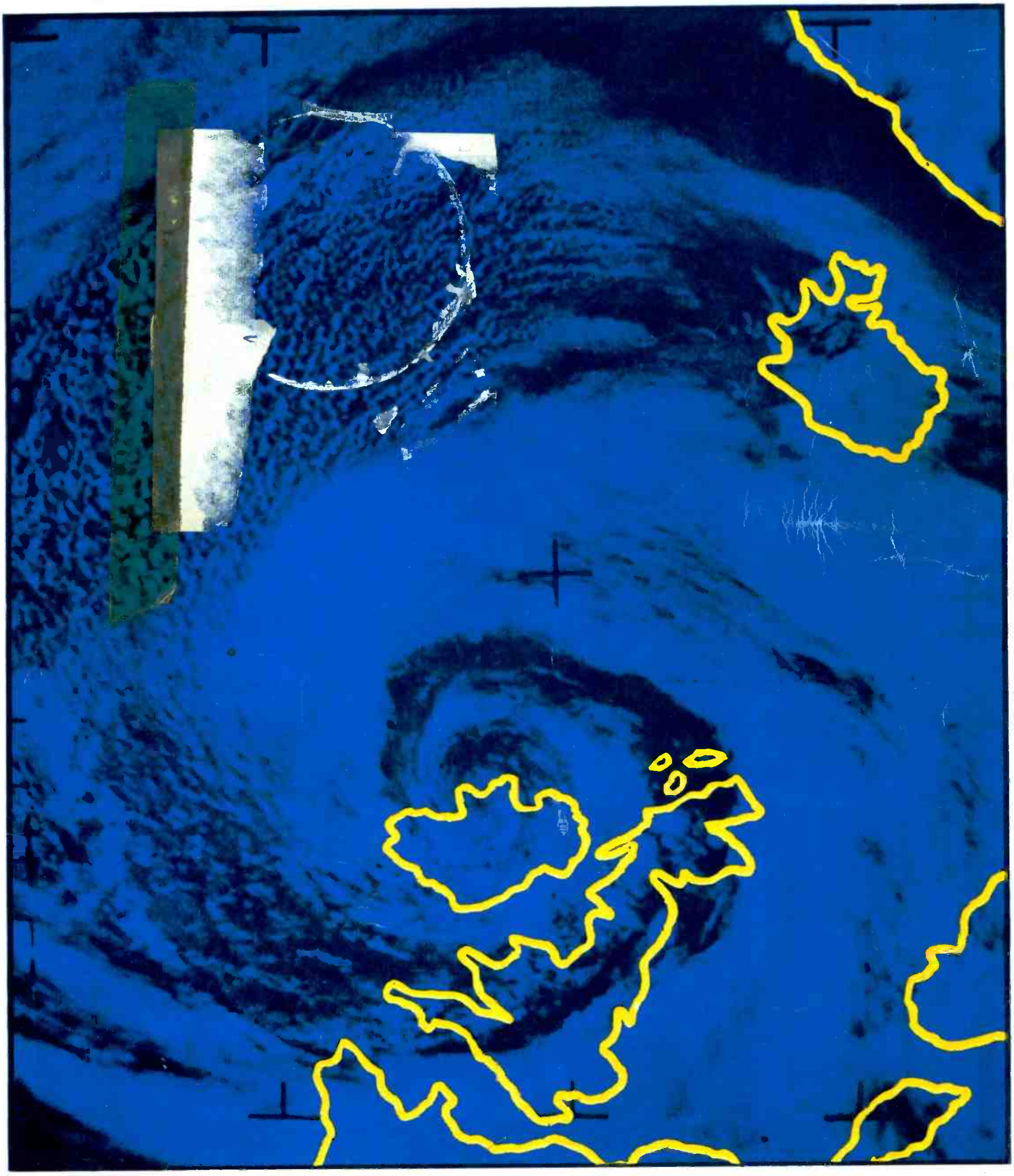
Wireless World

October 1971 17½p

Weather satellite receiver

Making a turntable

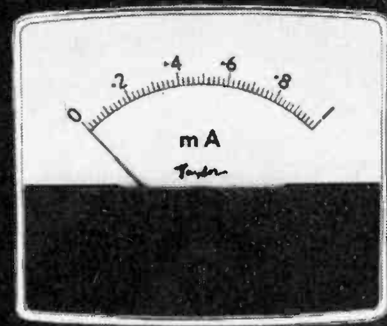


Designers specify them for their reliability and modern styling.
Buyers choose them for their competitive prices and delivery.

Taylor panel meters

are selected by equipment manufacturers everywhere.

new

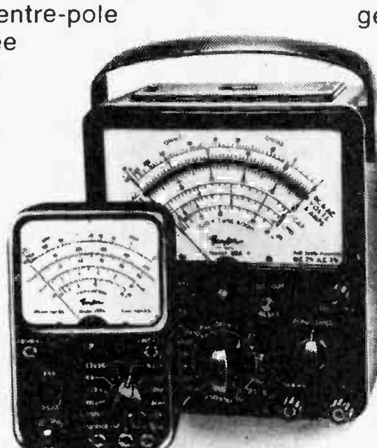


Vista Series
Popular, reliable panel meters with robust phenolic mouldings and scale lengths from $1\frac{3}{4}$ in to $4\frac{1}{2}$ in. This range combines compact functional styling with easy readability and excellent performance. Mechanically interchangeable with the Fyneline range.

Edgewise Series
Here's the latest in the range of three Edgewise panel meters, the Model 330 with a $2\frac{1}{4}$ in scale length. Ideal for today's crowded instrument panels, other scale lengths are $1\frac{1}{16}$ in (Model 11) and $1\frac{3}{4}$ in (Model 220).

Fyneline Series
Adaptable versatile series with scale lengths from $1\frac{3}{4}$ in to $4\frac{1}{2}$ in. Contemporary styling and clear shadow-free readings ensure maximum readability. This modern range maintains the Taylor reputation for reliability and sensitivity.

Taylor offers a comprehensive range of moving-coil and moving-iron panel meters. The moving-coil meters feature the proven Taylor centre-pole movement with practically friction-free operation, inherent magnetic shielding and high torque/weight ratio. They are sensitive, accurate instruments that conform generally to BS 89/54 with contemporary or conventional styling. Ask for the Panel Meter Shortform Catalogue.



Taylor makes test equipment too!
Two typical models are Taylor Model 88B, a robust, wide-range multimeter with automatic cut-out and polarity reversal facility, and the popular Taylor Type 127A, a pocket-sized multimeter for the service engineer and hobbyist. Ask for the Instrument Shortform Catalogue.

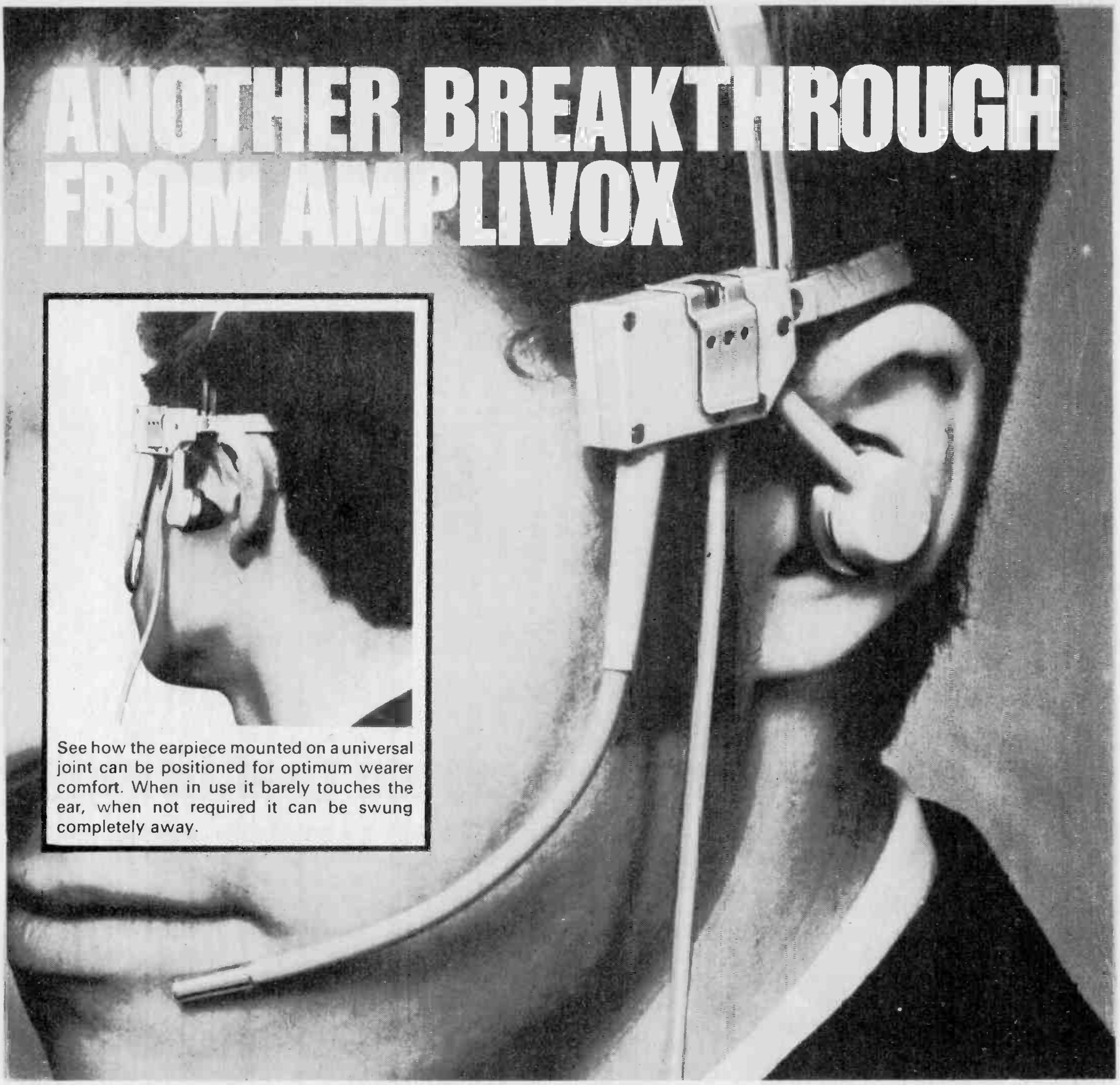
Taylor

Taylor Electrical Instruments Limited
Archcliffe Road, Dover, Kent. Tel: Dover 2634 Telex: 96283
THORN A member of the Thorn Group. Measurement Control and Automation Division.

WW—006 FOR FURTHER DETAILS

HIGH FIDELITY MOVING COIL STEREO HEADPHONES (TYPE LS43) Now available from DAYSTROM LTD. GLOUCESTER

WW—007 FOR FURTHER DETAILS



See how the earpiece mounted on a universal joint can be positioned for optimum wearer comfort. When in use it barely touches the ear, when not required it can be swung completely away.

For the first time — a new Amplivox headset offering full communications facilities yet under 2oz in weight.

The New Amplivox MINILITE – a breakthrough in super-lightweight headset design. MINILITE is feather light. No wearer fatigue. No wearer discomfort. New accoustic techniques have led to an earpiece that need barely touch the ear. So it's hygienic as well as comfortable. MINILITE is so light that it can be attached to the frame of a normal pair of spectacles. The telescopic 'Boom' is an accoustic tube that gives highest speech intelligibility. For all situations where the wearer has to use a headset continuously MINILITE pays off handsomely in terms of performance, comfort and operator satisfaction at a truly economical price.

Minilite is Wearer Right

Send for full MINILITE details straight away.

AMPLIVOX COMMUNICATIONS LIMITED

BERESFORD AVENUE, WEMBLEY,
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WW—008 FOR FURTHER DETAILS

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Compact, comprehensive catalogue
The complete BLUELINE range is covered in this catalogue. If you haven't yet received your copy, please write – or better still, phone 01-366 6371 and get a preview of the friendly way we make ourselves indispensable to your organisation.

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YOUR HOTLINE TO ELECTRONIC COMPONENTS

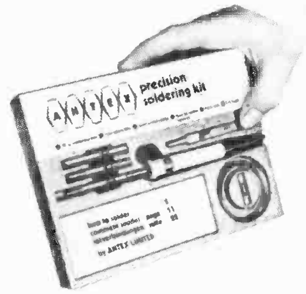
WW—020 FOR FURTHER DETAILS

cut out the coupon and answer your soldering problems

SK1 SOLDERING KIT

In rigid plastic "tool box" containing Model CN - 15 watts - 240 volts miniature iron fitted $\frac{3}{16}$" bit. Spare bits $\frac{5}{32}$" and $\frac{3}{32}$". Reel of resin-cored solder, heat sink, cleaning pad, stand and booklet "How to Solder".

£2·75



SK2 Soldering Kit

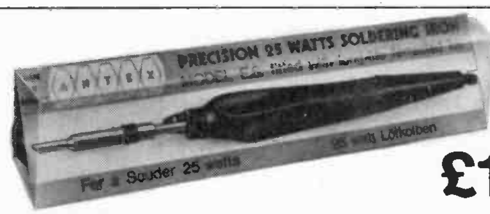
In polystyrene pack, containing 15 watt miniature soldering iron, 240 volts fitted with $\frac{3}{16}$" bit, 2 spare bits $\frac{5}{32}$" and $\frac{3}{32}$". Coil of resin-cored solder, heat sink, 1A fuse and booklet "How to Solder".

£2·40

Model CN 240/2
15 watts - 240 volts

£1·70

Fitted with nickel plated $\frac{3}{32}$" bit and packed in handy transparent box.



£1·83

ES240 D 25 watt soldering iron

In transparent display pack, fitted with long life iron-coated bit $\frac{1}{8}$" diam.

Interchangeable spare bits $\frac{3}{32}$", $\frac{3}{16}$", $\frac{1}{4}$" (extra) available. Improved design to ensure strong and reliable high speed iron. Heats up in 2 minutes.

GSS Desoldering Tool

Model GSS with $\frac{3}{32}$" tip diameter

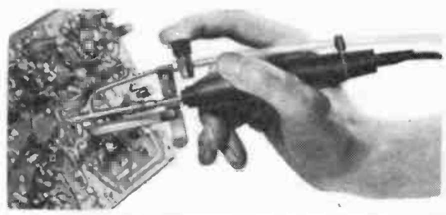
£4·67

De-soldering tool working on compressed air for industrial use with an air line or occasional use with foot pump. Efficient, self-cleaning operation on Venturi principle. Split-second action. Press valve control.

ESS Desoldering Tool

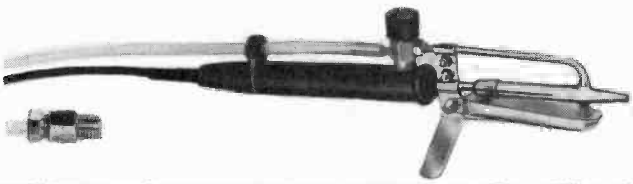
Model ESS with $\frac{5}{32}$" tip diameter

£4·67



Model ESS or GSS complete with foot pump

£5·65



M.E.S. Battery-operated 12 volt soldering iron

Complete with 15 ft (4·50m) lead, 2 heavy gauge clips for instant connection to car battery and a guide 'How to Solder'. Packed in strong plastic wallet.

£1·95

ANTEX

from electrical and radio shops or by Free Post (No stamp required) from **ANTEX Ltd., FREE POST, PLYMOUTH, PL1 1BR.** Tel (0752) 67377/8.

