable it is getting to the stage where one cannot afford the trained staff to offer advice to a customer without making a service charge. But would the man in the street accept this? I suspect not. But without some bolstering I fear that London electronic component shops will become even more rare. In the last analysis the customer suffers, because competition provides optimum availability and realistic prices.

Perhaps the tycoons checked returns versus outlay and effort. Perhaps they decided that profits determine the type of goods to be sold. Surely the customer must acknowledge that people work for reward.

The shop assistant quite rightly expects to be paid for his labour. The more successful a business is, the more profit available. This results in more money to pay staff well, to stock in depth, to expand ranges, to explore other areas of activity, and thus to offer a better service to the customer.

Try using the smaller shops which cannot afford High Street positions. Telephone enquiries will elucidate "gen" on components. A cheque in the post will provide by-return-service. If a component is not what is expected, a refund follows the return of the goods. Or, possibly, a visit to the edge of the City might prove helpful.

Ron Barrie,
Barrie Electronics Ltd,
London, EC3.

Having had similar experiences I sympathise and am completely in agreement with your correspondent B. W. B. Pethers (November Letters).

Since the age of twelve, when the BBC was but one year old, I have been buying components for home construction. I, too, shopped in the recognised "component areas" of London for some fifty years, which enabled me to enjoy the creative work in making many receivers and transmitters, but today this is no longer possible. Briefly, two recent experiences: I needed a 500pF twin variable capacitor and tried Lisle Street: "Blimey, you're a bit behind aren't you, we haven't stocked anything like that for more than five years." More recently I needed a few 2.7-ohm 1-watt carbon resistors, but more than a dozen shops in London were unable to supply. I did, however, as your reader mentioned, obtain them from the north — Durham.

Now in all fairness to these shopkeepers — who only seem to be interested in hi-fi, record and cassette players — I do think the fashion has changed and there are not nearly so many of us who like making things. Perhaps radio has become too complex to be as popular as it was originally?

Henry Hatch G2CBB,
South Croydon,
Surrey.

TRANSMITTER POWER AMPLIFIER DESIGN

I read with interest Mr O'Reilly's opening article in his series on Transmitter Power Amplifier Design in the September issue. There is one point in it where I feel the record needs setting straight. In the final paragraph he talks about the various methods of combining low power transistors to form higher power amplifiers, and whilst I do not quarrel with his technical arguments, I do disagree with his assertion that "Little success has been obtained by simply paralleling devices . . ."

I disagree with this statement on three counts. Firstly, Redifon Telecommunications Ltd, one of the leading companies currently manufacturing linear h.f. power amplifiers, make a range of medium to high power amplifiers from 100W to 1kW using the paralleling technique, which have designed-in protection against the failure modes mentioned in Mr O'Reilly's article. These amplifiers have been sold to a wide variety of professional users throughout the world as well as in the UK, and I think that amplifiers using this technique can justly claim a good share of the present market.

Secondly, in the early years of solid state amplifier design, devices available to the designer were of considerably lower power than those of today. Hybrid combining of such devices into power amplifiers would have involved multistage hybrid combiners which would not only have been more expensive but would also increase power losses due to the large number of hybrids and their dummy loads. Power amplifiers were therefore produced using the direct paralleling technique and proved commercially successful. It is this success, I believe, that gave added impetus to the device manufacturers to undertake the costly development of the higher power devices available today.

Thirdly, the chip construction of these high power transistors in most cases uses the overlay or interdigitated technique, which in effect consists of a very large number of lower power transistors connected in parallel, usually with some form of emitter ballasting to overcome the major problem of paralleling, namely gain equalisation.

The technical arguments for and against paralleling and hybrids combining of power transistors will continue, but I think the record shows that there has indeed been some considerable success achieved by using the direct paralleling technique for combining power transistors in h.f. linear power amplifiers.

C. R. Mitchell,
Redifon Telecommunications Ltd,
London, SW18.

Mr O'Reilly replies:
While not wishing to challenge the historic data Mr Mitchell provides, I would point out that my assertion that parallel connection is rarely the optimum method of combining relates to the present time (as was stated in my sentence preceding the one in question).

Early designs of 1kW amplifier contained many dozens of power transistors in the output stage and so the cost of hybrid combining would have been prohibitive. Direct parallel connection was achieved with some safety only by suitably de-rating the "average" device to ensure safe operation of the highest gain ones. There are obvious problems of cost and perhaps spares provisioning. Transistor gain selection can help load sharing in such circuits.

The major difference between many individual low power transistors and a modern r.f. power transistor is that in the latter the individual devices are manufactured simultaneously and have nearly identical characteristics. Thus with minimal internal ballasting very good power sharing is achieved.

Nowadays 1kW can be obtained from just four push-pull modules and the advantages of hybrid combining are obtainable at little expense. In choosing a circuit configuration the designer must weigh the cost of additional protection circuitry and additional output devices, to permit greater average de-rating, against the cost of a combiner. The cost of failure should also be borne in mind.

RAILWAY FAIL-SAFE

I would like to reply to Mr Cockerell's letter in the December issue on the fail-safe timing circuit shown in Mr Anderton's article on railway electronics (August 1975 issue).

The safety of a system employing such a circuit depends on the time delay remaining longer than a given value. If, as Mr Cockerell suggests, the square wave generator were to fail, there would never be an output from the circuit, and while this represents a failure, it is a safe failure.

The physical design of such a circuit employs screening techniques for the timing components, whereby all leakage currents would be to the 0V rail, giving rise to an increase in delay time. Should these screens become disconnected, no output will result.

The purpose of publishing this circuit was to illustrate the basic principle of the fail-safe design, which is the sequential charging of the timing capacitor, wherein the capacitor is used to perform two functions, i.e., timing and transferring the signal to the output stage.

E. Moorey,
M. L. Engineering (Plymouth) Ltd,
Plymouth.

PHASE EFFECTS IN LOUDSPEAKERS

It is easier to destroy than to create and I feel it must be a matter of regret that such a respected organisation as the BBC should have lent its name to the article which appeared in the January 1976 issue of your journal ("Audibility of phase effects in loudspeakers", pp 30-32) expressing, as it did, contempt and indifference for the research efforts of manufacturers who have designed and are producing linear phase loudspeaker systems.

I am managing director and head a research team at B & W Loudspeakers, who in October 1975 released a new three-unit dynamic loudspeaker system — DM6 — which has a transient performance comparable with the best full range electrostatic design and a substantially linear phase response. The design programme, spread over a period of two and a half years, involved enormous personal effort from our five design engineers, has resulted in the development of new measuring techniques, the use of new materials and the production of the first British linear phase loudseaker system.

A complete argument for phase linearity in loudspeaker design is too lengthy a subject to be dealt with by correspondence and is one on which we hope to publish a paper later this year. However, in view of the implication of gimmickry* on the part of manufacturers, I feel some immediate comment is called for.

The article dismisses phase as being quite unimportant, after a simple experiment employing an all-pass phase shift network and the opinion of an unspecified listening panel. It must be presumed that this experiment was carried out on a non linear phase loudspeaker and that the recordings used were made on an analogue tape recorder. If this was the case a little thought would have led the writer to realise that for the experiment to be even partially meaningful it would have been necessary to employ a linear phase loudspeaker system with digitally recorded material.

To those of us who have spent the major part of their working life on loudspeaker design it became apparent from the early days that the exact physical relationship between the drive units forming a multiway loudspeaker system was of importance. Indeed, if identical components are used both the spherical polar configuration and the sound impression will be changed by different placement of identical units on the baffle configuration. Linear amplitude measurements may be obtained by positioning the microphone to suit the configuration, but the phase characteristic of the system is changed and, being the only variable in the experiment, must account for the differing listening experience.

Both my company and one other British loudspeaker manufacturer have invested considerable sums of money in exploring loudspeaker transient behaviour. Not, as the article appears to suggest, as a gimmick but to advance the frontiers of knowledge and produce a better product. When one is involved in transient evaluation, phase linearisation, quite apart from its inherent advantages, is a basic step forward in good engineering practice, as it will be obvious to your readers that the transfer function of any network may be completely defined by reference to both its amplitude and phase characteristic.

Whilst the mechanism of hearing is a little understood subject it is relatively easy to prove that direct, as opposed to reflected, signals considerably influence the listening experience — hence, apart from other considerations, the importance of maintaining a linear free-field amplitude characteristic. I believe this is a theory to which Mr Harwood subscribes. It is therefore both logical and reasonable to suggest that unless we are to regard music as a steady state phenomenon the leading edge of a transient waveform would be clearly audible as a first arrival signal, the structure of which is determined both by the amplitude and the phase characteristic of the network — in this case the loudspeaker. In any event the subject is well documented and among others Hansen and Madsen, in a paper "Threshold of phase detection by hearing", presented proof that phase changes as small as 10° could be heard and that higher order changes were clearly detectable in normal semi-reverberant listening environments.

May I conclude by briefly commenting on two aspects of the article? First, gimmickry. Over the last two and a half years the research programme necessary to produce the B&W DM6 linear phase loudspeaker has cost, including capital investment in the necessary measuring equipment, some £75,000. Had we been looking for a gimmick I can assure you that there are plenty to be had at a much lower cost. Lastly, the thought that the BBC Research Department as represented by Mr Harwood will "remain agog with indifference" to the efforts of manufacturers will not, I feel, dismay them unduly. Speaking personally, my own company, which incidentally received the Queen's Award to Industry in 1973 for export achievement, is currently exporting some 80% of its entire output and selling these products in direct competition with all contenders throughout the world. During this current financial year our exports will approach £1M, and I venture to suggest that this success is of more significance than the apparent satisfaction which Mr Harwood derives from his "captive audience" not complaining.

John Bowers,
B&W Loudspeakers,
Worthing, Sussex

* *Editor's note:* The subtitle "Are 'linear phase' loudspeakers a gimmick?" was an editorial addition.

ELECTRODYNAMICALLY INDUCED E.M.F.

As you have not yet declared this correspondence closed, may I comment on John Gray's further contribution to it in the December 1975 issue? It seems to me a good thing that Faraday, when he performed his classical experiments — in 1831 wasn't it? — was unaware that "relative motion between a conductor and the system within which the conductor e.m.f. is to be detected was a basic requirement for electrodynamic induction of e.m.f. in the conductor" or he might not have tried what he did. Nor could present-day power-station generators be expected to work.

As "electrodynamic" is not defined in the relevant British Standard, 4727, I'm not sure exactly what it means, but presumably it must be relevant to the matter under discussion. Which is more than can be said of Einstein's axiom, cited by Mr Gray. That refers to the impossibility of measuring absolute velocity in a closed system (or at all); but what we have been discussing all this time is the measurement of *relative* velocity with reference to a field in *another* system. It is true that a passenger in a soundproofed lift moving at constant velocity relative to the earth would be unable to tell whether he was moving, up, down, or neither — unless, for example, he had apparatus for comparing the air pressure on a small area of the floor with that on a similar area of the ceiling, thereby establishing an observational link with the system "earth".

Incidentally, on the assumptions made by C. S. Evans in the October issue, I think the e.m.f. should be 200 times smaller than his 26V.

"Cathode Ray."

Electronic systems — 2

Background to a communications course

by P. R. Darrington

Communication between people, between machines and between machines and people is at the core of our society. Without communication, life would not be possible; indeed, without the communicating link of the DNA molecule, there would be no life.

In the somewhat more confined area of an electronic systems course, our concern is more specific and the two main subjects of interest are audio and visual communication. Both have arisen because the needs of people far outstrip their capabilities. People need to communicate with each other at a distance, or by "delayed action": information must sometimes be recorded for later use or the communicator requires that his message be modified in some way, perhaps to make it more entertaining.

The language that this kind of discussion is conducted in sometimes obscures the fact that these requirements can give rise to familiar objects. A "recorded, delayed visual communication" is better known as a photograph and "an electromagnetically-transmitted, melodic/visual stimulus" is not easily recognized as Top of the Pops. Such descriptions could be called breakdowns in communication and are fatuous, but can often be seen in print. We will try to avoid them.

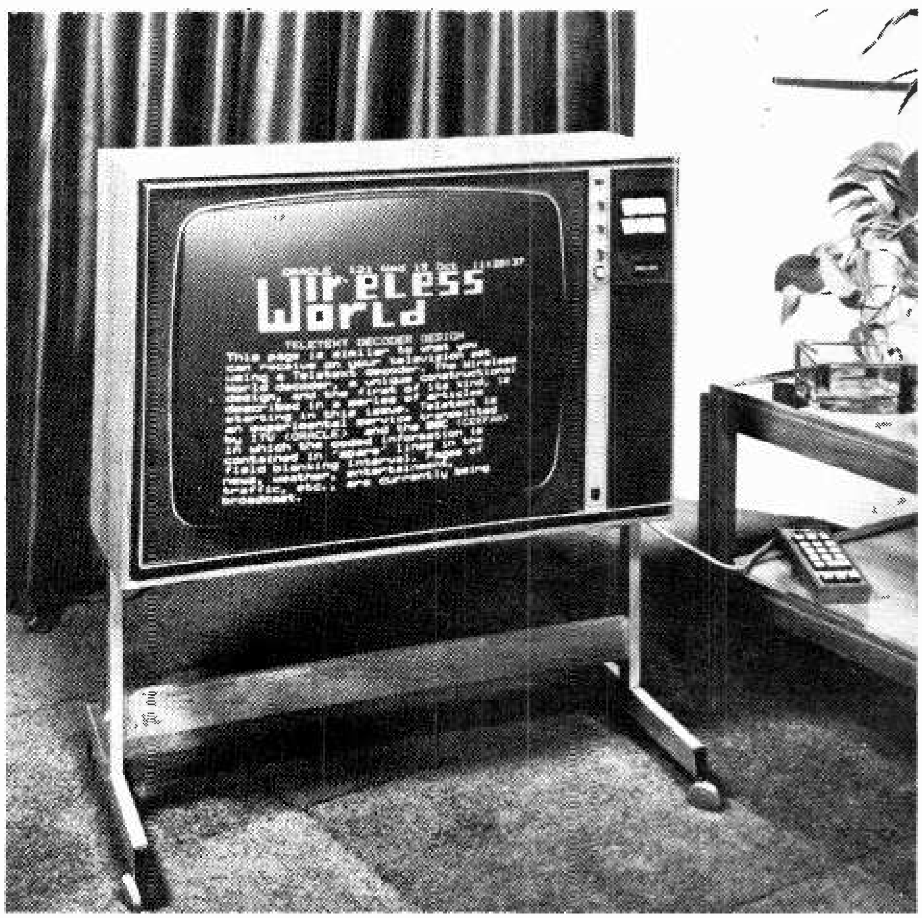
Communication between people is at the centre of the subject and can be effected by the use of newspapers, town criers, posters, films, radio, records, tape and television. Our concern is with the last four, as the intention is to use electronics to illustrate systems in action in society, electronics being a prolific user of systems of all kinds.

Aural communication

The easiest way to communicate aurally is to open one's mouth and bellow. However deep-chested the bellower, this method has a limited range and electronics, in the form of radio, is employed to enable the message to travel almost any distance from a few yards to millions of miles. The original sound is carried by the wave-motion of the air — a short-range mechanism. By impressing the low-frequency sound waves via a mechanical-to-electrical transducer onto a high-frequency radio wave, which does not suffer the rapid attenuation of an airborne wave, the message travels further. At the receiving end of the communication channel, the low-frequency sound is recovered and made audible by another transducer, this time electrical-to-mechanical — the loudspeaker or headphone.

Notice that the radio wave itself was not the message. Each cycle of the original radio wave is identical to any other and, as the probability of one being like the last is maximum and the recipient is aware of this, no information is carried. To reduce this probability, the sound wave changes, or modulates, the cycles of the radio wave. The message is then in the differences between cycles. This matter of modulation is crucial.

A Philips television receiver, adapted to receive and display Teletext information. The system is capable of displaying several hundred "pages" of news and data. Photograph taken by the Independent Broadcasting Authority at their research centre.



As in any aspect of communication, control or measurement, the transducers mentioned above are also crucial. They are the boundary between the familiar acts of talking, listening or seeing and the world of electronic activity which cannot be tested by any of our senses. If they are inefficient, as loudspeakers are, we spend too much on driving them and if they distort we lose some of the message.

Stored aural communication (oh, really!) is the domain of the disc or the tape, although one does sometimes wonder if a recording of, say, Vera Lynn singing a World War II song is really communication. If one has heard the record played a hundred times, the probability that, on the 101st playing, it will be different is fairly low. Where, then, is the message? Storage, however, is the aim of the high-fidelity class of equipment. Discs and tape have their pro's and con's, concerned with ease of handling, vulnerability to damage and wear, and physical size. There is also the matter of access time — not, perhaps, as important domestically as in a computer service bureau, but a factor to note, nevertheless. When one is at the wrong end of a C-120 cassette, discs can take on a new appeal.

The problem of noise (defined here as unwanted sound) is a thorny one, particularly with tape. Recording materials, both for discs and tape, are responsible for background noise which is reproduced as though it were part of the original sound. It constitutes an error which, in most cases, is not serious but merely irritating. When information is transmitted digitally, each small piece of information frequently being denoted by the presence or absence of a signal, a noise signal can fake the presence of a legitimate signal and cause a lot of trouble. All information-carrying chennels suffer from noise to a greater or lesser degree, but in the domestic, music-playing environment, the tape-recording process is more vulnerable than disc. Hence the appearance of the name of the inventor of a noise-reducing process on many cassettes and cassette recorders — Dolby.

Distortion in the waveshape of a signal is, again, always present, and can be considered a form of noise, because it often consists of added harmonics — unwanted sound. In a telephone system, distortion is not considered very important (unless one is in the habit of dialling a disc) but in a high-quality audio system, a very small amount indeed is unacceptable. Some of this is no doubt due to the peculiar genius of advertising copy-writers (one can listen to a heavily-distorting car radio without suffering) but it seems to be a fact that amounts of distortion which are imperceptible visually on an oscilloscope are easily discerned when listened to.

For many years, the audio amplifier has been subjected to intense examination by circuit designers, with the intention of reducing the amount of distortion contributed by this link in the chain. It is now down to around 0.005% in the top-class units. And yet the other elements in the audio system can contribute much larger amounts — a tape deck up to 2%; a loudspeaker about the same. It is as though a rare wine in a golden goblet were decanted through an old sock and drunk through a mouthful of black pudding.

The virtually distortionless and noiseless reproduction of music from one loudspeaker is not, of course, considered good enough now. In the last two or three decades, stereophonic reproduction has been adopted as standard and surround-sound is almost upon us (assuming that the manufacturers ever decide which kind to make). Hearing mechanisms and the psychology of hearing are relevant subjects for study in this business of multichannel sound. Surround-sound reproduction is not always intended to give the listener the impression of being in a concert hall, listening to music from the platform. If the music is recorded in a studio and is mainly synthetic, the listener is quite likely to be among the players. The surround-sound effect is being used not to convey the literal truth, but the truth in a modified form.

Visual communication

Electronics come into their own here for remote viewing and storage. Perhaps the most spectacular televisual communication is that between a space capsule and Houston, Texas — communication in a very real sense. In its more mundane sphere, the science is perhaps not quite so communicative; the predictability of a weekly American detective film reduces the information content to a low level.

In industrial applications, a television channel will become part of a feedback loop. It can be used to observe the effect of a control and to display it to the controller, who is thereby protected from a possibly hazardous working area.

The amount of information required to reproduce an acceptable picture is large (between 300000 and 800000 elements). This immediately rules out any idea of transmitting a picture by means of a "one-to-one" photocell/lamp connexion for each element. Such a channel in cable form would be grotesquely expensive in copper and very bulky. This "parallel" method of transmission is therefore abandoned and a "sequential" approach adopted, wherein one channel is modulated with the brightness of each element in turn, by scanning the scene. At the receiver, a similar scan is "in step" with that at the transmitter. The scanning of a picture is used in television at high speeds for real-time viewing or at much lower speeds for facsimile and amateur use (slow-scan television – s.s.t.v.).

Recently, the exploitation of transmitted television signals has been increased by the Teletext experiment, which may become a permanent service. The previously unused sections of a television wave, blanked lines between scans, are now used to carry coded information. The code can be used by a domestic receiver to instruct a local "character generator" to display letters, numbers and graphic characters, forming a page of information on entertainment, news, weather forecasts, news flashes, financial reports and the like.

In the next article, the use of modulation techniques for signal transmission will be discussed.

Announcements

The third residential vacation school on the subject **"RF Electrical Measurements"** is being organized by the Institution of Electrical Engineers (IEE) and will take place at the University of Lancaster 11-23 July 1976. The school will be of interest to those working in calibration and standards laboratories as well as to research workers who require familiarity with modern measurement methods. The subject will be dealt with at a level appropriate to recent graduates or senior technicians. Further information can be obtained from the IEE, Savoy Place, London WC2P 0BL.

"Electronics for electrical equipment" and **"How computers work"** are two part-time courses to be held at South London College, Main Building, Knights Hill, London SE27 0TX. The first is an eight-week course held each Tuesday evening from January 26 and the latter is a nine-week course held each Thursday evening from January 29. Further details can be obtained from the Senior Administrative Officer.

Regent Acoustics, Carrington House, 130 Regent Street, London W1R 6BR, has announced that it is now appointed as sole UK distributor for the American **direct cut** Sheffield **records.** These records are recorded from the studio directly to the master disc.

Quarndon Electronics, Slack Lane, Derby, best known for their stock holding and distribution of semiconductors from leading manufacturers, have announced the opening of a **microprocessor laboratory** at their premises in Derby.

Nitron has appointed **Peter Gray Electronics Ltd,** 21-23 Station Road, Henley on Thames, Oxfordshire as their sole agent to cover customers in the UK and Ireland. Nitron, a division of the McDonnell Douglas Aircraft Corporation, manufacture a range of p- and n-channel m.o.s. microcircuits, including non-volatile memories, calculator chips, data communication circuits and static r.o.ms.

Marshall's, 42 Cricklewood Broadway, London NW2 3ET, have announced their appointment as a specialist distributor for Mullard Ltd. This distributorship covers the full range of semiconductors, passive components and valves, specifically with reference to the radio, TV and hi-fi areas.

"Linear phase" loudspeakers

It has been brought to our attention that certain phrases in the article "Audibility of phase effects in loudspeakers" by H. D. Harwood in the January 1976 issue may be taken as criticisms of the quality of loudspeakers with "linear phase" characteristics now on the market. We would like to assure readers that in publishing this article we intended no such criticism. The high quality of sound reproduction of these products is not in question. The issue, as we see it, is the extent to which a "linear phase" characteristic contributes to this high quality, and Mr Harwood's article is presented as one viewpoint in the debate on this subject. We shall be glad to consider for publication any responsible articles or letters giving contrary results and conclusions to those of Mr Harwood.

Wireless World Teletext decoder

4 — Framing code detector, error circuits and storage

by J. F. Daniels

Discussion of the serial-to-parallel convertor, framing code detector, data latches, Hamming corrector, data store and code converter completes the description of the circuitry contained on digital board one.

Fig. 1 shows the serial-to-parallel converter, data latches and framing-code detector. IC_{21} is an 8-bit, serial-in, parallel-out shift register, which presents all eight bits of data in one "byte" to the inputs of the data latches at the same time. A strobe pulse is applied to the data latches, which causes the eight bits of data to be stored in the latches until the next strobe pulse arrives, eight clock periods later. A 7428 buffer i.c. is used for driving the strobe inputs of the latches, as the fan-in requirement of 16 could not be met by the more common 7402, two-input NOR gate. The timing of the strobe pulse is quite critical and it must, of course, occur only when the eight bits of data in each byte are correctly positioned in the 74164 shift register. The detection of the framing-code pulse initially sets the timing of the latch strobe pulses, and subsequently they are derived from a ÷8 output of the clock divider circuit (IC_{42}, pin 1).

Framing code detection

The framing-code detection circuit consists of only four inverter gates and a single 8-input NAND gate (23, 8). The output of this gate goes to "0" only when the eight outputs of the shift register are in a condition that causes all "1"s to be present at the gate input. It is possible, with the use of more complex circuitry, to detect the framing code in the presence of a single error, as was explained in the introductory article. However, this added complication will also increase the number of false framing code detections, and this can in some circumstances be more troublesome than the occasional missed framing code. This simple detector was found to be perfectly adequate.

Error detection and correction

Before continuing with a description of the parity and Hamming-code correc-

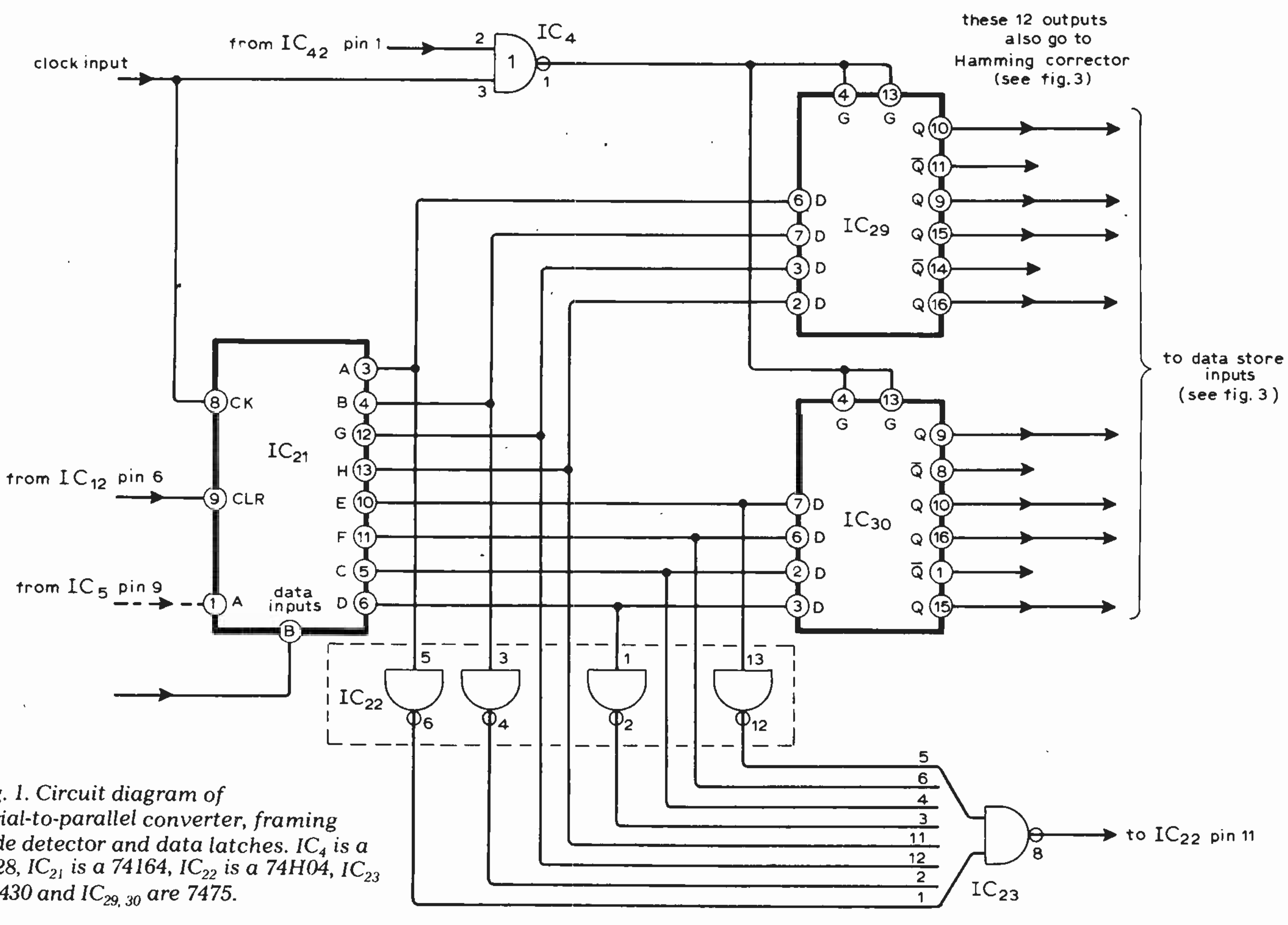


Fig. 1. Circuit diagram of serial-to-parallel converter, framing code detector and data latches. IC_4 is a 7428, IC_{21} is a 74164, IC_{22} is a 74H04, IC_{23} a 7430 and $IC_{29, 30}$ are 7475.

D	C	B	A	
0	0	0	0	error free reception
0	0	0	1	reject even order error
0	0	1	0	
0	0	1	1	
0	1	0	0	
0	1	0	1	
0	1	1	0	
0	1	1	1	
1	0	0	0	invert bit 7
1	0	0	1	" " 1
1	0	1	0	" " 3
1	0	1	1	" " 8
1	1	0	0	" " 5
1	1	0	1	" " 6
1	1	1	0	" " 4
1	1	1	1	" " 2

A,B,C & D are parity checks over the following bit no's

A checks on bits 1 2 6 8
B " " " 2 3 4 8
C " " " 2 4 5 6
D " " " 1 2 3 4 5 6 7 8

0 = parity check correct
1 = " " incorrect

Fig. 2. Table showing the results of four possible parity checks carried out over the Hamming coded groups, and the action required for each combination of results.

Fig. 3. Circuit diagram of the Hamming corrector. IC_7 is a 7404, $IC_{8,16}$ are 7410, $IC_{24,31,32}$ are 7486 and IC_{40} is a 74180.

tion circuits, it would be as well to explain in more detail some of the effects that can be caused by noise and distortion in the received signal, and what can be done about correcting them.

Below I have listed five different types of possible error in the data display, and I have put them in what I would consider to be in order of decreasing annoyance value:

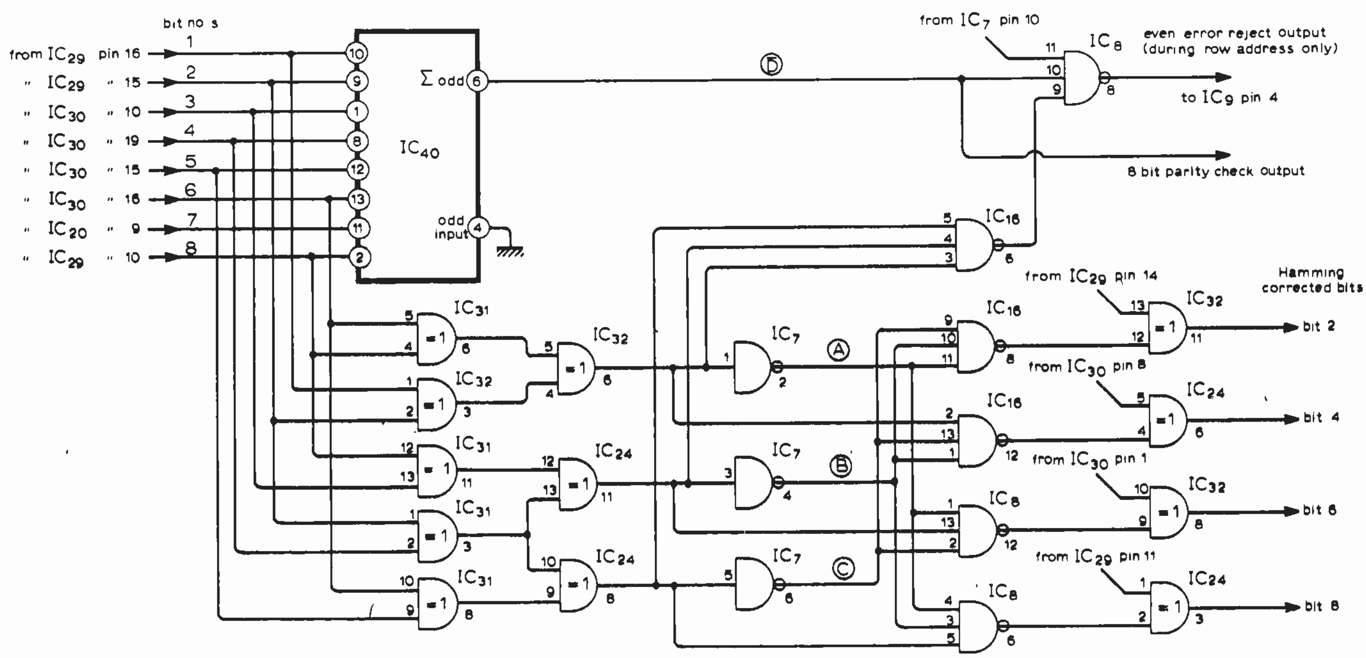
a) a row of complete "rubbish", i.e. random characters across a complete display row;
b) a row which begins correctly with intelligible data but which becomes rubbish somewhere across the row;
c) a row which is correct in terms of the data it contains but which takes up the position of another row in the display; this may leave a blank row where it should have been situated;
d) a row which should contain information, but which is displayed blank;
e) words which have individual letters incorrect, or missing – other than those caused by typing errors!

Apart from the Hamming correction circuits, which can be considered an instantaneous form of correction, another type of correction can be used which relies on the fact that the pages of information are transmitted cyclically, repeating every 15 seconds or so. If information is written into the data store every time the selected page is received – and not just the first time it arrives after being selected – then some errors such as missed rows, missed letters, etc., can be corrected. Bearing this in mind, we can now consider the types of error mentioned earlier, their causes, and whether they can be corrected by subsequent detections of the correct page.

Rows of complete rubbish are almost always caused by the detection of false framing codes. These arise in several ways. On normal data rows, for instance, a framing code detection will result whenever the sequence of data bits is 11100100. This will occur more often than might be expected since this sequence may occur across "byte barriers" e.g. the letters p , r will be represented by the data bits 00001110 01001111. It can be seen from this that the last four bits of the first group and the first four of the second group combine to form a framing code sequence.

This simple example shows how frequently these framing code detections might occur. The false detection, does not, however, cause any serious problems, as there are two fairly simple ways of overcoming it, both of which are used in this design. Firstly, the output of the framing code detector is gated with a pulse, derived from monostable 17, which only allows through framing codes that occur at the expected position on the television line. This gating pulse is sufficiently wide to allow for expected differences between TV channels, but not so wide as to allow through framing codes caused by byte barriers. Any framing codes which may occur before the correct one are also eliminated in this manner. (It is possible that framing codes may be detected in the colour burst with some types of data separator circuit.) Secondly, the reset waveform to the clock dividers consists not simply of framing code detections, but of the Data Allow latch waveform, which is derived as explained last month. This allows only the first framing code detected on any data line to set the initial timing of the latch enable pulses and ignores subsequent framing code detections on that line.

False framing codes which may be more of a problem, are those that can be detected on lines other than 17, 330 and 18, 331. It has already been pointed out that data is only "looked for" during lines 11, 21, 324, 334, and in this way



Thanks to Brandenburg's superb products...

we're taking a couple to the Montreal Olympics.

You've heard, perhaps, that nowadays Brandenburg are taking an Olympian view?

We're doing so for two important reasons. Our products. And to support the Olympiad ideal.

First, our products. (Then we'll tell you how to get – all expenses paid – to Montreal).

The Olympic Games began by Mount Olympus – the home of the Gods, and the highest place known to the ancient Greeks. Which is why the word 'Olympian' means superior, magnificent and all manner of other fine things.

Which appeals to us at Brandenburg no end.

For over 21 years the Brandenburg name has been associated with HV power supply technology, and we are now established as Europe's leading manufacturer in this field.

We have an unequalled line-up of products, from our high technology Ensign range to HV modules and meters. All designed to satisfy the most demanding applications. We've just recently released our resin encapsulated 200 Series modules, and there's our second generation Alpha II units reflecting the very latest in high voltage state-of-the-art.

In parallel to our increasing range of power supplies, we've a unique selection of NIM modules and MCAs for nucleonic research from our Nuclear Engineering Division.

These are just some of our winners. In the months and years to come, there'll be more. For Brandenburg, in the truest Olympian tradition, is always reaching to better even today's finest achievements in HV and nucleonic engineering.

From these Olympian heights, we turn to others.

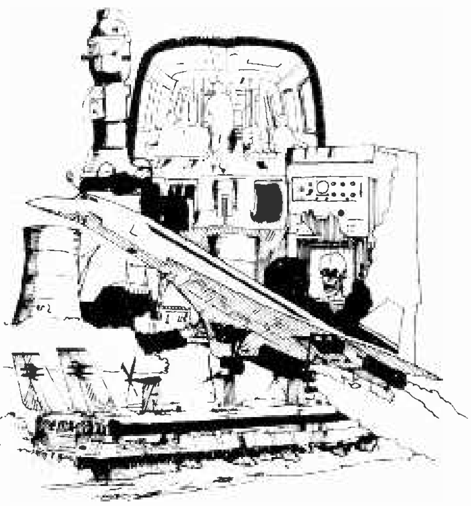
Two competitors will be Brandenburg's guests at a finals day – July 30th – at the 1976 Olympics. But to get there they'll have to work on it. We think the competition we've devised is fun, but it needs thought on your part – which is just as it should be.

So do look overleaf at the details.

Why are Brandenburg so keen on the Olympics? Well, we're British through and through – and we don't think Britain does enough at or for this extraordinarily prestigious event. In our own small way we're going to get our industry just a little more involved.

This is how you can win your tickets, your travel and your expenses to the Montreal Olympics next July. You'll try won't you?

1 Seven modern wonders of Brandenburg's world



First, we want you to list in order of importance these seven major British technological achievements. They are:

Concorde
The Hovercraft
The scanning electron microscope
The brain and body scanner
Linear induction motors
Fast breeder reactors
Man-made fibres

Using, as they say, your skill and judgement – and, we hope, having discussed the list with your friends and colleagues – put them in order of technological importance. It's as easy as that – or as hard. But at least mathematically, you stand a two in five thousand and forty chance of a first prize.

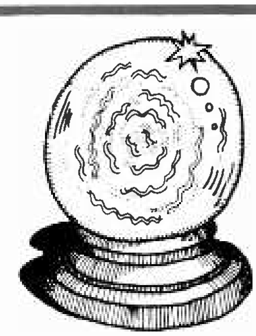
Our judges will themselves work out what they believe to be the answer. And whoever agrees with their selection is in with a splendid chance.

Our judges are:
Mr. Kim Bachmann of New Electronics; Mr. Rex Grimoldby of Brandenburg; Mr. Brian Jennings of Electronic Engineering; Mr. Stan Mash of Electronic Equipment News; Mr. Stephen Broadbent of Flight International and Mr. Dave Whiffen of Laboratory Weekly.

The opinion of the judges is, of course, final.

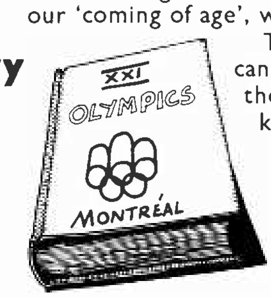
2 Look into a crystal ball

Obviously more than two entrants will get the first part of the competition correct. So, to get around this problem, we've got another question for you to answer (in 25 words or less). What technological achievement would you like to see next – and why? Again the judges will decide. And remember, we are taking two winners – so try hard, won't you, as you peer into the crystal ball.



3 In the year of the 21st Olympiad—and our 21st anniversary —21 prizes for "runners-up"

Brandenburg has been in HV engineering for 21 years. So, to celebrate our 'coming of age', we're awarding 21 prizes for 'runners-up'.



They're record books of the Olympiad – which we can't show you because they're not printed until after the Games. But they're magnificent volumes and we know you'll treasure your copy for ever.

Incidentally, all winners and runners-up will be informed by 7th May, 1976 and their names published in the afore-mentioned magazines.

4 How can I enter?

Just use our enquiry number – its 151 – and we'll send you an entry form. It's the only way we'll accept entries.

Brandenburg Limited, 939 London Road, Thornton Heath, Surrey, England. Tel: 01 689 0441 Telex: 946149.

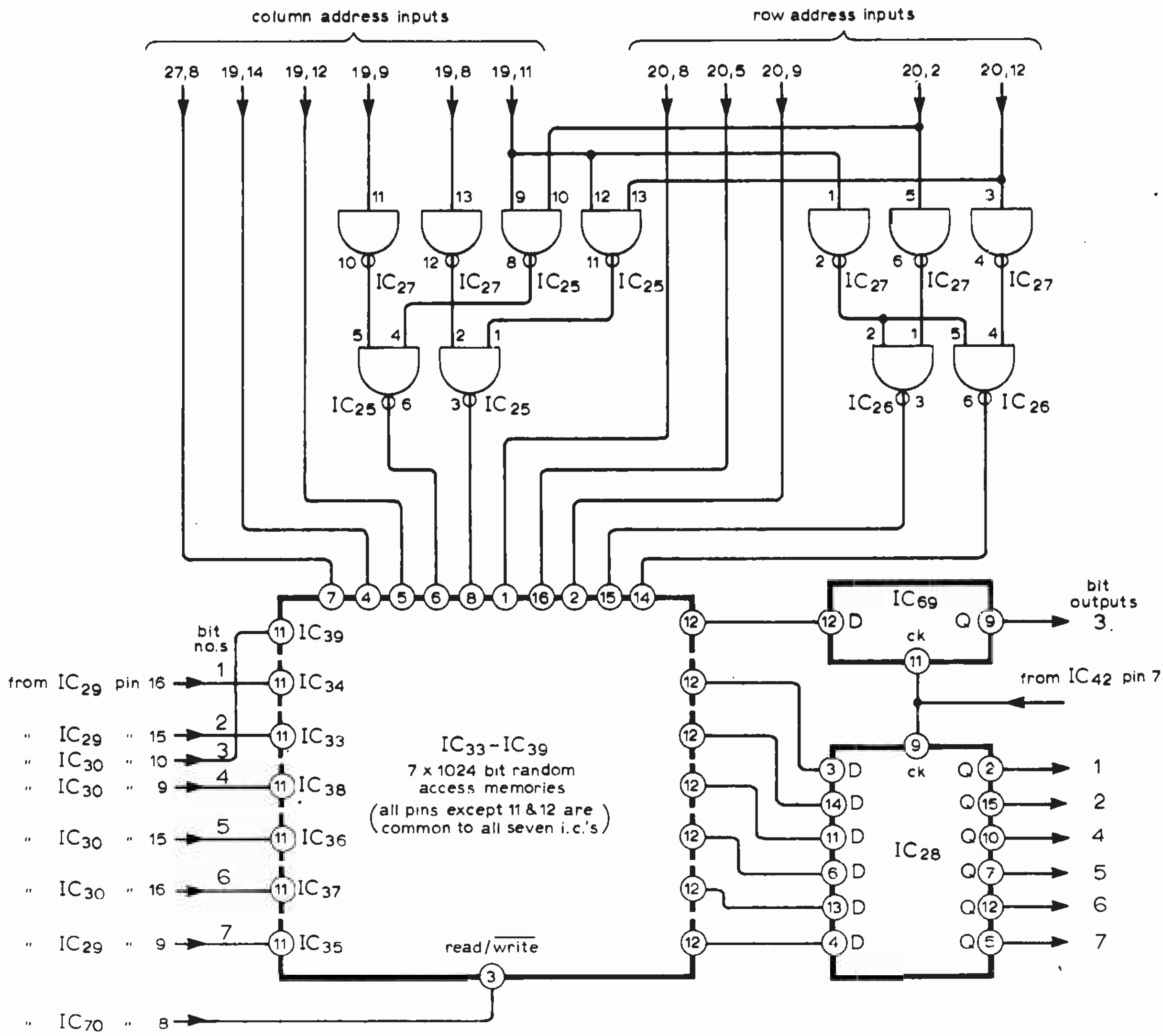


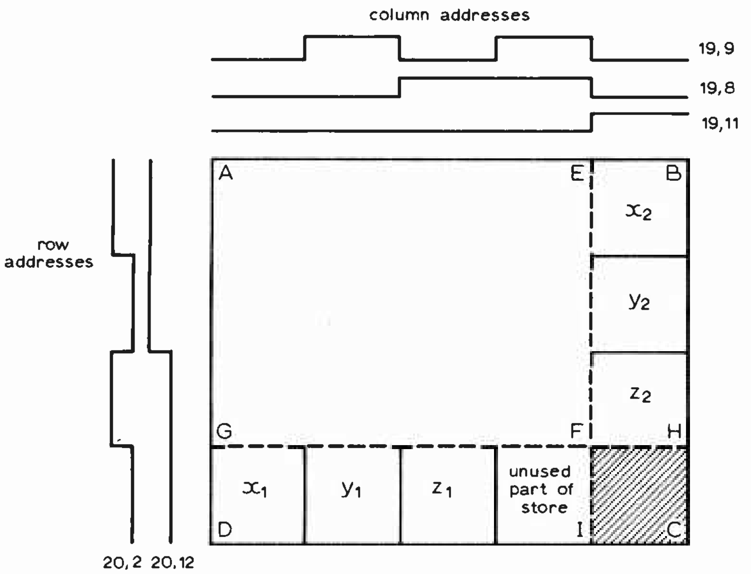
Fig. 4. Circuit diagram of the code converter and data store. $IC_{25, 26}$ are 7400, IC_{27} is 7404, IC_{28} is a 74174, IC_{69} is a 7474 and the r.a.ms are 2602B or 2102B.

detections during separated picture information are avoided. However, lines 16 and 329 carry another form of data, and lines 19, 332 and 20, 333 carry insertion test signals. Despite the precautions already taken it is still possible under some circumstances to detect a framing code at the correct time on one of these lines. It is this type of false detection that can cause lines of complete rubbish to be written into the display, and it is this type of error that is most objectionable. The simplest way of overcoming it in this design is to not look for framing codes on lines 16, 329, 19 & 20, 332 and 333 and this can be easily accomplished by inhibiting the entry of data into the 74164 shift register on these lines. This is achieved by feeding the QB output of IC_5 into the second data input of the shift register (shown dotted in Fig. 1). This solution to the problem has the disadvantage that if the allocation of lines in the vertical interval is changed in the future, a modification to the circuit may be required. For this reason the connexion is not included on the p.c.bs, but may be added by means of a wire link if it is found to be necessary.