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WW—012 FOR FURTHER DETAILS

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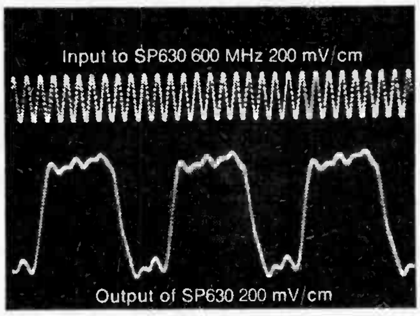
As European leaders in MOS and Bipolar technology
Plessey also offers you the most experienced
custom/customer design service available —
proven by more than 400 successfully completed designs.*

Ultra-High-Speed ECL Dividers



WW—250 for further details.

SP602 ÷2 500MHz
SP620 ÷5 400MHz
SP630 ÷10 600MHz
These three circuits form part of an expanding range of dividers.
Power consumption from only 60mW.
Operating temperature from −55°C to +125°C.
They are the only dividers available with full temperature range at this speed.
Commercial and military applications are already nearing production.

Unique LSI Computing Circuits

These DTL/TTL compatible circuits were initially developed for process control applications in ICI. Now generally available, they feature the following:

SP520 5-Bit Reversible Gray Code Counter

A 5-bit up-down counter with non-overflow facility with both Gray and binary outputs. The Gray code o/p's can be inhibited—effectively open-circuiting. This makes them ideal for 'addressed parallel highway wired-OR applications'. Reset to zero facility is also provided.

SP521 5-Bit Binary Rate Multiplier

Basically an arithmetic unit capable of multiplying together a frequency and a binary number. Has two-phase capability, is infinitely cascadable and eliminates the need for capacitors and other components, all as a result of internal Gray code operation.

SP522 Divider, Phase Lock and Comparator

Divides the master clock frequency (8F) by 8 giving two interlaced o/p's (1F). These can be used to clock the SP521. There is also an o/p at 2F. Locks the phase of any i/p signal to that of the master clock. Max. i/p frequency to phase lock circuit is 3.2F.
The comparator is a 5-bit up-down counter with reset facility to the central symmetrical state.

WW—251 for further details.

Quad decade complements MOS counter range

WW—252 for further details.

Device Number	Single or Quad Decade	Single or Dual Power Supply	BCD or Decimal Output	Current (I) or Voltage (V) Output	Carry Facility	Package
MP107B	S	S	BCD	V	✓	10 lead TO.5
MP108B	S	S	BCD	I	✓	10 lead TO.5
MP120B	Q	D	BCD	I	✓	16 lead DIL
MP123B	S	D	BCD	V		10 lead TO.5
MP124B	S	D	Decimal	V		16 lead DIL
MP125B	S	D	BCD	V	✓	14 lead DIL
MP126B	S	D	Decimal	I		16 lead DIL
MP127B	S	D	BCD	I	✓	14 lead DIL

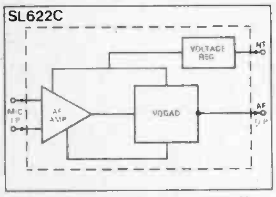
PLESSEY

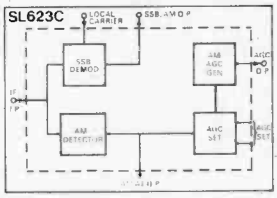
Plessey Semiconductors
Cheney Manor, Swindon, Wiltshire
Telephone: Swindon (0793) 6251
Telex: 44375

WW—013 FOR FURTHER DETAILS

Detectors, Demodulators & AGC Circuits

The SL622C, a microphone amplifier plus VOGAD and the SL623C, an SSB demodulator, low level AM detector and AM AGC generator are the latest additions to the successful range of SL600 communications circuits. This fully compatible series operates from a single power rail, has low power consumption, full AGC facilities and operates up to 140MHz.





WW—253 for further details.

1GHz Transistor Pair

The SL360 is a monolithic matched pair of transistors capable of being used at frequencies up to 1GHz. The particularly good low current betas make this device suitable for a wide range of applications.

Typical characteristics:

BV_{CEO}	15V	(I_C = 10μA)
h_{FE}	65	(V_{CE} = 2V, I_E = 5mA)
f_T	2.5 GHz	(V_{CE} = 5V, I_E = 5mA)
f_T	3.2 GHz	(V_{CE} = 5V, I_E = 25mA)
$V_{BE}(1) - V_{BE}(2)$	3mV	(V_{CE} = 2V, I_E = 1mA)
$h_{FE}(1)/h_{FE}(2)$	1.1	(V_{CE} = 2V, I_E = 5mA)
V_{CE} (Sat)	0.25V	(I_E = 10mA, I_B = 1mA)

These characteristics make the SL360 an ideal element for the design and manufacture of more complex UHF circuits.

WW—254 for further details.

Low Noise GaAs Microwave FET'S

Featuring high transconductance, low capacitance and operating frequency up to 4.5GHz.

GAT1	10dB gain at 1GHz	4dB noise figure
GAT2	8dB gain at 3GHz	5dB noise figure

Ideal for use in low noise front-end amplifiers.

WW—255 for further details.

Television and Audio Circuits

Colour TV on 2 Chips

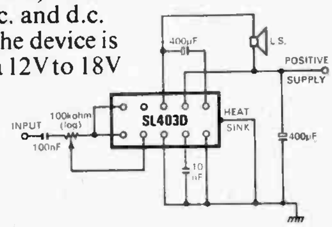
The SL435C and SL436B combined form the complete colour signal processing section of a colour television receiver (PAL system).

The following functions are incorporated:

Chroma amplification • PAL switch • Colour killer
Gated burst amplifier with 45° switch
Internal stabilisation • Reference amplifier
Matrixing for red, green and blue outputs
R-Y, B-Y balanced demodulator

6W Audio Amplifier

The SL403D is a 6W (3W rms) audio amplifier incorporating a.c. and d.c. short-circuit protection. The device is designed to operate from a 12V to 18V supply into loads from 3Ω to 15Ω. Total harmonic distortion at full output is typically less than 0.3%.



WW—256 for further details.

OPTO Character Recognition

The OPT6 is a linear array of 72 integrating elements designed for OCR, code recognition and position sensing applications where high data rates and high definition are required.

The 72 elements operate in current recharge mode and integrate for one line period. Two clock pulses and one data input pulse are required for scanning the shift register which will operate typically in the range 10KHz to 7MHz.

The 0.2″ × 0.08″ chip is mounted in a ¾″ glass windowed flat pack and dissipates about 300mW at maximum bit rate.

WW—257 for further details.

Product Summary

If you would like details of the full range of Plessey IC's please ask for our Product Summary. This includes details of nearly 300 standard bipolar and MOS IC's, package diagrams, MOS logic diagrams and bipolar logic diagrams.

WW—258 for further details.

Semiconductors

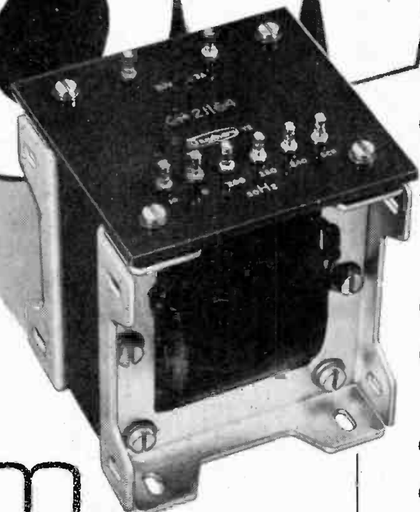
UK Distributors:

Farnell Electronic Components Limited
Canal Road, Leeds
LS12 2TU
Tel: (0532) 636311

SDS-WEL Components Limited
Hilsea Industrial Estate, Hilsea, Portsmouth
Hampshire. Telephone: (0705) 65311
5 Loverock Road, Reading, Berkshire
Telephone: (0734) 580616

SC101

TRANSISTOR POWER



Another range of standard transformers from Gardners – acknowledged leaders in electronic transformers – TRANSISTOR POWER SUPPLY TRANSFORMERS.

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You can select from more than fifty standard types and be sure of finding something suitable for any contemporary transistor power requirement – and most probably from stock! Write for GT.25.

GT.1	POWER CONTROLLING SATURABLE REACTORS 50W to 1kW with application notes.
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GT.25	TRANSISTOR POWER SUPPLY TRANSFORMERS.
GT.100	GENERAL REFERENCE CATALOGUE with data sheets of assemblies available for specially designed transformers.

There are nine other GT Brochures and we'll be pleased to mail any in which you are interested if you will post us this coupon.

Please indicate your requirement by circling the number/s below

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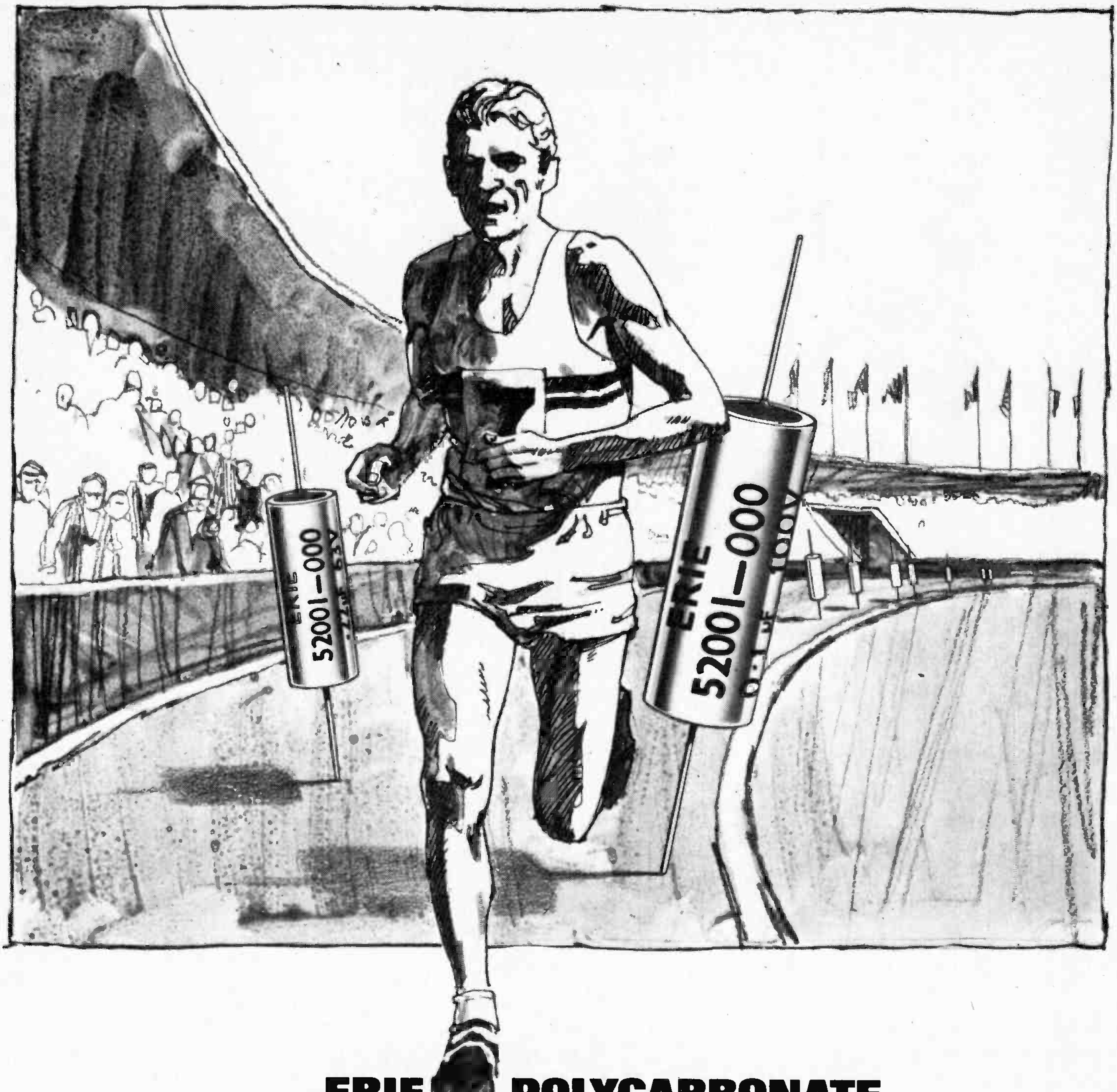

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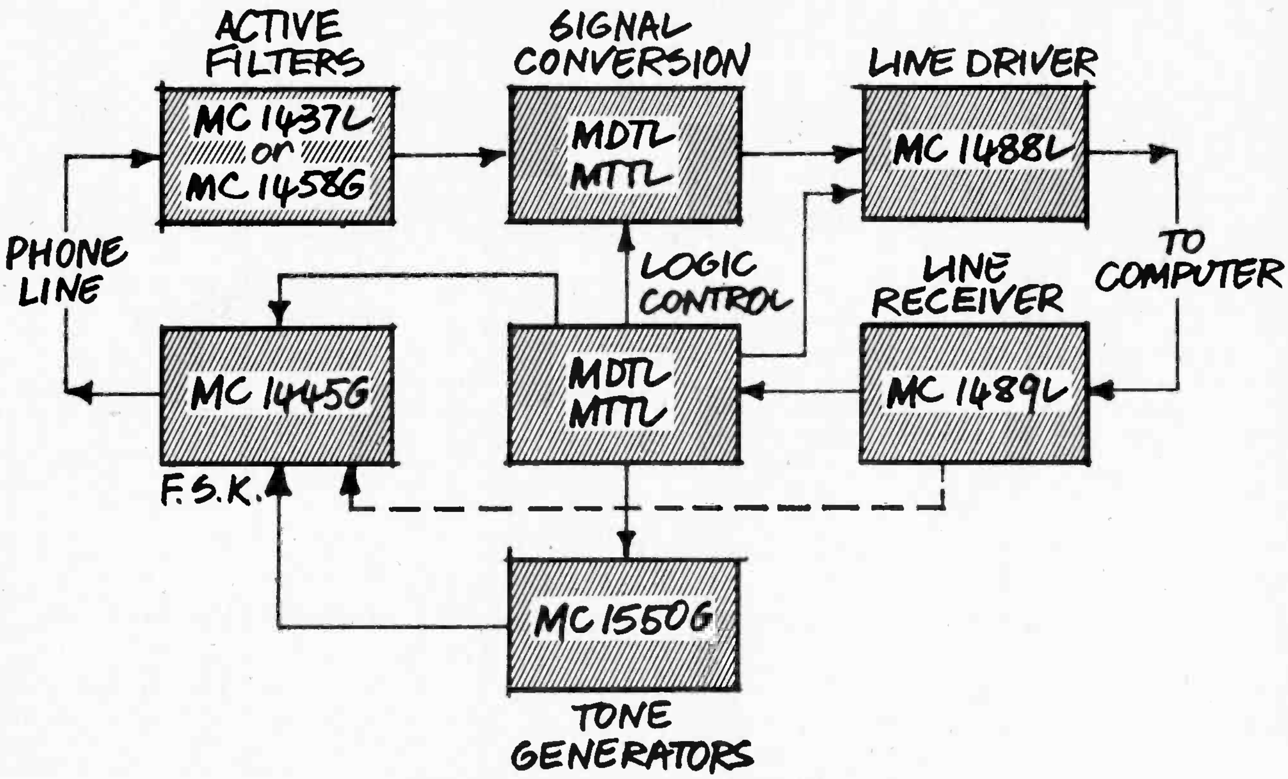
WW—016 FOR FURTHER DETAILS

An RS-232C Integrated Modem System



MODEM.

Motorola make the complete system.

Here's how Motorola give you the complete Modem system. With:

RS-232C Quad Line Drivers and Receivers.

The first and only monolithic quads in the industry to meet this stringent EIA spec. They're designated MC1488L and MC1489L.

Because they are quads they give you more board space, lower package count and they have direct compatibility with MDTL and MTTL logic circuits.

Op Amps for Active Filters.

The MC1437P (a dual MC1709C) and the brand new MC1458G (a dual MC1741C) are your ideal choices. The latter is internally compensated for frequency response. Both reliable devices cost considerably less than two single-packed op amps and compare favourably with mechanical resonators or reed systems.

Frequency-Shift Keyer.

The MC1445G is a dual-input, logic-controlled video switch that can connect either of two tone generators to an output line. It also has a low-impedance emitter-follower output stage.

Tone generators.

The MC1550G is a high-frequency differential amplifier that makes an ideal, ultra-stable oscillator with built-in bias circuitry at little more than the cost of a transistor.

Digital Logic.

MDTL or MTTL can be used to control the frequency-shift keyer and to perform other MODEM logic functions. Motorola offers a complete line in both families.

For full details of the Motorola Modem system and what it can mean to you write to:

Motorola Semiconductors, Dept. WW5, **York House, Empire Way, Wembley, Middlesex. Telephone: 01-903 0944.**

MOTOROLA Semiconductors

MANUFACTURING FACILITY AT EAST KILBRIDE, SCOTLAND

Distributors: Celdis Ltd, Reading. GDS (Sales) Ltd, Slough. Jermyn Industries Ltd, Sevenoaks. A. M. Lock & Co Ltd, Oldham. Semicomps Ltd, Alperton.

WW—018 FOR FURTHER DETAILS

High Dissipation Resistance Boxes

	Five Decade		
HD1	0 to 1,111,100 ohms by 10 ohm steps	1% Tolerance	£45.00
HD5	0 to 1,111,100 ohms by 10 ohm steps	5% Tolerance	£35.00
HD1/L	0 to 111,110 ohms by 0.1 ohm increments	1% Tolerance	£47.00

Jay-Jay Capacitance Boxes

Cat. Ref.			
	Three Decade Model		
C3	100 pf. to 0.111 mfd.	1% Tolerance	£22.00
PC3	100 pf. to 0.111 mfd.	½% Tolerance	£31.50
	Four Decade Model		
C4	100 pf. to 1.111 mfd.	1% Tolerance	£35.00
PC4	100 pf. to 1.111 mfd.	½% Tolerance	£48.00
	Switched Capacitance Boxes		
C100	1 mfd. to 100 mfd.	5% Tolerance	£65.00
C140	1 mfd. to 140 mfd.	5% Tolerance	£75.00
C60	0.1 mfd. to 61 mfd.	5% Tolerance	£59.00
C60P	0.1 mfd. to 61 mfd.	1% Tolerance	£110.00
	Air Spaced Capacitors		
VC1	10 to 160 pf.	1% Tolerance	£12.00
	Variable Capacitors		
VC2	20 to 1130 pf.	1% Tolerance	£22.00
VC4	50 pf. to 0.1114 mfd.	1% Tolerance	£28.75
VC5	50 pf. to 1.1114 mfd.	1% Tolerance	£43.00
	Precision Air Spaced Capacitors		
PVC1	5 to 200 pf.	½% Tolerance	£36.00
	Precision Variable Capacitor		
PVC2	15 to 100 pf.	½% Tolerance	£44.00
	Precision Incremental Capacity		
PVC4	±0.5 pf. and ±5 pf.	1% Tolerance	£36.00
	Precision Variable Capacitor		
SVC5	50 pf. to 1.1114 mfd. ±0.05% tolerance—major decade		£230.00

Jay-Jay Junior Decade Capacitance Boxes

Cat. Ref.	Accuracy 1%	
JC1	3 Decade 100 pf. to 0.111 mfd.	£12.90
JC2	3 Decade 30 pf. to 10,140 pf.	£13.70

Jay-Jay Inductance Boxes

Cat. Ref.		
L1	3 Decade 1 mH to 1 Henry	£37.00
L2	2 Decade 1 mH to 100 mH	£26.00
L3	2 Decade 10 mH to 1 Henry	£29.45

Jay-Jay "Point One" Resistance Boxes

Cat. Ref.	Average Accuracy 0.1%	
	Four Decade	
R5	0 to 111,100 ohms by 10 ohm steps	£24.00
R4	0 to 11,110 ohms by 1 ohm steps	£24.50
R3	0 to 1,111 ohms by 1/10 ohm steps	£25.00
	Five Decade	
R11	0 to 10 meg ohms by 100 ohm steps	£34.50
R7	0 to 1,111,100 ohms by 10 ohm steps	£29.25
R9	0 to 111,110 ohms by 1 ohm steps	£29.75
R10	0 to 11,111 ohms by 1/10 steps	£30.25
	Six Decade	
R20	0 to 1, 111, 110 by 1 ohm steps	£36.00
R21	0 to 111,111 by 0.1 ohm steps	£36.50
R22	0 to 11,111.1 by 0.01 ohm steps	£37.00

Jay-Jay Junior Decade Resistance Boxes

Cat. Ref.	Average Accuracy 0.4%	
	Six Decade	
J60	Range 0 to 1,111,100 ohm by 1 ohm steps	£18.90
	Five Decade	
J1	Range 0 to 1,111,100 by 10 ohm steps	£15.60
J2	Range 0 to 111,110 by 1 ohm steps	£15.40
	Four Decade	
J3	Range 0 to 111,100 by 10 ohm steps	£12.40
J4	Range 0 to 11,110 by 1 ohm steps	£12.20
	Three Decade	
J5	Range 0 to 11,100 by 10 ohm steps	£9.95
J6	Range 0 to 1,110 by 1 ohm steps	£9.90

Most ranges available from stock.
Write for descriptive leaflet or demonstration.

JJ INSTRUMENTS

J.J. Lloyd Instruments Limited

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Tel: Locks Heath 4221

WW—019 FOR FURTHER DETAILS

Power-Packed Performance With Gentle Finger Pressure— It's TRIO's 220-watt KR-7070 Auto-Tuning Receiver

"Outstanding" is the word that sums up TRIO's 220-watt (Both channels at 8 ohms) KR-7070 auto tuning stereo receiver. It's full-balanced three-way tuning (auto, manual and remote) gives it immediate operating versatility. Also a 3-FET, 4-gang tuning condenser FM front end for distinctive FM reception. Over-all amazing selectivity with 4 IC's and crystal filter FM IF stages. Many exemplary extras throughout.

SPECIFICATIONS OF KR-7070

- Continuous Power: 90/90 watts at 8 ohms
- Frequency Response (Main Input): 5Hz—120,000Hz (±1.5dB)
- Usable Sensitivity (IHF): 1.5μV
- Dimensions: 17"(W), 6-1/2"(H), 15"(D).

220-WATT (IHF 8Ω) AUTO TUNING AM/FM STEREO TUNER AMPLIFIER **KR-7070**

the sound approach to quality—

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STEREO HEADPHONE
WITH OPENED BACK SYSTEM **KH-71**

180-WATT (IHF 8Ω) SOLID STATE AM/FM
STEREO TUNER AMPLIFIER **KR-6160**

WW—009 FOR FURTHER DETAILS

Listening to music in the home

When we listen we become engrossed in the music and, with good equipment, we can often obtain the same satisfaction that we would enjoy in the concert hall. Of course, there are differences between the real and the reproduced. Many of these we recognise as such; we come to terms with them and they do not intrude.

More serious perhaps are the distortions which we do not consciously notice but which are nevertheless continuously producing a contradiction between the actual and the imagined. They produce listening fatigue, a condition detrimental to the true objective. These distortions have little to do with the popular conceptions of HI-FI or LO-FI sound; on the other hand they have much to do with good or bad engineering.

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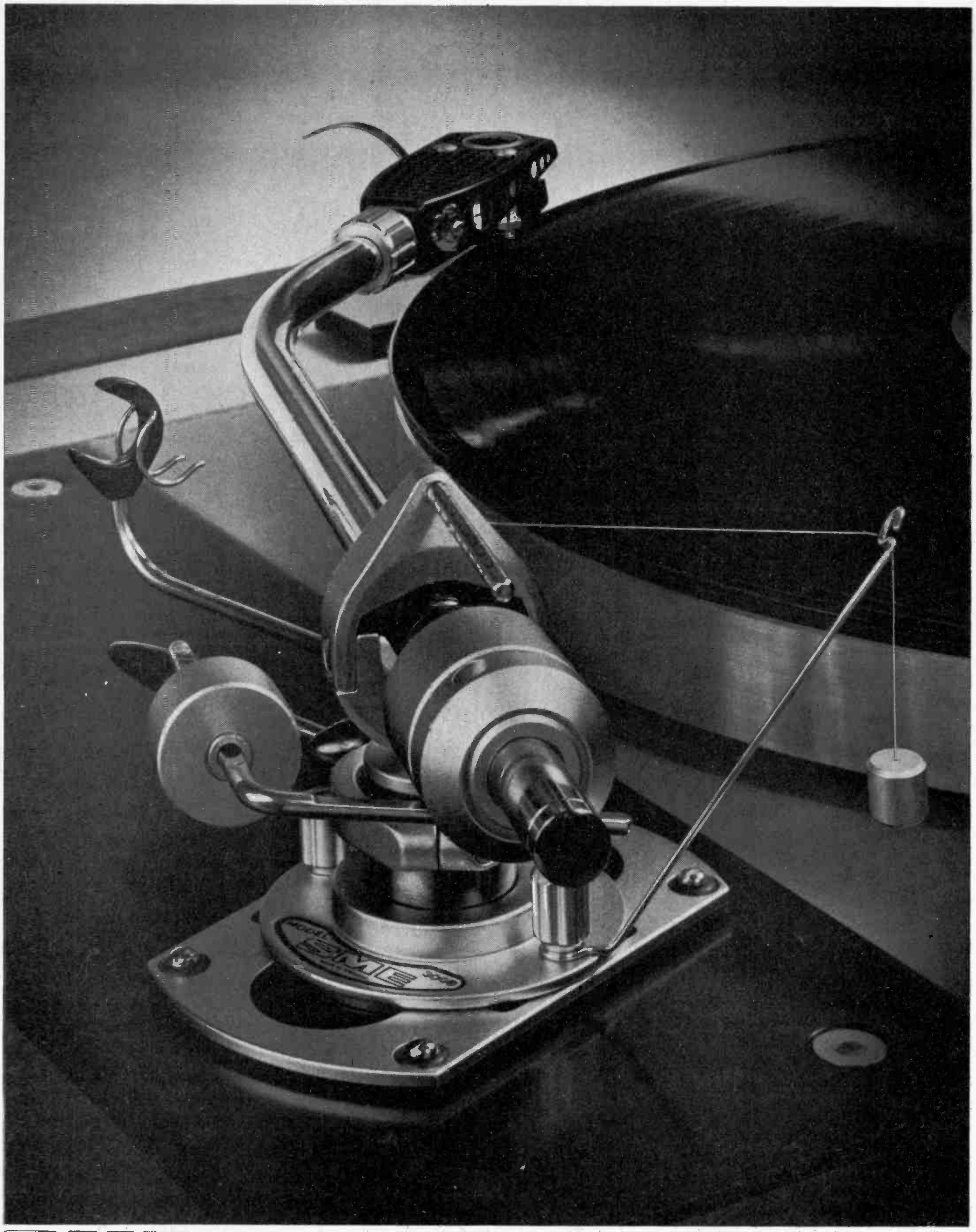
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WW 10

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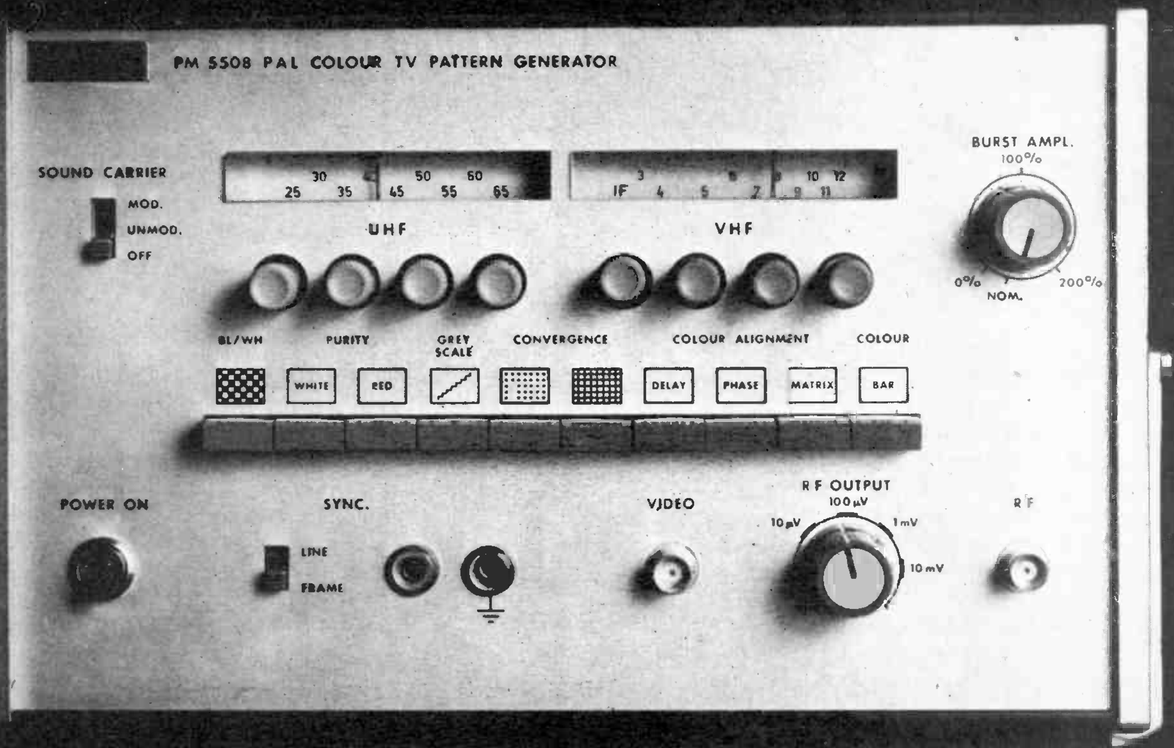
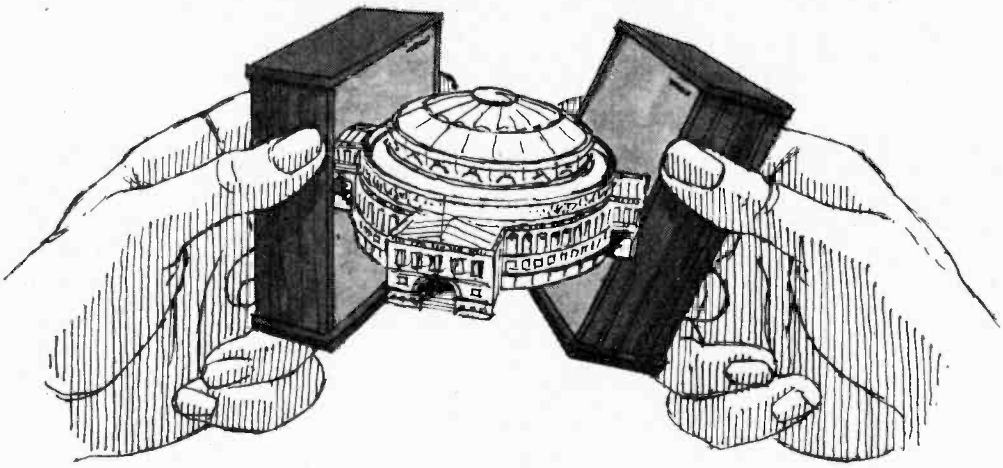


Philips for the best 'PAL' you could have

Colour television can win or lose you your friends – and your profits. Fast, efficient and reliable installation and after sales service will make sure you're on the winning side. Philips PM 5508 PAL Colour Pattern Generator provides your engineers with all the facilities for on-the-spot colour TV (and monochrome) service – for many adjustments you don't even need an oscilloscope; just use the receiver's picture tube instead.
Of course, though, a sensitive, 10 MHz double-beam oscilloscope, such as the Philips PM 3230, could increase your advantage further – even over the competition.
If you want to make friends and influence people just contact Pye Unicam straight away. Ask for a leaflet giving more information on the Philips PM 5508 PAL Colour TV Pattern Generator, the PM 3230 Oscilloscope and other radio and TV service equipment in the Philips range.