A second type of error, which is also quite disturbing but which is due to an entirely different cause, is apparent in rows which begin correctly with intelligible data, but turn to rubbish at some point across the line. For this to happen, the framing code must have been correctly detected, but somewhere across the line the divide-by-eight counter generating the latch strobe pulses gets out of step with the data bytes, and this causes the information to turn to rubbish. The most likely causes of this are that the clock oscillator is slightly off frequency, or that some particularly severe noise in the data line causes the clock generator to mistrigger.

The third type of error is the row which appears in the wrong position in the display. This probably has the secondary effect that the position it should have occupied in the display will be left blank, thus effectively making two rows of the display incorrect. This type of error is fairly uncommon in decoders employing Hamming correction, as single errors in the row address will be corrected automatically. Even if an even number of errors are present (2, 4, or 6), the row will still not be written into the wrong position, as even errors can be detected, and in this design they cause the Data Allow waveform to return to "0", preventing any data being written into the store on that row. This means that only errors totalling 3, 5 or 7 bits in the row address group will cause rows to appear in the wrong position on the screen, and this is rather unlikely, except in cases of severe interference (car ignition interference, etc).

The types of error dealt with so far are all very undesirable for the simple reason that they may occur in the display at any time, even if the page is read out correctly the first time, and it is for this reason that the extensive precautions described above are taken to prevent their occurrence. The remaining types of error to be described are less annoying because they are self correcting, i.e., a page may be read out which has errors such as rows or letters missing, but these will be corrected when the selected page is next transmitted in 15-20 seconds time. This is another good reason for having a short



page-access time, since corrections will be made faster.

A blank row in the display may be caused either by an even error detected in the row address group, or by a missed framing code. In either case this type of error cannot cause an already correct page to be made incorrect, and correct information will almost certainly be taken the next time the page is transmitted.

Nothing has yet been said about the parity bit contained in each of the display character groups. This is used in the following way: a parity check is made on each 8-bit data byte before it is written into the store, and if the check is satisfactory the seven bits of the character code are written in the normal manner. If, however, the check shows the parity to be incorrect, nothing is written into the store during that byte. (Anything already in the store at that address location will therefore be unaffected, as only the action of writing removes already-stored information.) This has the effect that when a page is first read out onto the screen, any parity errors will cause characters to be missing from the display. These letters will then be filled in 15 seconds or so later, when the page is next written into the store. Incorrect characters will only be read into the display if more than one error is present in the data word in such a way that the byte-parity is still correct.

This, then, is a brief resumé of the more common types of error that can be encountered in the teletext display, and we will now continue the circuit description by looking at the operation of the Hamming corrector circuit.

Hamming correction

It has already been explained that the Hamming-coded bytes contain four message bits and four parity bits. The use of four parity bits enables four separate parity checks to be carried out over the byte and in this way it is possible to determine which one, if any, of the bits is incorrect. If one of the message bits is found to be incorrect, then it is simply inverted, and hence corrected. The table in Fig. 2 shows the parity checks that are carried out and the action taken if one or more of the checks fails. The actual circuit, shown in Fig. 3 does not need to be quite as complicated as the table suggests because there is nothing to be gained by correcting the odd numbered bits (parity bits) and in fact only the message bits are corrected.

Fig. 5. Diagram showing the operation of the code converter circuit (see text for explanation).

Gates (32, 6), (24, 11) and (24, 8) indicate parity checks A, B and C respectively as shown in the table, and the results of these checks are fed into the four three-input NAND gates, (16, 12), (16, 8), (8, 12) and (8, 6). The output condition of these gates determines whether or not the bits from the $\overline{Q}$ outputs of the 7475 latches will be inverted or passed through the exclusive-OR gates unchanged. (Normally the $\overline{Q}$ outputs are inverted by these gates, but if an error is detected, the errant bit is passed through unchanged).

The 74180 eight-bit parity checking i.c. performs a dual function in this circuit. Firstly it is used simply as a parity checker for the ISO-7 coded characters, to determine whether they should be written into the store. Secondly, it is used in conjunction with gate (16, 6) to detect even-order errors during the Hamming-coded bytes. The input to gate (8, 8) from IC_7, pin 10 restricts the detection of even-order errors to the row address group only. As explained earlier an even-order error detected at the output of gate (8, 8) returns the Data Allow waveform to "0", thus preventing the writing of information into the store on that row.

Data store and code converter

The data store consists of seven 1024-bit static random-access memories (r.a.ms). These are m.o.s. devices, but are extremely easy to use, as they have fully t.t.l.-compatible inputs and outputs and require no external pull-up resistors. The printed-circuit boards are designed in such a way that holders may be used for these i.cs to reduce the possibility of damage by "leaky" soldering irons etc. The outputs of these i.cs are only capable of driving one t.t.l. load and must therefore be suitably buffered to obtain the normal t.t.l. fan-out of 10. They also have a somewhat variable access time, which depends on device type, temperature, and the particular 'location' in the store which is being addressed. Although the specification states that the access time will always be less than 1µs, it is important in this circuit that the bits are all time coincident at the output of the store, and this is achieved by using t.t.l. D-type latches on the outputs of the r.a.ms. These D-type latches perform the dual function of providing bit outputs that are time-coincident and with a full fan-out of 10 t.t.l. loads.

The read/write input of the store is normally at the "1" level during the display of data on the screen. When new information is written into the store,

To help readers to buy components, we print here a list of i.cs used in the decoder. The full parts list will follow later. $IC_{85\text{-}90}$ are required for a two-r.o.m. character generator, also described later.

1	7493	31	7486	61	7412
2	7408	32	7486	62	7410
3	74121	33	2602B	63	7404
4	7428	34	2602B	64	7474
5	7490	35	2602B	65	–
6	7404	36	2602B	66	7404
7	7404	37	2602B	67	7404
8	7410	38	2602B	68	–
9	74H10	39	2602B	69	7474
10	7493	40	74180	70	7410
11	7474	41	7402	71	7400
12	7427	42	7442	72	7474
13	7400	43	7402	73	2513 (u.c.)
14	7493	44	7410	74	7403
15	7400	45	7420	75	7403
16	7410	46	7402	76	–
17	74121	47	7442	77	–
18	7400	48	7442	78	7474
19	7493	49	7400	79	7474
20	74177	50	7400	80	7474
21	74177	51	7474	81	75107
22	74H04	52	7474	82	7403
23	7430	53	7474	83	7400
24	7486	54	7402	84	7410
25	7400	55	7474	85	2513 (l.c.)
26	7400	56	7474	86	7483
27	7404	57	7400	87	7421
28	74174	58	7410	88	7400
29	7475	59	7404	89	7402
30	7475	60	7412	90	7403

this input is pulsed to the "0" level for each newly stored character code.

The address inputs to the r.a.ms are obtained from the column and row address dividers. As there are six column-address and five row-address outputs, and only ten address inputs to the r.a.ms, a code-converter circuit is needed to reduce the address word from eleven to ten bits. The method of doing this was briefly described in an earlier article, but with the help of Fig. 5, both the necessity for having a code converter and the method of achieving the conversion should become apparent. For simplicity the diagram only shows the addresses actually involved in the code conversion circuit, and not all the row and column addresses.

The area enclosed by ABHG is the area covered by the teletext display, i.e., 40 characters by 24 rows, and the area AEID is the 32 by 32 matrix of the random-access memory store. It can be seen fairly easily from this that if no code converter were used it would only be possible to obtain a teletext display of 32 by 24 characters (enclosed by AEFG). However, it is also fairly obvious that the extra space available in the r.a.ms enclosed by GFID is more than enough to store the extra eight character codes for each of the 24 rows. This is indicated in the diagram where the characters displayed in square x_2 are in fact stored in position x_1 in the r.a.ms and similarly y_2 in y_1 and z_2 in z_1.

The method of achieving this in terms of gates is shown in Fig. 4 and the i.cs used are actually numbers 25, 26 and 27. It would take too long and serve little purpose to describe in detail this part of the circuit operation. Briefly, the circuit detects characters 32-40 on each row and changes the store row address to one of the unused rows between 24 and 31.

There are many ways in which the above code conversion can be performed, but it was considered that the method used was probably the cheapest in terms of i.c. types and it was adopted for this reason.

This completes the description of all the circuitry contained on digital board one, and next month the description will be continued by looking at the majority of board two which includes page and time detection, control logic, graphics and character generation.

Correction

In Fig. 1 of the January issue, IC_{14} was specified as a 7490. It should be 7493.

Standards

We are informed by the BBC that, from February 2, 1976, the character code shown in our January issue will be broadcast on BBC1. BBC2 will revert to the old standard.

Meetings

FEBRUARY

LONDON

2nd. BKSTS — "Psychoacoustics: microphone techniques and the criteria of hearing" by Michael Gerzon at 19.00 at Thames Television, Studio 7, Euston Road, NW1.

3rd. IEE — "Automatic handwriting and speech recognition systems" by R. Watson and B. Paye at 17.30 at Savoy Pl., WC2.

3rd. IEE — Faraday lecture on "The entertaining electron" by F. H. Steele in the evening at The New London Theatre.

4th. IEE — Faraday lecture on "The entertaining electron" by F. H. Steele, morning, afternoon and evening at The New London Theatre.

4th. I. Phys. — One-day meeting on "Absorption of sound and vibration" at Imperial College, SW7.

4th. IEE — Colloquium on "Antenna systems for frequency re-use" at 14.30 at Savoy Pl., WC2.

4th. BKSTS/RTS/IEE — Symposium on "Large screen television displays" at 16.00 at Studio 1, London Weekend Television, South Bank Television Centre, Upper Ground, SE1.

5th. IEE — Colloquium on "H.F. communication systems" at 10.00 at Savoy Pl., WC2.

5th. IEE — Faraday lecture on "The entertaining electron" by F. H. Steele, morning and evening at The New London Theatre.

6th. IEE — Faraday lecture on "The entertaining electron" by F. H. Steele, morning and afternoon at The New London Theatre.

9th. IEE — "Safety regulations arising from the low-voltage safety document" by J. B. Lievens at 17.30 at Savoy Pl., WC2.

9th. BKSTS — "Studio recording principles" by John Andrews at 19.00 at Thames Television, Studio 7, Euston Road, NW1.

10th. IEE/IEETE — Discussion on "Black boxes and their role in the teaching of semiconductors" at 17.30 at Savoy Pl., WC2.

10th. AES — "Low levels to line" by David Rees at 19.15 at the IEE, Savoy Pl., WC2.

11th. I. Phys/IEE — One-day meeting on "Metallisation systems for semiconductor devices" at Imperial College, SW7.

11th. IEE — Colloquium on "Stroke rehabilitation as a problem in control" at 10.30 at Savoy Pl., WC2.

12th. IEE — "MF broadcasting" by T. Kilvington at 17.30 at Savoy Pl., WC2.

16th. IEE — Colloquium on "Electronics against pollution" at Savoy Pl., WC2.

16th. BKSTS — "Studio techniques" by John Andrews at 19.00 at Thames Television, Studio 7, Euston Road. NW1.

17th. IEE — Colloquium on "Field effect transistor circuits" at 10.30 at Savoy Pl., WC2.

18th. I. Phys. — One-day meeting on "Adhesion of thin films" at 10.30 at Imperial College, SW7.

18th. IEE — Fourteenth annual lecture of the Electronics Division by Prof. C. Cherry at 17.30 at Savoy Pl., WC2.

18th. IEE — "Liquid crystal materials" by Dr G. W. Grey at 17.30 at Savoy Pl., WC2.

23rd. IEE — Discussion on "Reduction of electro-magnetically excited vibration and noise" at 17.30 at Savoy Pl., WC2.

23rd. BKSTS — "Monitoring sound in studio and home" by Spencer Hughes at 19.00 at Thames Television, Studio 7, Euston Road, NW1.

25th. IEE — "Marketing engineering products in 1976" by L. A. Williams at 17.30 at Savoy Pl., WC2.

26th. IEE — Discussion on "Towards a real professionalism" at 14.00 at Savoy Pl., WC2.

BIRMINGHAM

18th. RTS — "Politics and broadcasting" by Peter Hardiman Scott at 19.00 at the BBC Broadcasting Centre, Pebble Mill Road.

BLANDFORD

18th. IEETE — "Ultrasonics in TV" by J. C. Goodwin at 18.30 at Princess Mary Hall, School of Signals, Blandford Camp.

BOURNEMOUTH

10th. IEETE — "The work of the Independent Broadcasting Authority" by B. T. Hadley at 19.30 at Cotford Hall Hotel, Knyveton Road.

BRIGHTON

19th. IEETE — "Stabilise your a.c. supplies" by Max E. Symes at 19.30 at the Royal Albion Hotel, Old Steine.

CARMARTHEN

11th. IEETE — "Protective multiple earthing" by R. Hubbard at 19.30 at Carmarthen Technical and Agricultural College.

EXETER

5th. IEETE — "Fuel economy — control systems" at 19.30 at the Imperial Hotel, St Davids Hill.

GLASGOW

25th. IEE — Colloquium on "Electronics in the service of medicine" at the University of Strathclyde.

IPSWICH

5th. IEETE — "Hi-fi" by H. J. Dix at 19.30 at Room 1, Ipswich Town Hall.

MORDEN

24th. IEE — "Electronics on Saturday" by K. J. Dean at 18.30 at Merton Technical College, Morden Park, London Road.

REDHILL

5th. IEETE — "Automatic vehicle control — driverless buses and vehicles for the disabled" by J. Feaver and Dr G. Reynolds at 19.30 at Redhill Technical College, Gatton Point.

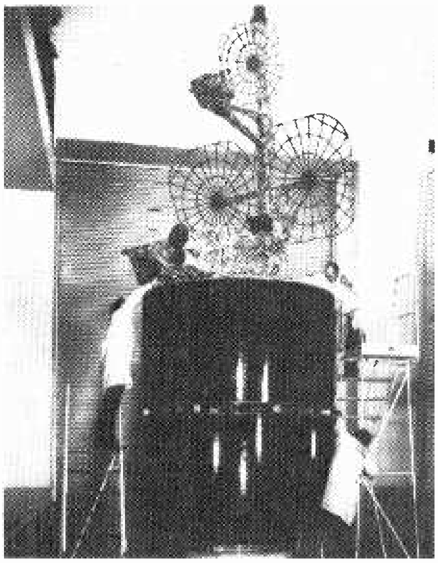
Tickets are required for some meetings: readers are advised therefore to contact the society concerned.

First Intelsat IV-A launched

The first in the series of Intelsat IV-A commercial communication satellites, capable of carrying 6,000 telephone calls and two television channels at once, was launched from Cape Canaveral, Florida on September 25, 1975. The satellite's capacity is almost twice that of each of the present communications satellites now in service. It is the first of six to be launched over the next few years.

The satellite carries 20 transponders, compared with 12 on each Intelsat IV, and a new antenna system that can concentrate several signal beams on to high traffic areas on each side of the Atlantic. Eighty-five per cent of all Intelsat use is for telephone transmission.

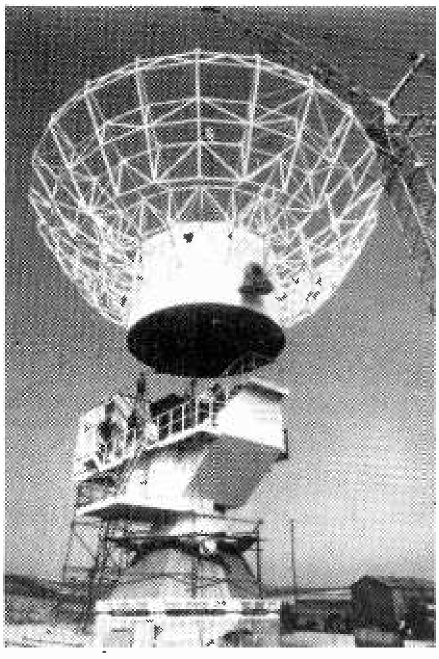
Using a technique of frequency re-use, the satellite will cast separate transmitting and receiving beams that will take in most of the Americas and Canada as well as Europe and Africa from its operating position in synchronous earth orbit 22,300 miles above the equator. The satellite is provided by Intelsat, the International Telecommunications Satellite Organisation, which was set up in 1964 to exploit satellites for commercial communications on a global scale. Britain is the second largest shareholder in the venture after the USA.



Intelsat IV-A communication satellite (see news item). British Aircraft Corporation Electronic & Space Systems Group at Bristol under contract to Hughes Aircraft Company manufactured major sections of the satellite including the spun structure, booster adapter, despun components, cable harness and solar arrays.

ESA's bird's eye

The European Space Agency plans to send up a high orbiting weather satellite as part of a world-wide effort to obtain even faster and more detailed information about the earth's weather and climate. The "Meteosat" satellite is due to start operating in mid 1977, and the data from its continuous observation should help to produce more reliable weather forecasts. Siemens, as the main contractor, is at present constructing the antenna for the main ground station for this project near Michelstadt in the Odenwald region. The purpose of the Meteosat weather satellite is to photograph cloud movements and general atmospheric phenomena. From its orbiting postion 36,000km above the equator at the Greenwich meridian, the satellite will be able to survey an area extending from northern Europe to the South Atlantic and from mid Atlantic to the Indian Ocean. One ordinary and one infra-red picture will be transmitted in digital form at half-hourly intervals to the ground station, where a computing centre will compare the newly received pictures with the previous ones. The functions performed by the satellite's transmission system include: transmitting the pictures taken by the satellite in the visible and infra-red range to the main station; transferring the processed meteorological pictures from the main station to the user stations; transmitting data from the unattended stations to the main station. The S band (2.1GHz or 1.7GHz) is used for traffic with the main station and the user station and the u.h.f. range (400 or 470MHz) is used for traffic with the unattended frequencies.



Main-station antenna near Michelstadt in the Odenwald region of Federal Germany for ESA's Meteosat weather satellite (see news item).

Satcom service for Alaska

Satellite Satcom I, designed specifically for Alaska communication services, was launched in mid December from the Kennedy Space Center at Cape Canaveral, USA. The satellite is urgently required for increased capacity voice, record and video services. These include critical operations for Alaskan pipeline communications, for telephone and public health services with the first 20 new small village earth stations under construction and also with 80 other small earth stations to follow in Alaska. Satcom I is the first of three that RCA will operate as part of its domestic satellite communications service available across the United States. The critical weight requirements of a high-capacity, 24-transponder communications satellite dictated the use of a three-axis stabilized spacecraft in place of the more familiar spinner type vehicle. Weight savings were achieved by the use of graphite-fibre epoxy composite materials instead of conventional substances for the communications input and output multiplexers, antenna horns, waveguide and support towers, which cut the weight of those subsystems in half. Satcom I has 24 independent 34MHz communication channels in the 500MHz bandwidth authorized for satellite communications. Information will be transmitted using alternate horizontal and vertical polarization. To prevent interference between these signals, wire grids are embedded in the four antenna reflectors. These are designed so that two reflectors will receive only horizontally polarized signals while the other two receive only the vertical.

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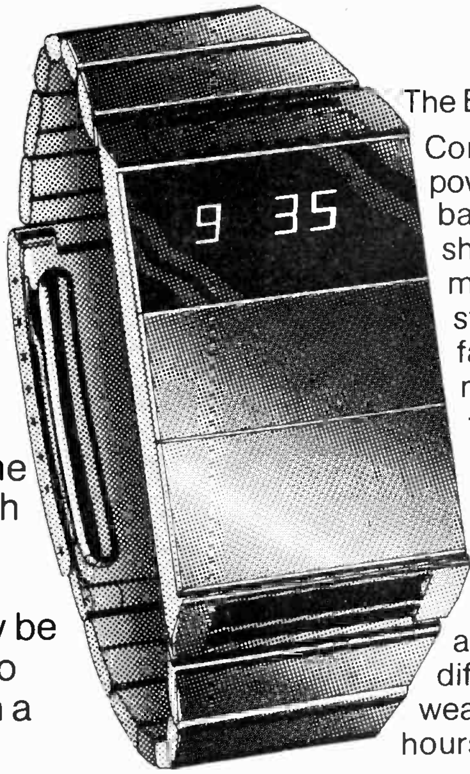

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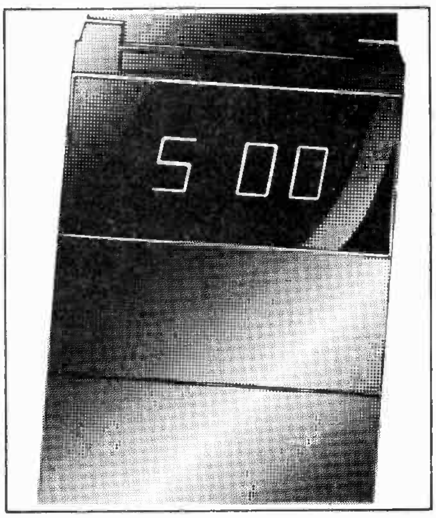

Large, bright, red display – easily read at night.
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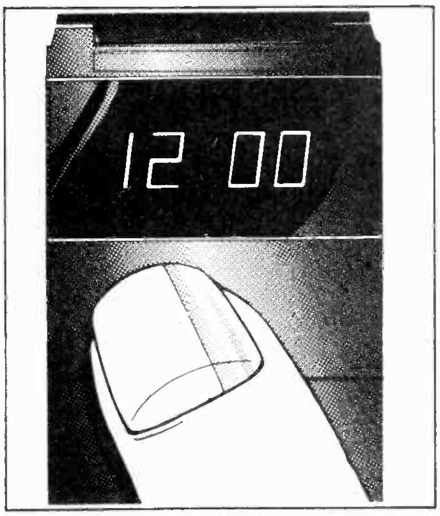

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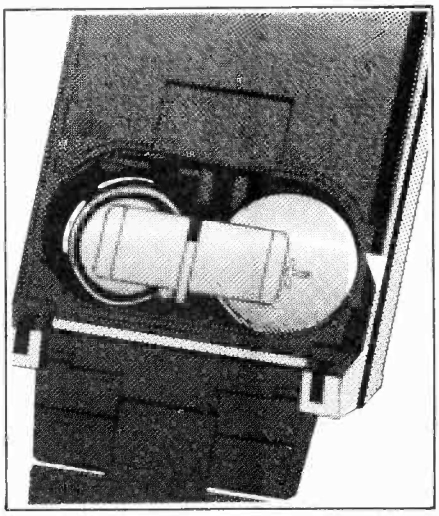

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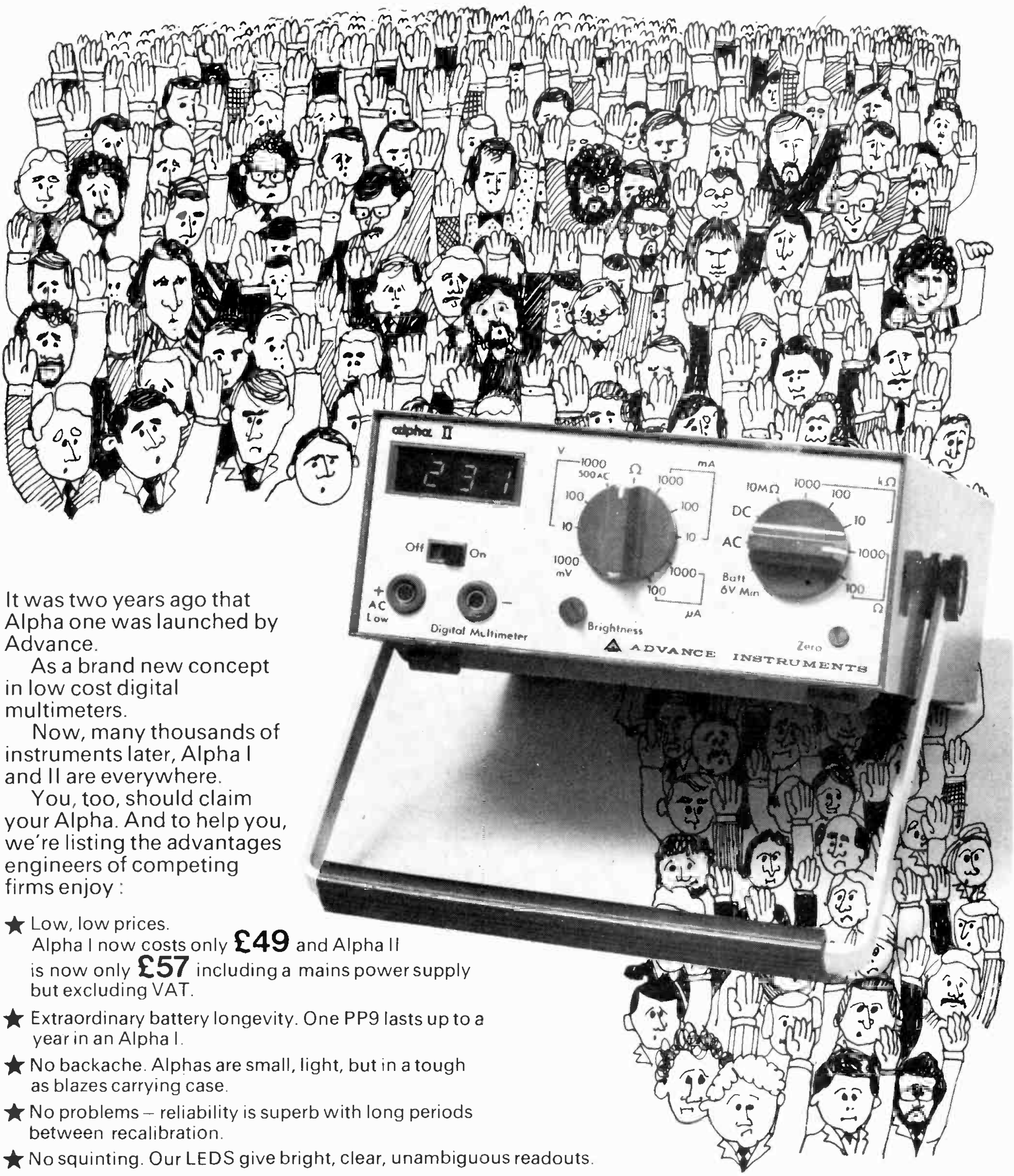

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Thermistor and thermocouple action

Methods of measuring temperature

by C. Budd

With the widespread use of the thermistor, the thermocouple seems to have been neglected. This article reviews the characteristics and principles of operation of the two devices and discusses their relative merits in practical applications

Thermistor action is based on the rapid variations of resistivity with temperature found in semiconductor materials. This component is a black sheep in the family of low-frequency semiconductor devices because it contains no junctions – just a piece of semiconductor material with two ohmic non-rectifying contacts. There are two basic types of thermistor, negative-coefficient types (n.t.c.) and positive-coefficient types (p.t.c.)

P.t.c. thermistors

In a metal, the forbidden energy band between the valence and conduction bands (see Fig. 1) has zero width and electrons can pass freely from one band to the other at any temperature other than absolute zero. The number of electrons available for conduction is practically independent of temperature. Theory shows that, approximately;

$$\rho = 2mv/ne^2l \qquad (1)$$

where m is the mass of each charge carrier (each electron in this case), v is the velocity of each charge carrier, n is the number of charge carriers available for conduction per unit volume, l is the average distance travelled by each charge carrier between collisions with the atoms of the material, e is the charge of each charge carrier (-1.602×10^{-19} coulombs for electrons), and ρ is the resistivity of the material. Because m, n, e, and l are constants and v increases with temperature the resistivity must increase with temperature. This effect, known as lattice scattering, is responsible for the small positive temperature-coefficient of resistivity in most metals.

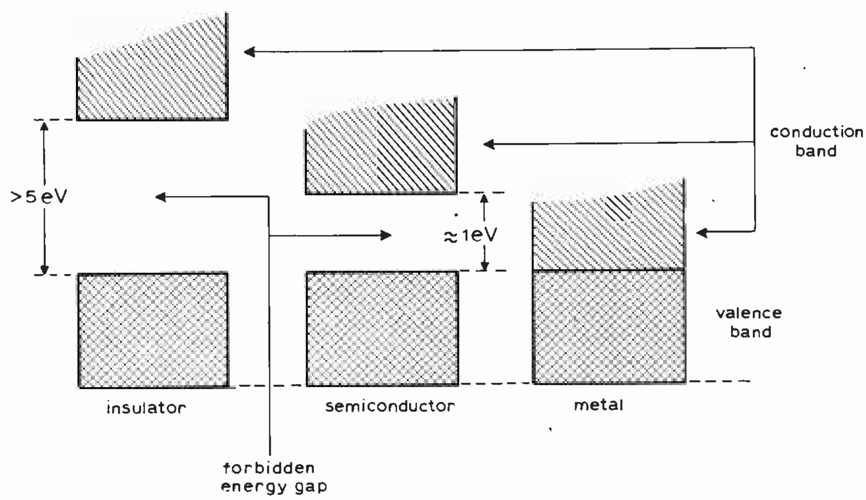
Lattice scattering is only apparent in semiconductors when the thermal energy is small enough, or the temperature is high enough to make the number of charge carriers available per unit volume a constant. This occurs in extrinsic (doped) silicon at about room temperature because ample thermal energy is available to excite electrons from the donor level to the conduction band in n-type silicons, or from the valence band to the acceptor level in p-type. A much greater temperature must be reached, however, before electrons can gain enough energy to pass from valence to conduction band and allow intrinsic conductivity. Therefore the number of charge carriers, either electrons or holes, available per unit volume is virtually independent of temperature, and the resistivity of the semiconductor will obey equation (1). The approximate relationship between resistivity and temperature is shown in Fig. 2. If the semiconductor sample is encapsulated, a resistor with a fairly large positive temperature coefficient of resistance is formed. The approximate relationship between temperature and resistance for this device is;

$$R = R_0 \cdot T^S \qquad (2)$$

where R_0 is a constant with the dimension of resistance which varies from device to device, R is the resistance of the device, T is the absolute temperature, S is a constant, about 2.7 for p-type silicon and 2.5 for n-type. Rearrangement and differentation of equation (2) shows that the temperature coefficient of resistivity of the thermistor is equal to S/T. Therefore, at a room temperature of 300°K and assuming that the silicon is p-type, the temperature coefficient of resistance should have a value of about 0.9%/K. In practice a figure of about 0.72%/K can be achieved.

Extrinsic silicon is not the only material that may be used in p.t.c. thermistors. Barium-titanate is commonly used and is capable of far greater changes in resistivity. The relationship between temperature and resistivity for barium-titantate is shown in Fig. 3. The

Fig. 1. Orbital electron energy bands in insulators, semiconductors and metals. At absolute zero temperature, only the valency bands are occupied but electrons may cross the energy gap, at higher temperatures, to become available as charge carriers.



resistivity drops slowly and uniformly as the temperature is increased until a critical point (the Curie temperature) is reached and the resistivity sharply increases by a factor of between 10,000 and 100,000. For the sample of $BaTiO_3$ represented in Fig. 3, the Curie temperature would be about 393°K and the transition from low to high resistance would occur over a range of a few deg Kelvin. This type of device is known as a switching thermistor and finds application in protection circuits. By adding other titanates, the switching temperature may be varied between about 170 and 490°K and the rate of change of resistance may be reduced to almost any desired level. Both silicon and barium-titanate based thermistors have non-linear temperature-resistance functions and are not generally suitable for thermometric use.

N.t.c. thermistors

If the resistivity of intrinsic (pure) semiconductor material is plotted about temperature, a graph such as Fig. 4 is obtained. Because the sample is pure, conduction is by means of electrons thermally excited into the conduction band and by the holes created in the valence band. The resistivity of the material, therefore, decreases with rising temperature. An approximate relationship between temperature and resistance for such a device is;

$$R = A \exp(B/T) \qquad (3)$$

where R is the resistance at temperature T, T is the absolute temperature, A is a constant for the device having the dimension of resistance. B is another constant for the particular device having the dimension of temperature. Rearrangement and differentiation shows that the temperature coefficient of resistance must be equal to $-B/T$ and this will usually lie between -2 and -7%K. Because the n.t.c. thermistor relies on intrinsic conduction, the semiconductor materials used must have fairly small forbidden-energy gaps to be useful at moderate temperatures. The energy gaps of germanium and silicon are too wide, so oxide semiconductors are almost exclusively used. In fact, the explanation of the resistance-temperature dependence given above is an over-simplification. Conduction in oxide semiconductors is less well understood than in elemental types.

The relationship between temperature and resistance is very non-linear, which makes the n.t.c. thermistor useless for accurate thermometric work. However, some n.t.c. thermistors may be regarded as having approximately linear characteristics over very limited temperature ranges and fairly simple correction can be applied to produce a cheap thermometer which is accurate over a limited range of temperatures. In this connection, thermistors encapsulated in glass beads do have the advantage of a very small heat capacity.

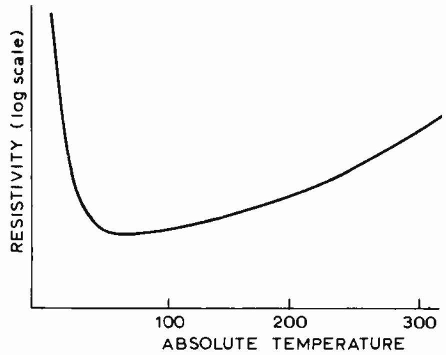


Fig. 2. Resistivity versus temperature graph for extrinsic silicon.

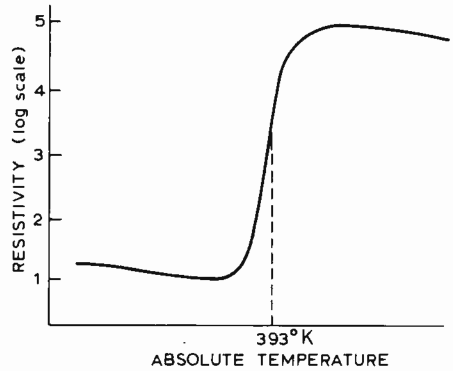


Fig. 3. Resistivity versus temperature graph for barium titanate.

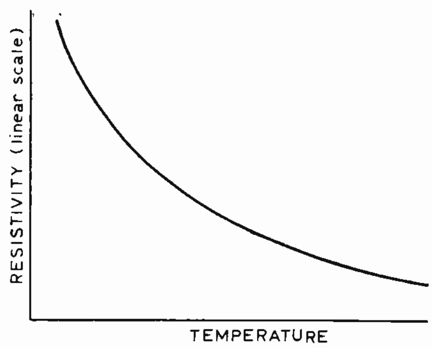


Fig. 4. Resistivity versus temperature for an intrinsic semiconductor material showing an approximate inverse-exponential curve.

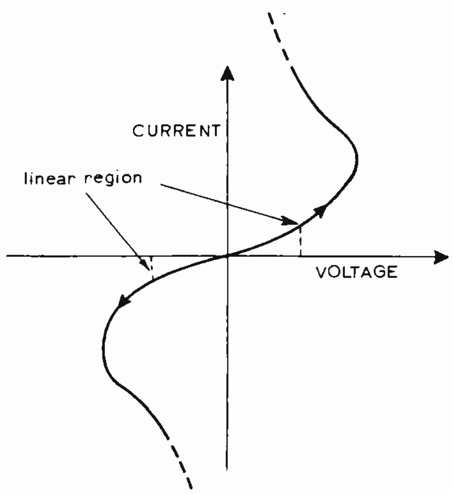


Fig. 5. Approximate current versus voltage characteristic for an n.t.c. thermistor heated by its own power dissipation.

Applications of n.t.c. thermistors include temperature compensation in transistor circuits and certain situations requiring non-linear resistance elements in which the thermistor is heated by its own power dissipation. The voltage-current characteristic for an n.t.c. device is shown in Fig. 5.

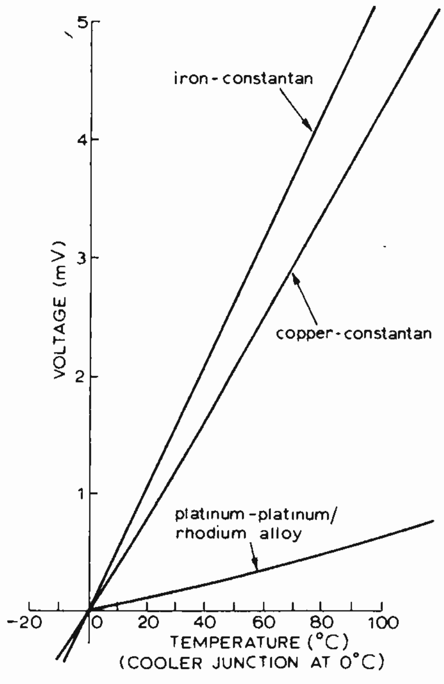
Thermocouples

If two different metals are joined together a voltage will appear between them known as the contact potential. This voltage will be very small and arises as follows. The free electrons available for conduction in a metal may be regarded as forming a gas which possesses a pressure, and permeates the metal's crystal lattice. Two different metals will have different gas pressures and when they are joined the difference in pressure will cause a net flow of electrons from one metal to the other. This momentary flow will cease when the effective force on each electron due to the pressure gradient is countered by an equal but opposite electrostatic force due to the resulting contact potential. The generated voltage will increase with temperature at a rate between zero and 60 microvolts per degree Kelvin and will be independent of the area of contact. A single metal to metal junction as described is called a thermocouple and several such junctions joined in series is called a thermopile.

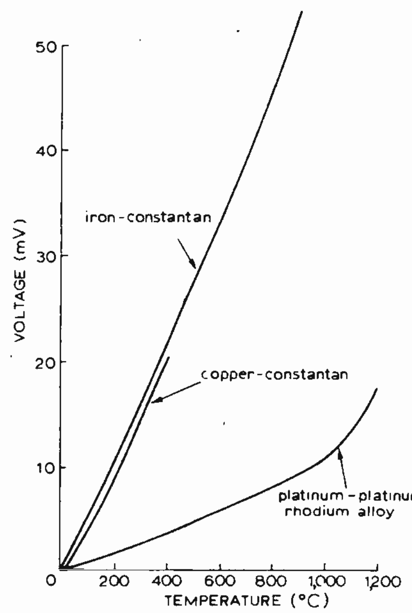
The actual contact potential of a thermocouple is rarely specified because the difference between a particular thermocouple's voltage at a particular temperature and the voltage developed by an exactly similar one at some reference temperature (usually zero degrees Celcius) is of more practical importance. On this basis, Fig 6(a), (b) show the difference-voltages developed by several common types of thermocouples for two different temperature ranges. The exact mathematical relationship between temperature and voltage for a thermocouple is rather involved, but a good approximation is given by the quadratic function;

$$V = A.T + B.T^2 \qquad (4)$$

where T is the difference in temperature between the variable and fixed thermocouples, V is the difference voltage developed between the variable and fixed-temperature couples, and A and B are constants for the particular thermocouple type and the particular reference temperature. Shown in Fig. 7 is a general graph, deduced from equation (4), of temperature against voltage for any thermocouple. The temperatures H and I are known respectively as the neutral and inversion temperatures of the thermocouple. This graph is, in fact, mainly of academic interest because many thermocouples (copper/iron being a notable exception)



(a)



(b)

Fig. 6(a)(b). Difference-voltages developed by several common types of thermocouples for two different temperature ranges.

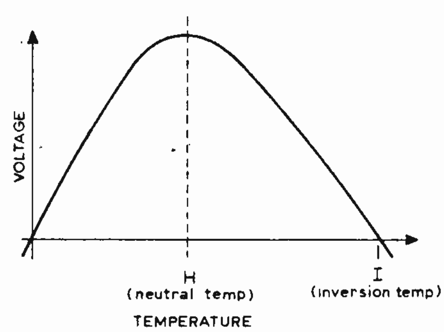


Fig. 7. General temperature versus voltage graph for a thermocouple.

either melt or undergo some chemical change before reaching the neutral temperature. Because B in equation (4) is often small enough, in a practical thermocouple, the temperature-voltage relationship can be regarded as linear over its useful range. Metal pairs used in common thermocouples are, iron/constantan – useable below 1030°K, sensitive and substantially linear. Copper/constantan – useable below 670°K, rather less linear and almost as sensitive as iron/constantan. Copper/iron – substantially non-linear, neutral temperature about 510°K. Platinum/platinum-rhodium alloy – much less sensitive than iron or copper with constantan, stable and linear at low temperatures and useable up to about 1370°K. The international temperature scale is defined between 903.16°K and 1336.16°K in terms of a platinum/platinum-rhodium alloy thermocouple pair; one couple being maintained at 0°C, the ratio of the concentrations of platinum and rhodium in the alloy being 9:1.

It is found that if several thermocouple-type junctions are connected in series and all held at the same temperature – see Fig. 8, the total voltage developed around the loop is zero. Using this principle, an arrangement such as Fig. 9(a) should act as a thermometer, giving a zero reading when the meter and the thermocouple are at the same temperature, and a steadily greater reading as the thermocouple temperature is raised above that of the meter. Such an arrangement is frequently used to measure the high temperatures of furnaces. This system has the disadvantage that the temperature corresponding to zero meter reading is the temperature of the meter itself and therefore varies with ambient temperature, slightly shifting the entire temperature scale as it does so. A circuit which overcomes these drawbacks is shown in Fig. 9(b), where two junctions between the connecting wires and the meter (or d.c. amplifier) are identical so the voltages they develop will be equal and opposite. The temperature of the sensing thermocouple (junction X) corresponding to zero meter reading will now be the reference temperature. The need for a reference temperature in the circuit of Fig 9(b) could be a considerable drawback if a simple thermometer is needed. In a remote temperature measuring application it will be necessary to station the meter or recorder and associated circuitry some distance from the thermocouple.