Pye Unicam Ltd
York Street Cambridge CB1 2PX
England
Telephone (0223) 58866 Telex 81215

PYE UNICAM LTD



it's all a **great illusion . . .**

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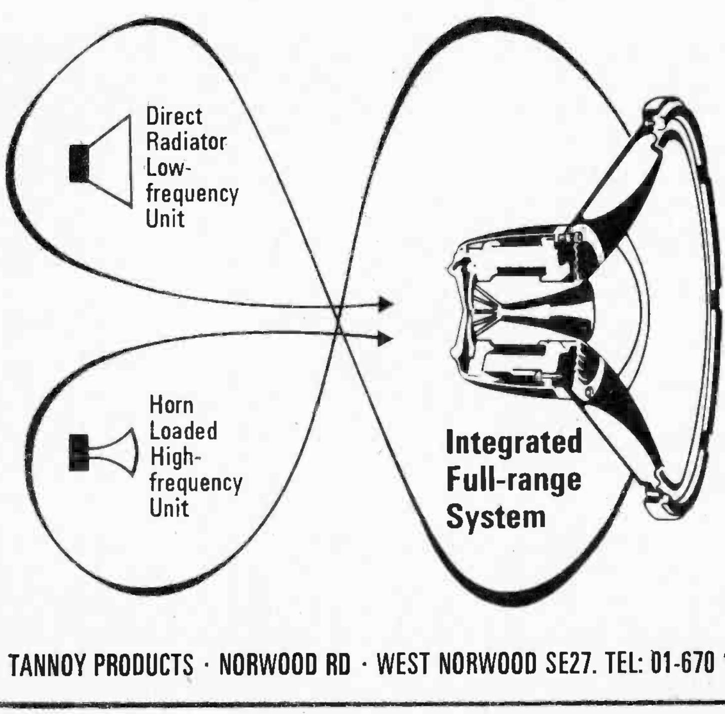
our own contribution to the magic— **two into one will go!**



THE Monitor GOLD*

DUAL CONCENTRIC

Frequency Response: 30-20,000 Hz. Power Handling Capacity: 15" 50 watts, 12" 30 watts. IIILZ 15 watts.
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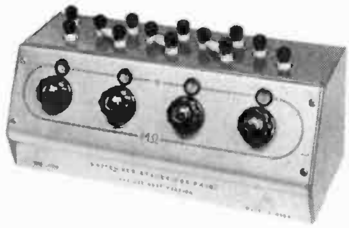

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STANDARD MEGOHMS
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Four decodes .01-.10-1.0-10 MΩ± .05% ... £98

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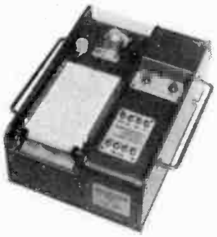
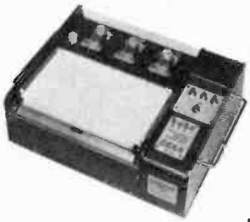
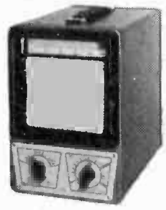
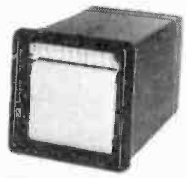



HIGH SPEED RECORDERS TYPE H320
Moving coil mechanism with natural frequency of oscillation of 5Hz and sensitivity of 8mA FSD. Syphon ink-pen with large reservoir capacity. Paper footage indicator. 8 chart speeds from 1.2 to 3000mm per hour selected by push buttons. Width of recording channel 80mm.
SINGLE CHANNEL RECORDER H320-1 .... £55
THREE CHANNEL RECORDER H320-3 .... £90



MULTI-RANGE UNIVERSAL PORTABLE AC/DC VOLTAMMETER TYPE H390
8 AC/DC current ranges 5mA to 5 Amps
6 AC/DC voltage ranges 5-500V.
6 Chart speeds 20 to 5400mm per hour.
Chart width 100mm
PRICE £78

PORTABLE RECORDING MILLIAMMETER H352
Sensitivity 1mA DC. D.C. resistance of the movement 10570 ohms. Chart width 100mm. Six chart speeds 20 to 5400mm per hour.
PRICE £52



SWITCHBOARD TYPE TEN CHANNEL EVENT RECORDER TYPE H30
Instruments provides permanent record of duration and sequence of up to ten operation. Syphon pens with large ink reservoirs are mounted on rotary relays energized from a 12V D.C. source. Six chart speeds 20 to 5400mm per hour.
PRICE £52

FOR IMMEDIATE DELIVERY

OSCILLOSCOPES

SYNCHROSCOPE C1-5

3-in. tube. Built-in time base calibrator. Voltage measurement scale. 10mc/s pass-band. Sensitivity 300mV per mm. Nine pre-set triggered sweep rates from 1 to 3000 μ sec. Free-running time base 20Hz to 200 kHz. Input alternator 1-10-100 times.
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Double gun rectangular tube giving display size of 40 x 100mm. Passband 5mc/s for 3db down. Sensitivity 500mm per Volt. 18 pre-set calibrated sweep durations from 0.2 μ sec/cm to 100m sec per cm. Free running time base 50Hz to 1mc. Built-in amplitude calibrator. Crystal time base marker.
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FULL SERVICING FACILITIES

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WHEATSTONE BRIDGE TYPE P316

Portable Bridge of 0.2% to 0.5% accuracy. Four decades of 1-10-100-1000μ steps. 10 position multiplier arms switch. Take range 0.00001μ to 1mμ. Internal power supply unit 230V/115V A.C. Built-in galvanometer of 0.12μA/mm sensitivity.
PRICE £49

WHEATSTONE BRIDGE AND CABLE FAULT LOCATOR TYPE P333

Portable dry battery operated instrument providing the following facilities:
Measurements of resistance from 0.005Ω to 1mΩ
Location of cable faults by Murray or Varley Loop Method.
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Use of four decade section as a resistance box. Accuracy for 1Ω to 100K 0.5% £4.
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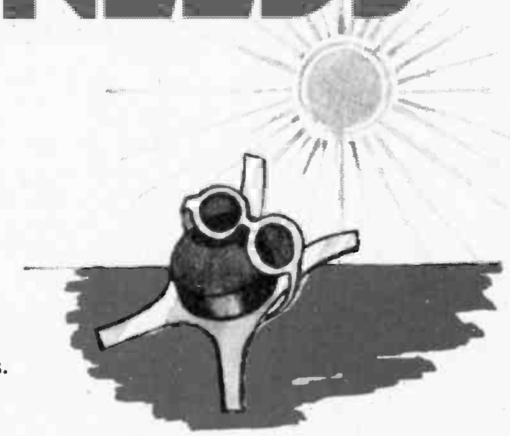
WW—026 FOR FURTHER DETAILS

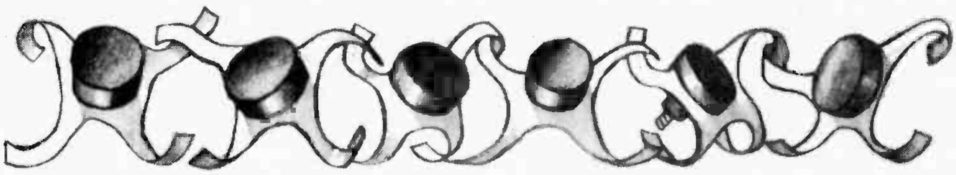
OUR STANDARD RANGE OF TRANSMITTING TRANSISTORS IS MADE FOR SPECIALISED NEEDS



The comprehensive range.
The first to meet special requirements with line-ups of standard u.h.f. and v.h.f. devices.
Includes more than 30 types of r.f. power semiconductor device for use from the lowest r.f. up to 1GHz. With c.w. power available from single devices ranging from 50W at h.f. to 20W at the highest u.h.f. Suitable for mobiles, base stations and pocket portables, because it's designed specifically for them.
And it's because we've made each device compatible with the next that they can be built in as line-ups.

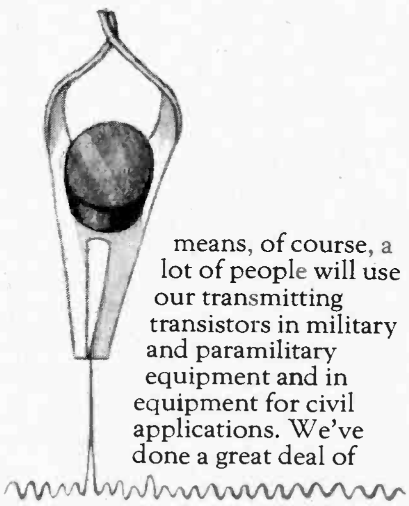
Which was how we field tested them.
For example, we designed a 17W class B f.m. amplifier to operate at 470MHz, using a three stage 'line-up'. It worked very well indeed. So did the others we designed. Even under the most punishing conditions and temperature extremes.

But that didn't surprise us.
As we handle all the manufacturing processes ourselves.
Which means we're able to control materials, geometry, diffusion and bonding a whole lot more accurately. And, at the same time, design in quality at every stage. Consequently every Mullard transmitting transistor is inherently stronger. Or, to put it another way, *ruggedised* from raw material through to finished product.



The proof is in their performance.
Take our 12V devices. Designed to operate from a 12V battery, they can withstand repeated accidental over-voltages of up to 16.5V. An overdrive of up to 20%. And any mismatching—given VSWRs of up to 50:1 at any phase. Devices designed to operate from other supplies also perform to the same high standards.

Which brings us to applications.
Continuous performance under the most punishing conditions



means, of course, a lot of people will use our transmitting transistors in military and paramilitary equipment and in equipment for civil applications. We've done a great deal of research on both kinds. And can offer in-depth advice, whether it's a.m., f.m. or s.s.b. that's required.

And that brings us to us.

Most you already know. Although it's worth remembering that, being UK based, we're somewhat nearer than most transmitting transistor manufacturers. Many devices in our range are available ex-stock. And we can offer fast delivery on those that aren't.

Then there's our technical advisory service. It's good. Very good. And staffed by experts who are always glad to help. However big or small the problems.

We're taking care of tomorrow too.

Developing sophisticated devices for sophisticated needs. Such as the new range of u.h.f. broadband modules with bandwidths of 380 to 512MHz, 50Ω input and output impedances and encapsulations that simplify module packing. And then there's the modules we're making for military use . . .

Design engineers who would like more information, write to Mullard (on your company notepaper please).

Mullard

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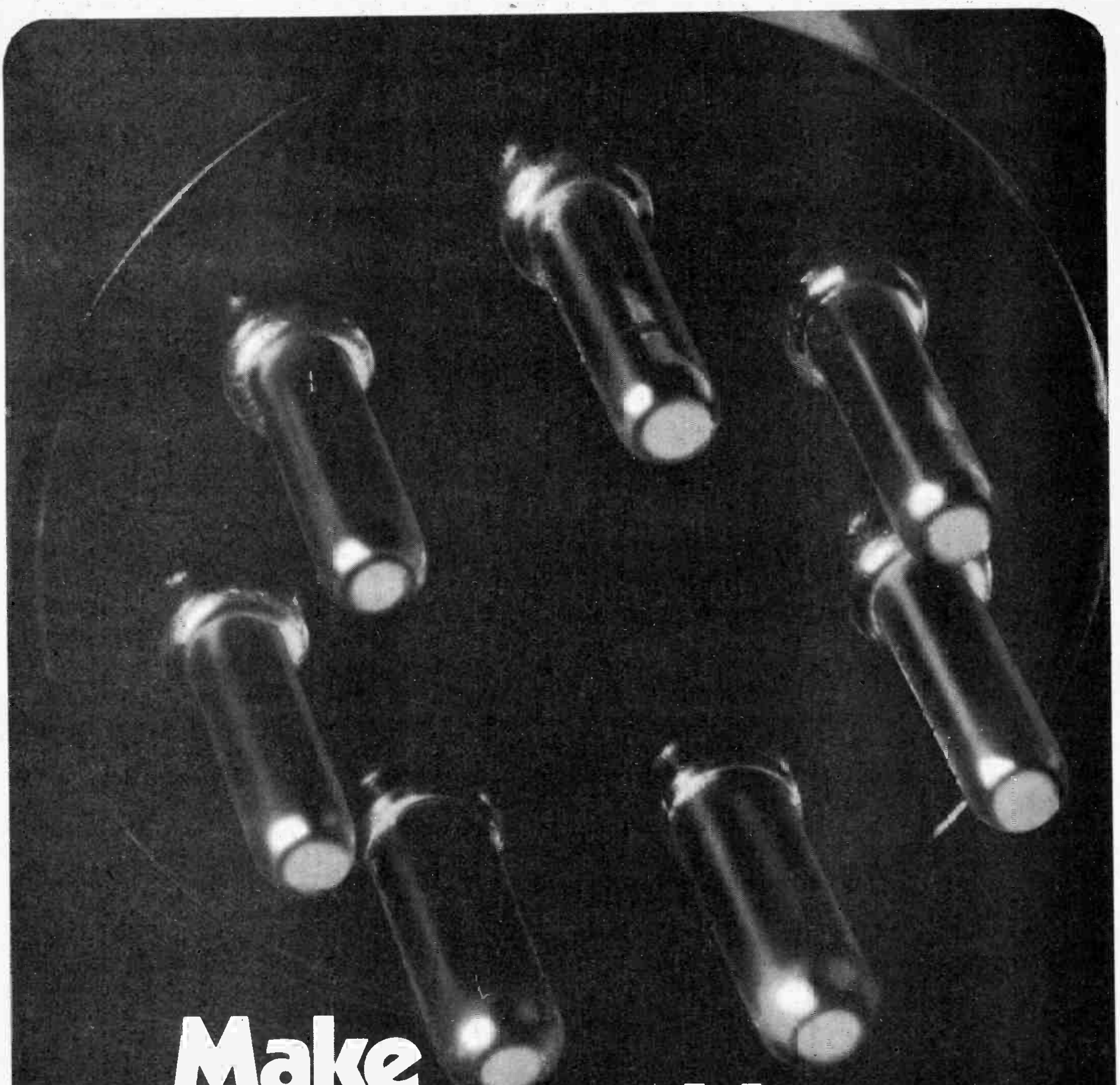
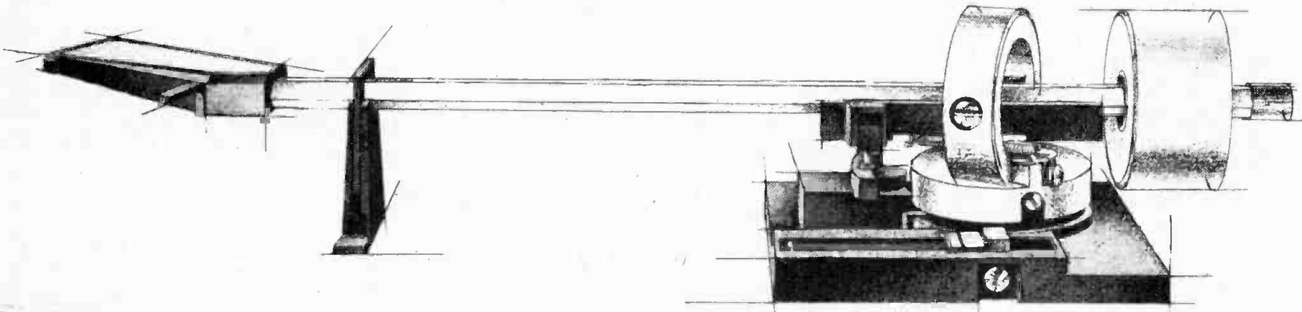
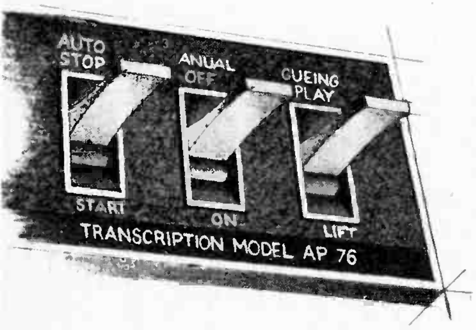
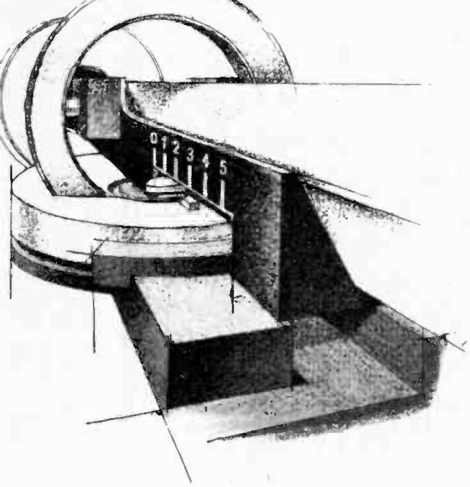


The Garrard AP76 transcription quality deck gives you a good deal to think about:







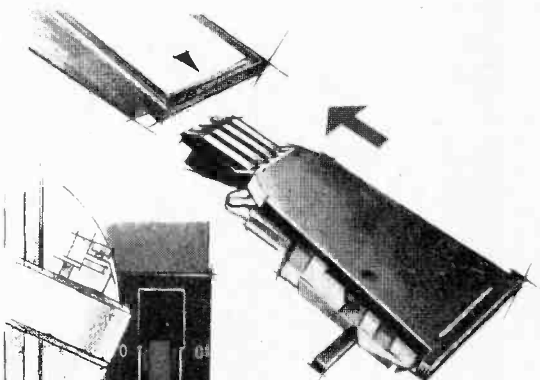
Forget the price for a moment, look at the features. □ Offers automatic play (start, stop and return) of single records at 33⅓, 45 and 78 rpm. □ Tab controls for viscous damped cue and pause, start/stop, manual/auto. □ Hexagonal, low resonance, aluminium pickup arm. □ Resiliently mounted counterbalance weight. □ Stylus force adjustment, calibrated 0 to 5 grams. □ Bias compensation calibrated for spherical and elliptical styli. □ Combined record speed and size selector. □ Slide-in cartridge carrier. □ 11½ inch non-magnetic turntable driven by 4-pole induction motor. □ Performance: wow and flutter better than 0.10% rms. Rumble (relative to 1.4 cm/sec at 100Hz) better than −49dB. This performance betters DIN 45-500 Hi-Fi standard. □ Black and silver finish as standard. Wooden base and rigid plastic cover available.

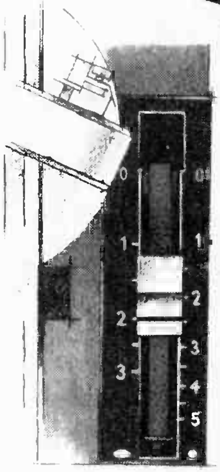
These are hard facts (and compare them with what the competition offers). Add in true quality engineering and the reliability based on 50 years' leadership in record players.

Now look at the price – recommended at £27.85. Fully £10 cheaper than the good competitive decks having the same features. Only Garrard can do it – by long experience and their comprehensive production programme across a whole range of quality players.

At £27.85 the AP76 gives you transcription quality.

Return the coupon below for full details of this and other Garrard decks – or ask your Hi-Fi dealer for a demonstration today.





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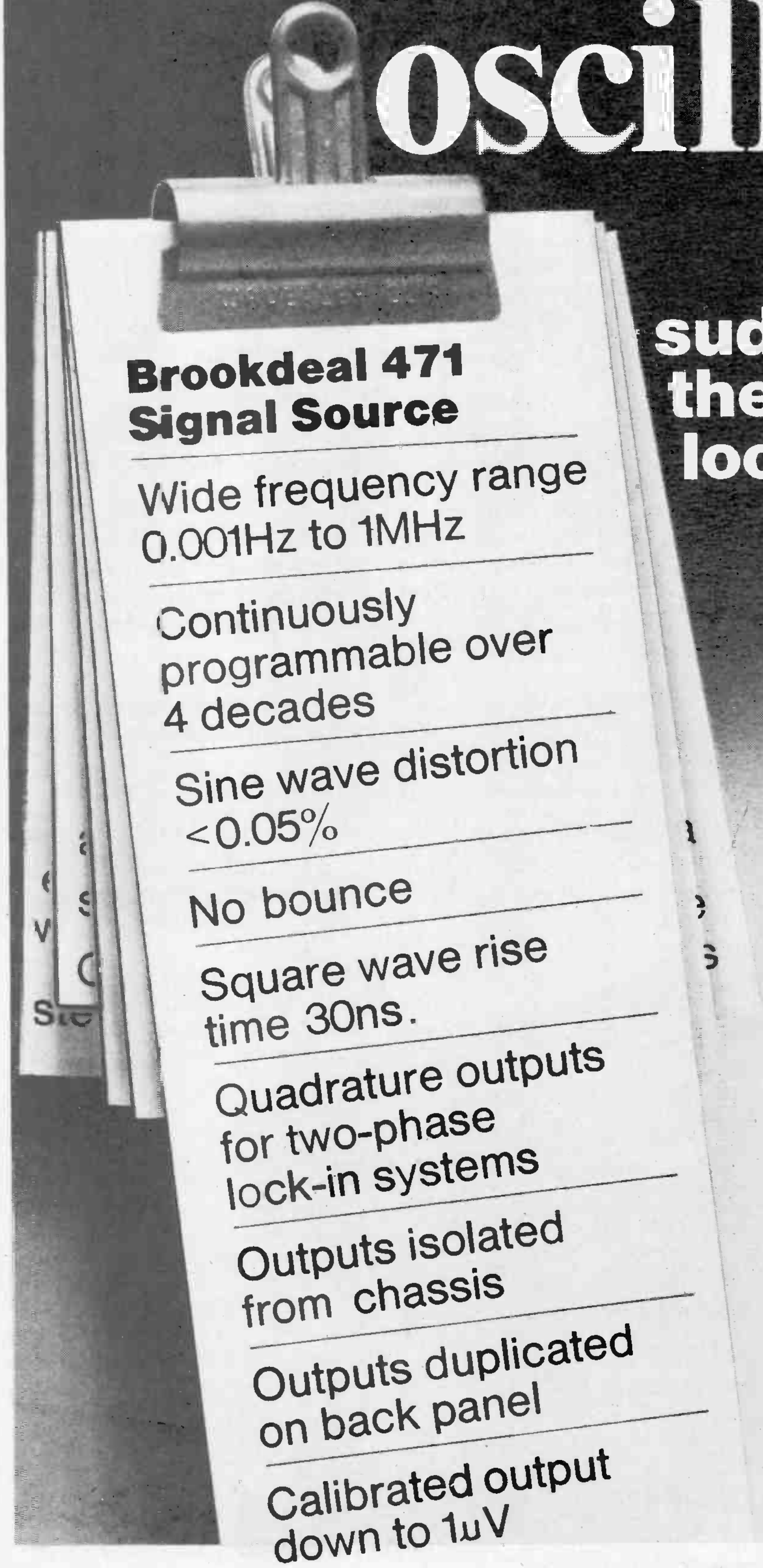

suddenly, all the other specs look shorter!

We took the design team that won a world reputation for advanced signal recovery instrumentation . . . and set them to work on an oscillator. Result, Brookdeal 471 – a superb all-purpose instrument with a list of features longer than your arm. If you know Brookdeal, you'll know it's time to throw your old ideas on oscillator price/performance overboard. We're giving you more performance . . . ! How much more? Enter the W.W. No. below on the reader enquiry service card and we'll reveal all . . .

Brookdeal Electronics Limited,
Market Street, Bracknell, Berks, England.
Telephone 0344 23931.

See the new Brookdeal 471 at:
Melex, Manchester 5th—8th October.
Interkama, Dusseldorf 14th—20th October.
E.P.G. Bristol 12th—14th October.
Het Instrument Exhibition,
Amsterdam 29th September to 7th October.

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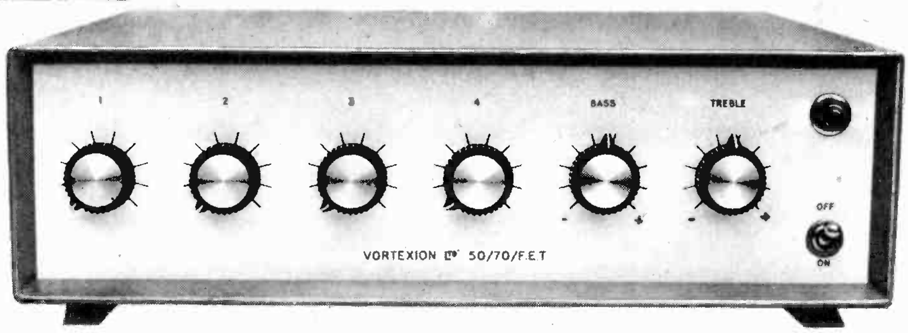
Vortexion

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



This is a high fidelity amplifier (0.3% intermodulation distortion) using the circuit of our 100% reliable 100 Watt Amplifier with its elaborate protection against short and overload, etc. To this is allied our latest development of F.E.T. Mixer Amplifier, again fully protected against overload and completely free from radio breakthrough.

The mixer is arranged for 2-30/60Ω balanced line microphones, 1-HiZ gram input and 1-auxiliary input followed by bass and treble controls. 100 volt balanced line output or 5/15Ω and 100 volt line.

50/70 WATT ALL SILICON AMPLIFIER WITH BUILT-IN 5-WAY MIXER USING F.E.T.s This is similar to the 4-way version but with 5 inputs and bass cut controls on each of the three low impedance balanced line microphone stages, and a high impedance (10 meg) gram stage with bass and treble controls plus the usual line or tape input. All the input stages are protected against overload by back to back low noise, low intermodulation distortion and freedom from radio breakthrough. A voltage stabilised supply is used for the pre-amplifiers making it independent of mains supply fluctuations and another stabilised supply for the driver stages is arranged to cut off when the output is overloaded or over temperature. The output is 75% efficient and 100V balanced line or 8-16Ω output are selected by means of a rear panel switch which has a locking plate indicating the output impedance selected.

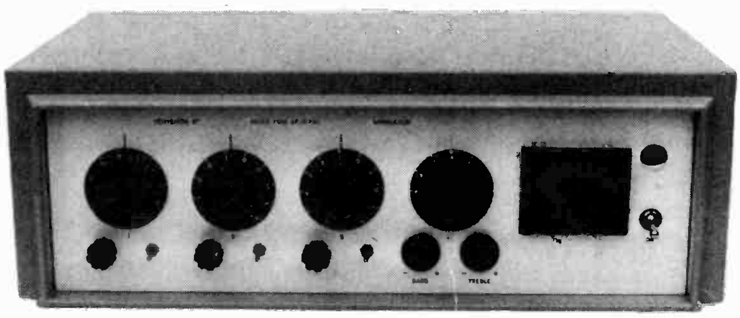
100 WATT ALL SILICON AMPLIFIER. A high quality amplifier with 8 ohms–15 ohms or 100 volt line output for A.C. Mains. Protection is given for short and open circuit output over driving and over temperature. Input 0.4 V on 100K ohms.

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

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

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

F.E.T. MIXERS and PPM's



Since we have been supplying professional mixers for 25 years we have delayed the introduction of solid state units until they were at least as good as their valve counterparts. (Which will continue where required.)

The various sections of the FET mixers and BBC type PPM's have been performing successfully for several years in other equipments with complete reliability. The PPM also uses an FET in its time constant circuit so that polyester capacitors can be used. The response from the 600Ω output (25Ω source impedance) is level 20 Hz to over 30 kHz with very low intermodulation distortion to zero level +12dB. The input signal voltage range is over twice that of the valve unit and the noise at least halved.

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

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ONKYO

JAPAN'S LEADING Hi-Fi EQUIPMENT

COMPLETE STEREO SYSTEMS

SM-10 Modular 20 Watts Total Output.
Dynamic Four Component Series.
28 Watts Total Output.
Multiac 50D Special 4-AMP System.
Multiac 60D Special 4-AMP System.

INTEGRA SERIES

725. Integrated Stereo Amplifier 22/22 W.
723. Integrated Stereo Amplifier 33/33 W.
225. Stereo Receiver 22/22 W.
423. Stereo Tuner.

A section from the range of accessories and equipment to provide complete audio installations including loudspeakers—cassette and cartridge tape decks—headphones, etc.

PHOTOGRAPH:

D.F. 700 Complete Component Stereo System —28 Watts Total Output.

Suggested retail price £152·91 inclusive of Purchase Tax.

Trade enquiries are invited at the Showrooms of the sole U.K. distributors:

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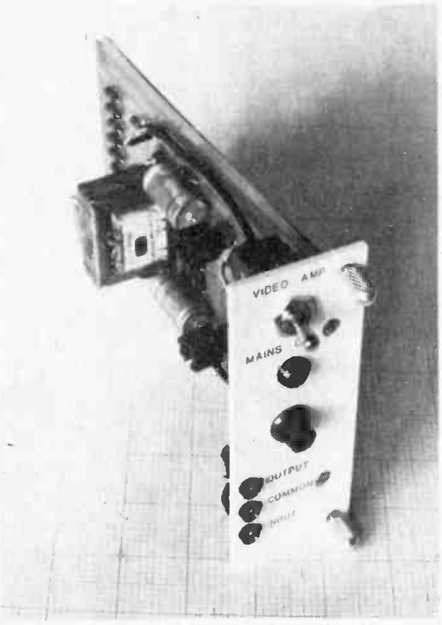
WW—031 FOR FURTHER DETAILS

5 OUTPUT VIDEO/PULSE DISTRIBUTION AMPLIFIER



28 MHz bandwidth
Fully Integrated Circuit
15KΩ input, 5 x 75Ω output
Twin Stab. Mains Power Supply

7" VIDEO/VIEWFINDER MONITOR

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Accelerator Spinwheel

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- ★ Several models available
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- ★ High Test Voltage

Style 330 H.P.C.
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Heavy Duty Epicyclic Drive

for the Really Heavy Job

- ★ The main housing of this powerful friction drive is only 1$\frac{1}{2}$" diameter and $\frac{1}{2}$" deep yet it delivers an output torque of 100 oz. ins. (6 lb. ins.).

- ★ The reduction ratio is 6:1
- ★ The complete assembly weighs only 3 oz.
- ★ Essential parts are hardened and ground to provide long life.

It's reliable if it's made by Jackson!