To prevent unwanted varying voltages it would be ideal to make the whole run, from each thermocouple to the instruments, in wire of the same metals as the thermocouple. This could be expensive, especially if the thermocouples are of the platinum/platinum-rhodium type, so an arrangement as shown in Fig. 10 may be used. This makes it possible for the whole run from each thermocouple to be made in

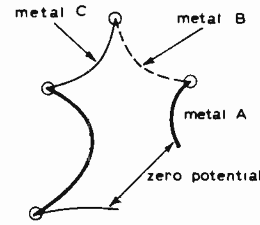
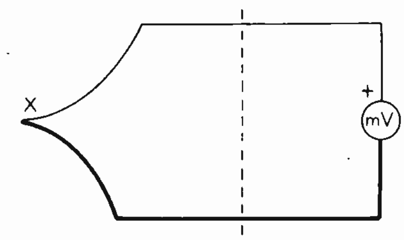
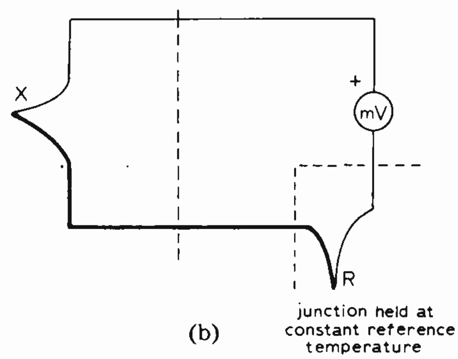


Fig. 8. Total voltage developed around a ring of thermocouples, all at the same temperature, is zero.



(a)



(b)

Fig. 9 (a). Simple thermocouple thermometer and a superior arrangement (b) where a second thermocouple is held at a constant reference temperature.

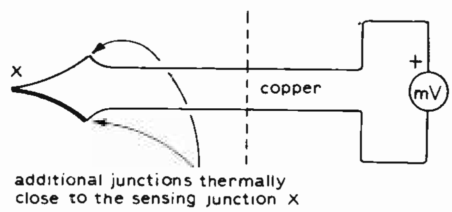


Fig. 10. Remote temperature-sensing arrangement which permits the use of copper wire for connecting the sensing thermocouple to the measuring instruments.

copper wire and obviates the need for an extra thermocouple at a reference temperature because the two connections between each pair of leads and the instruments are identical. The only additional requirement is that the two junctions created at each sensing point should be close enough to the main junction to be at the same temperature. A practical design for a thermocouple thermometer capable of remote measurement at seven different points is given in reference 1.

Pyrometers

The temperatures of bodies may be measured without physical contact by using an instrument called a total radiation pyrometer in which the heat and light radiation from an object is focused by a mirror onto a blackened thermocouple. The voltage developed by this thermocouple is compared with the voltage from an identical one at ambient temperature. The temperature of the object is determined from the difference voltage. The amount of radiation emitted by a body depends upon its emissive properties as well as the temperature and if it is not a black-body (i.e. a perfect radiator and absorber) the temperature measured by the total radiation pyrometer will be lower than the true temperature. Correction tables are available for the emmissive properties of an object, but the error may still be considerable. Total radiation pyrometers also have a disadvantage compared with direct contact thermometers because they can only be used with fairly large objects.

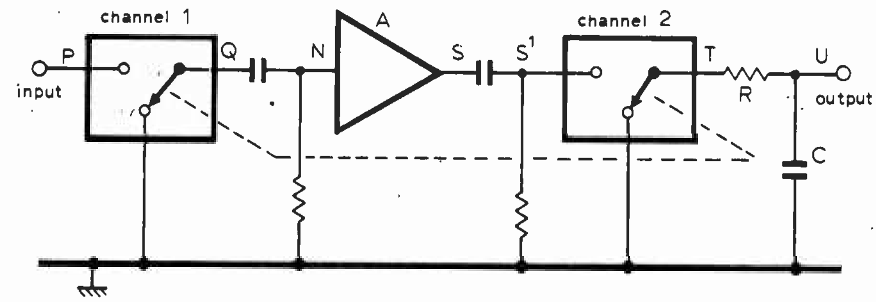


Fig. 11 (above). Outline of a d.c. chopper amplifier where channel 1 and 2 are fast switches which produce a square wave.

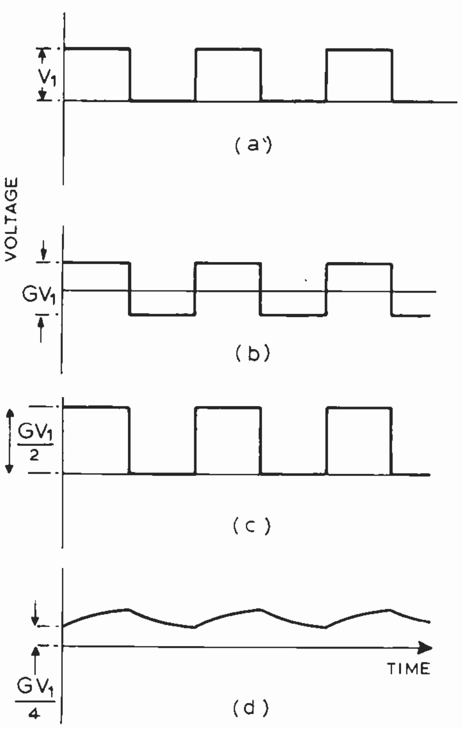
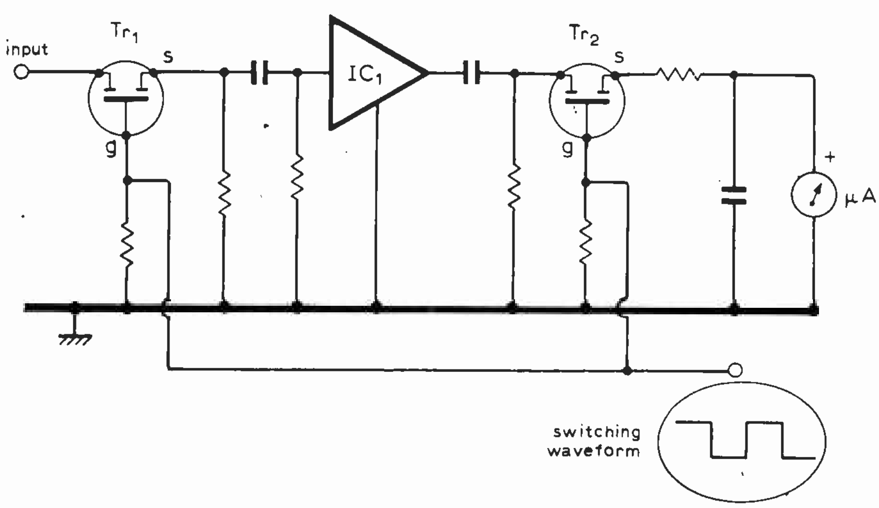


Fig. 12(a)(b)(c)(d). Waveforms at points Q, S, S^1 and U respectively in Fig. 11 where V_I is the input voltage and G is the gain of amplifier A.

Fig. 13 (below). Outline of a d.c. chopper amplifier for use in a thermocouple amplifier. Transistors Tr_1 and Tr_2 are enhancement-mode m.o.s.f.e.ts which are switched by the square wave input.



Practical thermocouple circuits

The output from a thermocouple is in the order of 40 μV/°K for a copper/constantan couple. This makes a d.c. amplifier generally impracticable because the variations in thermocouple voltage would be swamped by the thermal drift of voltages within the amplifier. For this reason a d.c. chopper or synchronous amplifier is often used. The outline of such an amplifier is shown in Fig. 11 Ch.1 is a fast switch which alternately connects point Q to the input voltage and ground for equal times. Thus, a square waveform such as that shown in Fig. 12(a) is produced at Q. This is a.c. coupled to amplifier A to produce a square-wave at S which is symmetrical about ground—Fig. 12(b). Ch2 is another chopper which alternately connects T to S^1 and ground. By synchronizing Ch.1 with Ch.2 T is connected to S^1 during positive half-cycles of the waveform at S^1, producing a waveform as shown in Fig. 12(c) at T. Resistor R and capacitor C act as a smoothing network to produce a d.c. output at U proportional to the input voltage at P. The actual amplification is performed on an a.c. signal to avoid thermal drift.

A m.o.s.f.e.t. switching circuit is shown in Fig. 13. Transistor Tr_1 and Tr_2 are enhancement-mode m.o.s.f.e.t.s. being switched by the square-wave voltage. An operational amplifier is a.c. coupled to the choppers. The chopping frequency is not important and an arrangement similar to that shown uses a frequency of 300Hz.

Correction for non-linearity

As shown in equation (4) and Fig. 7, all thermocouples have non-linear voltage temperature relationships, but for many applications the value of *B* in equation (4) is small enough, for them to be regarded as linear (*B* is about −0.02 for copper/iron and 0.04 for copper/constantan at 0°C). However, in an accurate thermocouple thermometer which operates over a wide portion of its useful range, some form of non-linear correction will be needed. There are many circuits capable of giving an adjustable non-linear response but they all depend on non-linear negative feedback to a d.c. amplifier. This technique is well described in reference 2.

References

1. "International Thermocouple Meter", *Electronics Today International*, December 1973.

2. "Experiments with Operational Amplifiers – 6", *Wireless World*, November 1972.

Gunn effect and avalanche oscillators

The generation of microwaves using solid-state diodes

by F. A. Myers, B.Sc., Ph.D.

Allen Clark Research Centre, The Plessey Company Ltd

Microwave solid-state oscillators have become well established in a new generation of electronic equipment. This article briefly discusses the operating principles of these oscillators and emphasizes the operational parameters that determine the choice of a device for a particular application.

Microwave solid-state oscillators have become well established in new generation electronic equipment, such as intruder alarms, man-pack radars, radar altimeters, distance measuring equipment etc. Gunn effect and avalanche diodes have played a major part in the development of these new systems and are replacing some of the older solid-state devices, such as multipliers, in many applications.

Gunn effect devices

It was established that when high electric fields are applied to a piece of gallium arsenide with ohmic contacts, a bulk negative resistance is produced which leads to the formation of a so-called high field domain. The domain propagates through the material at approximately the electron's velocity ($\approx 10^7$cms/sec) and gives rise to an oscillatory current through the device. If the device is placed in a suitable resonant circuit, microwave power can be extracted. Due to the high velocity of the electron, the active material lengths must be short in order to obtain useful power: the basic frequency is given by f = electron velocity length. Practical limits vary from about 20 microns for a C-band (4GHz) diode to 1.5 microns for a Q-band (40GHz) device. The high frequency limit is around 100GHz and is caused by an inherent time delay which sets up the electron distribution required for negative resistance. Difficulties in material growth also set the limit at around 100GHz.

The active layers involved (2-20 microns) are far too thin to be handled practically in the form of bulk crystals, i.e. by lapping down thicker crystals. This means that some form of epitaxial growth must be used on a highly conducting and almost metallic substrate which will form one contact and also provide the required mechanical strength. The process invented and used by Plessey, and now many others, is the arsenic trichloride vapour epitaxy process which allows good control of the material for carrier concentrations of 1×10^{15}/cc and above. Briefly, a substrate (n+) slice is very carefully lapped and polished to the required thickness and then a few microns of n+ gallium arsenide are grown epitaxially on this to mask remaining surface defects. The dopant in the gas stream is then reduced, in a continuous growth process, and the active layer of gallium arsenide is grown on to the so-called n+ buffer layer. The growth continues until the required thickness for the final device is obtained. At this stage the fabrication techniques used by various manufacturers diverge. The older technique requires that the growth ceases at this point and the slice is taken out of the reactor for contact metallization. This technique, although it produces usable devices, is rather difficult to control and produces devices with more variable characteristics such as device life and noise output. The more modern technique involves a further epitaxial growth of a thin n+ contact layer on to the active layer. The slice is then taken from the reactor and metallized. Contacting to highly-doped gallium arsenide is a far easier and more controlled process and produces a high yield of devices with virtually identical characteristics.

Semiconductor photoresist and etching techniques are used to define individual devices on the slice, after which they are diamond scribed and cleaved from the crystal. Individual devices are then bonded into packages suitable for mounting in a microwave environment. A brief pictorial summary of the fabrication of a typical low power ($\approx$20mW) diode is shown in Fig. 1. together with a scanning electron microscope photograph of such a

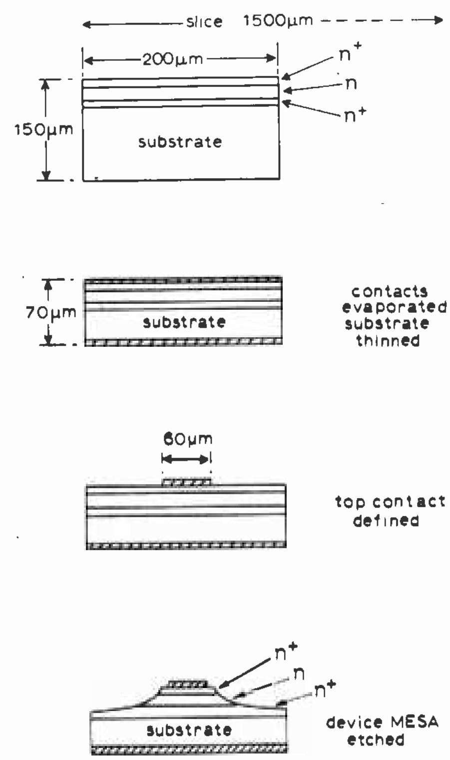


Fig. 1a

Fig. 1(a). Fabrication of a typical low power 20mW c.w. device. Scanning electron microscope photograph of such a device is shown at (b).

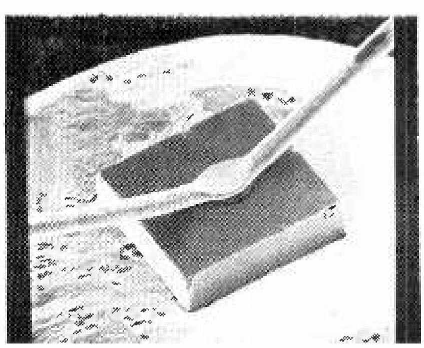


Fig. 1b

device. Low power devices are alloy-bonded thermally with the substrate against the package heat sink, and are limited to a few tens of milliwatts of power output. Higher output powers can be obtained by a technique known as flip chip ultrasonic bonding but both of these methods are now being phased out of production in favour of the much more reliable and efficient integral-heat-sink (i.h.s.) devices. This technique is virtually identical to that used for avalanche diodes and is described in that section.

If the formation of a domain in a Gunn effect device is suppressed by some means, usually by careful control of the material characteristics and the circuit, one is left with a classic two-terminal negative resistance device which will oscillate in the l.s.a. mode when placed in the correct circuit. Very high power levels and efficiencies are possible with this type of device. Unfortunately, because the device is very thick and heat sinking is difficult, practical devices will usually only oscillate in a pulsed mode with low duty cycles around 0.1%. Very high power levels, up to 1kW peak, have been generated at X-band and this device is the nearest competitor to the microwave tubes. It is, however, proving a very difficult beast to tame and is not yet in large scale systems use due to both material difficulties in making the device and the circuit difficulties in using it. But it still remains one of the most promising of the solid state pulsed generators for high power and high efficiency.

Avalanche diodes

The avalanche diode differs from the Gunn device in that the basic mechanism arises from a junction effect. Because of this it is possible to make devices from virtually any semiconductor although silicon and gallium arsenide are the more commonly used.

In the device the junction (either p-n or Schottky) is reverse biased into the breakdown region and the combination of the build up time of the resulting avalanche current and the drift of carriers across the depletion region gives rise to a phase delay between the current and voltage. This can result in negative resistance and hence oscillation in a suitable circuit. The maximum frequency limit of the avalanche device is determined by electron tunnelling. When the voltage breakdown is around 2V, the carriers cannot gain sufficient energy for ionisation and no negative resistance occurs which sets an upper frequency limit in excess of 300GHz. This mode of operation is commonly given the name IMPATT (impact avalanche transit time), or, more simply, the avalanche mode.

The main requirement of any technique for constructing avalanche diode generators is that it provides a structure from which heat can be efficiently removed. A process frequently used, known as the integral heat sink process, involves the deposition of a thick metal heat sink layer directly on the surface of the semiconductor slice. The junction is either a very shallow diffused p-n junction or a Schottky barrier. In either case the active region is adjacent to the metal heat sink which has a high thermal conductivity such as gold, copper or silver. Subsequent steps in the process include thinning the semiconductor slice from the back surface by mechanical or chemical polishing followed by photoengraving and chemical etching to define and isolate individual mesa diodes. The process and final diode structure is illustrated in Fig. 2. The integral heat sink is finally cut into square dice each supporting one diode chip. The dice are then bonded individually into conventional copper based microwave packages. The quality of the bond is important for high power operation and techniques such as thermocompression, and alloy or ultrasonic bonding have all been successfully applied. The final packaged diode configuration is shown in Fig. 3. These packages are similar for Gunn devices.

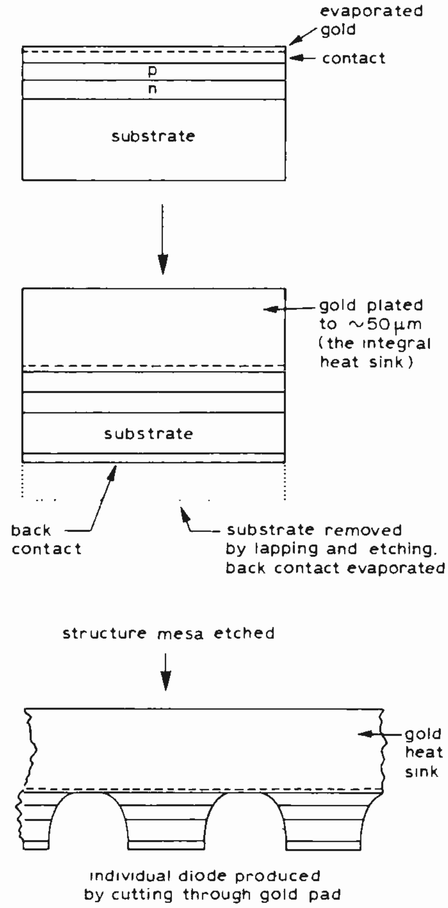


Fig. 2. Integral heat sink fabrication for an IMPATT diode. The active region of the device is adjacent to the metal heat sink for good thermal conductivity.

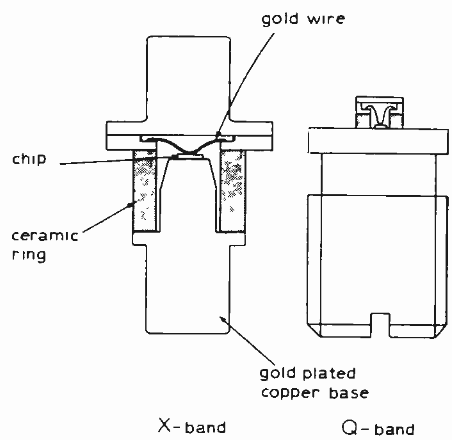


Fig. 3. Final packages for an IMPATT diode. These packages are similar for Gunn devices.

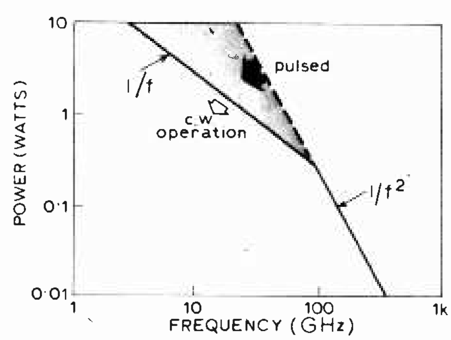


Fig. 4. Idealized plot of power output versus output frequency. The position of the $1/f^2$ line is controlled by the material properties of the semiconductor used.

TRAPATT device

In 1967 a second mode of oscillation was discovered. This new mode remained unexplained for some time and was initially referred to as the anomalous mode. The principal characteristic features of this mode were a very high conversion efficiency of up to 60%, and low frequency of operation. The mechanism giving rise to this mode was later identified by computer simulation techniques and showed that a new transient breakdown phenomenon was involved. This breakdown occurs when the voltage is applied very rapidly to the diode. Because there is an inherent delay in the build up of an avalanche current, it is possible to overdrive the field, if applied sufficiently rapidly, and create a dense hole-electron plasma. The space charge of the carriers reduces the electric field to almost zero in the plasma region and the velocity of the carriers drops accordingly. This state, in which the diode is filled with plasma and the voltage has collapsed to a low value, is referred to as a trapped plasma state. The diode then recovers gradually as the holes and electrons drift slowly out of the active region thereby restoring the field and voltage to their initial level. This has been called the TRAPATT (trapped plasma avalanche triggered transit) mode.

Comparison of applications

At the highest frequencies the modes of oscillation in Gunn effect and avalanche devices are transit-time limited and are subject to a general power-frequency limitation in which the relative output power decreases as $1/f^2$. The absolute level of output power is controlled by the conversion efficiency and the minimum impedance level

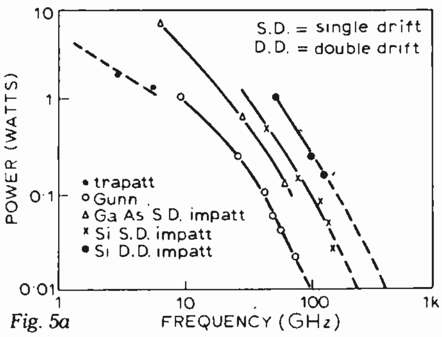


Fig. 5a

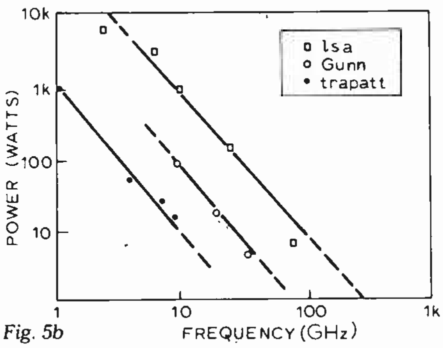


Fig. 5b

Fig. 5. Limiting plots of power versus frequency for (a) c.w. and (b) pulsed generation using current techniques and devices.

attainable in a microwave circuit. At lower frequencies, the devices are thermal-dissipation limited and become subject to a $1/f$ law relating relative output power to frequency. Shown in Fig. 4. is an idealised plot of power output versus frequency. The full line represents the output power limit for continuous wave operation, and the shaded area represents a region in which devices can be operated for very short duty ratios under pulsed operation. Whilst the position of the $1/f^2$ line is controlled by the material properties of the semiconductor used, the position of the $1/f$ line is set by the device's thermal resistance. Fig. 5(a) and (b) shows how actual results are aligned with these simple theoretical laws. In practice, the efficiency is about 10% for Si IMPATTs and 15% for GaAs IMPATTs. The corresponding figure for Gunn devices varies between 3% and 12% depending on whether the results are "state of the art" or readily reproducible. The TRAPATT efficiency is much higher, up to 60% at low frequencies (around 1GHz) and dropping to 25% at 10 GHz (X-band). Because the carriers spend a considerable fraction of each TRAPATT cycle travelling at their low field drift velocities, one would expect an upper frequency limit well below the IMPATT frequency limit. In practice, difficulties in the control of necessary circuit harmonics will restrict the TRAPATT oscillator to frequencies around X-band for the near future.

It can be seen from the power levels in Fig. 5. that these diodes cannot compete with existing vacuum devices, such as klystrons and magnetrons, which can generate power outputs from milliwatts up to megawatts. Solid-state devices have therefore tended to generate completely new applications which previously could not be satisfied by existing tubes because of size, reliability and power supply limitations. An attempt has been made to summarize the spectrum of applications in the microwave region from 1 to 100GHz in Fig. 6. The majority of systems lying within the region of solid-state devices are completely new. The possibility of some of these was appreciated before the advent of solid-state devices, but they were considered impracticable.

The decision on which class of solid-state source to use in a given application is usually based on the first-order considerations of output power required for the frequency of the system. Second-order factors may be considered with respect to conversion efficiency, noise and drive requirements.

The table over summarizes present views on preferred devices in a range of applications.

In addition, these devices can all be used as amplifiers but discussion on these is beyond the scope of this article.

The TRAPATT oscillator is best suited to high power pulsed applications such as radar transmitters. In this type of application it is in competition, up to X-band, with the high power pulsed modes of the Gunn and l.s.a. oscillator which can provide higher peak powers at a lower duty cycle. The specific advantage of the TRAPATT diode is its efficiency which becomes increasingly significant when very high power sources are required. Combinations of

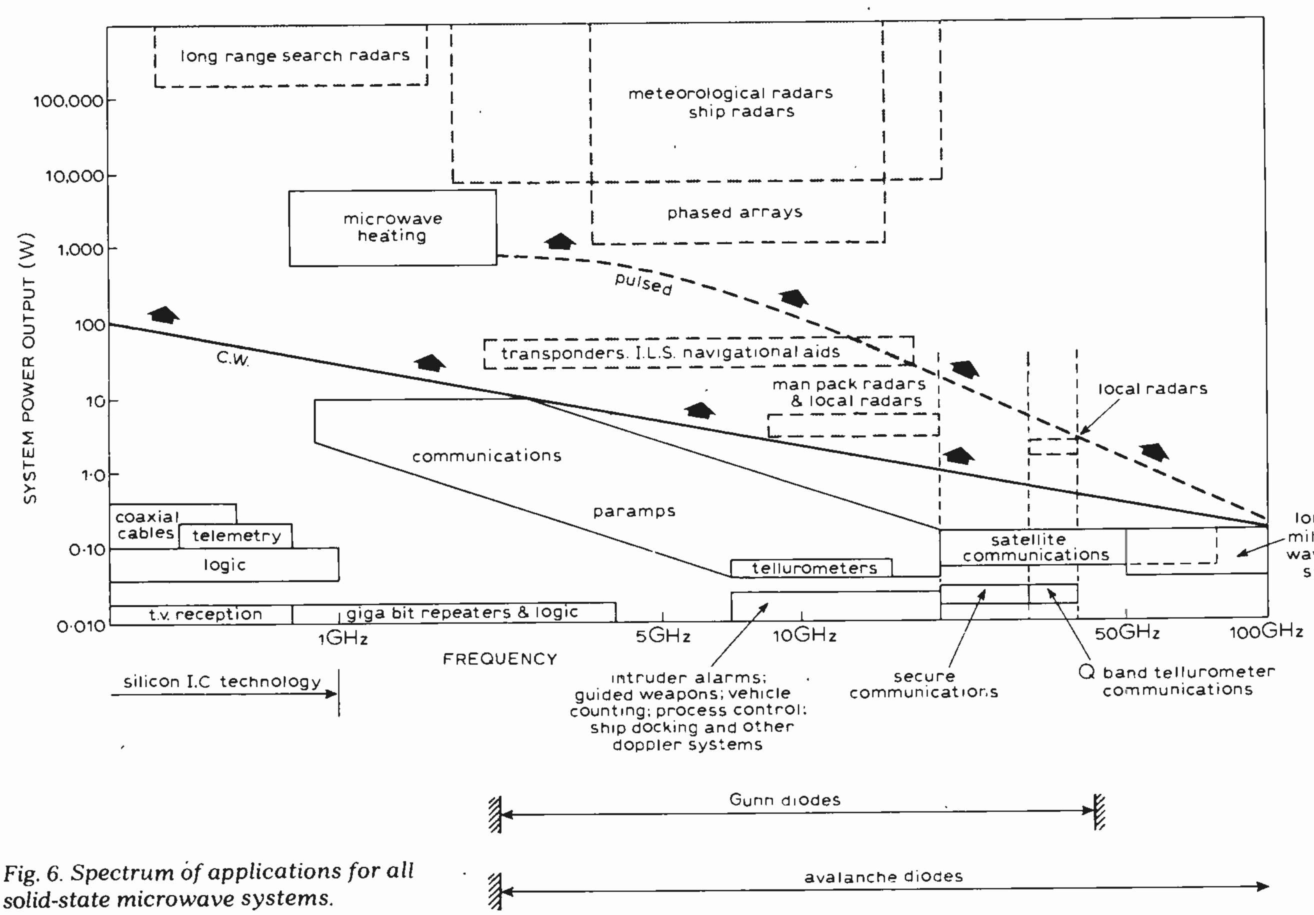


Fig. 6. Spectrum of applications for all solid-state microwave systems.

Application	Preferred device (advantages)
High pulsed power e.g. radar (primary & secondary)	Pulsed Gunn, l.s.a. (high peak power) TRAPATT (high efficiency)
Low power c.w. (<100mW) e.g. local oscillators intruder alarms	Either IMPATT or Gunn diode in many cases. Gunn diode has the advantage of lower noise and lower operating voltage
Medium power c.w. e.g. communication links (≈1W)	Either IMPATT or Gunn diode. IMPATT preferred for higher power and high efficiency, Gunn device for lower noise
High frequency applications (>40GHz) e.g. communication links, parametric amplifier pumps, etc.	IMPATT for high power and high frequency. Gunn diode when the noise performance is more important than high power for frequencies up to 60 GHz

these sources can be used where high powers are required, and the diode is well suited to phased array combinations because it can be operated in an amplifier mode. In this configuration the radar beam can be steered electronically by varying the phase of each element in the array.

The pulsed Gunn-effect device is particularly suited to applications requiring very short pulses, down to 1ns duration, and operates up to much higher frequencies than the TRAPATT. It is undergoing increasing exploitation in the field of miniature radars for both military and civil applications where its simplicity of use is a great advantage.

The IMPATT oscillator is generally preferred to the Gunn diode in c.w. applications requiring high power and/or high efficiency. Examples of these are free-space microwave communication links and trunk waveguide communications at millimetre wave frequencies. At frequencies above about 70GHz the IMPATT diode is the only solid state microwave source available and is finding applications as pump sources in parametric amplifiers, high frequency communication systems and high definition radar and imaging systems.

The principal disadvantages of the IMPATT in comparison with the Gunn diode are the noise performance and the high bias voltage. The IMPATT and TRAPATT diodes are fundamentally noisier than the Gunn diode and this precludes their use for certain applications. The noise originates in the avalanche multiplication process which produces a jitter in the current pulse from cycle to cycle under large signal conditions. Cavity control is not sufficient to completely overcome this problem. At a given frequency, the bias voltage on the c.w. Gunn diode is considerably less than the bias required on an IMPATT oscillator and this favours the Gunn diode in airborne or other similar applications where power supply voltages are limited. The table below lists some of the current applications for solid state devices. In principle, any of the devices (both pulsed and c.w.) can be used for these systems but the Gunn effect device has found the widest use. Of these systems, the intruder alarm has made by far the biggest impact to date and is discussed below.

Military (also civil variants)	Industrial	Domestic and commercial
Electronic counter measures	Small movement detection	Intruder alarms
Missile guidance systems	Dimensional measurements	Satellite broadcasting
Missile fuses	Beam braking system	Small boat radars
Instrument landing systems	Proximity detection	Collision avoidance radars
Transponders	Velocity, flow, rotational measurement	Anti shop-lifting systems
Navigation beacons	Vehicle and baggage identification	Distance measurement (tellurometry)
Altimeters		Telemetry
Secure communications		Educational equipment
Ship docking radars		
Perimeter defence		
Man-pack radars		
Range measurement		

Intruder alarms

If an object moves in a microwave beam, a small amount of Doppler shifted radiation will be reflected from it. This Doppler shift can be detected, amplified and used to trigger an alarm. Several requirements dictate the features of the final system. To obtain a high Doppler signal the carrier frequency should be as high as possible, consistent with allocated frequencies. Two of the bands in use in Britain are at 10.687GHz ± 12.5 MHz and 13.7 GHz ± 300MHz. Overseas, other frequencies around the X-band region are in use. For an X-band system, Doppler frequencies of interest, generated by an intruder, usually lie in the region of 10 to 100 Hz. For instance, a man moving at 3 m.p.h. will generate a Doppler frequency of about 90Hz, as given by the formula $f = 2 \times$ velocity of the target $\times$ frequency of radiation/velocity of light. Some of the requirements on the transmitter for such a system are therefore:

1. The device must operate in the X- or J-band region generating perhaps 10-20mW – usually adequate for most applications with ranges up to about 100m.

2. The noise output must be as low as possible because this determines the safety factor in the system and hence the false alarm rate — a very important parameter as these systems are often linked by telephone to a police station or central monitoring point.

3. The devices must be long-lived.

4. The devices must be stable with regard to environmental changes such as temperature.

5. The device must be as low cost as possible consistent with the above and capable of giving reproducible performance for large quantities of devices.

A Gunn device mounted in a well-designed waveguide cavity satisfies all of these requirements. Other types of resonant circuit may be used e.g. two potentially attractive systems are Gunn devices mounted in either microstrip circuits or lumped circuits. These are extremely competitive with regard to size and perhaps cost but cannot compare with a waveguide cavity with respect to noise output and stability. This is a direct result of the low Q-factor of these systems compared with waveguides. A typical waveguide cavity could be expected to have a loaded Q-factor of around 500 whereas the corresponding figure for a microstrip circuit would be around 20. These systems would thus seem suitable for very short range intruder alarms or some other system not requiring particularly good electrical performance.

Some means must be used to detect the reflected microwave signal. The most sensitive method is to use a separate detector diode mounted in a separate cavity. A small amount of non-shifted signal is fed into the detector and this is mixed with the reflected signal to produce the Doppler signal. An amplifier of modest gain (10,000) is then used to give reasonable signal levels after which some form of signal processing circuit is used to reduce false alarm rates by making the system less susceptible to triggering from spurious objects such as flapping curtains, falling leaves, etc. A diagram of such a system is shown in Fig. 7.

A system with somewhat reduced performance, but which is simpler and cheaper, utilises the Gunn device itself as the detector element. This is done by inserting a reasonably large resistor between the Gunn diode and the

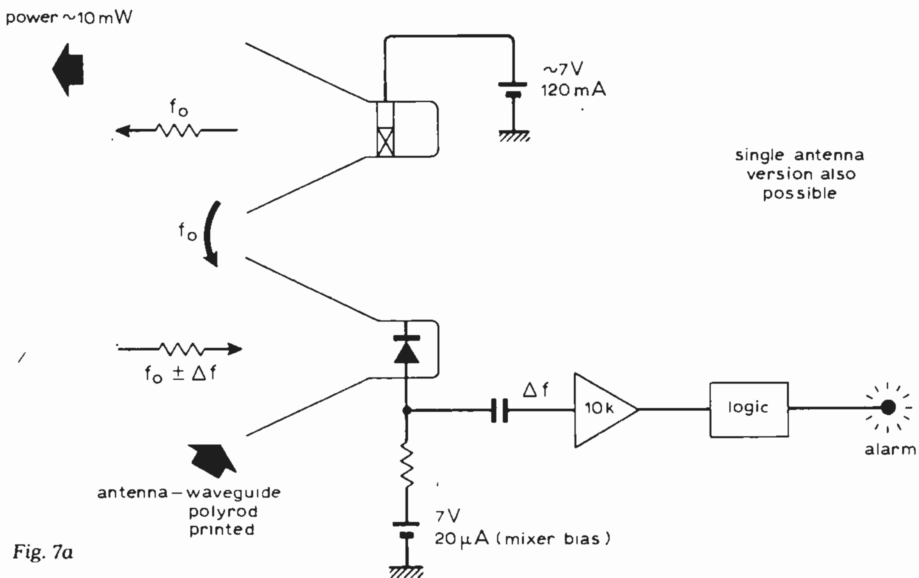


Fig. 7a

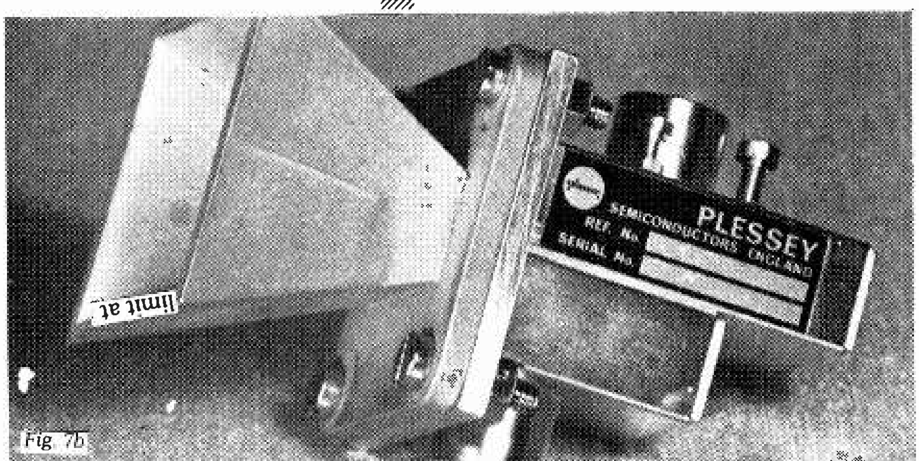


Fig. 7b

Fig. 7(a). Gunn diode intruder alarm system using a separate detector. (b) Typical transmit/receive module – normally used for ranges from 10 to 100m.

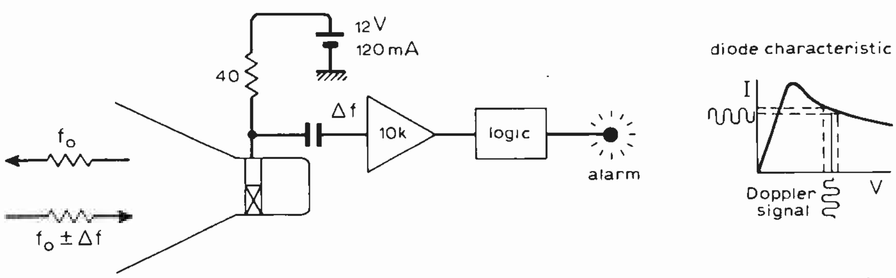
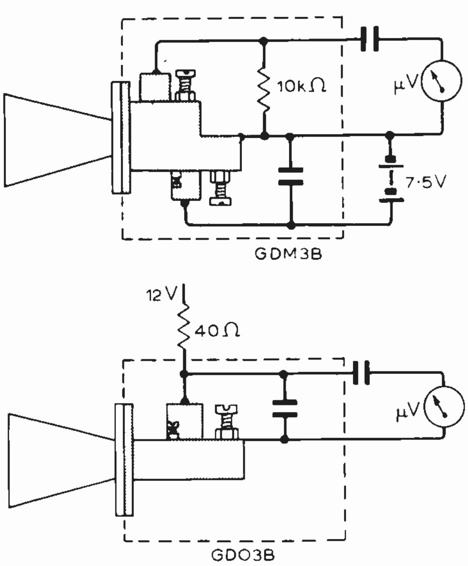


Fig. 8. Self-oscillating mixer alarm system. Due to a higher noise level and small signal from a moving object the circuit is only suitable for up to 10m.



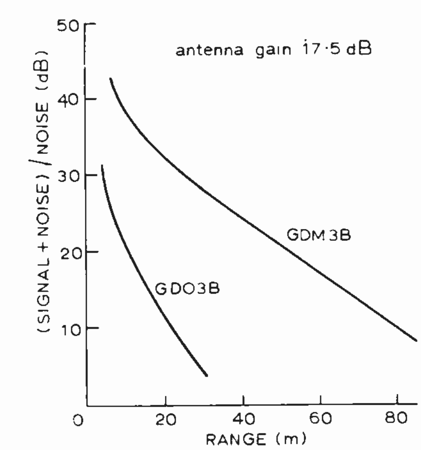


Fig. 9. (Signal + noise) / noise versus range of a self-oscillating mixer system and a separate-detector type using a man as the target, and the circuits used to obtain the range data.

constant voltage power supply. Any reflected signals modify the r.f fields in the cavity and modulate the current through the diode at the Doppler frequency. Because of the series resistor this is detected as a voltage fluctuation at the diode terminals. There are several requirements for such a self-mixing system:

1. The cavity Q-factor must be high to produce a large r.f. field across the diode from the reflected signals, and therefore modulate the current.
2. The Gunn device must have a large differential negative current voltage characteristic as this parameter determines the output.
3. The system noise is now determined by current fluctuations through the diode which must be minimised.

A waveguide cavity satisfies the first point and the n+ contact Gunn diode scores over the metal contact diode for the second and third points. A diagram of such a self-oscillating mixer system is shown in Fig. 8. The electronic circuitry is virtually identical to the first system, but has a somewhat higher noise level and produces a smaller signal from a given object. It is therefore, usable only for fairly short range systems of up to 10m, depending upon the antenna used. Shown in Fig. 9. is the (signal + noise)/noise output from the two types of system described as a function of range, using a man (radar cross section $\approx 0.5m^2$) as the target. The signal processing circuit can be as complex as the system allows. The circuit will usually include a notch filter to overcome problems of interference from fluorescent lights, and some form of pulse counting circuit so that several cycles of Doppler signal must be detected before an alarm is generated. This will reduce false alarms caused by spuriously generated signals of short duration. More sophisticated alarms use pattern recognition techniques so that they only respond to the characteristic return signal from a man. Intruder alarms using the microwave principles detailed above have been produced commercially in the U.K. since about 1968 and have now reached a very high level of manufacture. In Europe and the U.S.A. the commercial exploitation is roughly equivalent to that in the U.K. about two years ago.

Small radars utilising Gunn devices

The situation with pulsed Gunn devices is similar to that of c.w. devices — new applications rather than replacing existing devices — as the power levels are limited to a few tens of watts peak. Powers of around 100W peak can be obtained by combining several devices. A typical pulsed Gunn application is in the field of small radars, either for battlefield surveillance and patrol duties, or for small marine radars. Typical ranges are usually around 2-5km. A diagram of one type of microwave system in use in such a radar is shown in Fig. 10. The pulsed Gunn device is usually mounted in a waveguide cavity, the local oscillator device usually in a coaxial cavity incorporating a varactor diode which enables the frequency to be controlled electronically. This is used to maintain a constant i.f. over all operating conditions which reduces the bandwidth limitation on the i.f. amplifier. A complete radar system can be made small enough to be held and used in one hand. The information obtained by the radar may be given in the form of an audio tone, supplemented by a visual range indication. A photograph of a unit developed by the Royal Radar Establishment is shown in Fig. 11. In the case of marine radar the information may be displayed on a conventional cathode ray tube.

To date, the pulse devices are not in as common use as c.w. devices and most systems using them are of military origin. The potential market is immense, for instance, if a radar with the advantages of simplicity, small size and reliability could be made for a reasonable cost, the market could be in excess of 100,000 units. To a large extent the pulsed devices are analogues to the laser – a solution in search of a problem.

Acknowledgement
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Fig. 11. Small portable radar torch (SPRAT) in use. Photograph by courtesy of the Royal Radar Establishment who developed the unit.