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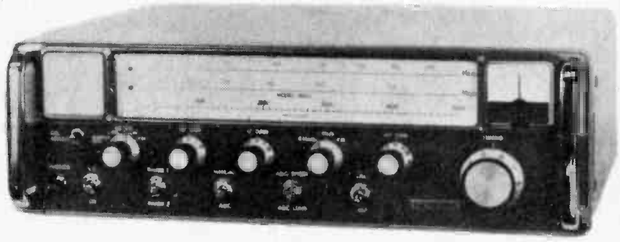
Eddystone solid-state VHF/UHF communication receivers

MODEL 990S



Single conversion receiver for AM and FM with continuous coverage from 230MHz to 870MHz.

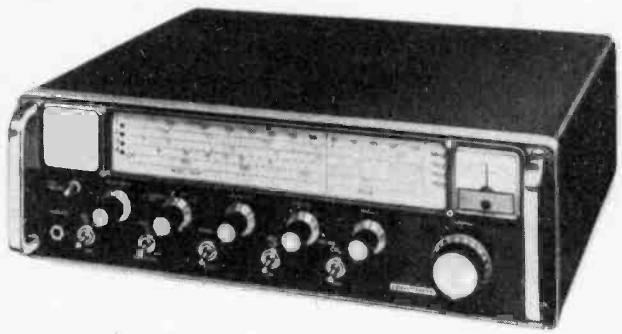
Exceptional stability and sensitivity.

Crystal calibrator.

Fixed or mobile operation.

Operation from standard AC mains or 12V DC supply.

MODEL 990R



VHF Receiver with continuous coverage from 27MHz to 240MHz. CW, AM and FM reception.

Crystal filter to suit 12.5kHz, 25kHz, or 50kHz channel spacing to customer requirements.

Designed for fixed or mobile point-to-point services, broadcast monitoring purposes, meteorological services, radio astronomy, aerial investigations, civil aviation and in radio laboratories.

Operation from standard AC mains or 12V DC supply.

Illustrated brochures obtainable from:

Eddystone Radio Limited

Alvechurch Road, Birmingham B31 3PP.
Telephone: 021-475 2231 Telex: 337081

A member of Marconi Communication Systems Limited

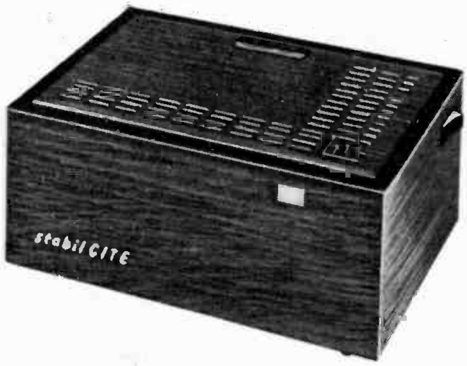
LTD/ED 88

WW—035 FOR FURTHER DETAILS

VARIABLE TRANSFORMERS ARE ALWAYS AVAILABLE FROM STOCK AT THE LOWEST PRICES

Fully shrouded variable transformers—input 250VAC output 0-260VAC

1 amp £7.00	10 amp £22.50
2.5 amp £8.05	12 amp £23.60
5 amp £11.75	20 amp £49.00
8 amp £15.90	



Constant voltage transformer stabilises mains voltage to ± 1%
output 240VAC ± 1%
input 240VAC ± 20%
capacity 250 Watts

price £12.50 with quantity discounts

New solid state variable voltage control
input 240VAC
output 25-240VAC

5 amp £9.50
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Telephone 01-723 2231

U.K. SPECIALISTS IN AUTOMATIC CONTROLS & SWITCHING

WW—036 FOR FURTHER DETAILS

MINIATURE

SOLDERING?

Want a really slender featherweight soldering Iron? Do you need a bit with a tip about the diameter of a pin? A range of interchangeable bits up to $\frac{3}{16}$"? A soldering performance equal to most 25 watt irons? Try the ADAMIN Model 15. One of the world's smallest irons. With slip-on bits, copper and long-life, and fully enclosed element. Your operators will be amazed—and more efficient. Clip the 24 volt version across any handy power unit, or use the mains version. Miniature price—£1.63 (list). Ask for leaflets 5/1005/7

LIGHT SOLDERING DEVELOPMENTS LTD.,
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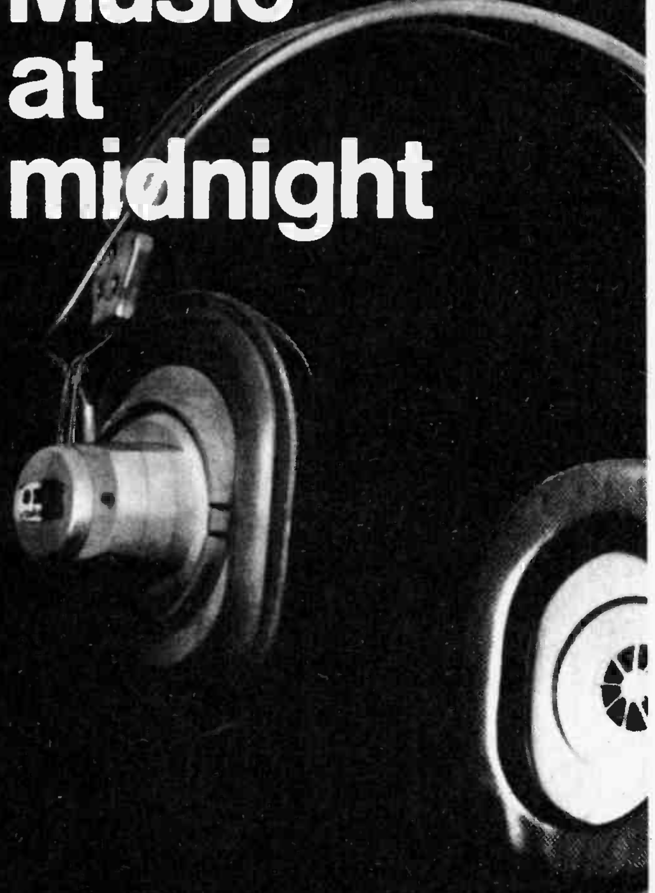
Telephone 01-688 8589 & 4559

WW—037 FOR FURTHER DETAILS

WW—040 FOR FURTHER DETAILS

Music at midnight



Midnight is a time for listening. Let the music be as late and as loud as you like; with headphones, it disturbs no one. Let the headphones be A.K.G. and you will find the quality staggeringly good. Made by a company whose professional microphones are known throughout the world and much used in this country, A.K.G. stereo headphones reflect the same fine quality of design and meticulous manufacture. They are just about as good as anything you can buy at any price. Go to the dealer displaying the A.K.G. Superhead and hear for yourself, without obligation. *Shown here, Model K.60 R.R.P.* £15.00

AKG

A.K.G. Equipment Ltd.
Eardley House
182-184 Campden Hill Rd. W8 7AS

WW—041 FOR FURTHER DETAILS

JERMYN
50p BARGAIN PACKS

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THIS MONTH:

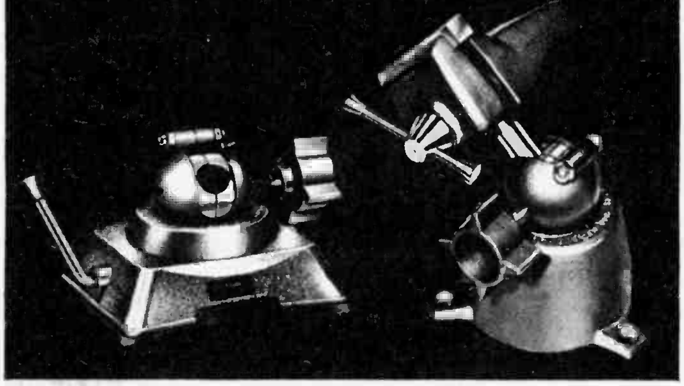
1N4148 (=1N914)	Signal Diode	18 for 50p
1N5060 (=A14D)	1 Amp Rectifier 400V avalanche protected	7 for 50p
2N2926 (Red)	NPN Silicon Transistor hfe 55 - 110	8 for 50p
2N2923	NPN Silicon Transistor hfe 90 - 180	7 for 50p
2N3721	Gen. Purpose Transistor	8 for 50p

Post and packing 10p for 1 or 2 packs; 3 packs or more post free.
Order any quantity, till sold (but we regret packs cannot be subdivided).

P.O. or Cheque payable Jermyn Industries, Vestry Estate, Sevenoaks, Kent.

WW—042 FOR FURTHER DETAILS

COLBERT
WORK POSITIONERS-300 SERIES



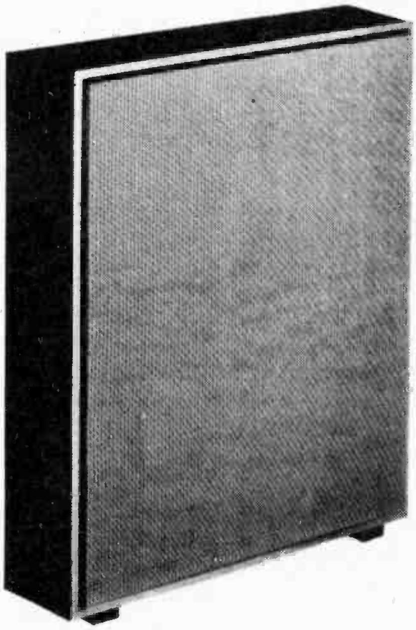
Colbert Pana-Vise WORK POSITIONERS are specially designed to quickly and easily achieve the most CONVENIENT, COMFORTABLE and TIME-SAVING work position. Available with vacuum clamp or screw-on base. They can be ROTATED, TIPPED, TILTED, ANGLED, ELEVATED, LOWERED. The required work position is firmly secured with a patented ONE KNOB CONTROL, a unique feature of COLBERT POSITIONERS. A series of special holders is available for various types of work. Full details available on request.

Distributors:

Special Products Distributors Limited
81 Piccadilly, London, W.1. Tel: 01-629 9556
Cables: Speciprod London
(made in U.S.A.)

WW—043 FOR FURTHER DETAILS

Stentorian SPEAKER SYSTEMS



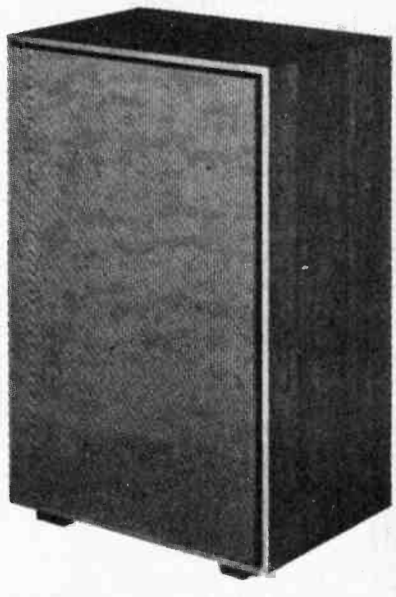
These superb new speaker systems make available even higher standards of performance in sound reproduction and uphold the high reputation gained by Whiteley Stentorian speakers throughout the world.
Attractively designed and soundly constructed, they are available in either Teak or Rosewood finish.

LC93

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

LC94

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



LC95

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

These products can be seen and heard in our showrooms at 109 Kingsway, London WC2.

WHITELEY ELECTRICAL RADIO CO. LTD.

MANSFIELD · NOTTS · ENGLAND · Tel: Mansfield 24762

London Office: 109 Kingsway, W.C.2. Tel: HOLborn 3074

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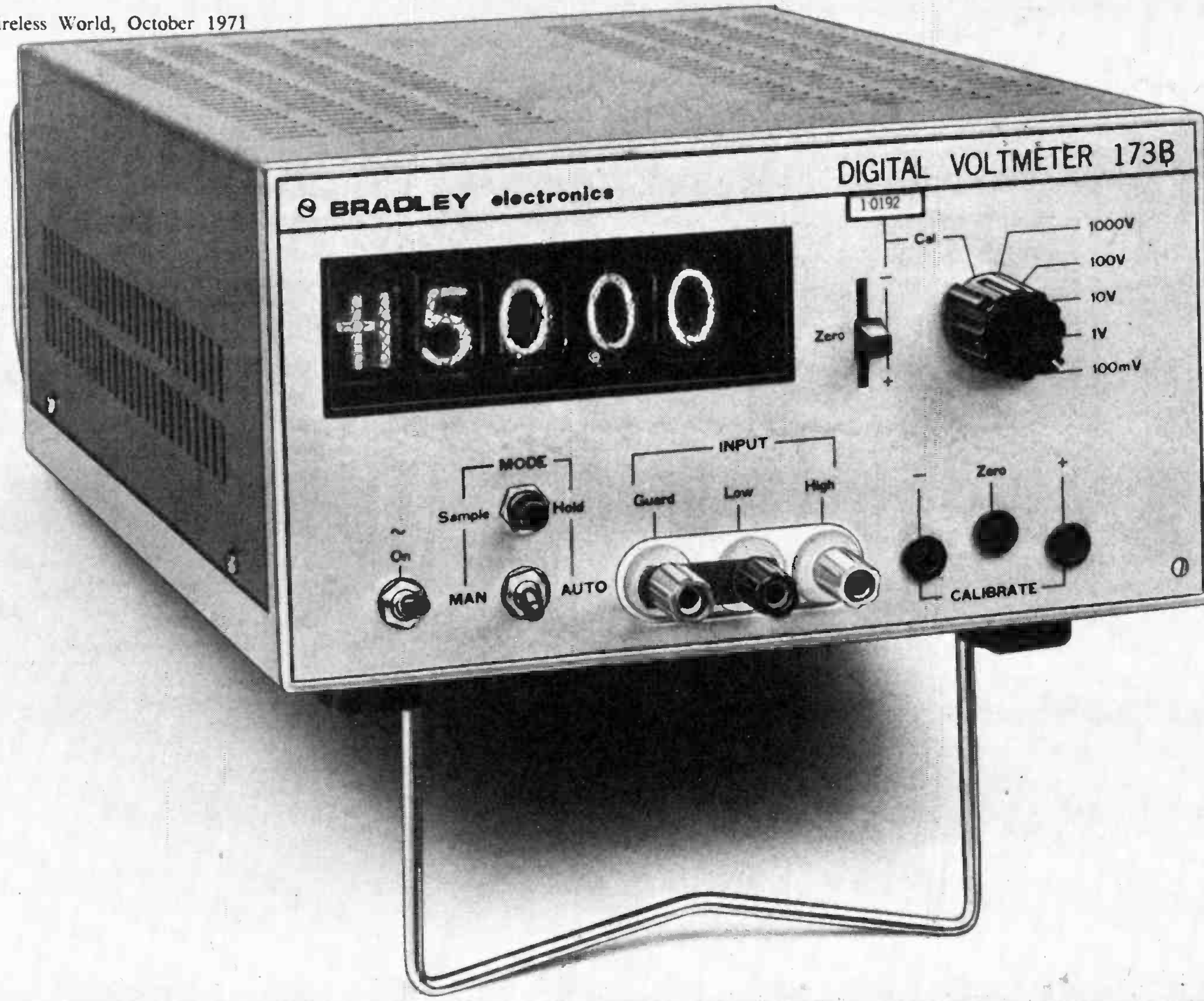


From Bradley. A £360 DVM now with 10µV resolution.

Bradley's compact 173B Digital Voltmeter will cost you only £360 in the U.K.

And at that price you mightn't expect any extras.

The 173B gives you six.