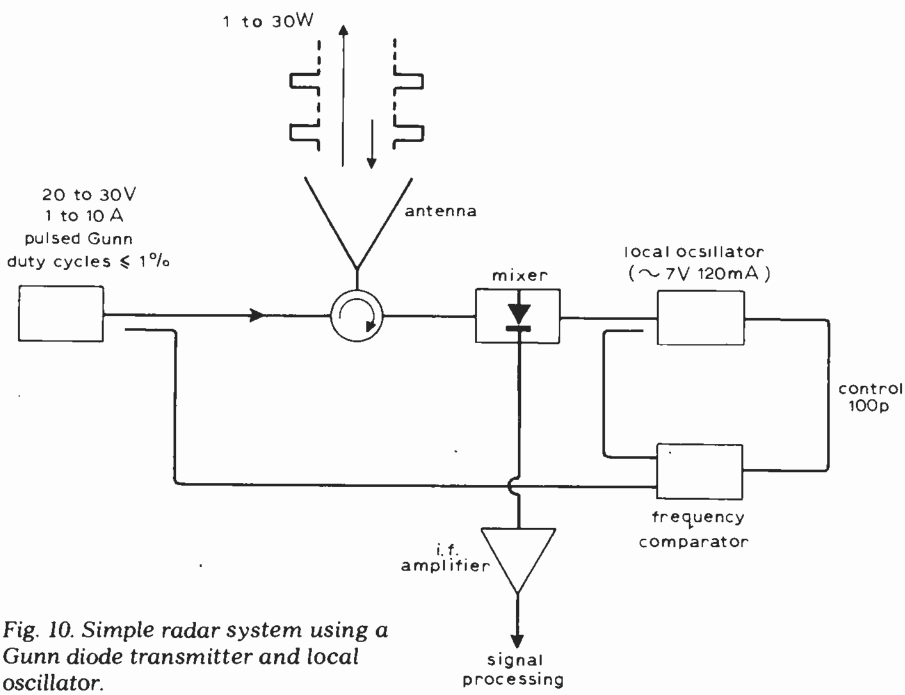
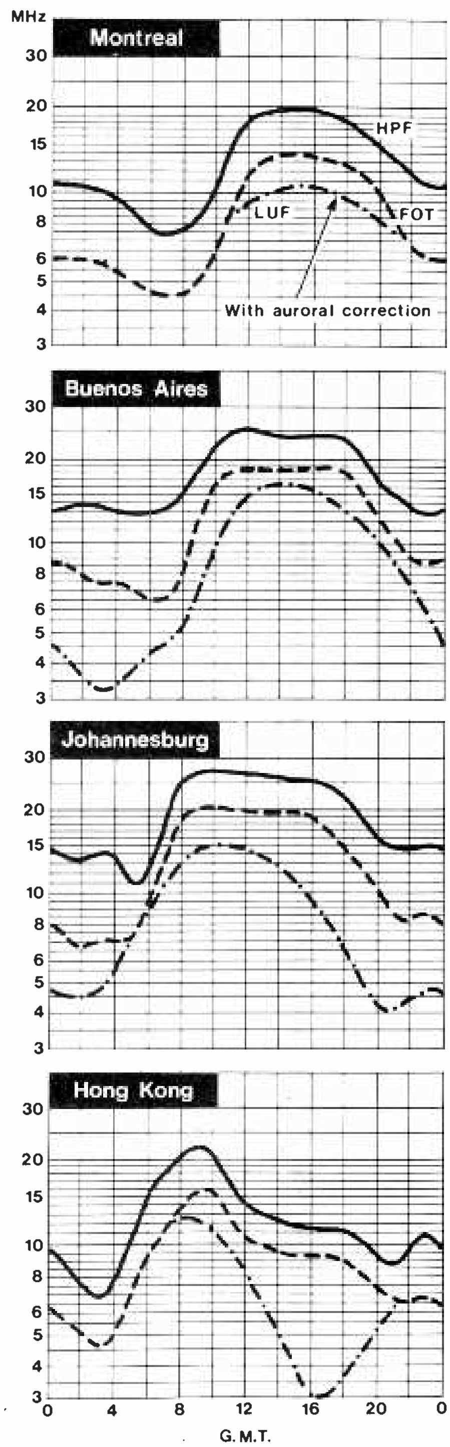


Fig. 10. Simple radar system using a Gunn diode transmitter and local oscillator.

HF predictions

The pattern of magnetic activity is now rather erratic and it is no longer possible to predict disturbed periods one or two months ahead with any confidence. From February 1974 until April 1975 there were two groups of days which were disturbed every solar rotation (27 days). That pattern continued until November 1975 but with the number of disturbed days in each group becoming fewer and fewer. Since August 1975 a new group has built up and its recurrence dates are around January 23 and February 19. Comparison with previous sunspot minimum periods suggests however that this new group will not persist and more notably that the next two years will have a minimum of magnetic and ionospheric disturbances.



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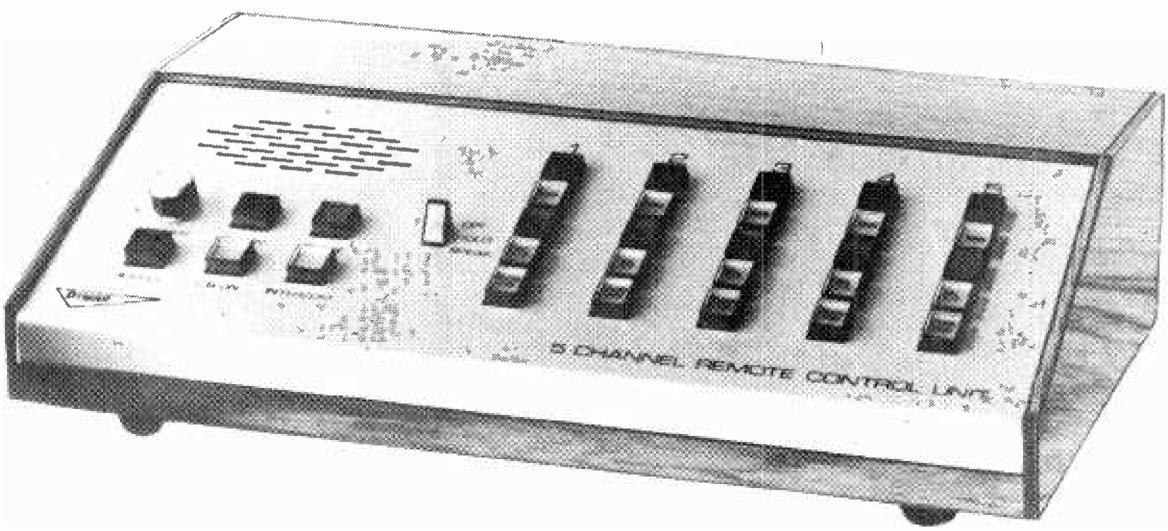

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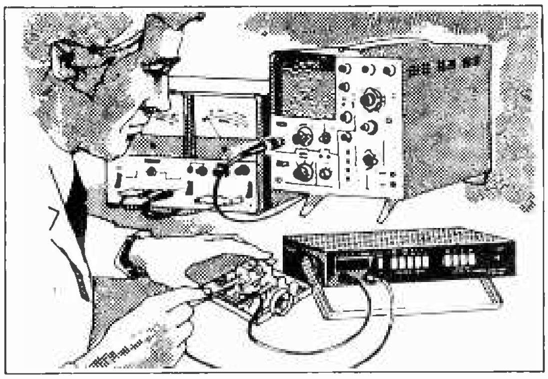

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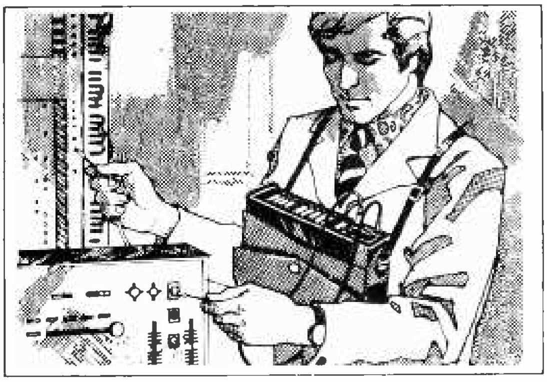

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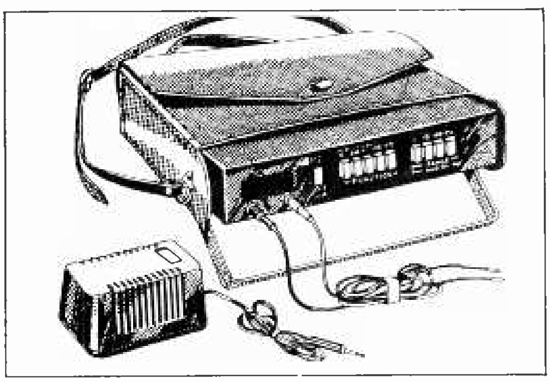

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10 V	1·0% ± 2 „	10 MΩ/40 pF	20 Hz–1 KHz
100 V	2·0% ± 2 „	10 MΩ/40 pF	20 Hz–200 Hz
1000 V	2·0% ± 2 „	10 MΩ/40 pF	20 Hz–200 Hz

Maximum overload – 300 V on 1 V range
500 V on all other ranges.

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Range	Accuracy	Input Impedance	Resolution
100 μA	2·0% ± 1 Digit	10 KΩ	100 nA
1 mA	0·8% ± 1 „	1 KΩ	1 μA
10 mA	0·8% ± 1 „	100 Ω	10 μA
100 mA	0·8% ± 1 „	10 Ω	100 μA
1000 mA	2·0% ± 1 „	1 Ω	1 mA

Maximum overload – 1A (fused).

AC Current

Range	Accuracy	Frequency Range
1 mA	1·5% ± 2 Digits	20 Hz–3 KHz
10 mA	1·5% ± 2 „	20 Hz–1 KHz
100 mA	1·5% ± 2 „	20 Hz–1 KHz
1000 mA	2·0% ± 2 „	20 Hz–500 Hz

Maximum overload – 1A (fused).

Resistance

Range	Accuracy	Measuring Current
1 KΩ	1·0% ± 1 Digit	1 mA
10 KΩ	1·0% ± 1 „	100 μA
100 KΩ	1·0% ± 1 „	10 μA
1000 KΩ	1·0% ± 1 „	1 μA
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DM6

How B&W pioneered the measurement of phase/impulse response

These measurements and oscillograms are, as far as we know, the first to be published anywhere in the world. They relate to two vital aspects of loudspeaker performance that have not been previously assessed: phase response and impulse response.

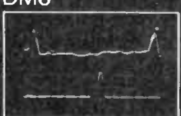
This breakthrough is a result of a major investment by B&W in entirely new measuring techniques and instruments in an area where accurate quantifications were previously thought to be prohibitively complex.

It is well known that 'square' or impulse waves are made up of a fundamental sine wave plus a harmonic series. Equally well-known is the fact that the amplitude of these harmonics must not only be correct but must also arrive in the correct phase or time if the desired wave shape is to be reproduced. It is this correction for phase or time in the design of the units, the crossover network and the physical placement of the units which enables the DM6 dramatically to improve the square or impulse waveform performance as set out below.

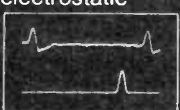
The 'third octave' room measurement is yet another meaningful method in assessing how well the balance of the DM6 conforms to the idealized curve shown.

Response to $\sin^2$ pulse of 0.33 ms half-amplitude duration.

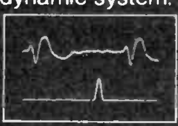
DM6



Full range electrostatic



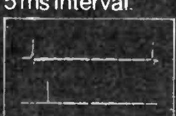
Normal 3-way dynamic system.



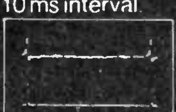
Impulse response of DM6.

Mid-frequency Squarewave

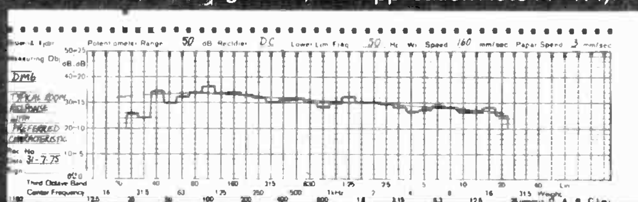
50 µs pulse at 5 ms interval.



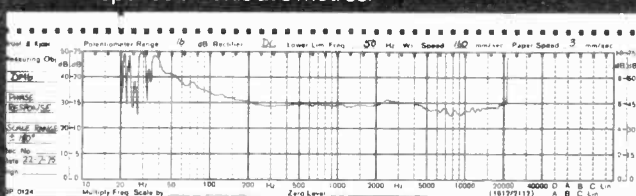
50 µs pulse at 10 ms interval.



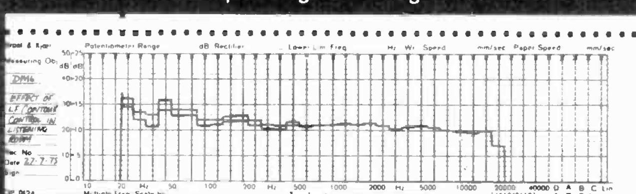
⅓rd Octave room response of system and optimum characteristic (from recommendation of "Relevant Hi-Fi Test at Home," Henning Møller, B&K Application Note 14-114).



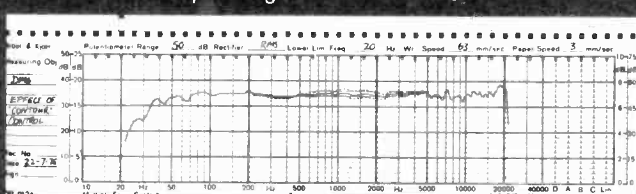
Phase Response on-axis at 3 metres.



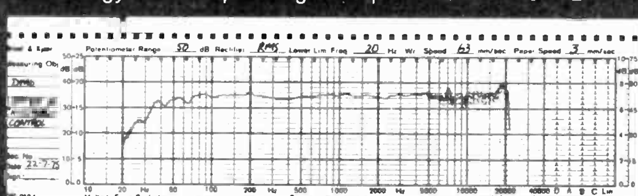
L.F. Contour Control Operating in listening environment.



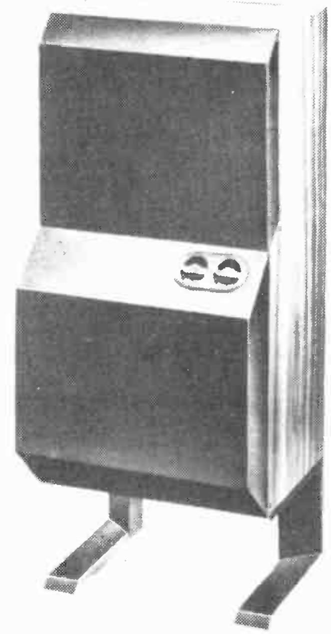
Contour Control operating between 500 Hz and 5 kHz.



H.F. Energy Control operating at frequencies above 5 kHz



New B&W DM6



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DM6 incorporates three entirely new drive units developed at the B&W factory.

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B&W Loudspeakers

Electronic circuit calculations simplified

7 — Active devices

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

Previous articles in this series have been devoted chiefly to calculations on inductors, capacitors and resistors and on combinations of these. Transistors and valves have been mentioned but the emphasis has been on methods of calculating the values of *L*, *C* and *R* necessary to give the required circuit performance. This article is devoted to calculations on the performance of the active devices themselves.

There are three main types of active device: the thermionic valve, the bipolar transistor and the field-effect transistor. Many of the properties of the f.e.t. are similar to those of the valve and it is possible to regard the f.e.t. as a valve without a filament or heater. Indeed f.e.ts are now being manufactured with characteristics very similar to those of certain valves so that these f.e.ts can be used as direct replacements for valves in old equipments: such f.e.ts are termed fetrons. Thus we are concerned only with two types of active device: the bipolar transistor and the f.e.t. We will deal with them in that order.

Basic common-emitter amplifier. Consider the simple common-emitter amplifier shown in Fig 1. The calculation of values of R_c suitable for a current output and a voltage output were given in Part 1: if the supply voltage is 9 and the mean collector current 1mA, R_c can be 8 kilohms for a current output and 4 kilohms for a voltage output. The problem is to calculate a suitable value for R_b. If β is the common-emitter current amplification factor (h_{fe}), then the mean value of the base current I_b is I_c/β. If β is 100 then I_b is 10μA. If the transistor is a silicon type there is a drop of 0.7V across the base-emitter junction and the voltage across R_b is therefore 8.3. Thus from Ohm's law:

$$R_b = \frac{8.3}{10 \times 10^{-6}} = 830 \text{ kilohms}$$

The calculation of a suitable value for C_b is dealt with in Part 5.

Bipolar transistors are inherently current-operated devices i.e. the curve relating collector current with base current is almost linear. Thus the amplifier of Fig. 1 would give a satisfactory performance for a current input. Provided R_c is large compared with the external load most of the signal-frequency collector current enters the external load and the current gain of the amplifier is only slightly less than β.

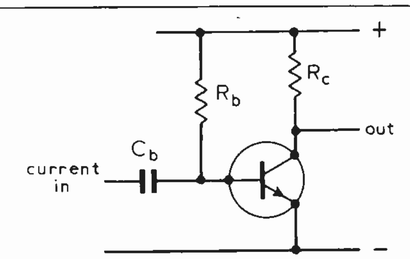


Fig. 1. Basic common-emitter amplifier. This circuit (and Fig. 2) have a number of serious disadvantages discussed in the text.

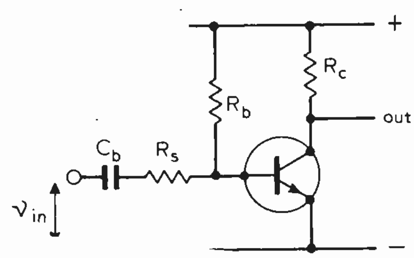


Fig. 2. The inclusion of the series resistor R_s enables the basic circuit to be used with a voltage input.

If, however, the performance of the circuit of Fig. 1 is measured with respect to the voltage applied between base and emitter, it is far from satisfactory: in fact the input-output characteristic is exponential in shape. The voltage gain is given by

$$\frac{v_{out}}{v_{in}} = g_m R_c \qquad (1)$$

The mutual conductance, g_m, of a bipolar transistor is generally much greater than that of a valve or f.e.t. and therefore permits very high values of voltage gain. For a bipolar transistor g_m is approximately 40mA/V for every milliampère of collector current. Thus if the mean collector current is 1mA, g_m is 40mA/V and if R_c is 5 kilohms, the voltage gain is given by

$$\frac{v_{out}}{v_{in}} = 40 \times 10^{-3} \times 5 \times 10^{3} = 200$$

This high gain is, however, accompanied by such poor linearity that the amplifier is unlikely to be used in practice except for signals of very small amplitude. The non-linearity is due to the variations in input resistance with input-signal amplitude and can be reduced by using a series resistor R_s (Fig. 2) large compared with the average value of input resistance so that input-resistance variations are swamped. For 1mA mean collector current an average value of input resistance is 2 kilohms so that a suitable value for R_s is 20 kilohms. The input current is now given approximately by v_{in}/R_s and is magnified β times in the transistor, giving an output current of $\beta v_{in}/R_s$ and an output voltage of $\beta v_{in} R_c/R_s$. Thus the voltage gain for the circuit of Fig. 2 is given by

$$\frac{v_{out}}{v_{in}} = \frac{\beta R_c}{R_s} \qquad (2)$$

For the typical practical values β = 100, R_c = 5 kilohms and R_s = 20 kilohms

$$\frac{v_{out}}{v_{in}} = \frac{100 \times 5}{20} = 25$$

a more modest gain but, of course, with a reasonable degree of linearity. It is significant that this gain and current gain of the circuit of Fig. 1 are both directly proportional to β.

Disadvantages of the basic amplifier. In practical versions of the circuits of Figs. 1 and 2 it is generally necessary to use a preset resistor for R_b and to adjust it empirically to give the required mean value of collector current. This is because the precise value of β is unlikely to be known. There is normally a tolerance of ±50% on the average value quoted by the manufacturer and therefore, for a nominal β of 100, values as low as 50 and as high as 150 are possible. This is a ratio of 3 : 1 and thus the value of R_b can also lie within a resistance range of 3 : 1. β also measures the gain of the circuit and this, too, can have any value within a range of 3 : 1. A third disadvantage of this basic circuit is that it has no means of stabilising the mean collector current. Thus the current could increase (for example as a result of a rise in temperature) and, for a germanium transistor, the increase could be sufficient to prevent normal operation of the circuit. Although it is possible to obtain a satisfactory performance from individual examples of the circuits of Figs. 1 and 2, these circuits are quite unsuitable where a number of amplifiers with similar performance are required. For mass production it is essential to have a circuit which will give a desired value of mean collector current, within a small tolerance, in spite of variations in β due to manufacturing spreads or due to temperature variations: this is known as d.c. stabilisation of the operating point. It is equally essential, of course, that all circuits should give the same signal-frequency performance in spite of manufacturing spreads and temperature variations. These two requirements are achieved by the use of negative feedback: a d.c. negative feedback circuit ensures that the mean collector current is determined by the values of passive components within the feedback loop and is thus independent of the transistor parameters. An a.c. negative feedback circuit similarly ensures that the gain and other aspects of the signal-frequency performance are also determined by passive components within a such a loop. Negative feedback has other advantages: for example it reduces distortion, so linearising the input-output characteristic and it makes possible desired values of input or output resistance. We shall now examine the negative feedback circuits commonly used and will show how d.c. stability and signal-frequency performance are related to the constants of the feedback loop.

D.c. stability. D.c. stability is ensured by using a negative feedback circuit in which any change in mean collector current produces a correcting change in base current. The collector current is passed through a resistor and the voltage generated across this is used as the source of base bias. Two commonly-used circuits are shown in Fig. 3. In (a) I_c flows through R_c and the voltage across R_c is used to drive current, through R_b, to the base. This is another way of saying that I_c splits at the junction of R_c and R_b: the current so fed back to the base is given by $I_cR_c/(R_c + R_b)$.

Let us attribute unwanted variations in I_c to a fictitious external input to the base of the transistor. This is a useful assumption because from it we can deduce that the factor by which negative feedback reduces unwanted variations in I_c is also the factor by which the d.c. gain of the transistor is reduced. This factor can easily be assessed as follows.

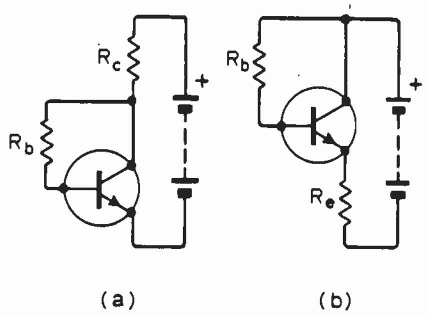


Fig. 3. Two fundamental methods of applying negative feedback to a bipolar transistor.

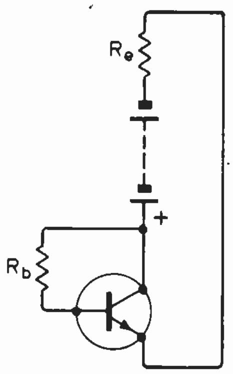


Fig. 4. Fig. 3 (b) redrawn to show its similarity to Fig. 3 (a).

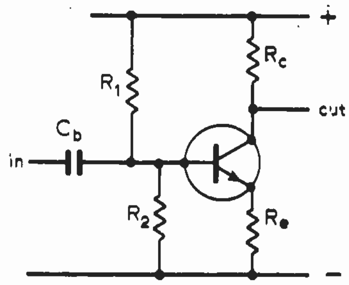


Fig. 5. Method of d.c. stabilising a transistor by a potential divider and emitter resistor.

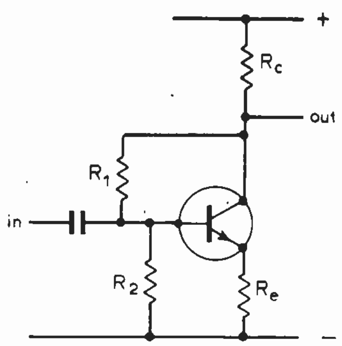


Fig. 6. Stabilising circuit based on a combination of the circuits of Figs. 3 (a) and (b).

In the absence of feedback a base current I_b gives rise to a collector current βI_b. The feedback current, as just shown, is a fraction of this and is given by $\beta I_b R_c/(R_c + R_b)$. As a result of this feedback the input current now required to give the same output current as before feedback was applied is given by

$$I_b + \beta I_b R_c/(R_c + R_b)$$

Formerly the input current was simply I_b. Thus the factor by which the d.c. gain of the transistor is reduced by feedback is

$$\frac{1}{1+\beta R_c/(R_c+R_b)}$$

and this is a direct measure of the factor by which variations in mean collector current are reduced by feedback. We can call this fraction the stability factor. Thus

$$\text{stability factor} = \frac{1}{1+\beta R_c/(R_c+R_b)}$$

Often R_b is large compared with R_c and we can say

$$\text{stability factor} = \frac{1}{1+\beta R_c/R_b}$$

The smaller the value of this fraction, the better is the d.c. stability of the circuit. For good stability $\beta R_c/R_b$ must be large compared with unity and the stability factor is then given approximately by the simple expression

$$\text{stability factor} \approx \frac{R_b}{\beta R_c} \qquad (4)$$

At first sight the circuit of Fig. 3(b) appears quite different from that of Fig. 3 (a). But if we redraw Fig. 3 (b) as in Fig. 4 we can see that the only way in which it differs from Fig. 3 (a) is in the position of the battery and as the battery is assumed to have negligible d.c. resistance this can have no effect on the behaviour of the circuit. Thus for the same values of R_b and provided R_e equals R_c, the two circuits of Fig. 3 have identical stability factors.

Practical circuits are usually based on Fig. 3 (b). There is usually little freedom in choosing a value for R_e because this is limited by the need to ensure a reasonable value of emitter current. Thus to achieve good stability R_b must be kept small. In practice the base of the transistor is often connected to a potential divider R_1R_2 as shown in Fig. 5 and R_b is then equal to the resistance of R_1 and R_2 in parallel. R_1 and R_2 are thus made as small as possible consistent with a reasonable drain current from the supply. The calculation of suitable values for R_1 and R_2 is given in Part 1 where one of the numerical examples has the following values:

$R_1 = 82$ kilohms; $R_2 = 30$ kilohms;
$R_e = 2.3$ kilohms.

For this example the parallel resistance of R_1 and R_2 is 22 kilohms and substitution of this and $\beta = 100$ in expression (4) gives

$$\text{stability factor} = \frac{R_b}{\beta R_c} = \frac{22}{100 \times 2.3}$$

$$= \frac{1}{10} \text{ approximately}$$

showing that variations in mean collector current are reduced to 1/10th of their unstabilised value e.g. a 50% increase in mean current is held, by this circuit, to 5%, a worthwhile improvement in stability.

Better d.c. stability can be achieved by combining the circuits of Figs. 3 (a) and (b). An example of such a combined circuit is given in Fig. 6 in which the base resistors are replaced by a potential divider R_1R_2 fed from the collector (not from the supply rail as in Fig. 5). High stability is possible from this circuit because both R_c and R_e contribute towards the stabilising process and the stability factor is therefore given by

$$\text{stability factor} = \frac{R_b'}{\beta R_c'} \qquad (5)$$

where
R_b' is the parallel resistance of R_1 and R_2'
R_c' is the sum of R_c and R_e.

The value of R_c' is fixed by the need to have an adequate value of collector current and a typical practical value is 5 kilohms. Let β be 100. From expression (5) the stability factor is now determined by R_b' which should be as small as possible to ensure high stability. In the circuit in the basic form shown in Fig. 6 it is unlikely that R_b' could be reduced below 20 kilohms: even this value of R_b' gives a stability factor of 1/25. There is, however, a two-transistor version of Fig. 6 which permits values of R_b' as low as 5 kilohms: this gives a stability factor of 0.01, an impressively low figure. This highly effective circuit is described later.

Signal-frequency performance. The two negative feedback circuits of Fig. 3 give d.c. feedback and, to be effective in stabilising mean collector current, reduce the d.c. gain of the transistor to a very low value. The negative feedback circuit, being purely resistive, also reduces the signal-frequency gain of the transistor to this same low figure. This reduction is, in general, undesirable and in Fig. 3 (a) can be eliminated by decoupling the mid-point of R_b to emitter but a simpler solution is to use the circuit of Fig. 3 (b) and to decouple R_e by a low-reactance capacitor. This leaves the d.c. stability unchanged and enables signal-frequency feedback to be applied by an independent negative feedback circuit.

It was shown that at d.c. Figs. 3 (a) and (b) are effectively the same circuit. This is not true at signal frequencies: this is shown in Fig. 7 which is a repeat of Fig. 3 but includes input and output terminals. At (a) R_b returns to the base a feedback current proportional to the output voltage. Such feedback reduces both input resistance and output resistance, so making the circuit suitable for use with a current input and a voltage output. The ratio of these two quantities is, in fact, equal to R_b and is thus independent of the transistor parameters. Thus, for the circuit of Fig. 7 (a):

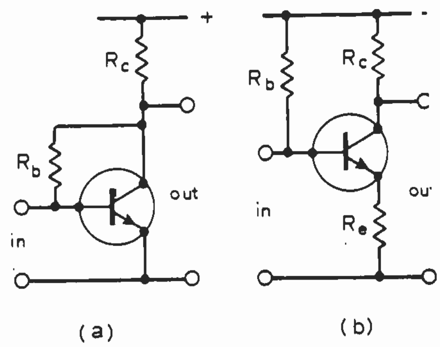


Fig. 7. A repeat of Fig. 3 but including input and output terminals to show that the circuits behave differently at signal frequencies.

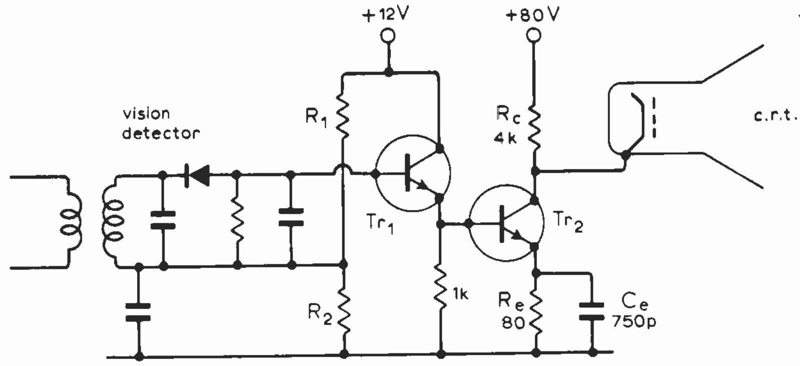


Fig. 8. A video amplifier based on the circuit of Fig. 7 (b).

$$\frac{v_{out}}{i_{in}} = R_b \qquad (6)$$

In Fig. 7 (b) R_e returns to the base-emitter circuit a voltage proportional to the emitter (and hence the collector) current. Such negative feedback increases both input resistance and output resistance, making this circuit suitable for use with a voltage input and a current output. The ratio of these two quantities is equal to $1/R_e$ and is thus independent of the transistor parameters. Thus, for the circuit of Fig. 7 (b):

$$\frac{i_{out}}{v_{in}} = \frac{1}{R_e} \qquad (7)$$

Video amplifier for television receiver. As a numerical example suppose the amplifier of Fig. 7 (b) is used to drive the cathode of a picture tube in a television receiver. Suppose that the tube requires a video input of 70V peak-to-peak value. The value of R_c to use is determined by the total capacitance shunting R_c, say 15pF, and the upper frequency limit of the video band, say 5MHz. The reactance of 15pF at 5MHz is approximately 2 kilohms and, as explained in Part 5, if R_c is also made 2 kilohms, the response will be 3dB down at 5MHz. If we make R_c 4 kilohms, the gain is doubled at low and middle video frequencies but the high-frequency loss is now 3dB at 2.5MHz and 7dB at 5MHz. This loss can, however, be offset by use of frequency-discriminating negative feedback and a value of 4 kilohms is suitable for R_c. If a video signal of 1.5V peak-to-peak is available from the vision detector to drive the amplifier then the amplifier requires a voltage gain of 70/1.5 i.e. approximately 50. The voltage gain of the amplifier is given by

$$\frac{v_{out}}{v_{in}} = \frac{R_c}{R_e}$$

which can readily be deduced from expression (7) by putting $i_{out} = v_{out}/R_c$. Thus

$$R_e = \frac{R_c}{50} = 80 \text{ ohms}$$

A common technique for maintaining the response at the upper end of the band is to shunt R_e by a capacitor which removes the negative feedback at high video frequencies. A simple way of determining the value of this capacitor is to equate the time constants in the collector and emitter circuits thus:

$$R_cC_c = R_eC_e$$

This gives

$$C_e = \frac{R_c}{R_e}.C_c = 50 \times 16\text{pF} = 750\text{pF}.$$

In a practical version of this amplifier provision must be made for ensuring d.c. stability and the obvious method is to use the 80-ohm emitter resistor in a circuit of the type shown in Fig. 5 but the low value of R_e introduces difficulties. From expression (5) it is clear that if R_e is 80 ohms then R_b' must not be very great compared with this to achieve good stability. In fact if $R_b' = R_e$ the stability factor is $1/\beta$ which represents excellent stability. R_b' is the parallel resistance of the two arms of the potential divider and it would be impractical to make R_b' much less than 1 kilohm. A solution to this problem commonly adopted in television receivers is to interpose an emitter follower between the potential divider R_1R_2 and the base of the video amplifier as shown in Fig. 8, direct coupling being used throughout. The value of R_b' is now effectively the output resistance of the emitter follower: this depends on the resistance in the base circuit of the emitter follower but in this example is probably of the order of 80 ohms, so permitting excellent d.c. stability in the vieo amplifier.

The emitter follower is also of value at signal frequencies because its high input resistance minimises shunting of the diode load. Because of the direct coupling between the detector and the video amplifier it is possible to arrange the standing voltages so that the amplifier is biased to cut off by black-level signals. This has the advantage that the amplifier can be operated from a supply only slightly greater than the required video output: in this example an 80-V supply is adequate. The emitter follower and potential divider can be fed from a lower supply voltage e.g. 12V.

The values of R_1 and R_2 can be calculated in the following way. The output from the detector is almost zero for white-level signals. For such signals 70V must be developed across R_c and therefore 1.5V across R_e. If both transistors are silicon there is an offset voltage of 0.7 between each base and corresponding emitter. Thus the voltage across R_2 must be $(1.5 + 2 \times 0.7)$ i.e. 2.9V. If we assume a bleed current of 0.5mA in the potential divider then Ohm's law gives R_2 as 5.8 kilohms. If the potential divider supply is 12V then R_1 must be 18.2 kilohms. It would be an advantage to make R_1 or R_2 preset so that it can be adjusted to secure correct operating conditions in the video amplifier.

Two-stage voltage amplifier. The basic circuits of Fig. 7 can be combined to form a two-stage amplifier in two ways. If the first stage is of type (a) and the second stage of type (b), the resulting amplifier has a low input resistance and a high output resistance, making it suitable for current amplification. If, however, the first stage is of type (b) and the second stage of type (a), the resulting amplifier has a high input resistance and a low output resistance, making it suitable for voltage amplification. We will consider the design of such a voltage amplifier.

The basic form of the amplifier is

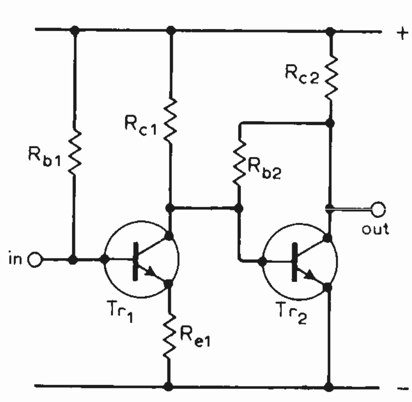


Fig. 9. Basic form of two-stage direct-coupled voltage amplifier.

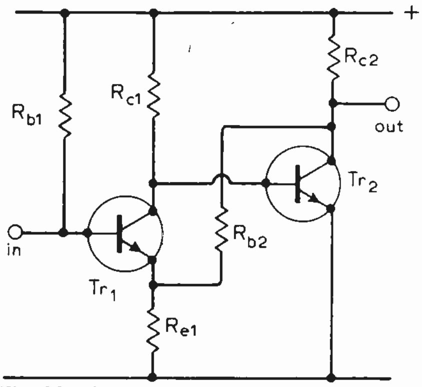


Fig. 10. This alteration to the position of R_{b2} makes little effect on the performance of the circuit.

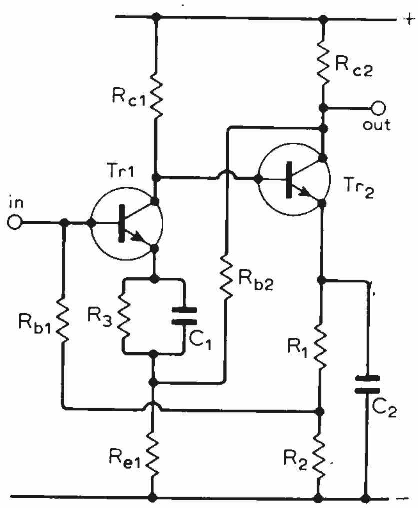


Fig. 11. Final form of the circuit of the two-stage voltage amplifier.

shown in Fig. 9 in which direct coupling is employed between the stages. The output current of Tr_1 is the input current of Tr_2 and by eliminating the terms in i between expressions (6) and (7) we have

$$\frac{v_{out}}{v_{in}} = -\frac{R_{b2}}{R_{e1}} \quad \ldots\ldots\ldots\ldots (8)$$

It is more usual to connect R_{b2} to the emitter of Tr_1 than to the base of Tr_2 and the circuit then has the form shown in Fig. 10. This change makes no fundmental difference to the performance of the amplifier because the feedback current injected into Tr_1 emitter by R_{b2} emerges from the collector and enters Tr_2 base with little loss. But it is clear from Fig. 10 that R_{b2} and R_{e1} constitute a potential divider across the amplifier output and so determine the voltage gain of the amplifier as mentioned in Part 1 and as indicated in expression (8). Signal-frequency feedback is thus provided by R_{b2} and R_{e1}. We now have to provide d.c. negative feedback to stabilise the mean collector currents of the two transistors.

It was mentioned earlier in this article that a most effective method of d.c. stabilisation is possible using a potential divider connected to the collector of the transistor, the base being fed from the tapping point. This method can readily be applied to the circuit of Fig. 10: all that is necessary is to put the potential divider R_1R_2 in the emitter circuit of Tr_2 and to return R_{b1} to the tapping point as shown in Fig. 11. D.c. stability then depends on the resistance in Tr_1 collector and emitter circuits and can be increased by the addition of R_3 in the emitter circuit. Decoupling capacitors C_1 and C_2 are required to eliminate the signal-frequency feedback which would otherwise result from R_1, R_2 and R_3. We will now calculate the values of the resistors required in a typical application of this circuit.

Before the calculations can be performed certain characteristics of the amplifier must be known or decided. For example suppose that the supply voltage is 15, that a voltage gain of 100 is required, that the amplifier must be capable of supplying an output signal of 3V amplitude and that the input resistance must be at least 50 kilohms. We must now decide the mean collector currents of the transistors. Here we may choose values giving maximum values of β or minimum noise. Let the current for Tr_1 be 0.3mA and for Tr_2 1mA. One more decision is necessary before calculation can begin and a convenient choice to make is that of Tr_2 emitter potential. Let us make this 6V. Ohm's law immediately gives the total emitter resistance for Tr_2 as 6 kilohms so that R_1 and R_2 can be 3 kilohms. To enable Tr_2 to deliver the required output voltage we can make R_{c2} 4 kilohms so that positive and negative collector voltage swings of 4V amplitude are possible. If Tr_2 is a silicon transistor its base potential is 6.7V, i.e. 0.7V above emitter potential. This is also Tr_1 collector potential. The voltage across R_{c1} is thus (15 – 6.7), i.e. 8.3 and because the mean current is 0.3mA, Ohm's law gives the value of R_{c1} as 28 kilohms. If the voltage drop across R_{b1} due to base current is neglected, Tr_1 base potential is 3V. If Tr_1 is a silicon transistor its emitter potential is thus 2.3 V, giving the total emitter resistance as 8 kilohms. We can thus make R_3 7 kilohms and R_{e1} 1 kilohm. To give the required voltage gain R_{b2} must be $100R_{e1}$ and is hence 100 kilohms.

The input resistance of the amplifier is made up of R_{b1} paralleled by the input resistance of Tr_1 which, by virtue of the feedback due to R_{b2} and R_{e1}, is very high. Thus the amplifier input resistance is effectively equal to R_{b1} which can be made 50 kilohms as required.

R_{e1} and R_{b2} determine the gain of the amplifier and should be narrow-tolerance components but this is not necessary for the other resistors provided that one of them (R_3 is suitable) is made preset so that it can be adjusted to secure correct operating conditions in the amplifier.

The stability factor for the amplifier is given by expression (5) in which R_c' is the sum of R_{c1}, R_{e1}, R_3 and R_b' is R_{b1}. Substitution of these values and $\beta = 100$ gives the stability factor as 1/72 representing a very high degree of stability.

Field-effect transistors. Fig. 12 illustrates the simplest form of single-stage f.e.t. amplifier. The value of the load resistor R_d depends on whether an output current or voltage is required and can be calculated as described in Part 1. Bias is applied from a source of suitable voltage V_g via R_g and because an f.e.t. requires no gate current R_g can be made any value up to say 100 megohms without effect on the performance of the circuit. The ratio of output current to input voltage is the mutual conductance g_m of the transistor, one of the parameters quoted by the manufacturer: a typical value is 2mA/V, the same order as for a valve.

The voltage gain of the simple amplifier is given by

$$\frac{v_{out}}{v_{in}} = g_m R_d$$

and, as for the current output, is proportional to the value of g_m for the particular transistor used. The mean value of drain current also depends on the particular transistor used and can easily be so far from the desired value that the required performance cannot be obtained. Satisfactory results can be obtained from individual circuits of the type shown in Fig. 12 but to obtain them it is usually necessary to adjust the bias voltage. This difficulty stems from the fundamental property of the simple biasing circuit that it fixes the gate voltage and not the mean drain current or the mutual conductance.

Thus as for bipolar transistors practical f.e.t. circuits require a biasing circuit to give a desired value of mean drain current and d.c. negative feedback to maintain this current in spite of variations in transistor parameters. Signal-frequency feedback is also necessary to give the required signal-frequency performance and to maintain this in spite of variations in parameters.

As for bipolar transistors enhancement-type f.e.ts require a gate bias voltage between that of the drain and that of the source: it is thus possible to use the d.c. biasing and stabilising circuits described earlier in this article. For example we can use the circuit of Fig. 3 (a): Fig. 13 shows an n-channel i.g.f.e.t. so stabilised. The stability factor is given by

$$\text{stability factor} = \frac{1}{1 + g_m R_d} \qquad (9)$$

and is independent of the value of R_g which can thus be made very high. If g_m = 2mA/V and R_d = 5 kilohms, both typical practical values, the stability factor is 1/11.

In the basic form of Fig. 13 the circuit has the disadvantage that R_g gives signal-frequency feedback but this can be eliminated by constructing R_g of two resistors in series and by decoupling their junction to source as shown in Fig. 14. R_{g1} and R_{g2} can be made equal and each may be several megohms, so retaining the chief feature of the f.e.t., its high input resistance.

For depletion-type f.e.ts the gate bias voltage lies outside the range of the drain and source voltage: this is also true of valves, of course, and the biasing circuit used for valves can also be used for depletion-type f.e.ts as illustrated in Fig. 15. The method of calculating the value of the bias resistor was described in Part 1. The stability factor is given by expression (9) by substituting R_s for R_d. Typical practical values are g_m = 2mA/V and R_s = 1 kilohm for which the stability factor is 1/5. Better stability can be obtained by using the potential divider circuit (Fig. 5) which enables higher values for R_s to be employed. The potential divider circuit can also be used with enhancement-type f.e.ts.

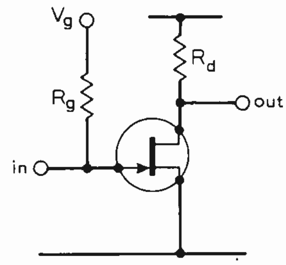


Fig. 12. Simplest type of f.e.t. amplifier which has a number of disadvantages.

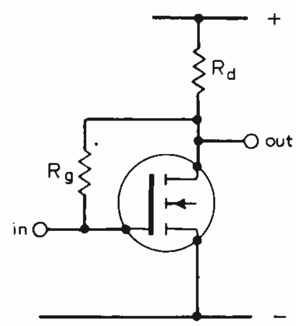


Fig. 13. Basic circuit for d.c. stabilisation of an enhancement type f.e.t.

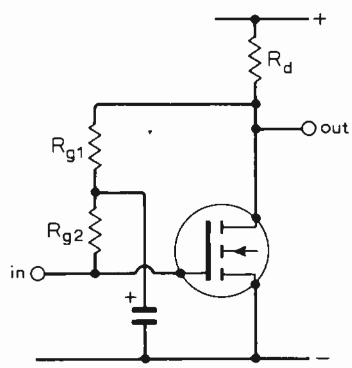


Fig. 14. Method of eliminating signal-frequency feedback in the circuit of Fig. 13.