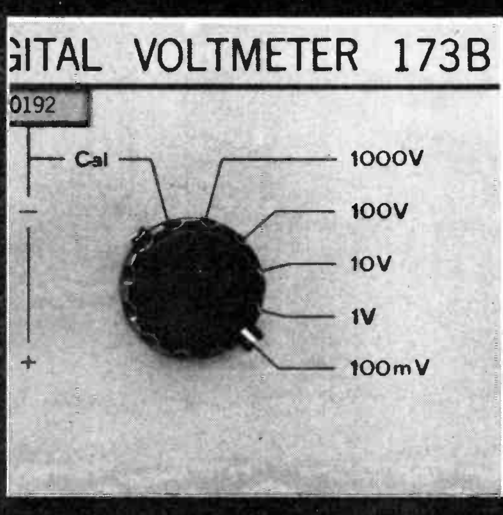
For instance, there's a scale length of 10µV to 1000 Vd.c. and with 50% overrange, maximum reading is 1500 Vd.c. with an accuracy of 0.01%.

There's guarded input giving high common mode rejection > 140 dB at line frequency.

There's display storage.

And 1-2-4-8 BCD data output. There is a standard unsaturated cell as an internal calibration reference. And the 173B gives you automatic indication of polarity.

In one small package, the 173B gives you a lot of DVM for your money.



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Electral House, Neasden Lane,
London NW10.
Telephone: 01-450 7811 Telex: 25583

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BRADLEY electronics

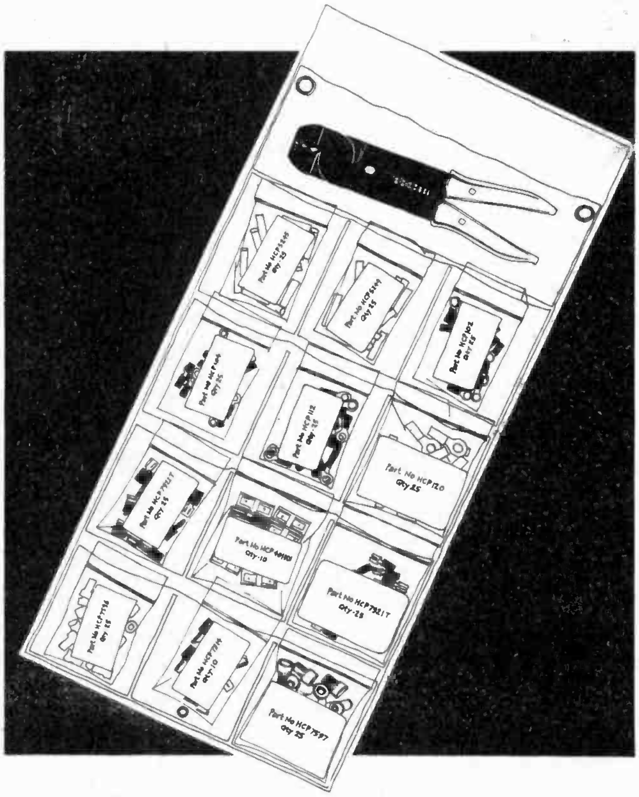
All Bradley instruments can be supplied with a British Calibration Service Certificate from our own B.C.S. approved standards laboratory.

WW—047 FOR FURTHER DETAILS

Terminate your wiring problems

Use Hellermann-GKN Compression Terminal Kits. They're ideal for general maintenance work on electrical and electronic equipment — domestic or industrial — and one of the Kits is specially made for automobile electronics.

Take your pick from three different Kits, each one containing 12 of the most popular compression terminals. With or without a hand crimping tool. The terminal packets are re-sealable, and fit into the pockets of the plastic wallet that can either be hung on a wall or folded neatly into a tool bag.



UNIVERSAL with pre-insulated terminals for general electrical maintenance and domestic appliances.
Kit No. 1. — without tool :£6.15 Kit No. 1-CT — including tool : £8.30

MAINTENANCE with pre-insulated terminals for factory and general maintenance.
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GARAGE with non-insulated terminals and covers used on most automobiles.
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All prices are subject to quantity terms. Each of these Kits can be made up to customers' requirements, subject to quantity.

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I'D RATHER HAVE A MINITEST"

The SEI MINITEST has made a remarkable impact in the pocket-sized multi-range meter market, by making itself a firm favourite with discerning people in the industry. Let's look into the reasons why.
First, the appearance. Diminutive, neat, wipe-clean cycolac case with shock and magnetic field proof steel liner. Controls are simple and easy to use.
Second, the range. The Minitest measures a.c. and d.c. voltages d.c. current and resistance over 20 ranges to a sensitivity of 20,000 and 2,000 ohms per volt d.c. and a.c. respectively.
Third, high voltage probes. These extend the range to 25 or 30kV d.c.
Little wonder the Minitest is preferred!

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Telephone 061-789 5081 Telex 667711
A Member Company of GEC Electrical Components Ltd.

SEI GEC

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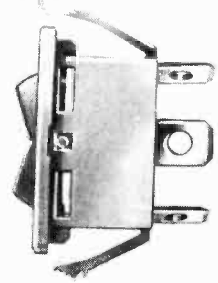
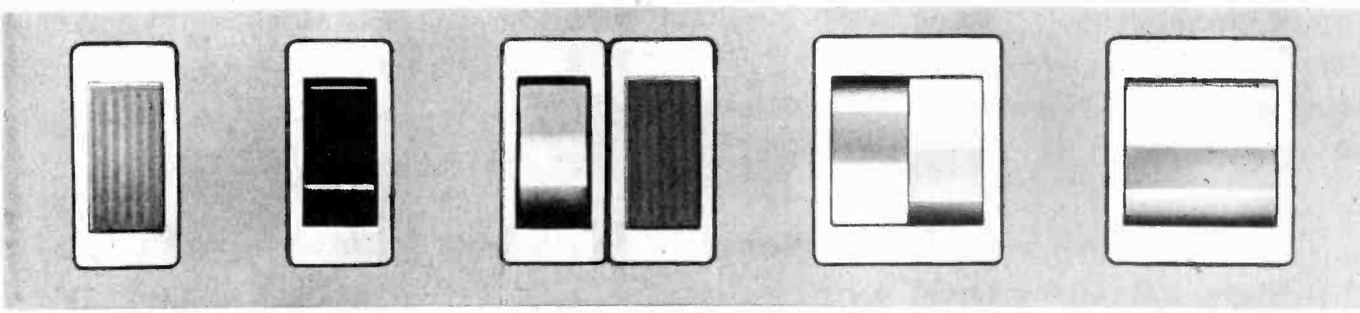
MY VITAL STATISTICS ARE 30mm. X 14mm. X 33mm. 250V 10 AMP A.C. SINGLE POLE SNAP-IN FIXING



now meet the family



1109 1100 1100/1109 1100 twins 1110

Being a snappy little 1100 rocker who is getting around fast, I am often asked about my family. Now, having managed to persuade them to have their photograph taken with me, I have much pleasure in introducing them.

1109—often seen around with me, is a most illuminating little pilot light with a variety of colour lenses. At times we are very close and can often be seen working together very harmoniously on a wide range of appliances and equipment.

The 1100 twins are going to be very popular and you can expect to see them on many companies' panels soon.

1110, the fat one, is double pole and the clever member of the family, he can operate two circuits at a time.

Like to know more about us? Give us a ring at 01-574 2442, we would certainly like to meet *YOU* some time. P.S. I have just been awarded my BS.3955 approval certificate.

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ARROW ELECTRIC SWITCHES LTD.

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Telex: 23332 Cables: ARROWHART LONDON Scottish office: 13 Murray Place, Stirling Phone: 0786 3823

Distributors: Comway Electronics Ltd., Downshire Way, Bracknell, Berks. RG12 1ND. Phone: Bracknell 24765
ITT Electronic Services Ltd., Industrial Estate, Edinburgh Way, Harlow, Essex. Phone: 0279-6 26777

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SPECIAL OFFER! Something all i.c. users should know....

Our I.C. Patchboard Educational Pack Type CK2/E is down in price!
For a limited period only, that is.
The educational pack comes complete with patchboard for twelve dual-in-line integrated circuits, input switches, output indicators, clock, internal power supply, patch leads, a selection of ten digital integrated circuits, and a comprehensive logic instruction book.
And as a bonus you also get the new handsome cabinet in which it is housed. Absolutely free.
At the special offer price of only £57, you save £5 per pack by ordering before 30th October 71. The basic patchboard type CK2/S is exceptional value too at only £48.
Ask us for further information *NOW*.

Limrose Electronics Ltd, Lymm, Cheshire, England.
Tel. Lymm 3019 (STD 092-575-3019)

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Jack Strips 310, 320, 510, 520, 810
Line Transformers
Resistor Lamps and Holders
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Resistor Bobbins, coils and spools
Bells and Bell Transformers 6V or 12V
Low Pass Filters
U Links and Sockets
Fuse mountings 4028 and Mounting H.15B.
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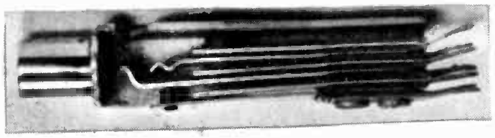
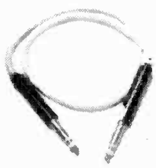
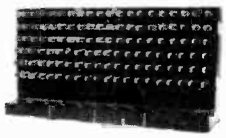
Patching and switchboard Cords
Patch Panels
Terminal Blocks and Strips
Uniselectors and Miniature Uniselectors
Ringing Generators







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This means you can be sure of getting exactly the lamp you're looking for when you ask for Vitality.

Miniature lamps from 3mm diameter upwards in voltages from 1.5 to 50V with all forms of bases.

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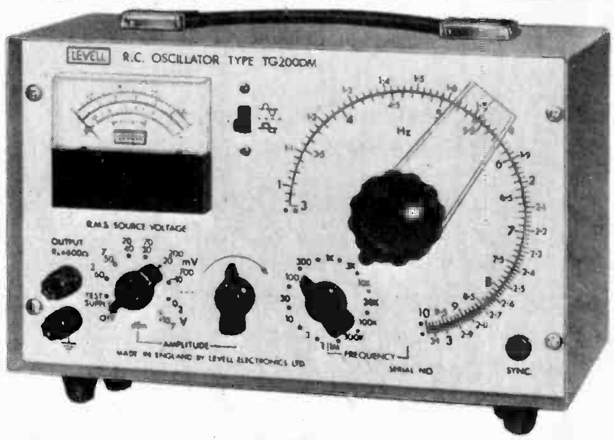
the choice is yours

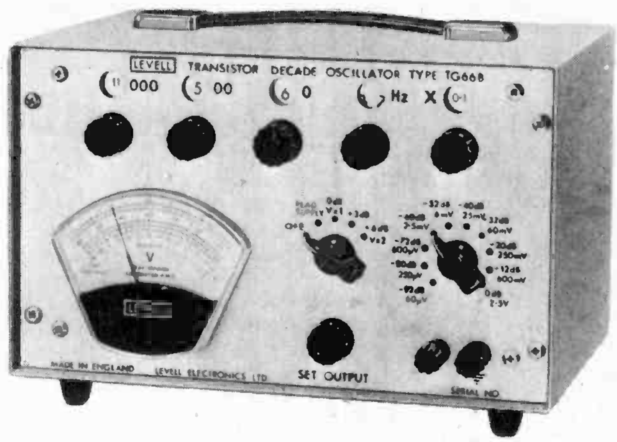
ANALOGUE or DIGITAL

1Hz to 1MHz R.C. OSCILLATORS



FREQUENCY	1 Hz to 1 MHz in 12 ranges. Acc. ± 2% ±0.03Hz.
SINE OUTPUT	7V r.m.s. down to <200μV with Rs = 600 Ω
DISTORTION	<0.1% to 5V, <0.2% at 7V from 10Hz to 100kHz.
SQUARE OUTPUT	7V peak down to <200μV. Rise time <150nS.
SYNC. OUTPUT	> 1V r.m.s. sine in phase with output.
SYNC. INPUT	±1% freq. lock range per volt r.m.s. input.
METER SCALES	0/2V, 0/7V & —14/+6dBm on TG200M & DM only.
SIZE & WEIGHT	7" high x 10¼" wide x 5½" deep. 10 lbs.

TG200	TG200D	TG200M	TG200DM
£42	**£45**	**£52**	**£55**
Sine O/P	Sine & Sq. O/P.	Sine O/P + meter.	Sine & Sq.O/P + meter.



FREQUENCY	0.2Hz to 1.22MHz on four decade controls.
ACCURACY	±0.02Hz below 6Hz, ±0.3% from 6Hz to 100kHz, ±1% from 100 kHz to 300 kHz, ±3% above 300 kHz.
SINE OUTPUT	5V r.m.s. down to 30μV with Rs = 600 Ω
DISTORTION	<0.15% from 15Hz to 15 kHz. <0.5% at 1.5Hz and 150kHz.
METER SCALES	2 Expanded voltage & —2/+4dBm.
SIZE & WEIGHT	7" high x 10¼" wide x 7" deep. 12 lbs.

TG66B	TG66A
£120	**£150**
Batteries only.	Mains unit & batteries incl.

Prices include batteries with 400 hour life.
Mains power units £10 extra. Leather cases £6 extra.

VISIT US AT M.E.L.E.X. STAND 21, 5TH-8TH OCT. AND ELECTRONIC INSTRUMENTS EXHIBITION, BRISTOL, STAND 5, OCT. 12TH-14TH

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Send for literature covering our full range of portable instruments.

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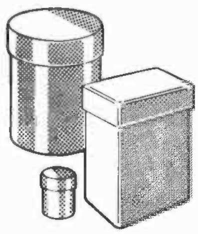
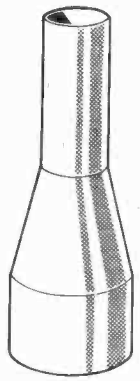
Magnetic shielding problems?

TELCON OFFER THREE SIMPLE ANSWERS



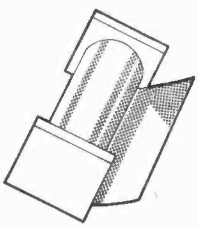
Standard shields

Telcon Metals offer an extensive standard range of high efficiency Mumetal shields, which fit most cathode ray, photo multiplier and radar tubes, together with a selection of boxes and cans for microphones pick-ups, transistors and transformers. These are normally supplied stove enamelled in hammer grey externally and matt black internally. Other finishes can be supplied by arrangement.



Fabricated shields

Telcon Metals offer complete facilities for fabricating special shields in Mumetal and composite shields in Mumetal/Radiometal to customers' individual requirements. All Telcon shields are made to close tolerances and have excellent finish and appearance. For the highest efficiency and extra close fitting tolerances, the 'Telform' technique is recommended. These shields can be produced in complex shapes with a minimum of welded seams and very close uniformity throughout batches. A comprehensive design/advice service is available to assist all customers.



'Telshield' wrap-around foil

Telshield' is an easy to use, feromagnetic shielding foil, which can be cut with scissors, wound into cylinders, cones, etc., and fixed with adhesive tape, clips or spot welds, to provide a permanent efficient shield. It is economical to use, especially for research, development and short-run applications which do not merit the tooling involved in the production of fully fabricated shields. 'Telshield' is supplied in a standard thickness of 0·05 mm, in widths of 150, 50 and 25 mm in convenient packs costing approximately £5. Other thicknesses and widths are available by arrangement.

Please send for further information to

TELCON

Telcon Metals Ltd.,
Manor Royal, Crawley, Sussex.
(Crawley 28800)

WW—060 FOR FURTHER DETAILS

"To get better quality components, look for *superior breeding*

Fine breeding in electrical components is like good breeding in dogs: it takes a long time, but the results are well worth the trouble.

Rendar Instruments have the experience and the technical know-how in standard, miniature and sub-miniature components, equal to a first-class pedigree. Enough to gain Ministry of Defence Approval.