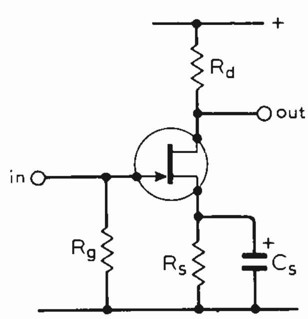


Fig. 15. Method of biasing and d.c. stabilising a depletion-type f.e.t.

Corrections

"Crossover networks and phase response", Nov. 1975 issue, p.531. The figures over the captions Fig. 5 and Fig. 6 should be interchanged. The filter proposed by Small is a modified fifth order filter, with final slopes corresponding to a third order filter.

"What's in a name?", Jan. 1976 issue, p.47. In the first column, the sentence beginning 23 lines from the the bottom should read: "So it could hardly be more wrong to choose this word to mean a progressive voltage change in an unchanging direction . . ."

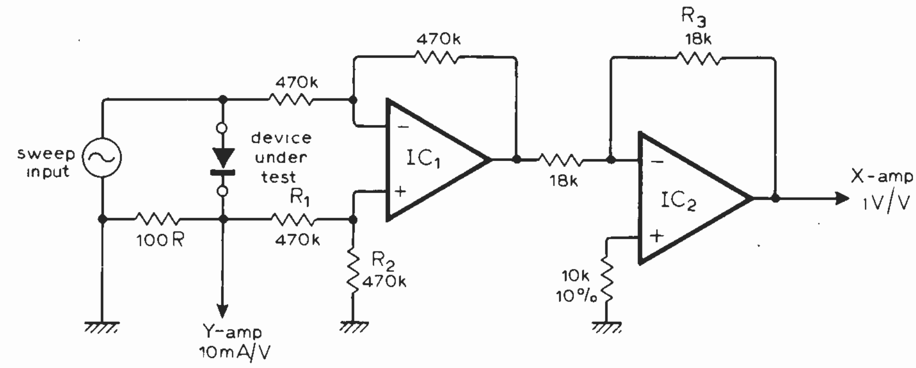
Schottky clock oscillator integrated circuit, type CO-238, mentioned in New Products, Nov. 1975 issue, p.548, will operate up to 100MHz, not 1,000MHz as stated.

Circuit Ideas

Diode curve tracer for oscilloscope

This circuit is designed to show the I/V characteristics of two-terminal devices on any oscilloscope which has an external X input. The sweep input can be any low voltage signal source, such as a 20V Variac. Current is monitored across the 100Ω series resistor, at a sensitivity of 10mA/V. This resistor also helps to limit the current. The floating device-voltage is monitored with a differential circuit and inverted with IC_2. When a device is reverse biased the current flowing through the monitor is approximately that through R_1 and R_2 plus the op-amp (741) bias current. If the oscilloscope X input has no amplifier, voltage sensitivity may be varied with R_3. Three terminal devices such as unijunction transistors may be traced if an external bias is provided. Maximum voltage across the device, which is the op-amp saturation voltage, may be increased by reducing the gain of IC_1.

S. Cahill,
Ulster College, Northern Ireland Polytechnic.



Simple c.r.o. input isolating probe

In many c.r.o. applications it is desirable to connect the Y deflection input to a p.d. that is floating with respect to the c.r.o. frame or earth. In some cases it is possible to float the c.r.o., but this is usually considered bad practice and may be potentially dangerous. Alternatively, it may be possible to float the circuit under test. However, neither of these expedients will solve the problem when one wishes to display simultaneously, with correct polarity on a double beam c.r.o., two p.ds, one of which may be referenced to earth whilst the other is floating.

The circuit shown overcomes such problems by the use of optical coupling between the floating test p.d. V_i and the c.r.o. input V_y.

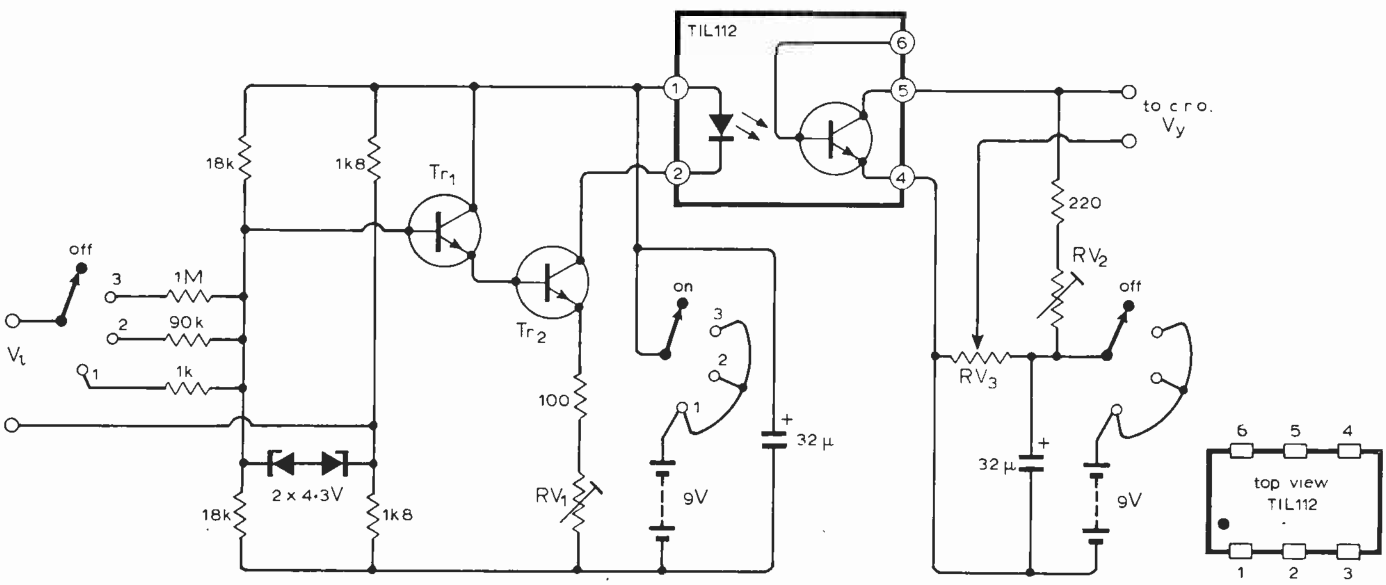
Two separate 9V batteries are used to power the input and output sides of the circuit, either or both of which may be earthed at any point to suit the test requirements. An inexpensive Texas i.c. opto-coupler is used and, in this circuit, has a bandwidth of about 30 kHz. A four-way switch gives three ranges and an off position.

Range 1 gives 1:1 transmission with an input resistance of 10kΩ and up to 2V peak-to-peak input.

Range 2 gives 10:1 attenuation, an input resistance of 100kΩ and up to 20V peak-to-peak input.

Range 3 gives 100:1 attenuation, an input resistance of 1MΩ and up to 200V peak-to-peak input. Two 4.3V zener diodes provide input protection. Initial setting up is as follows: Set RV_1 and RV_2 to give unity V_y/V_i on range 1. RV_2 should have a final value such that the output circuit phototransistor is biased to the centre of its linear range – about 4.5V between pins 4 and 5 of the i.c. RV_3 can be set to give zero d.c. output when the input terminals are shorted. This component is not essential and can be omitted if zeroing of output level is not needed. Assembly and layout are not critical but care must be exercised to preserve isolation between input and output sides of the circuit.

A. F. Sargent
Carshalton
Surrey

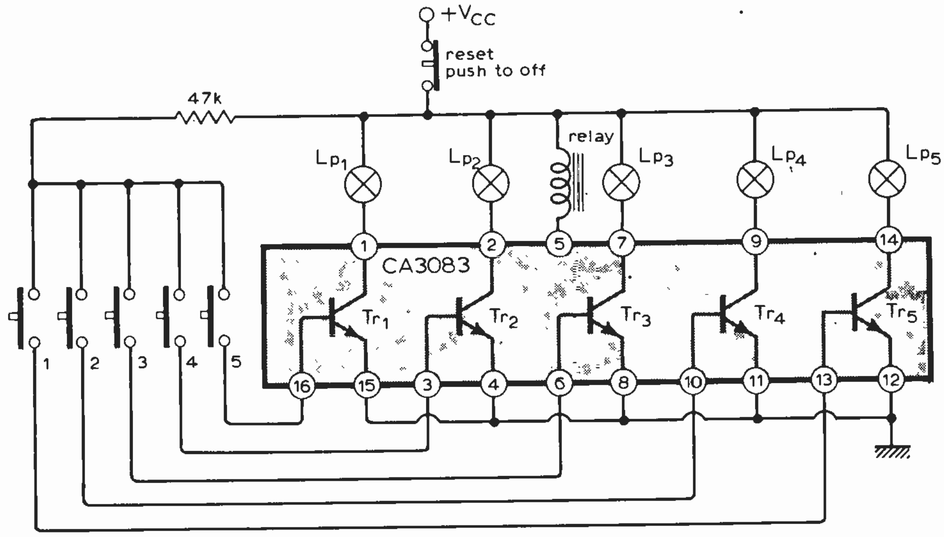


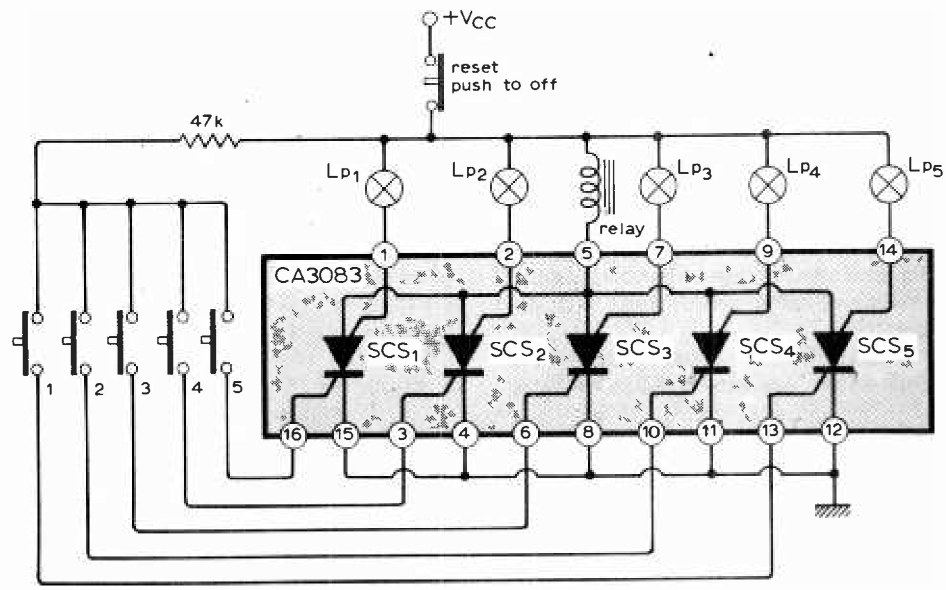
Alarm system with position indication

This application takes advantage of the p-n-p-n structure in the CA3083 transistor array i.c. which contains five n-p-n devices with separate substrate connection. The p type substrate and n-p-n structures of the transistors are utilised as p-n-p-n switches with common connection for anode (substrate). Thus, the transistor array is converted into a silicon controlled switch array. A relay forms the anode load and will be actuated if any of the s.c.s is triggered. By using five lamps in the circuit as shown, visual indication of the actuated channel is provided. Triggering sensitivity of the circuit is high and human touch will actuate the s.c.s. Alarm and visual indication will remain unless the circuit is reset.

Advantages of this circuit are miniaturization and low power consumption. In normal operating conditions, the s.c.s. will act as an open circuit. Use of dry battery cells makes the device small and portable. The number of channels can be increased by using two or more transistor arrays.

H. S. Kothari,
Central Electronics
Engineering Research Institute,
India.



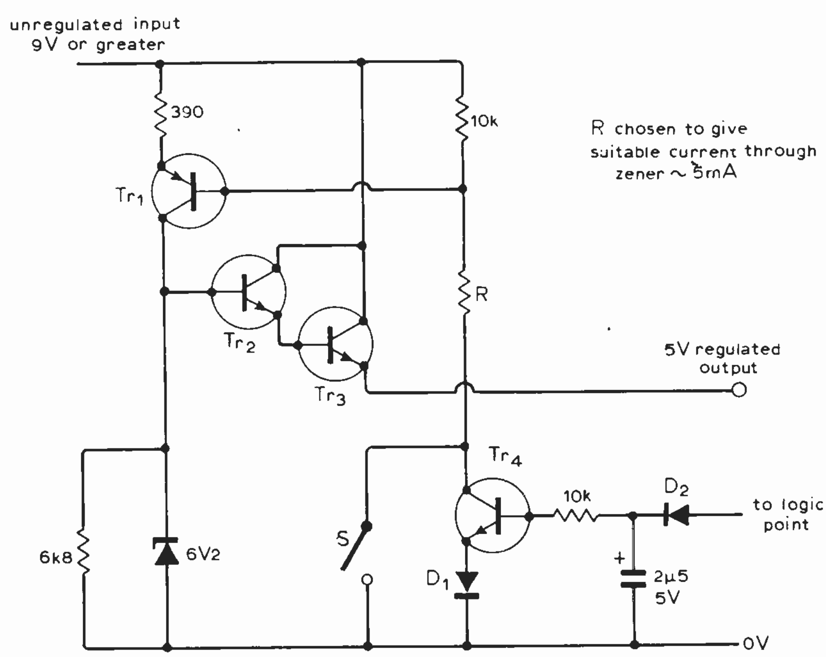


Automatic switch-off power supply

This power supply was designed to operate a digital exposure timer constructed from t.t.l. circuits. Because the logic is required only when the enlarger lamp is on, it was decided to automatically switch off the power supply when on standby. The supply to the t.t.l. circuits is turned on by closing the switch at the same time as the timing cycle is activated, which sets the timer output to 5V and turns on the lamp. Diode D_2 is also connected to this logic point and the power supply remains on when the switch is released. When the timer output goes low and the lamp is extinguished, gate current to Tr_4 is cut off which switches off Tr_1 and removes the current supply from the zener diode. The supply voltage therefore drops to zero.

This circuit is applicable to all uses where the logic is required for only part of the time, which allows a smaller transformer to be used to reduce weight and cost.

E. R. Rumbo,
Acton,
Australia

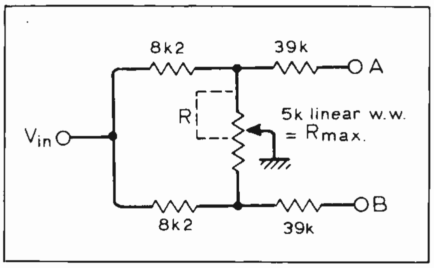


Single gang pan-pot

The use of a single-gang linear potentiometer as a balance control is well known. Shown here is a simple pan-pot for stereo audio mixers using the same technique. The circuit was designed to give the best approach to a sine law so that $A^2 = B^2$ is a constant, whatever the position of the wiper. The output was normalized at 90° (potentiometer at maximum) so:

$$\text{error } E = 20 \log \frac{A/A_{max}}{\sin(90 \times R/R_{max})}$$

is 0dB at $R = R_{max}$



The calculated error for the circuit is less than 1dB over the full range of the potentiometer. The input impedance, about 5kΩ, is constant within 10% over the same range $A_{max} = 0.35V_{in}$.

If zero error at 45° (signal panned to centre) is required and some deviation from the sine law can be tolerated, the 5kΩ should be changed to 10kΩ which gives $A_{max} = 0.49V_{in}$. Clearly for higher input impedances all the values may be multiplied by a constant. Outputs A and B are virtual earth summing points and the potentiometer should be wire-wound for minimum cross-talk. In practice there is no audible change of level as the image is panned.

J. Dawson,
K.J.E. Northover,
D. C. Threlfall,
Cambridge University Tape Recording Society.

Pulse generator

This pulse generator was designed to provide clock pulses of variable width and p.r.f. for t.t.l. circuits at a relatively low cost. It uses a versatile 74123 dual monostable i.c. which can be triggered from a positive or negative going edge and can be cleared or re-triggered if desired. The pulse width is determined by an external CR combination, the recommended maximum and minimum resistance being 50kΩ and 5kΩ respectively.

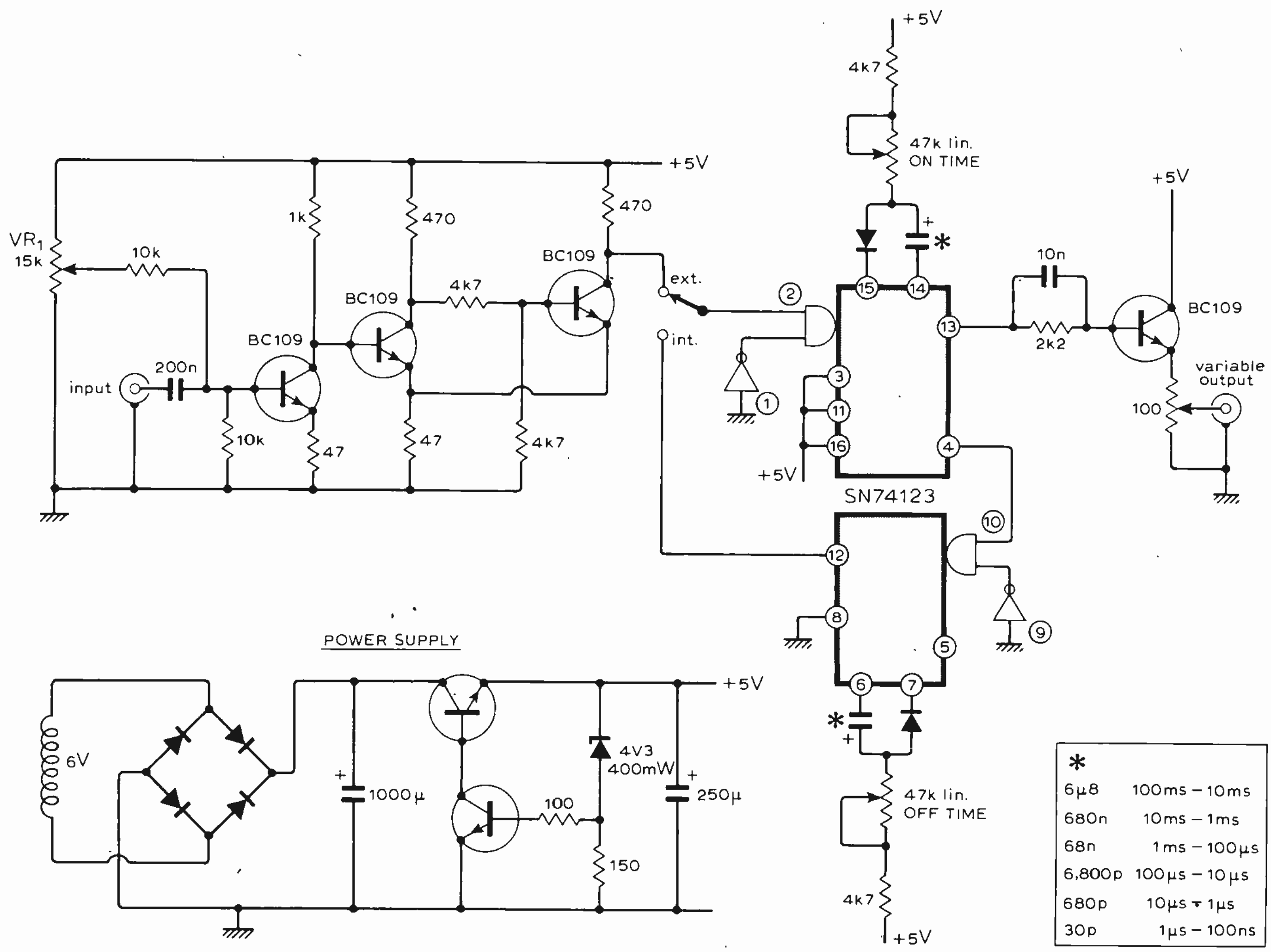
With the switch set to "internal," the monostables are connected in an astable configuration with each monostable being on for its own time period and off for that of the other monostable. The output is taken from an emitter-follower for low output impedance. The on time of each monostable is determined by its variable external resistor and one of a bank of six capacitors, giving on or off times between 100ms and 100ns. Therefore, it is not possible, as with some pulse generators, to set the pulse width greater than 1/p.r.f. — which gives no output.

With the switch in the "external" position the on-time monostable is driven by three transistors arranged as a Schmitt trigger. This gives a pulse of the same frequency as the input waveform, the pulse width being determined by the on-time variables. Potentiometer VR_1 determines the trigger level.

The circuit of a suitable power supply is shown.

Performance is above expectations, but wire lengths must be kept to a minimum if good pulse shapes are to be obtained at the highest frequency.

J. Garrett
Dublin
Eire



*	
6μ8	100ms – 10ms
680n	10ms – 1ms
68n	1ms – 100μs
6,800p	100μs – 10μs
680p	10μs – 1μs
30p	1μs – 100ns

World of Amateur Radio

Long-delay echoes

Despite the many apparently authentic reports of long-delayed echoes being received on h.f. in the period 1928-1938, a project carried out at the Cavendish Laboratory in 1973 by Peter Duffett-Smith, G3XJE, completely failed to detect any such echoes in the course of more than half-a-million automatic transmissions on 7, 9 and 20 MHz. But now new evidence — and a possible explanation — is put forward in a 245-page report, "Long delayed radio echoes" by D. M. Sears of Stanford University, who in a five-year period has obtained tape recordings that, although none reproduces exactly the transmitted signal, exhibit features which the author states "seem unlikely to have been generated except by an l.d.e. mechanism".

Sears and Crawford at an URSI symposium in Peru last August suggested that these curious echoes are due to very low group velocity (1 km/s) propagation effects near the peak of the F-layer. It is proposed that very weak fluxes of kilovolt energy electrons could cause delays of several seconds.

But this remains a Loch Ness monster of h.f. radio — the early records of "sightings" were clear and specific, yet intensive investigations since 1969 have failed to come up with a single incontrovertible recording!

National societies

In an era where many amateur radio societies are facing acute financial problems there has been surprisingly little questioning of the fundamental issues. As became clear at the recent annual general meeting of the RSGB — where members voted overwhelmingly in favour of giving the Society's council full power in determining subscription rates — most amateurs accept the need for professionally administered societies providing a full range of services to members.

But Pierce Healy, VK2APQ, writing in *Electronics Australia*, raises basic issues in questioning "what future is there for amateur radio societies?" He points out that the societies were formed and flourished as the result, almost entirely, of voluntary efforts on the part of the members: the "Wireless Institute of Australia", the oldest - established amateur radio society, being no exception. But during the past few years WIA has come to depend on executive staff, computerised membership records and a professionally produced journal. One result has been that rising subscriptions have reduced the percentage of Australian amateurs who belong to WIA from 54 to 50 per cent, and this process may be accelerated by a projected major increase in subscription rates.

Pierce Healy suggests that increasingly the amateur societies will be faced with only two possibilities: a membership willing to pay for high-cost tasks carried out on their behalf; or reversion to "the tried and proven voluntary effort system". The latter course, which he clearly favours, would be more economical but requires dedicated volunteers.

With thoughts increasingly turning to the next frequency conference in 1979 there is clearly a vital need for strong and effective societies, but he considers that unless high-cost amateur societies are willing to see themselves representing only a minority of amateurs in their own countries, they must depend for much of their effort on volunteers.

Notes and news

The Home Office has stated that it intends to undertake a review of the British amateur licence "when staffing time permits".

Colin Thomas, G3PSM, (73 Mexborough Avenue, Leeds LS7 3ED) who organises the "intruder watch" has asked for help from r.t.t.y. enthusiasts (whether amateur transmitters or listeners) in systematically checking and identifying non-amateur radio-teleprinter transmissions in exclusive amateur bands. The proposed "GB2ATG" weekly r.t.t.y news bulletin transmission is still awaiting final Home Office approval and licensing.

A 432.91 MHz amateur beacon station, GB3EM, has been installed in the country's highest room — the enclosed room near the top of the IBA's concrete television aerial support tower at Emley Moor, near Huddersfield, Yorkshire. A modified all-semiconductor Pye transmitter provides 10 watts output to a J Beam "8 over 8" aerial beaming 170° ETN (i.e., a direction slightly east of London). The aerial is mounted on the roof of the room almost 900 ft above ground and over 1700 ft above sea level, keeping transmission line losses to a minimum. The automatic keyer has been built by A. Robinson, G3TQA, on behalf of the Bradford University amateur society. Beacon keeper is H. P. Bottom, G8DHD, a member of IBA staff at Emley Moor.

Dr J. A. Saxton, director of The Appleton Laboratory, has accepted an invitation by the RSGB Council to become an Honorary Member. Dr Saxton was President of the society in 1970 and again in 1973.

The RSGB are proposing three n.b.f.m. simplex channels in the 70 MHz band, 70.5 MHz as calling channel and 70.475 MHz and 70.525 MHz as working channels.

In conjunction with representatives of a number of local societies concerned with repeater stations, the RSGB has formed a "repeater working group" and the Home Office has confirmed that the Society should provide an overall plan for the installation and operation of v.h.f. and u.h.f. repeaters in the U.K. and to be responsible for monitoring their operation.

An echo of the thirties

One of the oldest-established brand names in amateur radio — at one time the "world's largest builders of amateur communications receivers" — has recently changed hands: Hallicrafters amateur and citizen-band equipment will in future stem from Breaker Corporation of Arlington, Texas. The original Hallicrafters company of Chicago launched the "Super Skyrider" receiver in January 1935 and within a few years were producing a whole series of "Sky . . ." receivers. Many British amateurs used the Sky Buddy (selling in the U.K. for about £9) or the higher performance Sky Champion, which boasted an r.f. stage, in the years immediately before World War II.

A recent note from the Rev. Arthur Trewin, ZS5AX, of Durban, South Africa, mentions that although now 91 years old he is still active on the amateur bands. Formerly VQ5NTB, G2AT and ZS2AT, he recalls his first Uganda-to-U.K. contact in 1931 using a single P625 valve in the old "TNT" (tuned anode non-tuned grid) power oscillator transmitter and two-valve (0-v-1) receiver.

In brief

Brian Bower, G3COJ, appears to have pushed the U.K. record for the 432 MHz band to over 900 miles with a contact (July 1975) with the Swedish station SM5DSN . . . The Swiss national society USKA reports an increase during the year of 208 members to bring total membership to 2312 . . . Northern Radio Societies Association holds their annual convention at Belle Vue, Manchester on April 25 . . . The RSGB National VHF/UHF Conference is to be held for the first time at Brunel University, Uxbridge, Middlesex on May 8-9 . . . The British Amateur Radio Teleprinter Group's annual convention is at Meopham on May 22 . . . As an alternative to a national mobile rally, the RSGB is planning to hold an amateur radio exhibition at Alexandra Palace on July 30, 31 and August 1.

PAT HAWKER, G3VA

New Products

Digital i.c. test system

Teradyne has announced a digital i.c. test system for use in production and incoming inspection. The J325 computer-controlled test system is optimized for testing a wide spectrum of digital i.cs, including t.t.l., d.t.l., e.c.l., c.m.o.s. and static m.o.s. The different test demands of these technologies are satisfied by the availability of two basic test stations. One is optimized for testing c.m.os., static m.o.s. and h.t.l., the other for e.c.l. and t.t.l. A two-station J325 is priced at around £70,000. Teradyne Ltd, Clive House, Queens Road, Weybridge, Surrey KT13 9XB.
WW 301 for further details.

Miniature rotary switches

Two ranges of miniature rotary switches are the 5920 and 5922ER series. Designed for mounting directly on to a p.c.b., the 5920 series has angled terminals on a pitch of 2.45mm (0.1in) and a total height of 10mm when mounted. They have gold-plated silver contacts rated at 0.2V at 150V a.c. and can be supplied in a variety of single and multiple pole, multiple way switching configurations. The 5922ER series has been designed for panel-mounted applications, requiring an aperture of 10.2mm. They measure 20mm in diameter overall and can be supplied in various switching configurations. Contacts are silver, rated up to 0.3A at 220V a.c. Roxburgh Electronics Ltd, 22 Winchelsea Road, Rye, Sussex.
WW 302 for further details.

Noise cancelling mic

An efficient, moving coil, low impedance instrument designed to withstand demanding environments in industrial use has been introduced by Selsound. The microphones are available as inserts, type 2500, but can be provided with housings to suit specific customer requirements. Impedance is 25Ω and sensitivity 500μV at close proximity and normal speech level. The directional response gives −12dB at 1kHz at 90° and 270° off axis. Selsound Ltd, Victory Close, Industrial Estate, Chandlers Ford, Eastleigh, Hants.
WW 303 for further details.

Proximity switch

A heavy-duty, solid-state proximity switch, model 8-260, is a self contained barrel mounted switch designed for operation in severe environments. Manufactured by the Eldec Corporation and marketed in this country by Elliott Relays, the 8-260 is sealed by moulded epoxy in a one-piece construction for maximum protection against contamination. A load current rating of 1A permits lamp and relay operation — as well as a range of control circuitry requiring high input currents. Normally open or normally closed output switch versions are available. Sensing distance is 0.1in for ferrous metal targets and 0.05in for non ferrous metals. Elliott Relays, 70 Dudden Hill Lane, London NW10 1DJ.
WW 304 for further details.

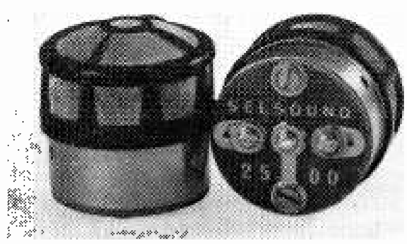
High-voltage high-stability resistors

Up to 7.5kV can be handled by new resistors from Erg Components. Rated at 2.5 watts at 70°C, they have a temperature coefficient of ±200 parts per million per deg. C. High value-stability is achieved (2% after 2000 hours at full load) by using a noble-metal resistive glaze on an alumina substrate. Erg Industrial Corporation Ltd, Luton Road, Dunstable, Beds LU5 4LJ.
WW 305 for further details.

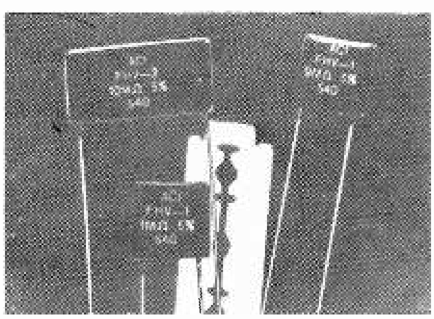
Multichannel analogue recorder

The Gould Brush 2400 direct-writing chart recorder has channel amplitudes of 100mm and 50mm and uses a servo-controlled pen motor to give frequency responses of 30Hz at 100mm, 50Hz at 50mm and up to 100Hz at lower amplitudes. The recorder is available in 12 configurations and can be used in two-, three- or four-channel form, with or without interchangeable plug-in preamplifiers. Portable or rack-mounted versions are available. The pen motor incorporates a non-contact servo feedback system known as Metrisite which gives a stiffness of 100g/mm and a linearity of 99.65% over the channel width. Rise time is less than 8ms for 100mm amplitude and 5ms for 50mm amplitude. Overshoot is less than 1% on square waves. Twelve chart speeds between 0.05mm/s and 200mm/s are provided. Gould Advance Ltd, Data Products Division, Raynham Road, Bishop's Stortford, Herts.
WW 306 for further details.

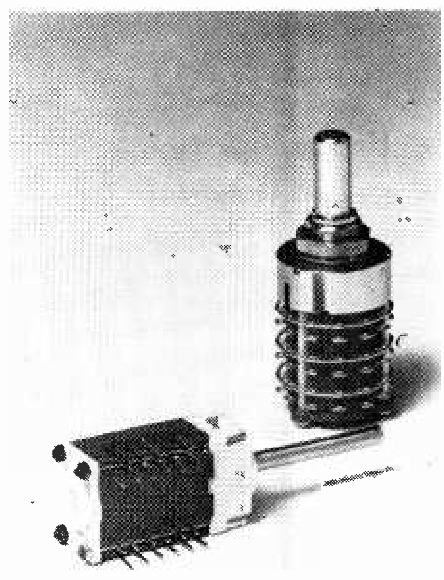
WW 301



WW 303



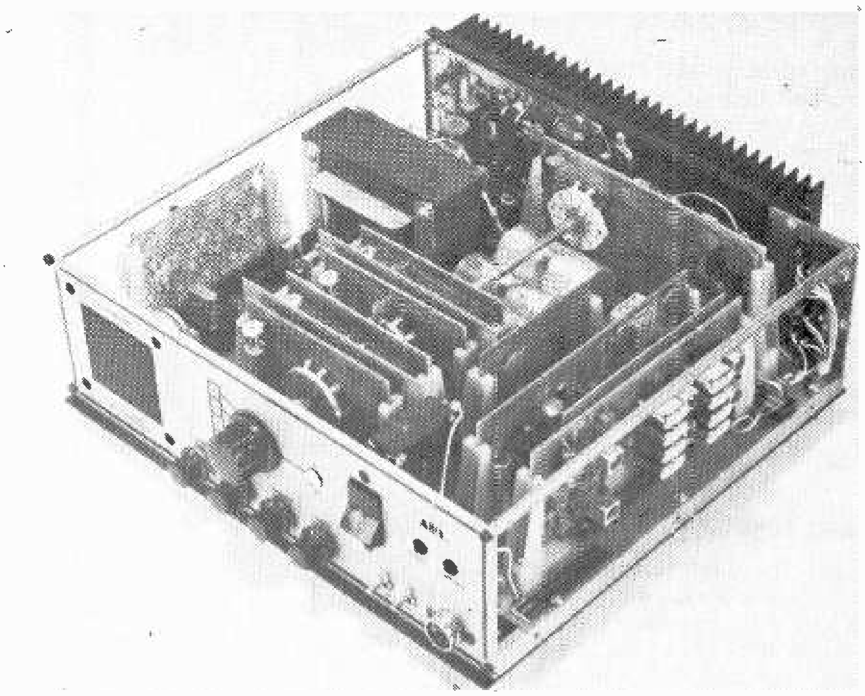
WW 305



WW 302

SSB transceiver for h.f.

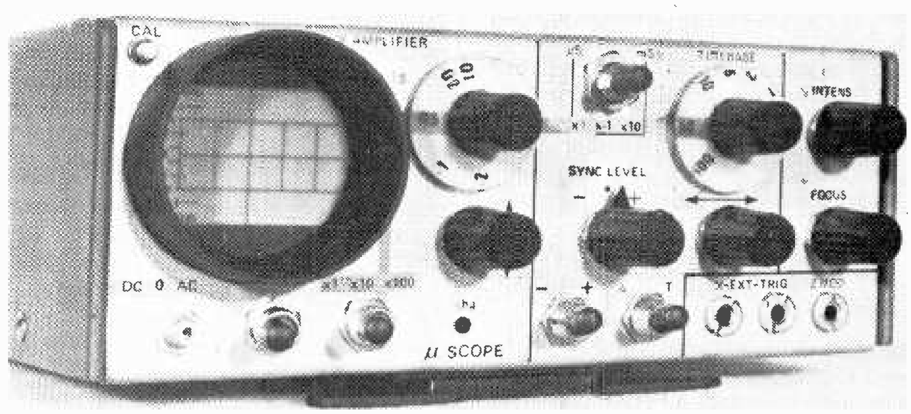
A single-sideband transceiver for the h.f. bands has been added to the AEL range of communications equipment. Covering 2 to 16MHz in four or six crystal-controlled channels, the transceiver – type AEL3030 – is designed for 12-volt mobile use. A version for fixed-station use has an internal 115/230V a.c. power pack. Output from the wideband p.a. is 150 watts p.e.p. with typical harmonic suppression of 50dB. Receiver sensitivity is 0.5μV for 20dB s+n/n. Above 5μV, a.g.c. action gives a 3dB increase in output for a 100dB increase in input level. Ten of the eleven p.c. boards are plug-in modules. Acro Electronics (AEL) Ltd, Gatwick House, Horley, Surrey.
WW 307 for further details.



WW 307

Mini battery-mains scope

The B1010 miniature battery-mains scope (137mmW × 195mmD × 64mmH) is a development of the Lawtronic A1010 with additional facilities. It is a 10MHz bandwidth scope, the y-amplifier sensitivity ranging from 10mV/div to 50V/div and timebase speeds from 1ms to 1s/div. The scope has a choice of free running or triggered timebase as a standard facility. A decibel scale on the graticule gives direct reading of amplitude response and modulation depths in communication applications. Rechargeable nickel cadmium cells give up to three hours operating time while operation and recharging can be from 240V, 110V a.c. and 12V d.c. The z-modulation display facility is retained and an internal y-amplifier calibrator has been added. Complete with carrying case, the B1010 costs £198.00. Lawtronics Ltd, 139 High Street, Edenbridge, Kent TN8 5AX.
WW 308 for further details.



WW 308

Broadband test oscillator

A general-purpose broadband test oscillator providing sine waves from 10Hz to 10MHz, with additional square wave outputs from 10Hz to 1MHz, has been introduced by Farnell. The LFM3 has a t.t.l. output at 5V up to 10MHz and a sync output of 6V pk-pk sine. The output of 1mV to 20V into open circuit is levelled in seven attenuator steps of 10dB per step from +10dB to −50dB with an uncalibrated fine level control providing a further nominal adjustment. Main output sockets for 600Ω and 50Ω are provided. The LFM3 is intended for general calibration and instrument test work and is particularly suitable for video amplifier and a.c. bridge measurements. Farnell Instruments Ltd, Sandbeck Way, Wetherby LS22 4DH, Yorkshire.
WW 309 for further details.

WW 309

Rapid heat irons

A range of 30, 60 and 100W soldering irons which heat up within seconds of switch-on are being marketed by Kelgray Products. For ease of working in confined spaces, the 60W and 100W Engel irons have built-in lights to illuminate the working area. A range of blades is available for use with the 100W unit which extends the application of this model to include thermo-cutting of man-made fibres and ropes. Kelgray Products Ltd, Bywell House, South Godstone, Surrey.
WW 310 for further details.

Audio test set

Facilities offered by the Amber 4400 test set include function, sweep, noise, audio comb and burst generators, autoranging digital level meter and frequency counter, wave and spectrum analyzers and a dual digital memory. Dimensions are 133mmH × 210mmW × 279mmD. Additional features include a balanced or unbalanced output capability of +30dBm, a 10dB per step output attenuator ranging from +30dBm to −70dBm, programmable operation for most functions and an internal crystal timebase for accurate frequency reference. The unit should be available at the end of January and will cost approximately £950. Scenic Sounds Equipment Ltd, 27-31 Bryanston St, London W1H 7AB.
WW 311 for further details.

Electronic multimeter

Use of an i.c. amplifier in a Philips multimeter enables a robust meter movement to be used but with a "sensitivity" of 500kΩ/V. The multimeter, type SMT111, has 35 ranges, including f.s.ds for direct voltages of 30mV to 300V, direct currents of 3μA to 300mA (40 to 60mV voltage drop), alternating voltages of 300mV to 600V, and alternating currents of 30μA to 3A (400 to 600mV drop). In addition, the meter has five resistance ranges, a battery-check switch position and a frequency response that extends up to 10kHz on the 60V range and 40kHz on the 300mV range. Overload protection of the i.c. and movement is provided. Accuracy is ±3 or 4%, depending on range. Price is £30 (excluding v.a.t. at 8%). Combined Electronics Services Ltd, 604 Purley Way, Waddon, Croydon CR9 4DR.
WW 312 for further details.

Solid State Devices

Names of suppliers of devices in this section are given in abbreviation after each entry and in full at the end of the section.

Analogue delay line

A charge-coupled device made by Fairchild, type CCD311, can delay analogue signals from 20μs to 25ms by varying the rate of externally supplied clock pulses. The device is a "spin-off" from the Fairchild 256-element c.c.d. image sensor and is thought to have potential as a time base corrector in video tape recording systems. The device could also be used for a wide variety of other applications, including phase equalization and convergence correction in video systems, delay equalization in speech transmissions and scrambling systems, and construction of complex analogue filters. A signal-to-noise ratio of 50dB or more and a bandwidth of 4MHz are claimed. The device, housed in an 18-pin dual-in-line package, is available from Fairchild in the U.S.A. and can be ordered in the U.K. from their Aylesbury, Bucks address. **Fairchild**

Linear optical sensor

An array of 1872 photodiodes at 15 micron centres forms the Reticon RL 1872F linear sensor. The device possesses its own low-dissipation commutating shift register, with a maximum data output rate of 20MHz. A ceramic dual-in-line package is used, a ground and polished quartz window covering the diodes. Clock generator, driver amplifer and integrator sample and hold boards are available for use in high-speed facsimile equipment. P.c. cards containing all required drive circuitry for the device are available. **Rapid Recall**

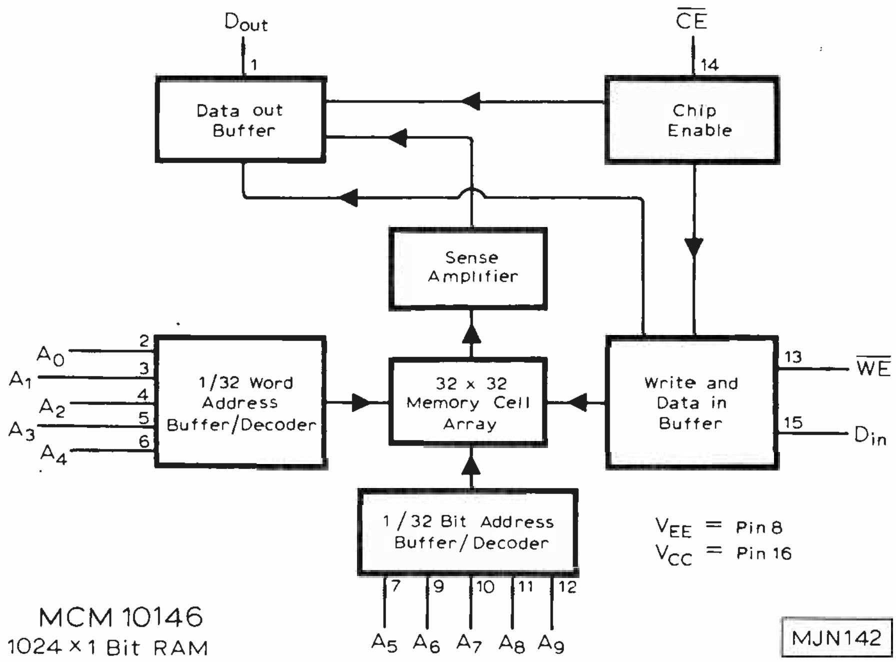
Low-cost micro processor

An 8-bit, p.m.o.s. microprocessor from National, the SC/MP, is capable of a 2μs cycle time and is powered by a single 10-14V supply; timing is on the chip. At £7.50 in quantities, the device is intended for use in toys, domestic appliances, car electronics and similar mass produced equipment which does not benefit from very high speeds or computing power. Multiple units can be bussed, each chip having "queueing" circuitry to organize the flow of information on the bus. **National**

Fast 1-kbit r.a.m.

With an access time of 22ns, the MCM10146 is claimed by Motorola to be the fastest 1024-bit random-access memory yet available. The 1024 1-bit words are stored in a 32×32 array and selected by 5-bit x and y co-ordinates. The "write enable" input controls operation; when low, data at the inputs is stored and, when high, the data is output, without inversion. Outputs can be wire-ORed. Power consumption is around 510mW and the device is in a 16-pin d.i.p. **Motorola**

Suppliers
Fairchild Semiconductors Ltd, Kingmaker House, Station Road, New Barnet, Herts.
National Semiconductor UK Ltd, 19 Goldington Road, Bedford.
A. Marshall (London) Ltd, 42 Cricklewood Broadway, London NW2 3ET.
Motorola Ltd, Semiconductor Division, York House, Empire Way, Wembley, Middlesex, HA9 0PR.
Rapid Recall Ltd, 9 Betterton Street, London WC2H 9BS.



MCM 10146
1024×1 Bit RAM

MJN142

Linear c.m.o.s. circuits

A further selection of tested circuits is published in Circards, set 28

by J. Carruthers, J. H. Evans, J. Kinsler & P. Williams

Paisley College of Technology

If logic circuits could be adapted only for amplifying functions, the exercise would still be worthwhile — it would avoid having to add separate operational amplifiers on those occasions when only simple signal processing is needed. In fact most other electronic circuits can be designed if care is taken to work with the characteristics of c.m.o.s. rather against them. A restriction is that only inverting stages can be used with negative feedback, there being no equivalent to the series-applied feedback circuits (e.g. voltage followers) common in operational amplifier designs. Non-inverting buffers or cascaded inverters lend themselves to positive feedback functions such as Schmitt trigger circuits. Variety can be introduced by using individual devices from certain c.m.o.s. i.cs in combination with inverters and gates.

As a general rule it is simpler to adapt those familiar circuits that use inverting amplifiers, unless the function required cannot be performed in this way.

Circuits that can be designed using inverting amplifiers include active filters such as the two-integrator loop, three-stage phase-shift oscillators, and the like. There is no need to restrict ourselves to simple buffers and inverters; other i.cs can be readily applied in analogue circuits of various kinds. For the more complex i.cs, the degree of internal interconnection reduces flexibility and it is less easy to see ways in which non-logic functions can be performed.

One form of flip-flop, the D-type, has a pair of outputs Q and $\overline{Q}$. When fed with a positive-going pulse on the clock input C, the output Q is forced to take up the logic state on the data input D at the instant of clocking. This state at the output is retained regardless of any variation at D until the next clock pulse. Such a flip-flop finds application in the processing of analogue signals, as in some forms of analogue to digital converters and phase-locked loops. In a particular application, the delta-sigma modulator, the integrator receives a current from the input voltage, which causes its output to change until the comparator output swings through zero. On the succeeding clock pulse the Q-output must change, since the D value has changed, and this changes the f.e.t. between its conducting and non-conducting states. The polarity of input and reference voltage must be opposite so that the fed-back reference can reverse the direction of integration. Combining the clock pulse with Q (or $\overline{Q}$) in a suitable logic gate gives a pulse train in which the average number of pulses is proportional to input voltage.

The above appears to be a complex system, but two properties of c.m.o.s. allow efficient use of the flip-flop. The sharpness of the transfer-function means that the region of doubt at the D input is very small i.e. that even voltages close to $V_s/2$ are clearly distinguished as either logic 0 or logic 1. Hence the comparator can be dispensed with, the flip-flop acting as its own comparator. Similarly the output of the flip-flop is well-defined, and for a stable supply voltage the f.e.t. and separate voltage reference can also be eliminated reducing the system to one op-amp and a flip-flop.

Similar considerations lead to economical circuits for Schmitt trigger, astable and monostable circuits, by making use of the S and R or set and reset inputs, also available in D-type flip-flops. It must be remembered that such circuits may depend on properties which may not be covered directly by manufacturer's data, although the experimental evidence for their satisfactory behaviour is clear.

A semi-digital mode of operation is where inverters are used to drive power transistors. Output stages for class-D power amplifiers are examples where this technique is of use, the c.m.o.s. drivers also helping to switch the transistors off rapidly, though delays may be needed at the inverter inputs to avoid the possibility of simultaneous conduction of both transistors.

There is one family of c.m.o.s. circuits designed specifically for use in linear and non-linear analogue circuits viz the analogue gate/bilateral switch. By driving a parallel complementary pair of m.o.s. transistors with anti-phase logic level signals their conduction can be linearized so that the transfer of voltage is near unity when lightly loaded. This extends over the whole supply range and these gates can be used to switch components in and out of circuit as well as for direct gating of signals. Applications include d. to a. conversion, waveform synthesis and switched filters.

The technology developed for logic applications in c.m.o.s. has proved to have many characteristics that can be pressed into the service of linear circuit designers. The very low cost of these i.cs must commend them, and with care their limitations can be overcome or side-stepped in a wide variety of applications.

Topics in Circards set 28 (linear c.m.o.s. - 2) are:

Transistor outputs.
Current differencing amplifier.
Frequency-to-voltage converter.
Two integrator oscillator.
D-type analogue circuits - 1.
D-type analogue circuits - 2.
Bandpass/notch filters.
Low-pass/high-pass filters.
D.C. feedback pair.

Circards are a unique way of collating and presenting data about circuits in a compact and easily retrievable way. The sets of 203 × 127mm (8 × 5in) doublesided cards are designed for easy filing in standard boxes and for easy access at the desk or at the bench, where transparent plastic wallets keep the cards in good condition.

Each card normally describes operation of a selected circuit, gives *measured* performance data and graphs, component values and ranges, circuit limitations and modifications to alter performance. Suggestions for further reading are included together with cross references to related circuits. The Circard concept was outlined more fully in the October 1972 issue of *Wireless World*, pp. 469/70.

Real and Imaginary

by "Vector"

DON'T PUT YOUR OFF-SPRING IN THE CAGE, MR WORTHINGTON

For the past 20 years the American electronics engineer has had it made. The exigencies of defence and the space race made him the blue-eyed boy. The universities couldn't turn him out fast enough and extra supplies were lured from Europe and the rest of the world with the bait of the almighty dollar. The beauty of it was — or so it seemed at the time — that you didn't need any overall experience. If, for instance, you knew your way around in gating circuits, that was sufficient. The golden age of the blinkered specialist had arrived. With the resources of Fort Knox behind it, the American electronics industry could virtually write its own cheques.

Then came the writing on the wall — and a rude bit of graffiti it turned out to be. The space programme went into mothballs and defence projects suffered the fiscal chopper. The electronics manufacturers, faced with cancelled contracts, suddenly became much more discriminating in their hiring and far more profligate in their firing, particularly in the specialist bracket. There are now a lot of electronics engineers in the States who are either looking for jobs or fearing that each payday may be their last. And it's on the middle-aged that the chopper is mainly falling, to a degree that the situation has been christened "The Mid-Career Crisis".

Why the middle-aged? For two main reasons. One is that statistics indicate that, as a generalisation, engineers are at their most inventive in their 20s and 30s, while at 40 they're going over the top — and Americans are great believers in statistics. The other factor is the sheer pace of the development in electronics technology, hare-like in its speed and its bewildering twists and turns. And, beyond doubt, in the struggle to keep abreast of developments, the older engineer is handicapped.

For instance, any engineer who graduated *circa* 1949 did so in terms of valve technology. His sole excursions into solid state would have been a cursory glance at a quaint museum piece called the crystal detector, plus something on the silicon diode and metal rectifiers. True, there were one or two papers appearing in the literature concerning a weird little device called the point-contact transistor which allegedly could be used to amplify weak signals, but nobody at university knew much about it. The serious business lay with the omnipotent thermionic valve and so our friend, having mastered various apsects of this device and a groundwork of electrical engineering, took his degree. After a year or so in the laboratory and/or industry he could legitimately regard himself as a fully-fledged electronics engineer, with WELCOME on the mat at the portals of the learned society of his choice. God, it seemed, was in His heaven and all was right with the world. Or was it?

For, by this time the trickle of information on transistors was becoming an avalanche and in due course the point-contact transistor was elbowed out by all sorts of outlandish varieties of which he knew nothing.

He was now faced with a choice of action. He could retreat up the power scale where valve technology was still supreme or he could try to latch on to the theory of these new-fangled solid-state, current-operated devices. Being still young and enthusiastic he chose the second course, but it wasn't easy to throw his valve indoctrination overboard and go it alone with a textbook that never seemed to answer the questions he wanted to ask.

Then, scarcely had he mastered transistors when two further innovations blew up in his face, namely the computer and the integrated circuit. As a guessing-stick man he had a built-in mistrust of computers and all his training rebelled against the miniscule size and seeming fragility of the i.c. package; give him ¼-watt resistors and solid connecting wire every time in preference to these minute chips of semiconductor which had been mucked around by photographic and etching processes of which he knew nothing. And there was more to it than that. Up to this point in time, his position as a designer of discrete circuits had been unchallenged but now the advent of whole subsystems on a semiconductor chip, plus the onset of computer-aided design, had kicked the ladder from under him. As a circuit designer he was rapidly moving into the dodo category; despite all his hard-won experience he was back to square one, competing against wet-behind-the-ears graduates with uncluttered minds, all avid to use the new technologies.

So, all honour to those who survived; whose minds were flexible enough to cope and triumph over adversity. But it seems that in the United States at least there are many that weren't able to do so — hence the so-called Mid-Career Crisis. The man who is over 40 finds it very difficult to change jobs and, if he's lucky enough to hold down his present one there is often an unpleasant climate in which the up-and-coming young Substrates leap-frog him to senior posts while he finds himself assigned to the humdrum routine chores.

So what's the answer? One approach over there is to arrange for group therapy, where engineers who are in this particular boat get together and discuss their problems among themselves. The philosophy behind this is "togetherness"; it is piously believed that when the over-40 engineer realises that he is not alone and that his anxieties are shared by others, then he won't worry nearly so much. A touch of Disneyland here, I fancy.

In considering the problem it's tempting to cast the top management as the heavy villain callously tying his victim to the railroad tracks of economic retrenchment. But it isn't as simple as that. In the American socio-economic structure (and equally in our own) any company has a rigid set of commandments to observe. The first of these is "Thou shalt keep thy shareholders happy" which, being interpreted, means providing them with an adequate return on their investment. Clearly this can't be done if, because of cancelled contracts, half the engineering staff is filling in its football pools in the firm's time. Equally clearly, expensive redundancies are to be avoided and sackings can involve unions and tribunals, while if either occur in quantity the news makes bad publicity in the media and causes the shares to sag. So the general philosophy is to give a leaden handshake to one higher-salaried engineer rather than to three lowly ones, particularly if he's shown signs of dragging his feet. Or, better still, make his life so frustrated that he opts out on his own.

So that's the way it's going in the States, it appears. We aren't nearly so defence-orientated over here, but cancelled Government contracts are causing headaches and the American electronics industry's ups and downs are often a foretaste of what's likely to happen here. As far as I know, no parallel situation exists with us but it wouldn't get publicity unless it reached epidemic proportions.

Nevertheless, if I were young Substrate I'd think seriously about getting out of engineering and into business management, for this is the area on which our industry's faith appears to be pinned. As Mr J. R. Thompson, chairman of the Science Education and Management Division of the IEE has pointed out, last year's starting salaries for engineers were in the £1,800-£2,000 bracket, while business graduates were offered from £3,250 to £4,800. And in management you're not over the top at 40. An industry with all cowboys and no Indians should be an interesting spectacle.

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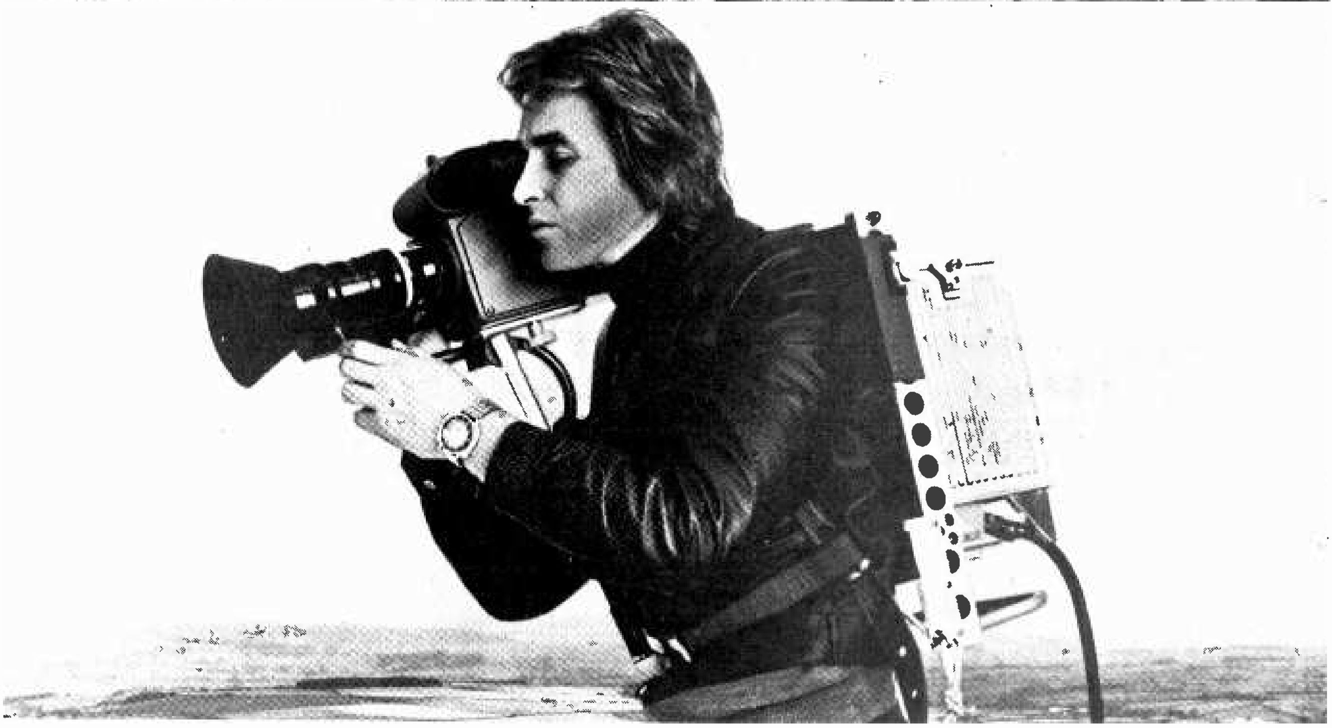

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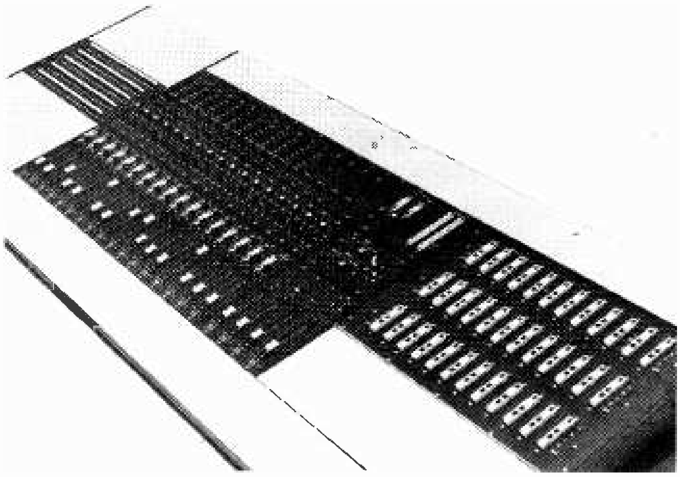

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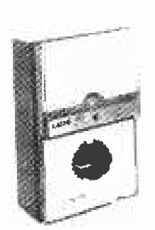

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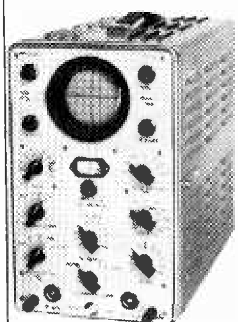

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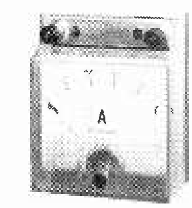

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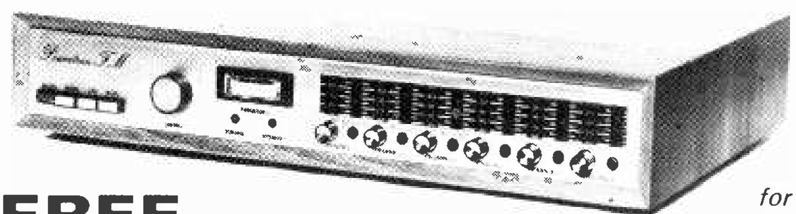
12	Set of capacitors, rectifiers, voltage regulator for power supply	£2.95
13	Set of miscellaneous parts, including sockets, fuse holder, fuses, inter-connecting wire, etc.	£1.50
14	Set of metal work parts including silk screen printed facia panel, acrylic silk screen printed tuning indicator panel insert, internal screen, fixing parts, etc.	£6.50
15	Construction notes (free with complete kit)	£0 25
16	Teak cabinet	£9 85
	One each of packs 1–16 inclusive are required for complete stereo FM tuner.	
	Total cost of individually purchased packs	£76 85

STEREO FM TUNER KIT

In the April and May issues of *Wireless World* there was published a novel design for an f.m. tuner which combines consistent high performance with the elimination of the critical setting-up procedure required by too many earlier tuners. This original circuit has been developed further and is used as the basis for our new slimline unit. The front end is a ready built pre-aligned module which then feeds an amplifier driven screened three section ceramic filter leading to an integrated circuit five-stage limiting amplifier providing excellent a.m. rejection. This is followed by a single coil integrated balanced demodulator from which the audio output may be taken. Temperature compensated varicap tuning allows stations to be selected either by a ten-turn tuning potentiometer or by a choice of six preset push-button controls. Each of the preset controls can be adjusted on the front panel with the settings being indicated by six LED lamps behind an acrylic silk screen printed facia panel insert. Additional circuitry includes temperature compensated AFC restricted to less than station spacing, inter-station muting, a single-lamp LED tuning indicator and a linear scale frequency meter. The stereo decoder, built on a separate board, is based on a well-proven integrated circuit phase-locked-loop to which has been added active filters to remove sub-carrier harmonics and 'birdies'. The power supply, to ensure station holding stability, uses an integrated circuit voltage regulator which is powered via a low-hum field specially designed TOROIDAL TRANSFORMER.

STYLED TO COMPLEMENT THE WORLD-WIDE ACCLAIMED LINSLEY-HOOD 75W AMPLIFIER



FREE TEAK CASE WITH FULL KITS

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MORE KITS ON NEXT PAGE!

****

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Typical P. & P. charges at November 1st (E & OE)

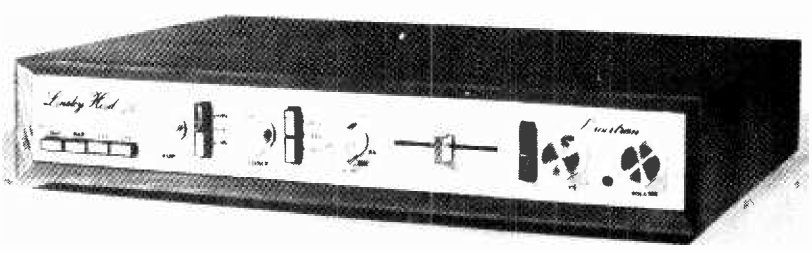
	L.H. 75 Watt		F.M. Tuner		T20+20	
	Air	Sea	Air	Sea	Air	Sea
Australia	£42 60	£11 40	£26.05	£7.25	£17.05	£4.65
Canada	£23 50	£8 00	£14 40	£5.05	£9.60	£3.45
Denmark	£10 50	£7.40	£6 00	£4.65	£4.75	£3.25
Germany	£10.50	£7.65	£6.00	£4.80	£4.75	£3.35
New Zealand	£41.60	£10.75	£25 25	£6.85	£16 85	£4.40
Norway	£11 40	£7.30	£6.70	£4.50	£5.20	£3.30
Rep. S. Africa	£25 00	£7.80	£15 15	£4.85	£10.35	£3.45
Sweden	£10 90	£7.25	£6.45	£4.50	£4.95	£3.25
Switzerland	£8.90	£6.85	£5 30	£4 25	£4.10	£3.10
U S A	£23 20	£9.85	£14 25	£6.30	£9 45	£4 05

****

75W AMPLIFIER KIT

In Hi-Fi News there was published by Mr Linsley-Hood a series of four articles (November 1972–February 1973) and a subsequent follow-up article (April 1974) on a design for an amplifier of exceptional performance which has as its principal feature an ability to supply from a direct coupled fully protected output stage, power in excess of 75 watts whilst maintaining distortion at less than 0.01% even at very low power levels. The power amplifier is complemented by a pre-amplifier based on a discrete component operational amplifier referred to as the Liniac which is employed in the two most critical points of the system, namely the equalization stage and tone control stage, positions where most conventional designs run out of gain at the extremes of the frequency spectrum. Unusual features of the design are the variable transition frequencies of the tone controls and the variable slope of the scratch filter. There is a choice of four inputs, two equalized and two linear, each having independently adjustable signal level. The attractive slimline unit pictured has been made practical by highly compact PCBs and a specially designed Toroidal transformer.

Hi-Fi News Linsley-Hood 75W/Channel Amplifier Mk III Version (modifications as per Hi-Fi News April 1974)



Full circuit description in handbook (pack 15—price 30p)

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Pack		Price
1	Fibreglass printed-circuit board for power amp	£0.85
2	Set of resistors, capacitors, pre-sets for power amp.	£1 70
3	Set of semiconductors for power amp. (now using BDY56, BD529, BD530)	£6.50
4	Pair of 2 drilled, finned heat sinks	£0.80
5	Fibreglass printed-circuit board for pre-amp.	£1 30
6	Set of low noise resistors, capacitors, pre-sets for pre-amp.	£2 70
7	Set of low noise high gain semiconductors for pre-amp	£2 40
8	Set of potentiometers (including mains switch)	£2 05
9	Set of 4 push-button switches, rotary mode switch	£3.70
10	Toroidal transformer complete with magnetic screen/housing primary: 0-117-234 V, secondaries: 33-0-33 V, 25-0 25 V.	£9 15
11	Fibreglass printed-circuit board for power supply	£0.65
12	Set of resistors, capacitors secondary fuses, semiconductors for power supply	£3.50
13	Set of miscellaneous parts including DIN skts, mains input skt, fuse holder, inter connecting cable, control knobs	£4.25
14	Set of metalwork parts including silk screen printed fascia panel and all brackets, fixing parts, etc.	£6.30
15	Handbook	£0.30
16	Teak cabinet	£9 85
	2 each of packs 1–7 inclusive are required for complete stereo system	
	Total cost of individually purchased packs	£72.25

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Dept. WW2

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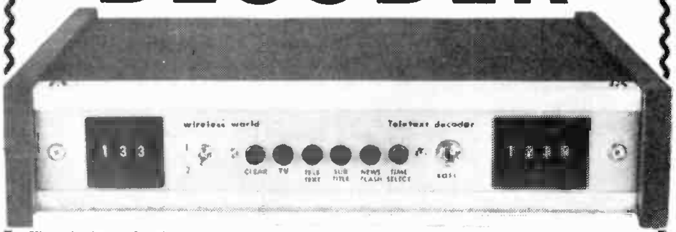
TELETEXT DECODER



The design of this decoder is being described in a series of articles being published by 'Wireless World' (from November 1975 issue). However, it is available NOW — exclusively from Catronics Ltd.

Our kit contains all the printed circuit boards and components necessary to build the complete decoder. Signal input required is a minimum of 0.5V detected video. The output is approximately 4V of R, G and B drive suitable for driving most types of colour Television sets.

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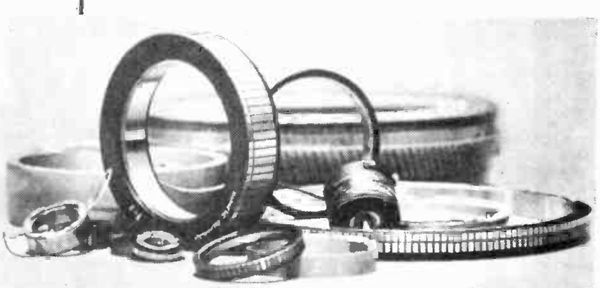

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150	100	**5.33**	85
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152	250	**10.32**	1.41
153	350	**12.47**	1.41
154	500	**14.33**	1.61
155	750	**21.94**	BRS
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Ref. No.	AMPS 12v	AMPS 24v	£	P&P p
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213	1.0	0.5	**1.86**	58
71	2	1	**2.41**	58
18	4	2	**2.97**	72
70	6	3	**4.43**	72
108	8	4	**5.09**	85
72	10	5	**5.50**	85
116	12	6	**5.80**	97
17	16	8	**7.48**	97
115	20	10	**10.91**	1.61
187	30	15	**14.20**	1.41
226	60	30	**17.67**	BRS

50 VOLT RANGE

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01-19-25-33-40-50V

Ref. No.	Amps.	£	P&P p
102	0.5	**2.71**	58
103	1.0	**3.55**	72
104	2.0	**4.95**	85
105	3.0	**6.10**	97
106	4.0	**7.98**	1.12
107	6.0	**12.71**	1.25
118	8.0	**13.63**	1.61
119	10.0	**17.75**	BRS

30 VOLT RANGE

SECONDARY TAPS
0-12-15-20-25-30V

Ref. No.	Amps	£	P&P p
112	0.5	**1.90**	58
79	1.0	**2.52**	72
3	2.0	**3.77**	72
20	3.0	**4.70**	85
21	4.0	**5.56**	85
51	5.0	**6.73**	97
117	6.0	**7.52**	1.12
88	8.0	**10.20**	1.25
89	10.0	**10.36**	1.41

60 VOLT RANGE

SECONDARY TAPS
0-24-30-40-48-60V

Ref. No.	Amps	£	P&P p
124	0.5	**2.48**	72
126	1.0	**3.68**	72
127	2.0	**5.33**	85
125	3.0	**7.90**	97
123	4.0	**9.19**	1.41
40	5.0	**10.24**	1.25
120	6.0	**12.07**	1.41
121	8.0	**15.75**	BRS
122	10.0	**19.40**	BRS
189	12.0	**20.25**	BRS

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Ref. No.	VA (Watts)	AUTO TAPS	£	P&P p
113	20	0-115-210-240	**1.75**	51
64	75	0-115-210-240	**3.05**	72
4	150	0-115-210-220-240	**4.33**	72
66	300		**6.11**	85
67	500	,, ,,	**9.36**	1.25
84	1000	,, ,,	**14.36**	1.61
93	1500	,, ,,	**19.02**	BRS
95	2000	,, ,,	**25.41**	BRS
73	3000	,, ,,	**36.84**	BRS

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VA	Ref.	£	P&P p
60	243	**4.37**	97
350	247	**10.93**	1.41
1000	250	**26.31**	BRS
2000	252	**44.12**	BRS

SCREENED MINIATURES

Ref.	mA	Volts	£	P&P p
238	200	3-0-3	**1.62**	39
212	1A1A	0-6, 0-6	**1.93**	46
13	100	9-0-9	**1.56**	25
235	330 330	0-9, 0-9	**1.64**	25
207	500.500	0-8-9, 0-8-9	**2.02**	51
208	1A 1A	0-8-9, 0-8-9	**3.07**	58
236	200, 200	0-15, 0-15	**1.56**	25
214	300, 300	0.20, 0.20	**2.03**	58
221	700 (DC)	20-12-0-12-20	**2.38**	58
206	1A 1A	0-15-20, 0-15-20	**3.63**	72
203	500, 500	0-15-27, 0-15-27	**3.15**	72
204	1A 1A	0-15-27, 0-15-27	**4.14**	72
S112	500	12, 15, 20, 24, 30	**1.97**	58

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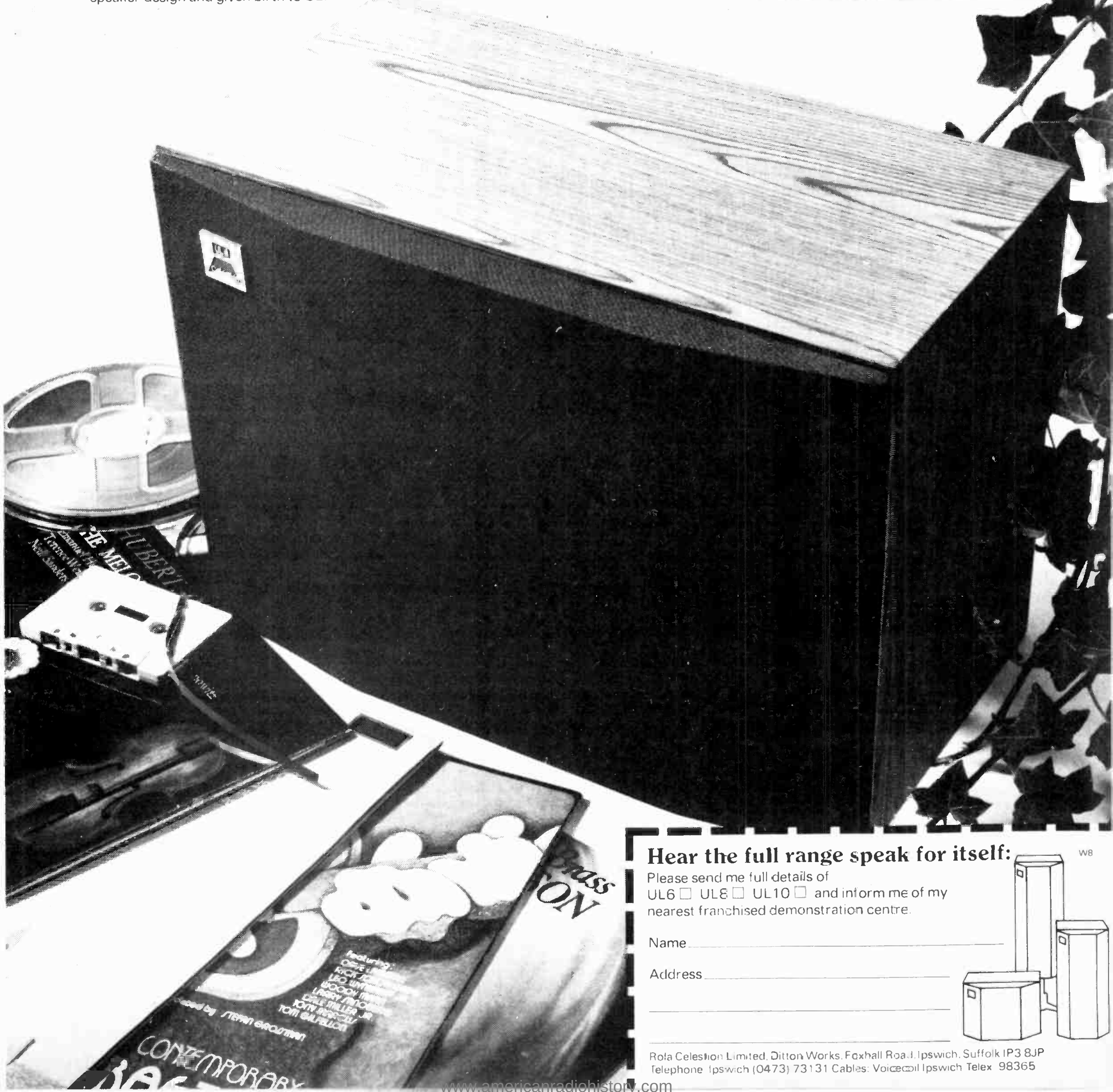

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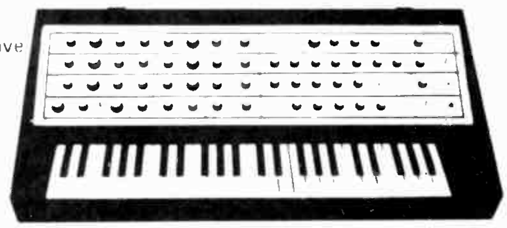
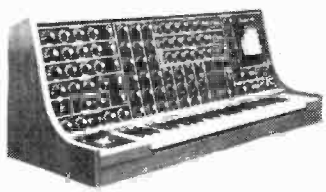


S.A.E. please for price list

The 4600 SYNTHESISER



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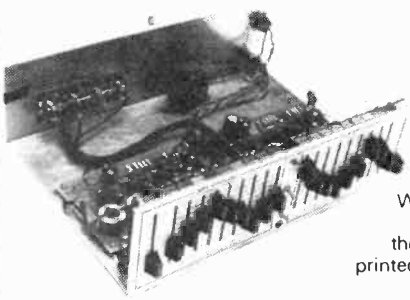

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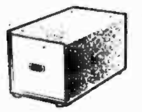
TRANSFORMERS

CASED TRANSFORMERS



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Prim. 120/240V Sec. 120/240V Centre Tap with screen

VA (WATTS)	REF No.	PRICE Cased £	PRICE Plugs 2 Pin + 1 Earth £	PRICE Open £	Post £
20	148	5.25	0.98	3.75	0.72
60	149	9.03	0.98	4.70	0.72
100	150	9.87	0.98	5.35	0.85
200	151	12.29	0.98	8.61	0.97
250	152	13.81	0.98	10.31	1.18
350	153	16.54	0.98	12.50	1.28
500	154	18.38	0.98	14.31	1.44
750	155	28.72	1.25	22.12	0.A.
1000	156	37.44	1.25	30.57	0.A.
1500	157	44.37	1.25	34.98	0.A.
2000	158	52.45	2.95	38.91	0.A.
3000	159	77.18	2.95	61.51	0.A.

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Primary 240V with Screen

VOLTS Sec. 1	VOLTS Sec. 2	MILLIAMPS Sec. 1	MILLIAMPS Sec. 2	REF No.	PRICE £	Post £
3-0-3	–	200	–	238	1.56	0.34
0-6	0-6	500	500	234	1.56	0.34
0-6	0-6	1000	1000	212	2.12	0.46
9-0-9	–	100	–	13	1.60	0.34
0-9	0-9	330	330	235	1.62	0.34
0-8-9	0-8-9	500	500	207	1.69	0.46
0-8-9	0-8-9	1000	1000	208	2.79	0.46
15-0-15	–	40	–	240	1.55	0.34
0-15	0-15	200	200	236	1.56	0.34
20-0-20	–	30	–	241	1.55	0.34
0-20	0-20	150	150	237	1.56	0.34
0-15-20	0-15-20	500	500	205	2.88	0.58
0-20	0-20	300	300	214	2.03	0.61
0-20	–	3500	No Screen	1116	3.45	0.97
20-12-0	–	700	–	221	2.50	0.61
12-20	–	(D.C.)	–	–	–	–
0-15-20	0-15-20	1000	1000	206	2.85	0.72
0-15-27	0-15-27	500	500	203	3.16	0.58
0-15-27	0-15-27	1000	1000	204	4.55	0.72

12 and 24 VOLTS PRIMARY 200-240 Volts

AMPS 12V	AMPS 24V	REF No.	PRICE £	Post £
0.3	0.15	242	1.66	0.34
0.5	0.25	111	1.60	0.46
1	0.5	213	1.90	0.61
2	1	71	2.47	0.61
4	2	18	3.07	0.62
6	3	70	4.50	0.72
8	4	108	5.11	0.85
10	5	72	5.63	0.85
12	6	116	5.80	0.85
16	8	17	7.26	0.97
20	10	115	10.96	1.18
30	15	187	14.06	1.36
40	20	232	15.63	0.A.
60	30	226	17.70	0.A.

30 VOLTS

PRIMARY 200/240V
SECONDARY 12, 15, 20, 24, 30V

AMPS	Ref. No.	Price £	Post £
0.5	112	2.04	0.61
1	79	2.57	0.66
2	3	3.91	0.72
3	20	4.80	0.85
4	21	5.58	0.85
5	51	6.75	0.95
6	117	7.52	0.97
8	88	9.93	1.18
10	89	10.27	1.18

50 VOLTS

PRIMARY 200/240V
SECONDARY 19, 25, 33, 40, 50V

AMPS	Ref. No.	Price	Post £
0.5	102	2.71	0.61
1	103	3.58	0.76
2	104	5.30	0.85
3	105	6.10	0.85
4	106	7.97	1.08
6	107	12.93	1.18
8	118	13.75	1.44
10	119	17.79	1.86

AMPS	Ref No.	Price £	Post £
0.5	124	2.51	0.72
1	126	3.75	0.72
2	127	5.36	0.85
3	125	7.91	0.97
4	123	9.20	1.18
5	40	10.22	1.18
6	120	12.10	1.36
8	121	15.74	0.A.
10	122	20.10	0.A.
12	189	18.87	0.A.

AUTO TRANSFORMERS

VA (Watts)	Ref. No	PRICE Cased	PRICE Plugs 2 & 3 pin £	PRICE Open £	Post £
Tapped at 115, 220, 240 Volts					
20	113	4.31	0.25	1.88	0.61
Tapped at 115, 200, 220, 240 Volts					
150	4	6.99	0.25	4.28	0.72
200	65	7.67	0.25	5.21	0.78
300	66	8.67	0.25	6.11	0.85
500	67	11.82	0.25	9.48	1.18
750	83	14.81	0.95	11.30	1.28
1000	84	18.38	0.95	14.35	1.44
1500	93	23.26	0.95	19.22	0.A.
2000	95	35.07	1.80	25.49	0.A.
3000	73	50.61	2.35	34.87	0.A.

BRIDGE RECTIFIERS

ONE AMP	Price	FOUR AMP	Price
50 P.I.V.	0.25	100 P.I.V.	0.55
100 P.I.V.	0.25	200 P.I.V.	0.59
200 P.I.V.	0.28	400 P.I.V.	0.65
600 P.I.V.	0.30	600 P.I.V.	0.75

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100 P.I.V.	0.40	100 P.I.V.	0.70
200 P.I.V.	0.45	200 P.I.V.	0.80
400 P.I.V.	0.50	400 P.I.V.	0.90

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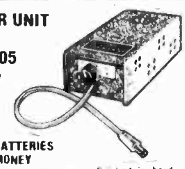

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0-5 mA	170	0-5mA	200
0-10mA	6	0-10 mA	6
0-50 mA	0.5	0-50 mA	0.5
0-100 mA	0.5	0-100 mA	0.5
0-500 mA	0.5	0-500 mA	0.5
0-1 AMP	0.5	0-1 AMP	0.5
0-2 AMP	0.5	0-2 AMP	0.5
0-25 Volt	15K	0-25 Volt	15K
0-50 Volt	50K	0-50 Volt	50K
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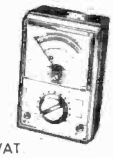

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NAS0161W	100V	.28	NAS0651W	100V	.65	NAS1001W	100V	.72
NAS0161X	100V	.28	NAS0651X	100V	.65	NAS1001X	100V	.72
NAS0162W	200V	.30	NAS0652W	200V	.61	NAS1002W	200V	.78
NAS0162X	200V	.29	NAS0652X	200V	.61	NAS1002X	200V	.76
NAS0164W	400V	40	NAS0654W	400V	.72	NAS1004W	400V	1.09
NAS0164X	400V	.38	NAS0654X	400V	.70	NAS1004X	400V	1.04
NAS0166W	600V	.50	NAS0656W	600V	.88	NAS1006W	600V	1.36
NAS0166X	600V	.48	NAS0656X	600V	.76	NAS1006X	600V	1.36
3.5AMP CLIPPED TAB			**8.5AMP ISOLATED TAB**			**15 AMP ISOLATED TAB**		
NAS0351W	100V	.52	NAS0851W	100V	.68	NAS1501W	100V	1.05
NAS0351X	100V	.52	NAS0851X	100V	.68	NAS1501X	100V	.95
NAS0352W	200V	.56	NAS0852W	200V	.76	NAS1502W	200V	1.02
NAS0352X	200V	.56	NAS0852X	200V	.76	NAS1502X	200V	1.02
NAS0354W	400V	.68	NAS0854W	400V	.88	NAS1504W	400V	1.51
NAS0354X	400V	.67	NAS0854X	400V	.85	NAS1504X	400V	1.48
NAS0356W	600V	.85	NAS0856W	600V	1.10	NAS1506W	600V	1.89
NAS0356X	600V	.84	NAS0856X	600V	1.06	NAS1506X	600V	1.84

Devices with Internal Trigger have "W" suffix. "X" denotes Standard Triac.

THYRISTORS

1.6AMP TO5 ●			4AMP ISOLATED TAB			6AMP ISOLATED TAB		
NAS006P	50PVV	.25	NAS106P	50PIV	.26	NAS206P	50PIV	.37
NAS006Q	100PIV	.28	NAS106Q	100PIV	.30	NAS206Q	100PIV	.42
NAS006R	200PIV	.31	NAS106R	200PIV	.36	NAS206R	200PIV	.50
NAS006S	400PIV	.40	NAS106S	400PIV	.57	NAS206S	400PIV	.77
NAS006T	600PIV	.52	NAS106T	600PIV	.90			

8AMP ISOLATED TAB			16AMP ISOLATED TAB	
NAS306P	50PIV	.41	NAS806P	.50
NAS306Q	100PIV	.47	NAS806Q	.58
NAS306R	200PIV	.59	NAS306R	.73
NAS306S	400PIV	.85	NAS806S	1.15

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TAA263	TO18	.62	●TBA810AS	1.08	●741	8 Pin	.35
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555	8-pin	1.05			723	14 Pin	.67

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6-30pF **10p ea.**
4p c/o Varley 700 Ω relay **50p ea.**

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W. WOUND POTS 1 Ω-100K Ω at **30p** each Colvern or Reliance styles + 25% VAT

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MODERN DISC CERAMICS £1.00 a hundred. **£8.00** a thousand + 25% VAT. Phone or write for list.

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SLEEVING 2000 pieces approx. size ¾" x 2mm. Price **£1.00** + 33p P&P + VAT 8%.

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TMC MINIATURE LEVER SWITCHES CONTACTS 4C/4C action L/L **50p each + 8% VAT.**

BNC PLUGS 50Ω straight entry at **35p** each + 8% VAT.

AMPHENOL UG 58A/U N SOCKETS. Chassis mounting at **35p** each + 8% VAT.

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We have the largest retail selection of components available. Phone or write if you are in difficulties obtaining a particular component.

C.O.D. service welcome. All mail order by return. Official orders welcome to Government establishments, Education Authorities, etc.

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TELETYPE 28 without keyboard. Good condition (can be used as receive only) **£32.50** ea.

TELETYPE 28 with housing, keyboard and Power supply **£45** ea.

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Type TSA covering 10MHZ-1 GHZ. 25KHZ resolution. **£325.**

Can be extended to 44GHZ with additional plug-in units at nominal cost.

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MARCONI TF1020A RF Power Meter 150 and 300 Watts. As New. **£60** ea.
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KELVIN & HUGHES Single Channel Recorders with spare paper **£18** ea.
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100K + 100K LIN DUAL GANG
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FHACHI RAMP MODULE FX21 24 Volt DC input for 18 volt saw tooth output. Requires only external capacitor and 100K ohm potentiometer to control frequency range up to 100KHZ (eg 50 mfd electrolytic gives sweep of approx. 1 cm per second). In or out sync capability. Price **£5.75.** P. & P. 20p.

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★Beehive Trimmer 3/30 pf.
Brand new Qty 1–9 **13p** ea P & P. 15p. 10–99 **10p** ea P. & P. 25p: 100–999 **7p** ea. P. & P free

DELIVERED TO YOUR DOOR 1 cwt. of Electronic Scrap chassis boards etc. No Rubbish FOR ONLY **£4.50.** N Ireland £2 extra
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GRATICULES. 12 cm by 14 cm in High Quality plastic. **15p** each. P & P 8p.

★Vast quantity of good quality components —NO PASSING TRADE—so we offer **3 LB. of ELECTRONIC GOODIES** for £1 70 post paid

HF Crystal Drive Unit. 19 in rack mount. Standard 240V input with superb crystal oven by Labgear (no crystals) **£5** ea. Carr £2
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FIBREGLASS PRINTED CIRCUIT BOARD. Brand New Single or Double sided Any size **1½p** per sq. in Postage 20p per order
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FHACHI VCO MODULE FX11—10HZ-100KHZ
Size 2 x 1⅛ x ⅝"H. Input 12V to 24V DC (not centre tapped) 18V input giving 10V constant amplitude output Requires only a 1 meg ohm potentiometer to tune entire range — or can be swept with a saw tooth input Price **£5.75.** P & P 20p

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LOW FREQUENCY WOBBULATOR

For alignment of Receivers, Filters, etc. 250KHz to 5MHz. effective to 30MHz on harmonics. Three controls—RF level. sweep width and frequency. Order LX63. Price **£8.50** P. & P. 35p.
As above but can have extended cover range down to 20KHz by addition of external capacitors. Order LX63E. Price **£11.50** P. & P. 35p.
Both models can be used with any general-purpose oscilloscope. Requires 6.3V AC input. Supplied connected for automatic 50Hz sweeping. An external sweep voltage can be used instead. These units are encapsulated for additional reliability, with the exception of the controls (not cased, not calibrated).

20HZ to 200KHZ SINE AND SQUARE WAVE GENERATOR

In four ranges. Wien bridge oscillator thermistor stabilised. Separate independent sine and square wave amplitude controls. 3V max sine 6V max square outputs. Completely assembled P.C. Board, ready to use. 9 to 12V supply required. **£8.85** each. P. & P. **35p.** Sine Wave only. **£6.85** each. P. & P. **35p.**

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5 MHZ to 150 MHZ (Useful harmonics up to 1·5 GHZ) up to 15 MHZ sweep width. Only 3 controls, preset RF level, sweep width and frequency. Ideal for 10·7 or TV IF alignment, filters, receivers. Can be used with any general purpose scope. Full instructions supplied. Connect 6·3V AC and use within minutes of receiving. All this for only **£6.75.** P. & P. **35p.** (Not cased, not calibrated.)

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TYPE A	TYPE B	TYPE C	TYPE D
Input: 12V DC	Input: 12V DC	Input: 12V to 24V DC	Input: 12V to 24V DC
Output: 1.3kV AC 1.5MA	Output: 1.3kV DC 1.5MA	Output: 1.5kV to 4kV AC 0.5MA	Output: 14kV DC 100 micro amps at 24V. Progressively reducing for lower input voltages
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MAKE YOUR SINGLE BEAM SCOPE INTO A DOUBLE WITH OUR NEW LOW PRICED SOLID STATE SWITCH. 2 HZ to 8 MHZ. Hook up a 9 volt battery and connect to your scope and have two traces for ONLY **£6·25.** P. & P. 25p.
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SERVICE TRADING CO

RELAYS

SIEMENS PLESSEY, etc. MINIATURE RELAYS

1	2	3	4	1	2	3	4
52	4–8	2c/o	**75p***	700	16–24	4 M2B	**65p***
58	5–9	6 c/o	**85p**	700	16–24	4 c/o	**85p***
185	8–12	6 M	**65p***	1250	18–36	2 c/o	**65p***
230	9–18	2 c/oHD	**75p***	2500	36–45	6 M	**65p***
430	15–24	4 c/o	**85p***	2500	31–43	2 c/oHD	**65p***
700	12–24	2 c/o	**65p***	15k	85–110	6 M	**65p**

(1) Coil ohms; (2) Working d.c. volts; (3) Contacts; (4) Price HD=Heavy Duty. All Post Paid. (*Including Base)

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6 VOLT D.C. 1 make con. **35p**. Post 15p.

9 VOLT D.C. RELAY
3 c/o 5 amp contacts. 70 ohm coil **75p**. Post 15p

12 VOLT D.C. RELAY
3 c/o 5 amp contacts. 120 ohm coil **75p**. Post 15p

24 VOLT D.C.
2 HD c/o 700 ohm coil **75p**. Post 15p.
4 c/o 300 ohm coil **85p**. Post 15p.
100 VOLT a.c. 2 c/o. **65p**. 3 c/o **75p**. Post 15p.

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24V D.C. 3 c/o **75p**. Post 20p. Base 15p.

24 VOLT A.C. Mfg. ITT 3 h.d. c/o contacts **55p**. Post 20p. Base 15p extra.

55 VOLT A.C.
3 heavy duty c/o contacts. Price **55p**. Post 20p. Base 15p.

230 VOLT A.C. RELAY
240V. A.C. heavy duty 3 c/o contacts. Price **75p**. Post 20p. Octal base 15p extra.

220/240 VOLT AC RELAY
3 c/o 5 amp cont. Sealed Mfg. ISKRA **£1.25**. Post 20p. Base 15p extra.

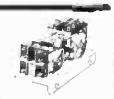
ARROW 230/240V AC 2 c/o 15 amp contacts. Amp connectors **£1.00**. Post 20p.

110 VOLT A.C. 2 c/o. 20 amp **£1.25**. Post 15p

CLARE-ELLIOT Type RP 7641 G8
Miniature relay. 675 ohm coil 24 volt D.C. 2 c/o. **70p**. P.P.

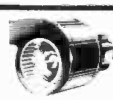
MANY OTHERS FROM STOCK, PHONE FOR DETAILS

LATCHING RELAY



Twin latching relay. 'flip-flop' 2c/o each relay. Mains contacts. 115 volts A.C. or 50 volt D.C. operation or 240 volts A.C. with 2.5K resistor. **85p**. Post 20p

PRECISION CENTRIGUGAL BLOWERS

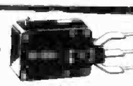


Mfg. by Smiths Industries. Miniature model. Series SF/200. Size 95mm x 82mm x 82mm. Aperture 38mm x 31mm. 12 c.f.m. **£2.75**. Post 50p.
Mfg. by Airflow Developments Ltd.
Precision made, continuously rated, smooth running 230/240v A.C. motor 80c.f.m. As illustrated but with round aperture **£6.50**. Post 75p.
Mfg. by Woods
Extremely powerful 220/250v A.C. 0.3 amp. 2,700 r.p.m. continuously rated. Capacitor start. Cast construction. Aperture 66mm x 50mm O/A 200mm. **£12.00**. Post £1.00

230 VOLT FAN ASSEMBLY

Continuously rated, removable aluminium blades. Price **£1.25**. Post 50p.
VAT 25%

C/O MICRO SWITCH



VERY SPECIAL OFFER. Mfg. by C.E.M. 3 amp 250 volt. 10 amp 125 volt. 50 for **£3**. Post 36. 100 for **£5**. Post 50p. 1,000 for **£45**. Post paid.
DOUBLE POLE C/O or 2 make/2 break micro switch. 10 amp 250 v A.C. With detachable roller assembly. 10 for **£2.50**. Post 50p. (Min. order 10)

COIN MECHANISM (Ex-London Transport)

Unit containing selector mechanism for 1p, 2p & 5p coins. Micro switches, relays, solenoid-operated hopper 24 volt D.C. Precision built to high standard. Incredible VALUE at only **£2.50**. Post £1. **VAT 25% (Total price inc. VAT & Post £4.21)**

230–250 VOLT A.C. SOLENOID

Similar in appearance to illustration. Approximately 1½ lb. pull. Size of feet 1⅞" x 1⅜". Price **£1.00**. Post 25p

SOLENOID HEAVY DUTY MODEL

230/250v A.C. Apprx. 10lb. pull. 4" long x 2⅜" wide x 3" high **£2.50**. Post 50p

24 VOLT DC SOLENOIDS

UNIT containing 1 heavy duty solenoid approx. 25 lb. pull at 1 in. travel. 2 solenoids of approx. 1 lb. pull at ¼ in. travel. 6 solenoids of approx. 4 oz. pull at ¼ in. travel. Plus 1 24V D.C. 1 heavy duty 1 make relay. Price **£2.50**. Post £1.00. **ABSOLUTE BARGAIN.**

240 V A.C. SOLENOID OPERATED FLUID VALVE

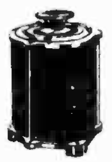
Rated 1 p.s.i. will handle up to 7 p.s.i. Forged brass body, stainless steel core and spring. ⅛ in. b.s.p. inlet/outlet. Precision made. British mfg. PRICE **£2.25**. Post 50p. NEW original packing.

600 WATT DIMMER SWITCH

Easily fitted. Fully guaranteed by makers. Will control up to 600 watts of all lighting except fluorescent at mains voltage. Complete with simple instructions. **£2.75**. Post 25p.

1000 watt model	**£4.00**. Post 25p
2000 watt model	**£8.00**. Post 40p

VARIABLE VOLTAGE TRANSFORMERS



Carriage extra

INPUT 230 v. A.C. 50/60
OUTPUT VARIABLE 0/260 v. A.C.
BRAND NEW. All types.

200W (1 Amp)	£10.00
0.5 KVA (Max. 2½ Amp)	£11.50
1 KVA (Max. 5 Amp)	£16.50
2 KVA (Max. 10 Amp)	£30.00
3 KVA (Max. 15 Amp)	£33.00
4 KVA (Max. 20 Amp)	£60.00
(max. 37.5 Amp)	£102.50

LT TRANSFORMERS

0, 6, 12 volt @ 10 amp	**£5.60** Post 70p
0, 10, 17, 18 volt @ 10 amp	**£7.90** Post £1.00
0, 6, 12 volt @ 20 amp	**£9.00** Post £1.00
0, 12, 24 volt @ 10 amp	**£9.50** Post £1.00
0, 4, 6, 24, 32 volt @ 12 amp	**£9.90** Post £1.00
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Other types to order at short notice — Phone your enquiries.

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Step up step down 0 115 200 220 240 volts
At 75 watt **£2.64** Post 40p. 150 watt **£3.50** Post 50p. 300 watt **£6.20** Post 60p. 500 watt **£9.20** Post 75p. 1000 watt **£12.00** Post 90p

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★ FOUR EASY TO BUILD KITS USING XENON WHITE LIGHT FLASH TUBES, SOLID STATE TIMING + TRIGGERING CIRCUITS, PROVISION FOR EXTERNAL TRIGGERING. 230-250v. A.C. OPERATION. ★

★ **HY-LITE STROBE Mk IV**
Designed for use in large rooms, halls and utilizes a silica tube, printed circuit. Speed adjustable 1-20 f.p.s. Light output greater than many (so called 4 Joule) strobes. Price **£15.40**. Post 75p ★

★ **RANGE OF THREE OTHER STROKE KITS FROM STOCK. FROM £6.30 to £22.00 S.A.E. (Foolscap) for details.** ★

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★ **BIG BLACK LIGHT**
400 Watt. Mercury vapour ultra violet lamp. Extremely compact and powerful source of u.v. Innumerable industrial applications also ideal for stage display, discos etc. P.F. ballast is essential with these bulbs. Price of matched ballast and bulb **£21.00**. Post £1.50. Spare bulb **£8.00**. Post 65p ★

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★ **BLACK LIGHT FLUORESCENT U.V. TUBES**
4ft. 40 watt £5.50 (callers only) **2ft. 20 watt £4.25**. Post 60p (For use in stan bi-pin fittings) MINI **12in. 8 watt £1.60**. Post 25p. **9in. 6 watt £1.30**. Post 25p. Complete ballast unit and holders for either 9" or 12" tube. **£1.70**. Post 30p (9" x 12" measures approx.) ★

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★ **U.D.I. SINGLE CHANNEL. 750 watt MANUAL/AUTO DIMMER** ★
750W Solid State Fader, with three functions. Manual fade: Auto fade-up; Auto fade-down. Automatic cycling up and down. Functions selected with three position rocker switch. Two ranges of cycling for 'Flashing' or 'Slow blending'. Ready built module 6" x 3" glass fibre board incorporating 10 amp TRIAC. Two or more modules for top quality colour blending and flashing effects. PRICE **£15.00**. Post 65p ★

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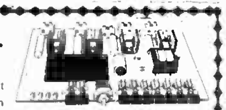
SQUAD LIGHT



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. Can be used on same circuit as radio mikes or sensitive amplifiers. A whole new range of lighting effects possible with astounding results. Already in use in London's foremost theatres, night clubs and discos. Conforms to all R.F.I. tests, including Common Market regulations. Supplied in tough well designed case with embossed front panel. Price only **£60.00**. Post 75p. S.A.E. (Foolscap) for further details.

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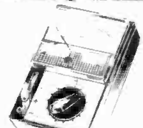

MULTI RANGE METER A.C. volts 2.5-500. D.C. volts 2.5-500 (Sensitivity 2000Ω/V DC & AC). DC current 0/1/10/100 mA. Ohms range. Sturdy compact moving coil instrument with 21 ranges, dimensions 120x 80x 44mm. Weight 0.32 kg. SERVICE TRADING CO. Price **£5.00**. Incl. leads and battery. Post 50p. (Total price inc. VAT & Post **£5.94**).

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90mm Diameter.
Type 65C5. 2A D.C. M/C. 5A D.C. M/C. 10A D.C. M/C. 20A D.C. M/C.
Type 62T2. 1A A.C. M/I. 20A A.C. M/I. 300V A.C. M/I. ALL ABOVE **£2.50**. Post 30p
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VAT

VAT AT 8% MUST BE ADDED TO ALL ORDERS FOR THE TOTAL VALUE OF GOODS INCLUDING POSTAGE UNLESS OTHERWISE STATED

GEARED MOTOR

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. **£3.85**. Post 50p.

REVERSIBLE MOTOR

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.

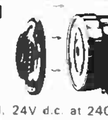
20 r.p.m. GEARED MOTOR

230/240 volt 20 r.p.m. motor. **£1.00**. Post 20p

BODINE TYPE N.C.I. GEARED MOTOR

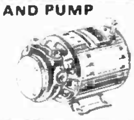
(Type 1) 71 r.p.m. torque 10 lb. in. **Reversible** 1/70th h.p. cycle .38 amp. **(Type 2) 28 r.p.m.** torque 20 lb. in. **Reversible** 1/80th h.p. 50 cycle .28 amp. The above two precision made U.S.A. motors are offered in 'as new' condition. Input voltage of motor 115v. **A.C.** Supplied complete with transformer for **230/240v A.C. input.**
Price, either type **£6.25**. Post 75p or less transformer **£3.75**. Post 65p
These motors are ideal for rotating aerials, drawing curtains, display stands, vending machines, etc. etc.

BENDIX MAGNETIC CLUTCH



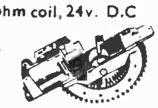
A superb example of Electro-mechanics! The main body is in two sections. The coil section is fixed and has a ⅝in. sleeve. The drive section rotating on the outer perimeters. The uniting plate has ⅜in. ID bearing concentric with main section and 18-tooth cog wheel.
When energized transmission is extremely powerful. 24V d.c. at 240 MA. OUR PRICE JUST £2.50. Post 45p.

ROTARY VACUUM AIR COMPRESSOR AND PUMP



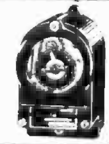
Carbon vane, oil-less. 100/115V A.C. 1/12 h.p. motor. 50/60 cycle. 2875/3450 r.p.m. 20" vacuum. 1.25 c.f.m. 10 p.s.i. (approx. figures). New unused surplus stock, with elect. connection data. Fraction of maker's price. **£12.00**. Post £1.00. Suitable transformer **£3.50**. Post 50p.

UNISELECTOR SWITCHES—NEW



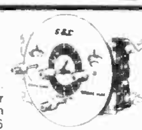
4 BANK 25 WAY FULL WIPER 25 ohm coil, 24v. D.C operation **£6.90**. Post 50p.
8 BANK 25 WAY FULL WIPER 25 ohm coil, 24 v. D.C. **£7.90**. Post 50p.
8 BANK 25 WAY FULL WIPER 24 v. D.C. operation **£9.50**. Post 65p.

TIME SWITCH



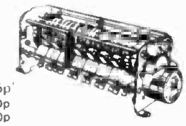
'Horstmann' Type V Mk II Time Switch. 200/250 volt A.C. Two on/two off every 24 hours, at any manually pre-set time. 30 amp contacts. 36-hour spring reserve in case of power failure. Day omitting device. Fitted in heavy high impact case, with glass observation window. Built to highest Electricity Board 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**.)

PROGRAMME TIMERS



230/240 Volt A.C. 15 RPM Motors. Each cam operates a c/o micro switch. Ideal for lighting effects, animated displays etc. Ex equipment tested. Similar to illustration.

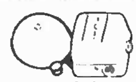
2 cam model	15 r.p.m.	**£2.00** post 35p
4 cam model	15 r.p.m.	**£2.50** post 40p
8 cam model	20 r.p.m.	**£4.75** post 60p

8 cam model each cam fully adjustable. 6 r.p.m. Mfg. by Magnetic Devices **£7.50**. Post 60p

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 **£1.70**. Post 20p. **50 WATT** 1, 5, 10, 25, 50, 100, 500, 1k ohm **£2.10**. Post 25p. **100 WATT** 1/10/25/50/100/250/500/1k/1.5k/2.5k/5k ohm. **£3.30**. Post 35p
Black Silver Skirted knob calibrated in Nos. 1-9, 1½ in. dia. brass bush. Ideal for above Rheostats, 22p ea.

'GENTS' 6" ALARM BELL

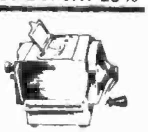


200/250 volt AC/DC. **Brand New.** Price **£5.00**. Post 75p (illus.) **VAT 25%.**

'STC' 6" RED ALARM BELL

Brand New. Price **£4.00**. Post 50p. **24/48V DC. VAT 25%**

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 **£30.00**. Post 80p.
1000 VOLTS 1000 megohms **£36.00**. Post 80p.

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BI-PAK

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

NEW

PUSH-BUTTON STEREO FM TUNER

Fitted with Phase Lock-loop

OUR PRICE ONLY

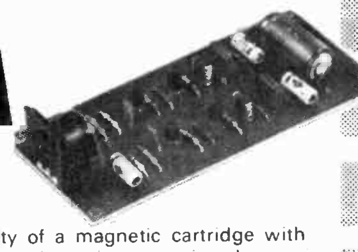
£19.95

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 **T461**.
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:
Sensibility 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.

£2.65

VAT ADD 25%

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

STEREO PRE-AMPLIFIER PA100

OUR PRICE **£13.50**

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.

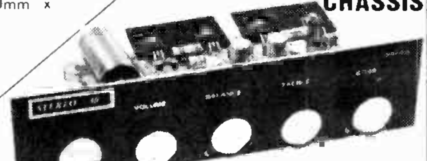
Frequency Response + 1dB 20Hz - 20KHz. Sensitivity of inputs
1. Tape Input 100mV into 100K ohms
2. Radio Tuner 100mV into 100K ohms
3. Magnetic P.U. 3mV into 50K ohms

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 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 £27.55.** plus 62p 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 £9.20** plus 62p postage

STEREO 30 COMPLETE AUDIO CHASSIS



7+7 WATTS R.M.S.

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, mains 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).

£15.75 P & P 45p

TRANSFORMER £2.45 plus 62p p & p
TEAK CASE £3.65 plus 62p p & p

AL10-20-30

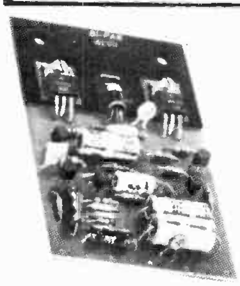
AUDIO AMPLIFIER MODULES

Ideal for record players, recorders, stereo amplifiers, etc.

Harmonic Distortion Po=3 watts f=1KHz 02.5%
Load Impedance 8-16ohm
Frequency response ±3dB Po=2 watts 50Hz-25KHz
Sensitivity for Rated O/P — Vs=25v. RL=8ohm f=1KHz 75mV. RMS
Size: 75mm x 63mm x 25mm

AL10 3w R.M.S.	**£2.30**
AL20 5w R.M.S.	**£2.65**
AL30 10w R.M.S.	**£2.95**

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 — 3,4,5, 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.

£3.95

NEW PA12

NEW PA12 Stereo Pre-Amplifier completely redesigned for use with AL10/20/30 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.

£6.50

PS12

Power supply for **AL10/20/30, 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.

OUR PRICE £1.20
Transformer T538 £2.30

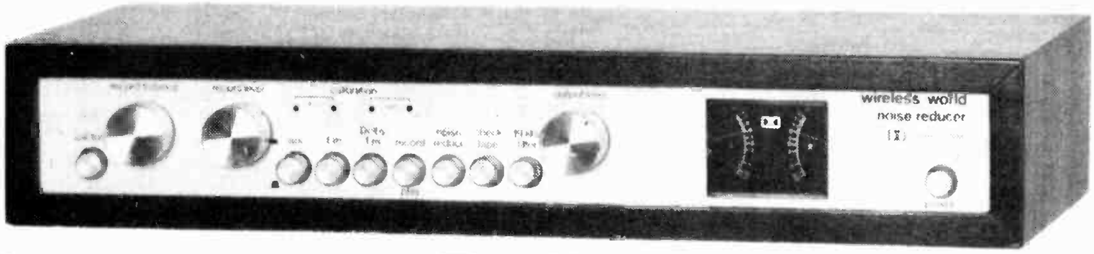
Stabilised Power Supply Type SPM80

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

£3.00

BI-PAK

P.O. BOX 6, WARE, HERTS.



Wireless World Dolby™ noise reducer

Trademark of Dolby Laboratories Inc.

We are proud to announce the latest addition to our range of matching high fidelity units.

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

The kit includes:

--complete set of components for stereo processor

--regulated power supply components

--board-mounted DIN sockets and push-button switches

--fibreglass board designed for minimum wiring

--solid mahogany cabinet, chassis, twin meters, front panel, knobs, mounting screws and nuts

Typical performance

Noise reduction: better than 9dB weighted

Clipping level: 16.5dB above Dolby level (measure of 1% third harmonic content)

Harmonic distortion 0.1% at Dolby level typically over most of band, rising to a maximum of 0.12%.

Signal-to-noise ratio: 66dB (20Hz to 20kHz, signal at Dolby level)

30mV sensitivity.

PRICE: £34.40+VAT

Calibration tapes are available for open-reel use and for cassette (specify which) .... **Price £1.80**+VAT*

Single channel plug-in Dolby™ PROCESSOR BOARDS (92 x 87mm) with gold plated contacts are available with all components .... **Price £6.50**+VAT

Single channel board with selected fet .... **Price £2.00**+VAT

Gold plated edge connector .... **Price £1.27**+VAT*

Selected FET's **54p** each+VAT, **96p**+VAT for two, **£1.76**+VAT for four

Please add VAT at 25% unless marked thus*, when 8% applies
We guarantee full after sales technical and servicing facilities on all our kits

Buy it with Access

BARCLAYCARD

Please send SAE for complete lists and specifications

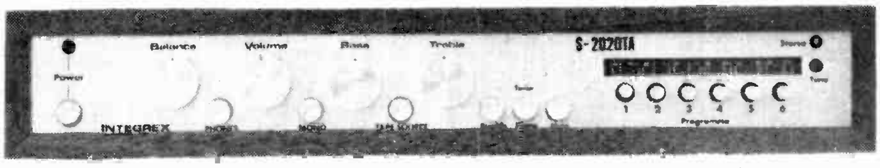
INTEGREX LTD.

**Portwood Industrial Estate, Church Gresley,
Burton-on-Trent, Staffs DE11 9PT
Tel. Swadlincote (0283 87) 5432. Telex 377106**

INTEGREX

S-2020TA STEREO TUNER/AMPLIFIER KIT

SOLID MAHOGANY CABINET



A high-quality push-button FM Varicap Stereo Tuner combined with a 20W 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. All sockets, fuses, etc., are PC mounted for ease of assembly. Tuner section: uses Mullard LP1186 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 @ 1.8μV.THD typ. 0.4%

PRICE: £48.95+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 £26.31+VAT
With ICPL Decoder £30.58+VAT
With Portus-Haywood Decoder £32.81+VAT

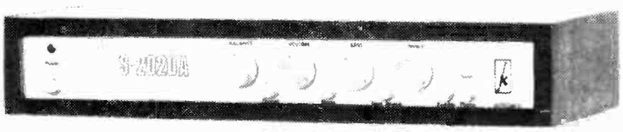
STEREO MODULE TUNER KIT

A low-cost Stereo Tuner based on the Mullard LP1186 RF module requiring no alignment. The IF comprises a ceramic filter and high-performance IC Variable INTERSTATION MUTE. PLL stereo decoder IC

Sens. 30dB S/N mono @ 1.8μV
THD typically 0.4%
Tuning range 88—104MHz
LED sig. strength and stereo indicator

PRICE: Mono £25.55+VAT
Stereo £28.65+VAT

S-202A AMPLIFIER KIT



Developed in our laboratories from the highly successful "TEXAN" design. PC mounting potentiometers, switches, sockets and fuses are used for ease of assembly and to minimize wiring

Typ. Spec. 20+20W r.m.s. into 8-ohm load at less than 0.1% THD. Mag. PU input S/N 60dB. Radio input S/N 72dB. Headphone output. Tape In/Out facility (for noise reduction unit, etc.). Toroidal mains transformer.

PRICE: £30.94+VAT

ALL THE ABOVE KITS ARE SUPPLIED COMPLETE WITH ALL METALWORK, SOCKETS, FUSES, NUTS AND BOLTS, KNOBS, FRONT PANELS, SOLID MAHOGANY CABINETS AND COMPREHENSIVE INSTRUCTIONS

BASIC NELSON-JONES TUNER KIT	£13.13+VAT
BASIC MODULE TUNER KIT (Mono)	£13.25+VAT
BASIC MODULE TUNER KIT (stereo)	£15.25+VAT
PHASE-LOCKED IC DECODER KIT	£4.47+VAT
PUSH-BUTTON UNIT	£3.50+VAT
PORTUS-HAYWOOD PHASE-LOCKED STEREO DECODER KIT	£7.93+VAT

WW—077 FOR FURTHER DETAILS

the test equipment people

On these pages you will find just the briefest selection from the vast range which we hold in stock at any one time.

If you are seeking a specific item and it is not listed, it will pay you to ring us first — we believe we offer the best prices and the best service. WORLD WIDE EXPORT.

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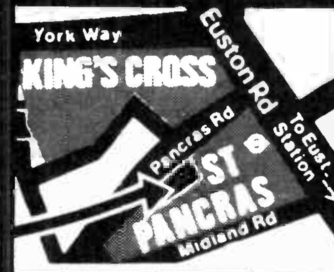


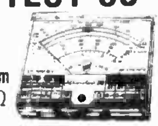
MULTIMETERS

SUPER TESTER 680R ICE

20,000 Ohm per Volt Sensitivity. Fully screened against external magnetic fields. Scale width and small case dimensions (128 x 95 x 32mm). Accuracy and stability (1% in D.C., 2% in A.C.) of indicated reading. Simplicity and ease of use and readability. Full ranges of accessories. 1000 times overload. Printed Circuit board is removable without de-soldering. More ranges than any other meter. Ask for free catalogue . . . **£18.50**

FANTASTIC NEW MICROTEST 80

MEASURES ONLY 90 × 70 × 18mm Electronic zero Ω



Amazing Value at £11.95

3 fields of measurement and 40 ranges

PRINTED CIRCUIT BOARD IS REMOVABLE WITHOUT SOLDERING

Volts d.c. 6 ranges: 100mV, 2V, 10V, 50V, 200V, 1 000V (20kΩ/V) 2% precision on d.c. and a.c.
Volts a.c. 5 ranges: 1 5, 10V, 50V, 250V, 1,000V (4kΩ/V).
Amp. d.c. 6 ranges: 50μA, 500μA, 5mA, 50mA, 500mA, 5A.
Amp. a.c. 5 ranges: 250μA, 2 5mA, 25mA, 250mA, 2.5A.
Ohms 4 ranges: Low Ω, Ω × 1, Ω × 10, Ω × 100 (from 1/10 di Ω until 5MΩ)
V Output 5 ranges: 1 5V, 10V, 50V, 250V, 1.000V
Decibels 5 ranges: +6dB, +22dB, +36dB, +50dB, +62dB
Capacity 4 ranges: 25μF, 250μF, 2.500μF, 25,000μF

Accessories (extra) available to convert Microtest 80 & Supertester 680R into following SIGNAL INJECTOR, GAUSS METER, ELECTRONIC VOLTMETER, AMPER-CLAMP, TRANSISTOR TESTER, TEMPERATURE PROBE, PHASE SECUENCE INDICATOR — Send for details

I.C.E. Signal Injector, Model 63

Data Summary
Basic Output
Frequencies. 500 kHz & 1 kHz
Power Supply: Internal 1 5v cell VARTA 245 1ECR1 (or equivalent)

Dimensions: 13 x 13 x 120 mm (including 15 mm prod-tip)
Weight: 20 gm approx

Technical Description

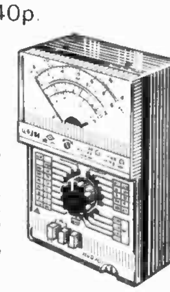
The I C E Signal Injector Model 63, is a compact, self-powered unit which has been designed to assist the electronics and radio-technician in fault-finding in both vacuum-tube and transistorised equipment. It is particularly valuable in the location of failures in radio receivers, amplifiers, etc.

A small, hand-held, moulded plastic body contains the transistorised oscillator circuit, its 1 5v cell, and is fitted with a conductive prod-tip for application to the circuit under test. A thumb-operated spring-loaded button permits application of power to the oscillator, at will, thus conserving battery life.

The circuit of the Signal Injector Model 63 incorporates two transistors and two inductors in a blocking-oscillator configuration which produces two basic frequencies, namely 500 and 1 kHz, of nominally rectangular waveform of fast rise-time, so containing high-order harmonics covering a wide frequency spectrum.

£5.95. P&P 40p.

MORE RANGES FOR LESS MONEY!

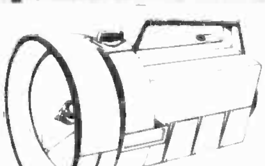


AC/DC Multimeter type U4324. A DC 0 06-3A — 6 Ranges. A AC 0 3A — 5 Ranges. V DC 0 6-1200V — 9 Ranges. V AC 3-900V — 8 Ranges. Freq. In the range of 45 to 20kHz. Resistance 500 ohm to 5 Mohm — 5 Ranges. Decibel —10 to +12dB. Accuracy ±2 5% DC ±4% AC. Dimensions 167 x 98 x 63mm.

All above Multimeters are brand new

Only **£9.75.**

POST & PACKING 60p



MODEL 964

STROBETTE

STROBOSCOPE TACHOMETER
Two Units in One

SOME SPECIFIC APPLICATIONS

- To check and analyze motion while designing data processing units
- To check register in printing presses
- To check balance in balancing machines
- To check speed of motors, gear reducers, etc
- To check speed of pulleys, gears, fans, shafts or anything that rotates over 200 RPM
- To observe motion of packages, bottles, cans, envelopes, etc., while they are being manufactured.
- To observe belt slippage
- To demonstrate strobe action to students

SPECIFICATIONS

STROBOSCOPIC FLASH RATE—200 to 6,000 flashes per minute.
TACHOMETER SPEED RATE—200 to 6,000 R P M
ACCURACY—3% better
CALIBRATION—At 3,600 F.P.M. against any known synchronous speed — 7200, 3600, 1800, 1200, 900 RPM, etc
CIRCUITRY—100% solid state
FLASH DURATION—Approximately 10 to 25 microseconds
FLASHLIGHT COLOR—Xenon white 6 500 K
FLASH ENERGY— 40 Watts-second (Joules)
DUTY CYCLE—Below 1,000 FPM = 30 minutes; 1 000 to 3 600 FPM = ½ duty cycle; 3 600 FPM and above = ¼ duty cycle
BEAM ANGLE—80
PHYSICAL—High impact case. Plastic lens. Mirror type reflector
SIZE—3" x 3" x 7" with 4" diameter reflector
WEIGHT—27oz (.76 Kg). Shipping weight 4 lb (1 8 Kg)
TRIPOD MOUNTING—Built-in ¼-20 thread tripod socket
POWER—220 VOLTS 50/60 Hz 22 watts

FANTASTIC VALUE £49.50

Only £89.50

"TOUCHLESS" RETRO-REFLECTIVE TACHOMETER

FEATURES

- Reads RPM from as far as 24" away!
- Four ranges 0-1,000, 3,000, 10,000, 30,000 RPM
- Instant field calibration.
- Reads low or high speed on any type of machinery
- Battery powered — built-in voltage checker
- "Touchless" (no torque loss) measurements
- Direct reading mirror type scale
- Hand portable (only 32 oz.) (0 9 Kg)
- Accuracy 1½% of full scale
- Aluminium case — baked enamel finish
- Reads on marked shafts as small as 1/16" diameter
- Marking tape provided
- Complete solid-state circuity
- Push-button reading
- Hidden probe cable, extends to 24" (60cm).

SPECIFICATIONS

Photocell: Photo transistor. **Lamp: GE No. 222X** **Batteries:** One 5 4 V type TR-134R. Except Model B 912. **Accuracy:** 1½% of full scale. **Meter:** Shock-proof movement, large clear-face dial. **Calibration:** From any fluorescent light 50 to 60 cycles. **Dimensions:** 5⅛" (130.0 mm) wide, 7½" (190 0 mm) high, 2½" (63 5 mm) deep

Carrying case **£12.50**

Shown on these pages are just a few samples of our huge stock. If the item you require is not shown please give us a ring.

BROKERS LTD

Carriage and packing charge extra on all items unless otherwise stated.

Please note: All instruments offered are secondhand and tested and guaranteed 12 months unless otherwise stated.

HIGH POWER BATTERY MOTOR

6v/12v operated. Strong enough to power a motor mower, go-cart or similar. Speed easily variable Series wound, so virtually impossible to stop, very hard duty Snip at **£3.50.** VAT and postage 85p

Less powerful 12 volt motor suitable for fan or heater. **£2.00.** Post and VAT 65p.

MAINS TRANSISTOR PACK

Designed to operate transistor sets and amplifiers Adjustable output 6v, 9v 12 volts for up to 500mA (class B working) Takes the place of any of the following batteries PP1, PP3 PP4 PP6 PP7 PP9 and others Kit comprises main transformer rectifier, smoothing and load resistor condensers and instructions Real snip at only **£1.50**. VAT and Postage 60p

MULTI-SPEED MOTOR

Six speeds are available 500, 850, and 1 100 r p m and 8 000 12,000 and 15 500 r p m Shaft is ¼in diameter and approximately 1 in long 230/240v Its speed may be further controlled with the use of our Thyristor controller Very powerful and useful motor size approx 2 in dia x 5 in long Price **£1.40** + 45p post & VAT

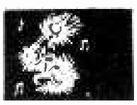
DC HIGH CURRENT PANEL METERS

3½" wound wide angle 240 movement meters flush mounting fitted with external shunts made by Crompton Parkinson brand new still in maker s cartons These are a real bargain at £5 50 each Reasonable quantities available in the following ranges 0-10 amps, 0-20 amps, 0-30 amps, 0-40 amps, 0-50 amps Post and VAT 80p each

TAPE DECK

In metal case with carrying handle heavy fly wheel and capstan drive Tape speed 3¾ Mains operated on metal platform with tape head and guide Not new but guaranteed good working order Price **£1.50** plus VAT and Postage £1 50

SOUND TO LIGHT UNIT



Add colour or white light to your amplifier Will operate 1 2 or 3 lamps (maximum 450w) Unit in Box all ready to work **£7.95** plus 95 VAT and postage

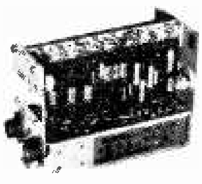
OVEN THERMOSTAT

Made by the famous Diamond H Company this has a sensor joined by a capillary to a variable control and when fitted with a knob is ideal for many ovens or processes 50p each + post and VAT 15p

HONEYWELL PROGRAMMER

This is a drum timing device the drum being calibrated to equal divisions for switch-setting purposes with trips which are infinitely adjustable for position They are also arranged to allow 2 operations per switch per rotation There are 15 changeover micro switches each of 10 amp type operated by the trips, thus 15 circuits may be changed per revolution Drive motor is mains operated 5 revs per min Some of the many uses of this timer are Machinery control Boiler firing Dispensing and Vending machines Display lighting animated and signs Signalling etc Price from makers probably over £20 each Special snip price **£9.95.** £1 00 Post and VAT Don t miss this terrific bargain

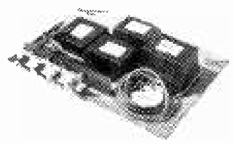
BREAK-DOWN UNIT



Contains hundreds of useful parts some of which are as follows — 66 silicon doides equivalent OA 91 68 resistors mostly ½ watt 5% covering a wide range of values 4 x 1 mfd 400v mfd condensers 15 x 01 mfd 100v condensers 2 RF chokes 8 x B9 valve holders 1 x 4H choke 1 x 115v transformer 1 boxed unit containing 4 delay lines also tag panels trimmer condensers suppressors etc on a useful chassis sized approx 9" x 5" x 7" Only 75p (the 66 diodes would cost at least 10 times this amount) This is a snip not to be missed Post and VAT 75p

THIS MONTH'S SNIP

MULLARD UNILEX



A mains operated 4 + 4 stereo system Rated one of the finest performers in the stereo field this would make a wonderful gift for almost any one In easy-to-assemble modular form and complete with a pair of Goodmans speakers this should sell at about £30 — but due to a special bulk buy and as an incentive for you to buy this month we offer the system complete at only **£15.50** including VAT and postage

GPO PUSH BUTTON DIALLING UNIT

Will take the place of the normal rotating dial has 10 numbered keys so suitable for other digital systems A desk mounting unit with rubber feet this is a very intricate and expensive piece of apparatus New and unused — our price only £9 each + £1 36 post and VAT

TWIN OUTPUT POWER PACKS

These have two separately R C smoothed outputs so can operate two battery radios on a stereo amp without cross modulation (they will of course operate one radio/tape/cassette/calculator, in fact any battery appliance, and will save their cost in a few months) Specs Full wave rectification double insulated mains transformer — total enclosed in a hard P V C case — three core mains lead-terminal output — when ordering please state output voltage 4½v, 6v, 7½v, 9v, 12v or 24v Price **£3.95.** Post and VAT included

TERMS Where order is under £5 please add 30p surcharge to offset packing expenses

J. BULL (ELECTRICAL) LTD.

(Dept. W.W.), 103 TAMWORTH ROAD CROYDON CRO IXX

YOU MAY BE IN TIME

For a valve volt-meter at **£7.50** — a signal generator at **£8.50**, an oscilloscope at **£12.50** — a frequency standard at **£19.50** as these and many other good buys were offered in our December Advanced Advertising News Send s a e for a copy today Subscribers received this list at least a month ago, chances are best buys will have been snapped up, so whilst writing why not send a few stamped envelopes and receive these newsletters directly they are printed

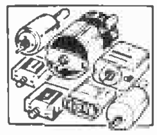
MAINS TRANSFORMERS

All standard 230-250 volt primaries

		£ p
1v	1 amp (special)	1.75
2 4	5 amp	.85
6 3v	2 amp	1 25
6 3v	3 amp	1.75
9v	1 amp	.95
9v	3 5 amp	2.50
12v	1½ amp	1.50
12v	1 amp	1.00
6 5v-0 6 5v	1 amp	1.50
18v	1 amp	1.50
24v	2 amp	2.25
24v	3 amp	3.50
12 0 12v	50mA	1.20
6 0 6v	50mA	1.20
8 0-8v	½ amp	1.50
18 0 18v	2 amps	3.50
25v	1½ amp	1.95
50v 2 amp & 6 3v	1 amp	4.50
60v 5 amp & 5v	1 amp	7.50
27v	8 amp	4.50
30v	37 amp	22.00
80v tapped 75v & 70v	4 amp	5.50
230v 60mA & 6 3v	1 5 amps	1.75
275-0 275v at 90mA & 604v	3 amps	2.25
EHT Transformer 5000v 23mA	(intermittent)	5.50
Charger Transformers		
6v and 12v	2 amps	1.50
6v and 12v	3 amps	2.25
6v and 12v	5 amps	3.50

Add 30p per £ to cover postage and VAT 25% And 25% except for industrial types

ONLY £1.50 FOR SEVEN ELECTRIC MOTORS



7 powerful batt motors as used in racing cars and power models Output and types vary for use in hundreds of projects - Tools toys models etc All brand new reversible and for 1½ 12v batts Wiring diag inc VAT & Post 40p FREE plan for min power station

1 R.P.M. MOTOR + GEAR BOX

Made by the famous Chamberlain & Hookham Ltd These could be made to drive clock or similar Really robust reliable unit Price **£1.50** + 30p post & VAT

BLACK LIGHT

As used in discotheques and for stage effects etc Virtually no white light appears until the rays impinge on luminous paint or white shirts etc We offer 9" 6w tubes complete with starter choke lamp-holders and starter holder Price **£2.75** + 30p post Tubes only **£2.** Post & VAT 50p

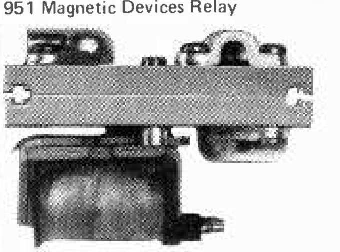
230 volt/175 watt model £6.50. Post & VAT 92p.

Relays

Co-ax Relays for Aerial Switching

951 Magnetic Devices Relay

SPECIAL OFFER



- Available with 12V or 24V DC coil
- Single Change-over contact
- For use with UR43 co-ax cable
- Characteristic impedance 50 ohms
- Nominal frequency 450 MHz
- VSWR approx. 1.1 : 1
- Cross-talk 39dB
- Contact rated at 1 amp or 50W max

£5 each

Inc. P & P and VAT

When ordering specify operating voltage required

Cash with order

REL Equipment & Components Ltd.

Components Division

Croft House, Bancroft, Hitchin, Hertfordshire, SG5 1BU, England

Telephone: (0462) 50551/2/3 · 52202 · 52776/7/8/9 Telex: 82431

WW — 049 FOR FURTHER DETAILS

The 'MISTRAL' Digital Clock

* A Complete Kit or fully built *

Kit £12.50 (Incl) Built £18.00.

- Pleasant green display
- 24 Hour readout
- Silent Synchronous Accuracy
- Fully electronic
- Pulsating colon
- Push button setting
- Building time 1Hr
- Attractive acrylic case
- Easy to follow instructions
- Size 10.5 x 5.7 x 8cm
- Ready drilled PCB to accept components

Exetron Time Ltd offer this unique transformerless design at a substantial saving on retail price. The kit is complete less mains lead – all you require is a soldering iron, solder, and screwdriver to assemble your own digital clock

EXETRON Time Ltd
Regal House,
Penhill Road,
LANCING, Sussex.

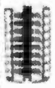
Payment: CWO, Cheque, Access, Barclaycard. (Quote Number)

NEW PRODUCTS

PROTO BOARDS

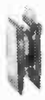
Build & test circuits as fast as you think!

PB100	10 IC cap breadboard kit. 4.5 x 6.0 x 1.3"	£17.45
PB101	10 14-DIP cap. 5-way post. 940 solderless tie points. 5.8 x 4.5"	£26.15
PB102	12 14-DIP cap. like PB101 with 1,240 tie points. 7.0 x 4.5"	£34.90
PB103	24 14-DIP cap. 4 5-way posts. 2,250 tie points. 6.0 x 9.0"	£52.35
PB104	32 14-DIP cap. 3,060 solderless tie points. 8.0 x 9.76"	£69.80



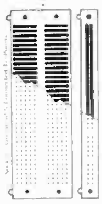
LOGIC MONITOR
Simultaneously displays static and dynamic logic states of DTL, TTL, HTL or CMOS DIP ICs. Pocket size. **£59.95**

PROTO-CLIP
For power on/hands off signal tracing. Bring IC leads up from PC board surface for fast trouble shooting.
PC14 14-pin **£3.25**
PC16 16-pin **£3.40**



SOCKETS & BUS STRIPS

Plug-in, wire, test, modify or expand without patch cords or solder. Snap together to form breadboard needed.



PN/Description	1.3" -Hole	Hole-to Term'ls	Price
QT59S Socket	6.5"	6.2" 118	£10.90
QT59B Bus	6.5"	6.2" 20	£2.20
QT47S Socket	5.3"	5.0" 94	£8.75
QT47B Bus	5.3"	5.0" 16	£2.00
QT35S Socket	4.1"	3.8" 70	£7.45
QT35B Bus	4.1"	3.8" 12	£1.75
QT18S Socket	2.4"	2.1" 36	£4.15
QT12S Socket	1.8"	1.5" 24	£3.30
QT8S Socket	1.4"	1.1" 16	£2.85
QT7S Socket	1.3"	1.0" 14	£2.65

7400 Series TTL

	1	25	100+
SN7400	0.14	0.13	0.12
SN7401	0.14	0.13	0.12
SN7402	0.14	0.13	0.12
SN7403	0.14	0.13	0.12
SN7404	0.15	0.14	0.13
SN7405	0.15	0.14	0.13
SN7406	0.30	0.29	0.28
SN7407	0.30	0.29	0.28
SN7408	0.15	0.13	0.12
SN7409	0.15	0.13	0.12
SN7410	0.14	0.13	0.12
SN7411	0.23	0.22	0.21
SN7412	0.19	0.18	0.17
SN7413	0.30	0.29	0.28
SN7414	0.71	0.70	0.69
SN7415	0.30	0.29	0.27
SN7416	0.28	0.27	0.26
SN7417	0.28	0.27	0.26
SN7420	0.14	0.13	0.12
SN7421	0.95	0.94	0.93
SN7422	0.25	0.24	0.23
SN7423	0.26	0.25	0.22
SN7425	0.26	0.25	0.22
SN7426	0.26	0.25	0.22
SN7427	0.26	0.25	0.22
SN7428	0.39	0.38	0.37
SN7430	0.14	0.13	0.12
SN7432	0.25	0.24	0.22
SN7433	0.36	0.35	0.34
SN7437	0.27	0.26	0.22
SN7438	0.27	0.26	0.22
SN7439	1.10	1.08	1.06
SN7440	0.14	0.13	0.12
SN7441	0.70	0.69	0.66
SN7442	0.63	0.60	0.53
SN7443	1.00	0.99	0.90
SN7444	1.08	1.07	1.05
SN7445	0.85	0.83	0.70
SN7446	1.03	1.00	0.85
SN7447	1.03	1.00	0.85
SN7448	0.85	0.83	0.70
SN7450	0.14	0.13	0.12
SN7451	0.14	0.13	0.12
SN7453	0.14	0.13	0.12
SN7454	0.14	0.13	0.12
SN7455	0.40	0.39	0.38
SN7460	0.14	0.13	0.12
SN7462	0.45	0.44	0.42
SN7464	0.45	0.44	0.42
SN7465	0.45	0.44	0.42
SN7470	0.30	0.27	0.25
SN7471	0.60	0.59	0.58
SN7472	0.25	0.24	0.21
SN7473	0.30	0.27	0.26
SN7474	0.31	0.29	0.26
SN7475	0.40	0.39	0.38
SN7476	0.31	0.29	0.26
SN7478	0.65	0.63	0.61
SN7480	0.43	0.41	0.36
SN7481	1.00	0.95	0.90
SN7482	0.75	0.70	0.62
SN7483	0.81	0.80	0.68
SN7484	0.90	0.86	0.85
SN7485	1.25	1.15	1.00
SN7486	0.31	0.28	0.25
SN7489	3.50	3.20	3.00
SN7490	0.45	0.42	0.35
SN7491	1.00	0.95	0.90
SN7492	0.45	0.42	0.35
SN7493	0.45	0.42	0.35

SN7494	0.48	0.45	0.40
SN7495	0.60	0.56	0.50
SN7496	0.70	0.67	0.60
SN7497	0.70	0.69	0.68
SN74100	1.35	1.30	1.25
SN74104	0.31	0.29	0.26
SN74105	0.31	0.29	0.26
SN74107	0.31	0.29	0.26
SN74109	1.00	0.97	0.95
SN74110	0.55	0.50	0.45
SN74111	0.81	0.80	0.76
SN74114	1.00	0.97	0.95
SN74115	1.00	0.97	0.95
SN74118	1.00	0.95	0.90
SN74121	0.31	0.29	0.25
SN74122	0.44	0.41	0.37
SN74123	0.62	0.58	0.50
SN74125	0.70	0.65	0.60
SN74126	0.75	0.70	0.65
SN74128	1.40	1.35	1.30
SN74132	2.10	2.05	2.00
SN74136	0.95	0.90	0.85
SN74140	2.50	2.45	2.40
SN74141	0.75	0.70	0.62
SN74145	1.15	1.10	1.05
SN74147	2.95	2.90	2.85
SN74148	2.30	2.25	2.20
SN74150	1.35	1.30	1.25
SN74151	0.68	0.62	0.55
SN74152	1.55	1.50	1.45
SN74153	0.68	0.62	0.55
SN74154	1.55	1.50	1.45
SN74155	0.68	0.62	0.55
SN74156	0.68	0.62	0.55
SN74157	0.90	0.85	0.80
SN74158	1.50	1.45	1.40
SN74160	0.95	0.90	0.80
SN74161	0.95	0.90	0.80
SN74162	0.95	0.90	0.80
SN74163	0.95	0.90	0.80
SN74164	1.60	1.55	1.50
SN74165	1.60	1.55	1.50
SN74166	1.40	1.30	1.15
SN74170	2.40	2.30	2.20
SN74173	1.65	1.60	1.55
SN74174	1.15	1.10	1.00
SN74175	0.97	0.90	0.80
SN74176	1.10	1.05	1.00
SN74177	1.10	1.05	1.00
SN74180	1.10	1.05	1.00
SN74181	3.50	3.45	3.35
SN74182	1.10	1.05	1.00
SN74184	1.60	1.55	1.50
SN74185	2.30	2.25	2.20
SN74188	4.90	4.85	4.80
SN74190	1.75	1.70	1.65
SN74191	1.70	1.65	1.60
SN74192	1.25	1.05	1.00
SN74193	1.25	1.05	1.00
SN74194	1.10	1.05	1.00
SN74195	0.90	0.85	0.80
SN74196	1.05	1.00	0.95
SN74197	1.05	1.00	0.95
SN74198	2.05	2.00	1.70
SN74199	2.05	2.00	1.70
SN74200	6.00	5.95	5.80
SN74221	1.80	1.75	1.70
SN74251	1.80	1.75	1.70
SN74278	3.00	2.90	2.80
SN74279	1.20	1.15	1.10
SN74293	1.00	0.95	0.90
SN74298	2.60	2.55	2.50

'LS' and 'S' Series TTL also available

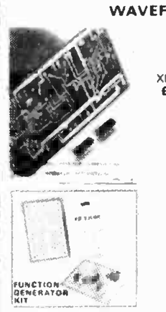
HIGH-SPEED TTL

	1	25	100+
SN74H00	0.34	0.33	0.30
SN74H01	0.34	0.33	0.30
SN74H04	0.38	0.37	0.34
SN74H05	0.37	0.36	0.33
SN74H08	0.40	0.39	0.37
SN74H10	0.36	0.35	0.33
SN74H11	0.36	0.35	0.33
SN74H20	0.36	0.35	0.33
SN74H21	0.36	0.35	0.33
SN74H22	0.36	0.35	0.33
SN74H30	0.36	0.35	0.33
SN74H40	0.36	0.35	0.33
SN74H50	0.36	0.35	0.33
SN74H51	0.36	0.35	0.33
SN74H52	0.36	0.35	0.33
SN74H53	0.36	0.35	0.33
SN74H54	0.36	0.35	0.33
SN74H55	0.36	0.35	0.33
SN74H60	0.36	0.35	0.33
SN74H61	0.36	0.35	0.33
SN74H62	0.36	0.35	0.33
SN74H71	0.80	0.78	0.75
SN74H72	0.74	0.73	0.70
SN74H73	0.90	0.88	0.85
SN74H74	0.87	0.85	0.81
SN74H76	0.90	0.88	0.85
SN74H101	0.80	0.78	0.75
SN74H102	0.80	0.78	0.75
SN74H103	1.10	1.09	1.05
SN74H106	0.95	0.93	0.90

LOW-POWER TTL

	1	25	100+
SN74L00	0.34	0.33	0.30
SN74L02	0.34	0.33	0.30
SN74L03	0.39	0.37	0.34
SN74L04	0.39	0.37	0.34
SN74L10	0.34	0.33	0.30
SN74L20	0.39	0.37	0.34
SN74L42	1.62	1.58	1.50
SN74L51	0.34	0.33	0.30
SN74L73	0.74	0.71	0.68
SN74L74	0.89	0.87	0.80
SN74L90	1.62	1.58	1.50
SN74L93	1.74	1.71	1.65
SN74L95	1.62	1.58	1.50
SN93L00	1.50	1.45	1.40
SN93L01	1.60	1.55	1.50
SN93L08	3.20	3.10	2.90
SN93L09	1.80	1.75	1.70
SN93L10	2.80	2.75	2.65
SN93L11	4.20	4.10	3.90
SN93L12	1.80	1.75	1.70
SN93L14	1.70	1.65	1.60
SN93L16	3.20	3.10	2.95
SN93L21	1.50	1.46	1.42
SN93L22	1.80	1.76	1.70
SN93L24	2.80	2.72	2.60
SN93L28	3.70	3.60	3.42
SN93L34	4.00	3.70	3.50
SN93L38	4.20	4.10	3.90
SN93L40	6.50	6.30	5.90
SN93L41	6.50	6.30	5.90
SN93L60	3.00	2.90	2.70
SN93L66	2.70	2.65	2.55

WAVEFORM GENERATOR KITS



XR-205K
£12.30

Here's a highly versatile instrument at a fraction of the cost of conventional unit. Kit includes two XR205 IC's, data & applications, PC board (etched & drilled, ready for assembly) and detailed instructions.

The Function Generator Kit features sine, triangle and square wave. THD 0.5% typ. AM/FM capability.

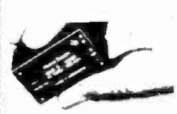
XR-2206KA FUNCTION GENERATOR KIT £11.50

Includes monolithic function generator IC, PC board, and assembly instruction manual.

XR-2206KB FUNCTION GENERATOR KIT £16.00

Same as XR-2206KA above and includes components for PC board.

PICO-PAC



THE SMALLEST *REGULATED* AC/DC POWER SUPPLY EVER

Only 1.70" x 1.00" x 0.85", output preset ±5%, 9 models.

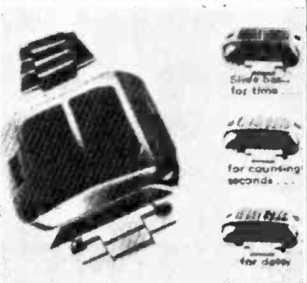
Volts	mA
5	140
8	115
10	100
12	90
15	70
18	50
20	35
22	25
24	15

£15.00 each

PREMIUM QUALITY COMPONENTS

We've been buying and selling top quality components for nearly ten years. We handle only original parts, from the world's leading manufacturers and our customers include some of the largest and most quality-conscious companies. Now you can take advantage of our component buying skills and power and select from a broad range of advanced circuits.

NEW Solar Powered Watch with 100-YEAR CALENDAR



Solar cells draw power from the sun (10 to 15 minutes per day) or from ambient light (slightly longer) to keep batteries fully charged. Batteries operate up to 10 years. LSI circuitry is programmed to provide a calendar to the year 2100, automatically adjusting for 30 and 31 day months, even leap years. Automatic brightness control adjusts LED for perfect viewing even in outdoors. Shows minutes and hours, counts out seconds or shows the date. Easily adjusts to reset hour or date without affecting calendar. Shock and water resistant. Accurate to 5 seconds per month. **Price: £298.50 each.**

HIGH-BRIGHTNESS L.E.D.s

.200" dia.

ED5053 = RED
ED5053Y = YELLOW
ED5053G = GREEN
ED5053O = ORANGE

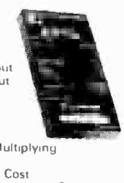
.125" dia.

ED 209 = RED
ED 209Y = YELLOW
ED 209 G = GREEN
OC-1 = CLIP FOR ED5053

STANDARD MICROSYSTEMS

	1-up	25-up	100-up
COM2502	£6.60	£5.30	£4.62
COM2502P	£4.65	£3.95	£3.50
COM2017	£7.05	£6.00	£5.00
COM2017P	£4.75	£4.15	£3.75
COM2502H	£12.80	£11.25	£10.30
COM2017H	£12.80	£11.25	£10.30
COM2601	£16.40	£14.25	£13.15
COM5016	£6.70	£6.15	£5.60
KR2376-ST	£11.50	£9.20	£8.19
KR3600-ST	£12.00	£10.20	£9.25
NMX5010	£6.70	£6.15	£5.55

INTERFACE MODULES



CY1010	Instr. Amp. Bipolar Input	£18.98
CY1011A	Instr. Amp. Bipolar Input	£31.90
CY1020	Instr. Amp. FET Input	£22.00
CY1021	Instr. Amp. FET Input	£31.90
CY1021A	Instr. Amp. FET Input	£38.50
CY2137	DAC, 10 Bit, Low Drift	£30.80
CY2218	DAC, 12 Bit, 2 Quad Multiplying	£96.80
CY2237	DAC, 12 Bit, Low Drift	£46.20
CY2735	DAC, 4 Digit BCD, Low Cost	£57.75
CY3035	ACD, 8 Bit, Sect. Counting, Low Cost	£57.75
CY3635	ADC, 3 Digit BCD, Sect. Count, Low Cost	£77.55

C-MOS Types

	1	25	100+
4000AE	0.17	0.14	0.12
4001AE	0.17	0.14	0.12
4002AE	0.17	0.14	0.12
4004AE	1.93	1.55	1.29
4006AE	0.97	0.78	0.64
4007AE	0.17	0.14	0.12
4008AE	0.79	0.64	0.53
4009AE	0.46	0.37	0.31
4010AE	0.46	0.37	0.31
4011AE	0.17	0.14	0.12
4012AE	0.17	0.14	0.12
4013AE	0.46	0.37	0.31
4014AE	0.83	0.67	0.55
4015AE	0.83	0.67	0.55
4016AE	0.46	0.37	0.31
4017AE	0.83	0.67	0.55
4018AE	0.83	0.67	0.55
4019AE	0.46	0.37	0.31
4020AE	0.92	0.74	0.61
4021AE	0.83	0.67	0.55
4022AE	0.79	0.64	0.53
4023AE	0.17	0.14	0.12
4024AE	0.64	0.52	0.43
4025AE	0.17	0.14	0.12
4026AE	1.42	1.14	0.94
4027AE	0.46	0.37	0.31
4028AE	0.74	0.59	0.49
4029AE	0.94	0.76	0.63
4030AE	0.46	0.37	0.31
4033AE	1.14	0.92	0.76
4035AE	0.97	0.78	0.64
4040AE	0.88	0.71	0.58
4041AE	0.69	0.56	0.46
4042AE	0.69	0.56	0.46
4043AE	0.83	0.67	0.55
4044AE	0.77	0.62	0.51
4047AE	0.74	0.60	0.50
4048AE	0.46	0.37	0.31
4049AE	0.46	0.37	0.31
4050AE	0.46	0.37	0.31
4051AE	0.77	0.62	0.51
4052AE	0.77	0.62	0.51
4053AE	0.77	0.62	0.51
4055AE	1.08	0.87	0.72
4056AE	1.08	0.87	0.72
4060AE	0.92	0.74	0.61
4066AE	0.58	0.47	0.39
4069AE	0.18	0.15	0.12
4071AE	0.18	0.15	0.12
4076AE	1.27	1.02	0.85
4081AE	0.18	0.15	0.12
4510AE	1.27	1.02	0.85
4516AE	1.27	1.02	0.85
4518AE	1.82	1.46	1.21
4520AE	1.82	1.46	1.21
4901AE	0.35	0.32	0.30
4911AE	0.35	0.32	0.30

ADTECH REGULATED POWER SUPPLIES

	Output Vdc	Amps	Prices
RED-BARON SERIES: 5 to 28V/0.8 to 3.0 Amps.			
APS5-3	5	3.0	
APS12-1.6	12	1.6	
APS 15-1.5	15	1.5	£22
APS 24-1	24	1.0	
APS 28-0.8	28	0.8	
GREEN HORNET SERIES: 5 to 28V/2 to 6 Amps.			
PS5-6	5	6	
APS12-4	12	4	
APS15-3	15	3	£35
APS24-2.2	24	2.2	
APS28-2	28	2	
BLACK BEAUTY SERIES: 5 to 28V/4 to 10 Amps.			
APS5-10	5	10	
APS12-7	12	7	
APS15-6	15	6	£54
APS24-5	24	5	
APS28-4	28	4	
BLUE MAX SERIES: 5 to 28V, 9 to 25 Amps.			
APS5-25	5	25	
APS6-22	6	22	
APS12-17	12	17	
APS15-15	15	15	£107
APS20-11	20	11	
APS24-10	24	10	
APS28-9	28	9	

All goods new, to full manufacturer's spec. No substandard parts sold. Visitors welcome, by appointment. Colleges, Govt. and Account orders welcomed.

TERMS: Non-Account Customers, Cash with Order. Standard P&P 50p. Please add VAT to overall total.

RASTRA ELECTRONICS LTD.

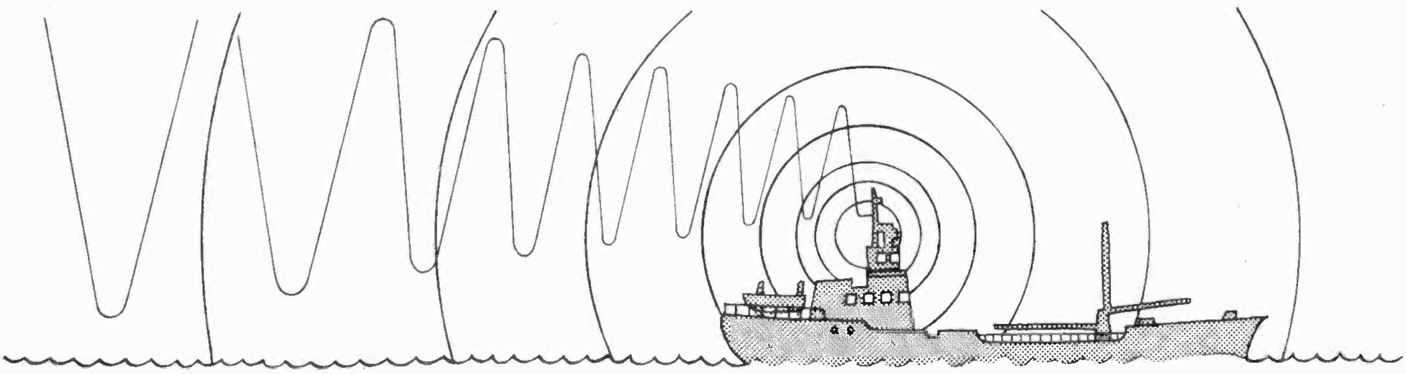
275-281 King Street · Hammersmith · London W6 9NF · Tel. 01-748 3143/2960 · Telex 24443

WW—080 FOR FURTHER DETAILS

Appointments

Advertisements accepted up to 12 noon Monday, February 2, for the March issue subject to space being available.

DISPLAYED APPOINTMENTS VACANT: £6.99 per single col. centimetre (min. 3cm).
LINE advertisements (run on): 99p per line (approx. 7 words), minimum three lines.
BOX NUMBERS: 40p extra. (Replies should be addressed to the Box numbers in the advertisement, c/o Wireless World, Dorset House, Stamford Street, London SE1 9LU).
PHONE: Allan Petters on 01-261 8508 or 01-261 8423.
Classified Advertisement Rates are currently zero rated for the purpose of V.A.T.



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. 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 vacancies at some of our coastal radio stations, so if you're 19 or over, write to: ETE Maritime Radio Services Division (R/B/1), ET 17.1.1.2., Room 643, Union House, St. Martins-le-Grand, London EC1A 1AR.

Post Office Telecommunications

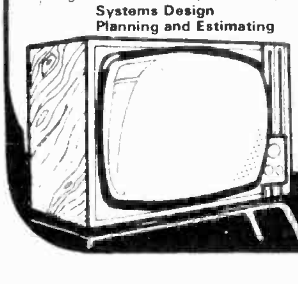
93

A Career With BRITISH RELAY TV

TV Communal Aerial Systems
Video and Audio Communications

A vacancy has arisen for a Manager based in Edinburgh to control the Company's activities in the above fields for the whole of Scotland.
Applications are invited from suitably qualified and experienced persons. Preferably with management or supervisory background and sound practical experience in the following aspects.

Systems Design **Planning and Estimating** **Project Control** **Installation Supervision** **Test and Commissioning**



The salary is negotiable and a Company Car is provided. Enquiries and applications for interview will be treated in strict confidence and should be made in writing to

The General Operations Manager
British Relay Limited
55 Melville Street
EDINBURGH EH3 7HN

(5085)

BRITISH RELAY TV

Opportunities in the
ELECTRONICS FIELD

People with analogue or digital qualifications / experience seeking higher paid posts in: TEST - SERVICE - DESIGN - SALES.

Phone: Mike Gernat, Ref. W.W.

NEWMAN APPOINTMENTS
360 Oxford Street, W.1,
01-629 0501

(94)

How many professional new T.V. broadcasting systems have you pioneered lately?

Zanzibar, Nigeria, Korea, Oman and, most recently, Indonesia?

Over the past few years, Pye TVT have been breaking technological barriers in the broadcasting industry. Installing complete T.V. Broadcasting systems in countries, which have never before seen television and in places where existing systems are converting monochrome to colour.

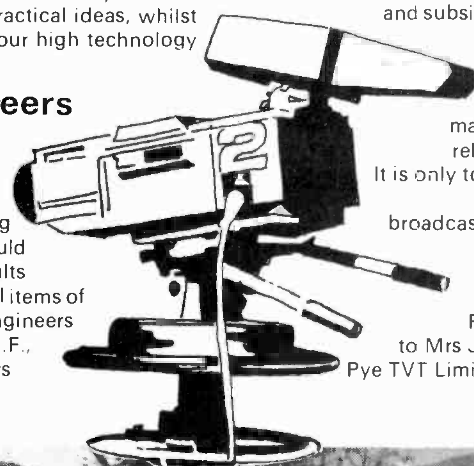
Because each new system is a one-off, custom built job with unique technical innovations and maybe installed in widely differing conditions both in climate and terrain, we offer an unlimited challenge and interest to really creative engineers who have imaginative yet practical ideas, whilst being sufficiently resilient to thrive in our high technology business.

Senior Systems Engineers (Transmitters)

Who are self motivated and capable of aligning complete T.V. transmitter systems to customer specifications using modern test equipment. Applicants should be able to locate and rectify complex faults involving the whole system or individual items of equipment and work with customers' engineers of many nationalities. Experience in U.H.F., Klystrons and/or high power transmitters is essential.

Senior Installation Engineers

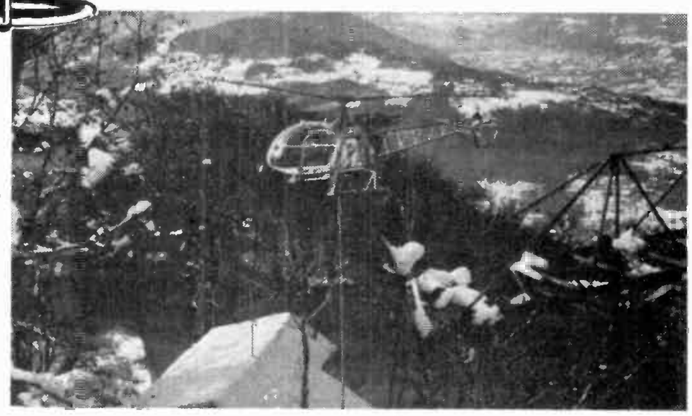
Working either independently or as a head of a small team which may involve taking charge of local labour, you'll be installing and commissioning V.H.F. and U.H.F. transmitters practically anywhere in the world. Your experience could have been gained with a U.K. or overseas broadcaster, but whatever your background, you should be a very competent T.V. transmitter engineer. Projects vary in length and in certain cases your family may be able to join you. Overseas allowances will be paid in addition to basic salary and subsistence.



All appointments will be based in Cambridge and besides excellent salaries, will receive many worthwhile benefits, including relocation expenses in certain cases.

It is only to be expected that an organisation involved for so long in pioneering broadcasting would have been responsible for many firsts throughout the industry. With your help, we hope to produce many more.

Please write with full career details to Mrs J. A. Macnab, Personnel Manager, Pye TVT Limited, P.O. Box 41, Coldhams Lane, Cambridge, CB1 3JU.



A member of the Pye of Cambridge Group

Pye TVT Limited

PO Box 41 Coldhams Lane Cambridge England CB1 3JU
Tel: Cambridge (0223) 45115 Telex: 81103 PYE TVT CAMBGE

Instrumentation and Control Systems

The Electronics and Applied Physics Division has a vital role as a centre for advanced electronic knowledge and as a source of specialised equipment for the multi-disciplinary laboratory at Harwell, for the whole UK Atomic Energy Authority and for industrial projects. Our responsibilities cover a broad range including measurement system design, transducers, semiconductor technology, and signal processing and communication in both analogue and digital forms, often requiring knowledge of both hardware and software.

Our work ranges from initiating applied research aimed at anticipating future needs, to tackling immediate problems in close collaboration with workers in other disciplines. We participate in the nuclear power programme, and we have research and development programmes in the environmental, marine and medical fields.

Applicants should have a clear interest in some of the above areas and should possess a good Honours Degree in Electrical/Electronic Engineering or in Physics with a bias towards Engineering; preference will be given to those with postgraduate experience in an appropriate area and who have scientific or technical management potential.

Appointments will be either to the permanent staff or to Fellowships with a salary or stipend in the range £3500–£5000 depending upon experience and ability.

Further enquiries and requests for application forms should be sent to:
Appointments Section 'A', AERE, Harwell, Oxon. OX11 0RA

HARWELL

ELECTRONIC ENGINEERS AND AN INSTRUCTOR

Vacancies exist for Electronic Engineers and an instructor to join the technical back-up team of an expanding department, involved in electronic calculators and business equipment systems.

Electronic Engineers should have a good basic electronic background, preferably with some experience of pulse and counting circuitry.

The Instructor should have a similar technical background in addition to proven teaching ability.

Please telephone or write for more details and application forms to:

Mr. D. D. Davies
Sumlock Anita Ltd.
1 Frogmore Road, Apsley
Hemel Hempstead, Herts.
Tel. Hemel Hempstead 61771

Sumlock Anita Ltd.
Rockwell International

M.SC. COURSE IN ELECTRICAL ENGINEERING

with specialisation in any one of the following:

Electrical Machines
Communication Systems
Electronic Instrumentation
Control Engineering and Digital Electronic Systems
Design of Pulse and Digital Circuits and Systems

The Course, which commences in October 1976, may be taken on a Full Time, Part Time, Sandwich or Block Release basis, and is open to applicants who will have graduated in Science or Engineering, or who will hold equivalent qualifications, by that date. The Science Research Council has accepted the Course as suitable for the tenure of its Advanced Course Studentships.

A Diploma Course, in some of the above topics or in Power Systems, is also open to applicants with the above, or slightly lower qualifications.

Research in Electrical Engineering

Applications are also invited from similarly qualified persons who wish to pursue a course of research leading to the Degree of M.Phil. or Ph.D. in any of the above topics.

Application forms and further particulars from the Head of the Department of Electrical Engineering (Ref. M.Sc. 4), The University of Aston in Birmingham, Birmingham B4 7PB. (5100)

THE UNIVERSITY OF ASTON IN BIRMINGHAM

UNIVERSITY OF DURHAM
INSTITUTE OF EDUCATION

Colleges of Education Television Recording Unit

ENGINEER

An Engineer is needed to assist in the maintenance and operation of a Monochrome Television Recording Unit serving Colleges of Education in the Durham area, based at Neville's Cross College.

The Unit provides videotapes on a wide range of subjects for use in the training of student teachers. High quality recordings are made on locations throughout the county, using a well equipped Mobile Television Control Vehicle. The successful applicant will join a team of six and will be expected to undertake not only engineering duties but also will have the opportunity to participate fully in a wide variety of production tasks.

Essential qualifications are a general knowledge of television techniques and equipment and a current driving licence. Salary: Local Authority Scale T3: £2,922-£3,282.

Applications, including the names of two referees, should be sent to the **Secretary, University of Durham, Institute of Education, 48 Old Elvet, Durham,** not later than Friday, 6th February, 1976.

5113

MEDICAL PHYSICS TECHNICIAN

GRADE IV

Area Medical Physics Department

Required for duties in the INTENSIVE CARE UNIT and in the wards primarily at Leicester General Hospital.

The work involves close contact with patients. It will include care, use and maintenance of intensive care equipment and sophisticated monitoring systems both in the Unit and throughout the hospital.

A technician qualified ONC/HNC (Electronics) will be required. Experience whilst desirable is not essential, as training in this aspect of work will be provided.

Salary: Technician IV, £2346-£3267. New entrants would normally start at minimum.

Applications stating age, qualifications and previous experience together with the names of two referees, to the **Sector Administrator, Leicester General Hospital, Gwendolen Road, Leicester LE5 4PW.**

Closing date: 31st January 1976

(5109)

Leicestershire Health Service

LEICESTERSHIRE AREA HEALTH AUTHORITY (TEACHING)

YAMAHA

require an

AUDIO ENGINEER

We require an Engineer to service Yamaha Hi Fi products. Applicants must be used to working on current sophisticated audio products and should be able to repair these without assistance to the highest standards.

Please apply in writing to:

(5114)

Natural Sound Systems Ltd.

Strathcona Road, North Wembley, Middlesex HA9 8QL

Looking for a new job?

Perhaps we can help!

We have regular contact with hundreds of electronics and electrical companies needing qualified electronics engineers and technicians and TV service engineers.

We can, therefore, help you to find an interesting and well paid job. All you need to do is to return the coupon below or give us a ring. Our service is confidential and costs you nothing.

TJB Technical Services Bureau,
3A South Bar,
Banbury, Oxfordshire.
Banbury (0295) 53529

TJB

Technical Services Bureau is a division of Technical & Executive Personnel Ltd and is solely concerned with job placement in the Electronics and Electrical Industries

Please note that this service is available only for engineers who are (or will be) available in the U.K. for interview.

Please send me an "Application for Registration" form

NAME ....

ADDRESS ....

....

.... (90)

Depot Engineers

Due to continually increasing commitments we need to expand our shore based engineering staff at our service depots at Cardiff and Tilbury.

The work is concerned with installation and service of our world famous communication equipment on board commercial vessels of all types.

In some instances opportunities may exist for overseas travel.

The ideal candidate will probably have served as a Radio or Electronics Officer at sea and will have three or more years sea service.

A company vehicle is provided for business and personal use.

If you are interested and would like to know more please write or telephone (reverse charges) to:

Jonathan Smith,
International Marine Radio Co. Ltd.,
Peall Road, Croydon, CR9 3AX
Telephone 01-684 9771

ITT Marine

(5093)

Inner London
Education Authority

South Thames College

Audio-Visual Technician

Grade 6

responsible for

College CCTV System and All Audio-Visual Aids

(including first line maintenance and operation).

Applicants must have an appropriate advanced CGLI or equivalent or higher qualification and six years' experience (including training period).

Salary: Grade 6 £3156-£3762, with, additionally, £411 London Allowance added.

Application forms and further particulars from Vice-Principal, South Thames College, Wandsworth High Street, London SW18 2PP, to whom they should be returned within two weeks of the date of this advertisement.

THE UNIVERSITY OF LEEDS

Department of Physical Chemistry

ELECTRONICS: DESIGN AND DEVELOPMENT

Applications are invited for a post to assist research groups within the department in the design and development of electronic equipment. Applicants should have a degree or its equivalent and a working knowledge of modern electronics including computers, digital techniques and radio-frequency circuitry.

The appointment will be at the Experimental Officer Grade with starting salary in the range £2370-£3594 (under review).

Applications (three copies) stating age, experience and qualifications and naming three referees should be sent as soon as possible to the Registrar, The University, Leeds LS2 9JT.

(5091)

AREA SALES MANAGER

H.F. & U.H.F.

Our client is in the business of HF & UHF transmitters and receivers and radio antenna. We are seeking a person experienced in this field, who will be fluent in French. Based at Weybridge. Sales territory: French speaking African countries. Salary C. £4,500.

Write or phone V. Green
S&W SERVICES
26a HIGH STREET, HOUNSLOW, MIDDX.
01-572 7363

(5105)

PRODUCTION MANAGER

RELAY/ELECTRONICS

A leading installer of burglar alarms systems, now expanding to produce its own range of Control and Electronic Equipment, seeks person with relevant design and management expertise to develop from scratch the manufacturing division in EC1. Salary negotiable A.A.E.

For details please contact:
I.C.S. APPTS. 01-278 9551

(5119)

CCTV ENGINEER

The successful applicant will:

a) Be experienced in the servicing of all types of CCTV equipment including Video Tape Recorders.

b) Be preferably with some experience of Colour Cameras and VTR's

c) Be capable of working to a large degree on own initiative with a minimum of supervision.

d) Be resident in (or willing to move to) the Edinburgh area.

P.T.S. (Electronics) Ltd.
St. Alkmunds Way
Derby

5112

Teach

TELEPHONY

to Post Office Students at

ACTON TECHNICAL COLLEGE

Do you have a real interest in teaching, a sound knowledge of Post Office equipment and a Telecommunications Technician Certificate? Then join a **team** of teachers who would welcome your expertise.

In return we offer you a rewarding and interesting career as a Lecturer II with good prospects.

Starting salary in the range £3,279-£5,493 plus £351 London Weighting.

For further details and application form write or telehone NOW:

Registrar & Clerk to the Governing Body
Acton Technical College
High Street
LONDON W3 6RD
Telephone: 01-993 2344 ext. 2371

5108

PAE PARK AIR ELECTRONICS

RF DESIGN ENGINEER

Our planned Company expansion has created an opportunity to join our team engaged on the design of VHF Transmitters and Receivers for use in the Airports of the World.

The person we are looking for must be keen to work as a member of this specialist team and be prepared to take the responsibility of working on the project as a whole. The successful applicant will be formally qualified and will have had really relevant experience in our field. Reporting to the Development Manager and will be keen to progress a career in the expansion phase the Company is entering at the moment.

Salary will be in line with the job responsibility. There is an excellent contributory pension scheme, World Wide Air Fare rebates for holiday travel, and relocation assistance will be given.

If you would like to work for a small company which offers career prospects and big company benefits in this pleasant rural area, please contact Clive Picking at:

PAE *PARK AIR ELECTRONICS LIMITED*

Ryhall Road, Stamford, Lincolnshire, England
Telephone: Stamford 2187
Member of the International Aeradio Group

PAE

(5153)

CHELSEA COLLEGE
University of London

TELEVISION TECHNICIAN

A Television Technician (Grade 5) is required to operate and maintain a wide range of audio and video equipment. The successful candidate will be expected to work closely with academic staff and students, and assist in the interpretation of their requirements in television terms. The television service at the college is expanding and the installation and commissioning of new equipment will present additional responsibilities. Salary Scale: £3161-£3617 per annum (inclusive).

Application forms from: **Personnel Officer, Chelsea College, Manresa Road, London SW3 6LX.**

LONDON BOROUGH OF BARKING
BARKING COLLEGE OF TECHNOLOGY

LECTURER GRADE I/II IN TELECOMMUNICATIONS AND ELECTRONICS

required, principally for full-time courses in Marine Radio and for City and Guilds of London Institute Telecommunications Certificate. Applicants should have appropriate qualifications and experience. Appointment on the Grade II scale will depend upon the extent of such experience and qualifications obtained.

Burnham Scales (I) £2,649 to £4,377 (II) £3,279 to £5,493 both plus £351 London Weighting. Application forms and further details from the Registrar, Barking College of Technology, Dagenham Road, Romford, Essex RM7 0XU. Completed forms to be returned to him within 14 days of this notice.

5017

UNIVERSITY OF EXETER

ELECTRONICS TECHNICIAN

A vacancy has arisen in the Department of Biological Sciences for a Technician in the Electronic Workshops, within the Grade range 3 to 5. The appointed technician will be required to provide a repair and maintenance service for electrical and electronic equipment for use in research and teaching.

Salary: £2,325 to £3,207 p.a.

Applications are invited from qualified persons, and/or persons interested in attending ONC or HNC courses. These should be sent, together with the names and addresses of two referees, to the Administrative Officer (staffing), University of Exeter, Northcote House, The Queen's Drive, Exeter EX4 4QJ, by 29th January, 1976. Please quote reference no. 1/79/5058. (5104)

LEICESTER POLYTECHNIC

ELECTRONICS TECHNICIAN

required in the School of Chemistry, to be responsible for (a) the design, development and construction of prototype electronic equipment for chemical applications; (b) the maintenance of existing equipment.

Successful applicant must have a knowledge of analogue and digital electronics and will probably have at least two years' experience subsequent to taking a Full Technological Certificate in Electronics, a HND in Electronics or a Degree in Electronics.

Salary: £2277 - £2529 p.a.

Apply in writing, giving full details, to: **Staffing Officer, Leicester Polytechnic, P.O. Box 143, Leicester, LE1 9BH.**

(5094)

CA CAPITAL APPOINTMENTS LTD

Recession?
Don't you believe it!

We have more jobs for good Electronic **Design Development and Test Engineers** than ever before. All areas UK, all applications. Salaries to £5,000 (5128)

34 Percy Street, London, W.1
01-636 9659 (day) or
550 0836 (evg.)

CLARENDON LABORATORY, University of Oxford, offers 3 year appointment to holder of Grad. Inst. P., with considerable experience in cryogenics and related applied physics techniques to join Nuclear Orientation research group having helium dilution refrigerator. Salary according to age, experience and qualifications within the range £3,378 to £5,010 p.a. Transit accommodation available. Apply in writing giving full particulars of education, training and experience to Dr. A. J. Croft. (5142)

RCS ELECTRONICS have the following vacancies: Electronic Engineer with general electronic experience for work on 74 Series Logic R.F. and Digital Circuits. Design & Development Engineer with wide experience in R.F. and Digital Equipment. Apply: R.C.S. Electronics, National Works, Bath Road, Hounslow, Middx. Phone: 01-572 0933. (5140)

EXPERIENCED CLOSED CIRCUIT TELEVISION SECURITY SYSTEM Design and Project Engineer capable of taking full responsibility for major projects. Must be thorough, self-motivating and imaginative. Also required experienced CCTV Technicians. Excellent salary and benefits to right people with world-wide travel prospects. Please ring Brian Kent, Windsor 51966. (5123)

AGENTS WANTED

DANISH COMPANY seeks contact with British manufacturer of magnetic tapes (Compact Cassette and Open Reels) for possible agency in Scandinavia or Denmark. Please write to: Per Meistrup, Aksel Moellers Have 12, DK2000 Copenhagen F, Denmark.

(5134)

SERVICE MANAGER
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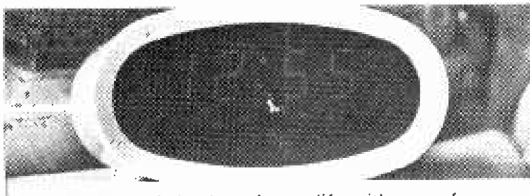

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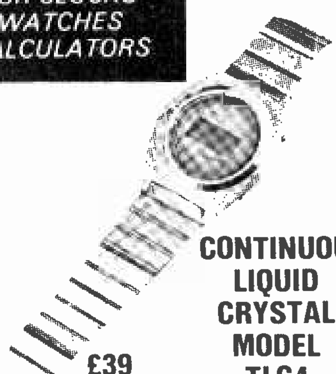

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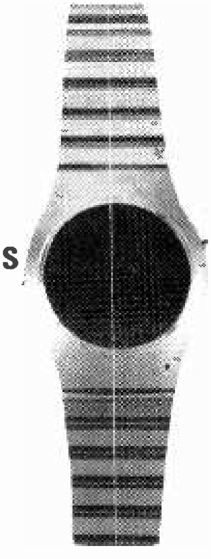

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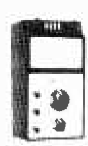

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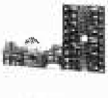

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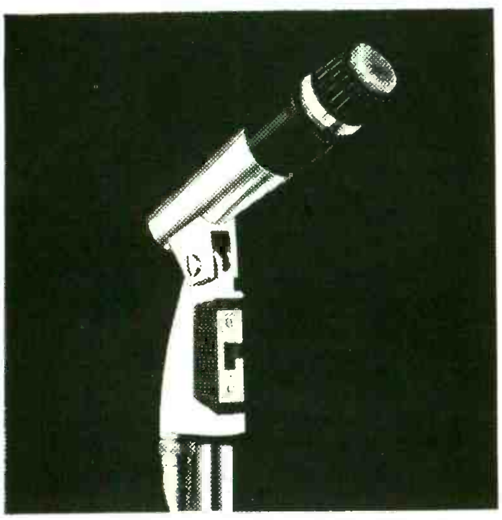

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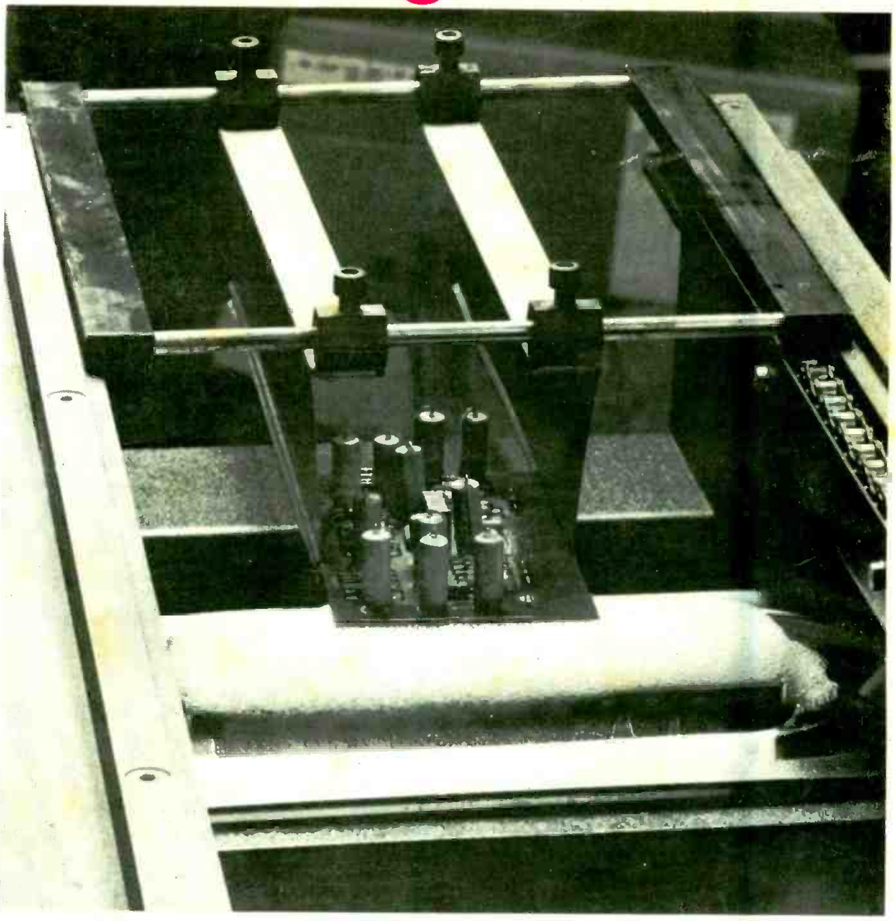

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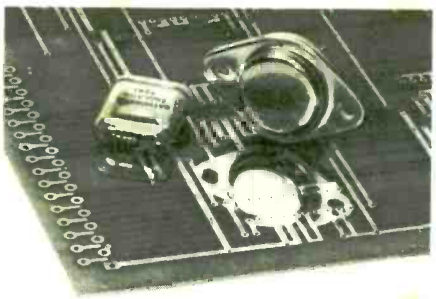

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