You could benefit from this if you are dogged by small component troubles. Using components from the well-bred Rendar range could bring about a substantial improvement in the reliability of the equipment you are handling.

You will find this in the sound design, the first class materials, the precise machining and careful assembly of all the Rendar components you use.

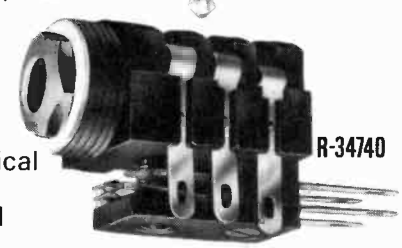
And the cost will probably be little more than you are paying now.

Why not send today for further details about the complete range of Rendar components?

RENDAR COMPONENTS OF THE MONTH

(These illustrations are all life size)

Miniature and standard size jack plugs and sockets. Plugs in both screened and unscreened versions; socket bodies in high melting point thermoplastic; many other interesting specifications and performance figures (see individual technical data sheets). Rendar were first in the field with 3.5 mm probe miniature jack plugs!



RENDAR FOR RELIABILITY

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INSTRUMENTS LTD
BURGESS HILL, SUSSEX, ENGLAND
TELEPHONES: BURGESS HILL 2642-4
CABLES: RENDAR, BURGESS HILL

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Head in the clouds
The Versatower System offers a range of telescopic, tilt-over towers from 25 to 120 feet for lighting and radio communication in static, portable and fully mobile forms.
The Versatower stands alone in offering full interchangeability. This gives complete freedom of application at any time for the towers to be adapted, simply and quickly, to a different purpose or size according to the users new requirements.
Continuing development of the system will bring added flexibility and an even wider range of applications.
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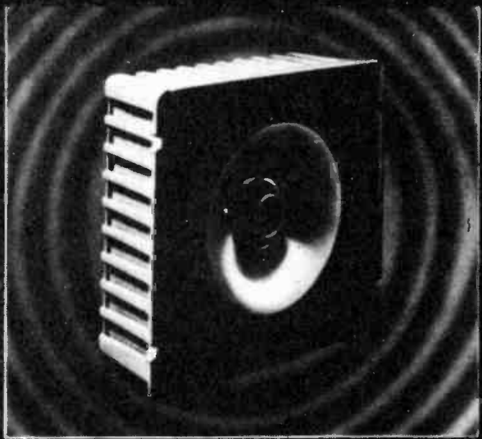
ZERO-100 S
now the world's most advanced Hi-Fi deck as a single player.

THE SIMPLEST HI-FI LOUDSPEAKER KIT IN THE WORLD!



JUST ONE FULL RANGE JORDAN-WATTS DRIVING UNIT— 20 Hz—20,000 Hz 12 watts

HERE FOR ONLY £13 IS RICH FULL BASS AND SPARKLING CLARITY THROUGHOUT—AT LESS COST THAN A TWEETER ASSEMBLY

Send for Constructor's Brochure free from your Hi-fi Dealer or

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ADDRESS ....

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LOUDSPEAKERS

THE VOICE OF HIGH FIDELITY

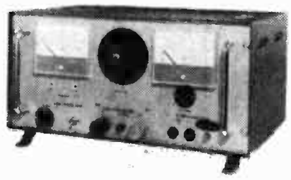
WW—064 FOR FURTHER DETAILS

POWER UNITS

Valradio

Now available with 3 OUTPUTS making these units more versatile for:

DEVELOPMENT PRODUCTION TESTING SERVICING



Type VRU/30/20*—£144·35

*OUTPUT 1, 0-30V 20A DC.
Will provide accumulator performance from AC mains for production testing and servicing of battery operated equipment. Output continuously variable 0-30V at up to 20A.

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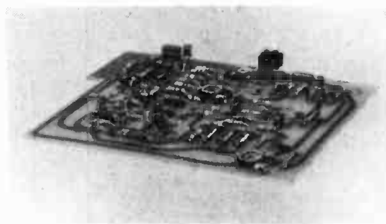

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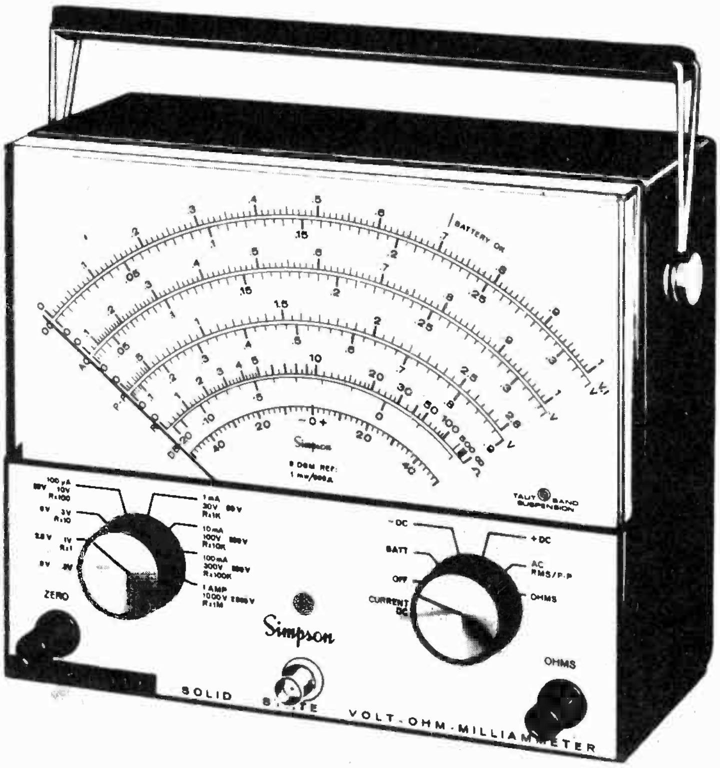

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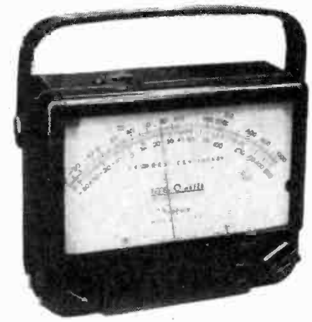

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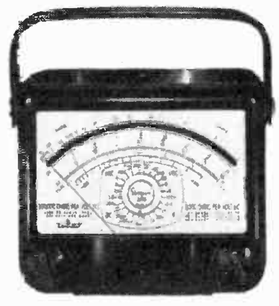

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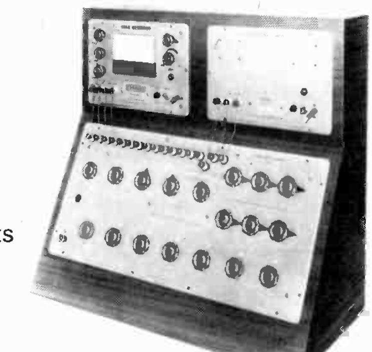

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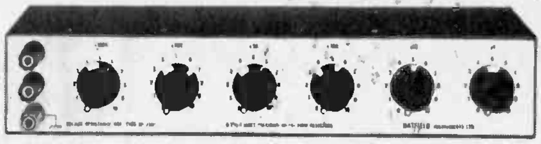

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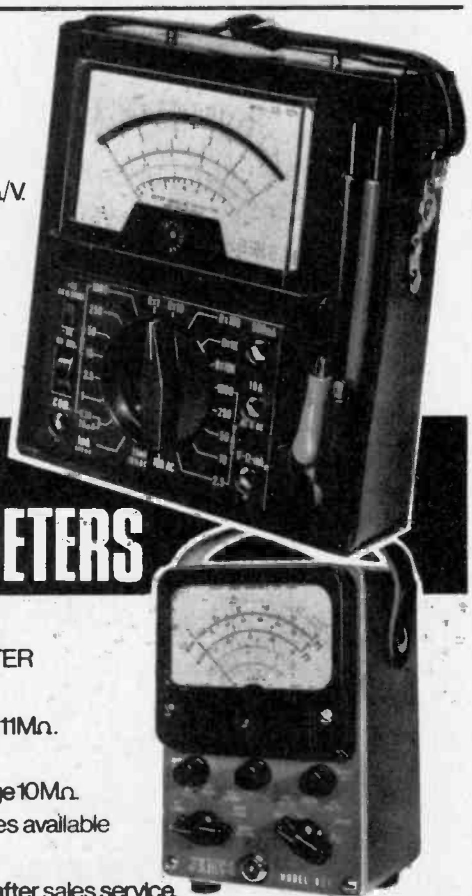

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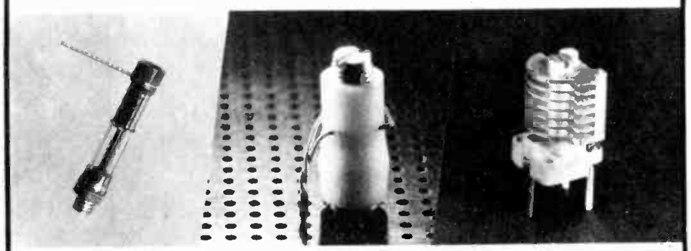

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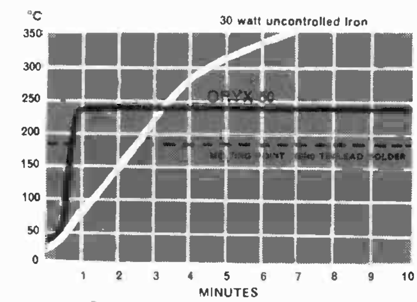

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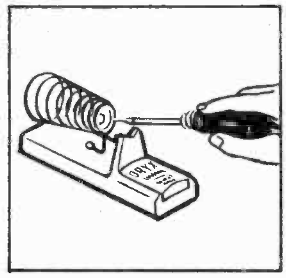

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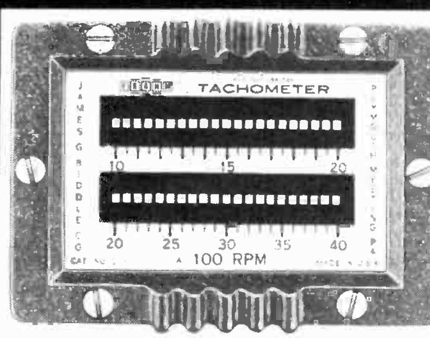

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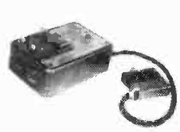

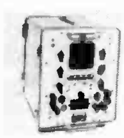

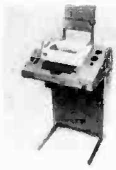

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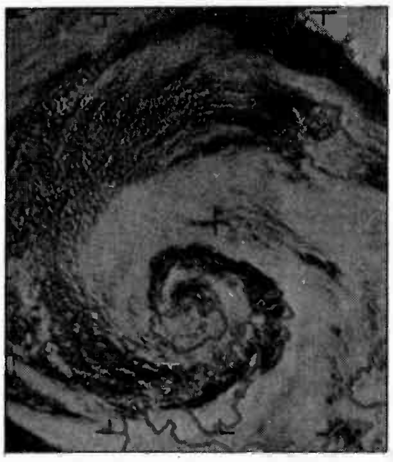
Wireless World

Electronics, Television, Radio, Audio

Sixty-first year of publication **October 1971** **Volume 77 Number 1432**

Wireless World
Weather satellite receiver
Making a turntable
October 1971 17½p



Our **cover photograph** is a satellite weather picture, received by the weather satellite station at Ambassador College, St. Albans, showing a depression centred over the west coast of Ireland. The equipment used at the college is more complex, and hence gives better results, than the simple system described in this issue.

IN OUR NEXT ISSUE

Pickup arm for home construction. This design complements R. Ockleshaw's turntable in this issue. Detailed drawings show how to make and assemble the parts.

Electrostatic headphones—constructional details of a very high-quality constant charge push-pull design using easily obtained components.

Tape recording survey—progress report on tape quality, reel-to-reel and cassette recorders, and noise reduction systems.

Contents

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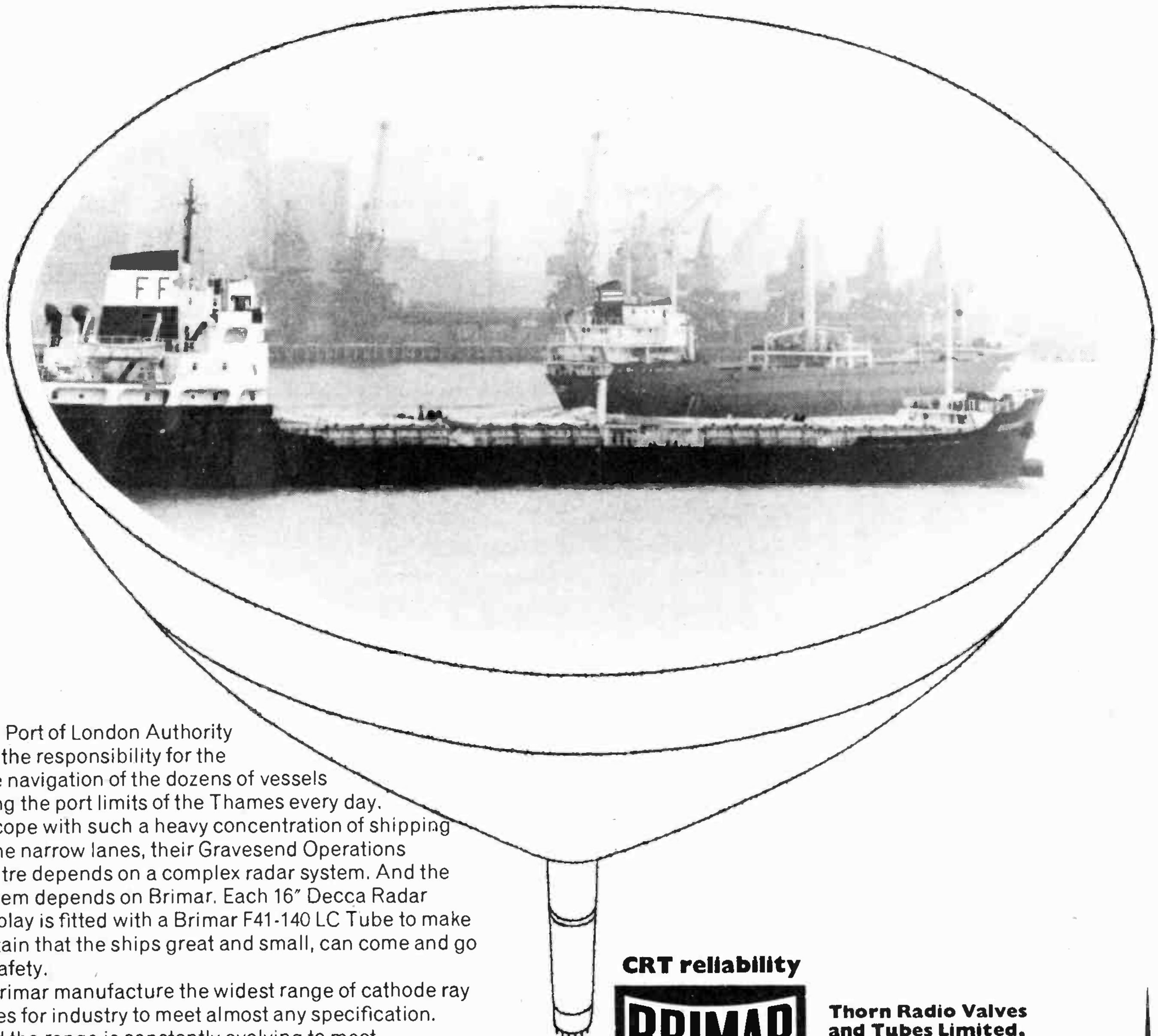

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Wireless World

The Domestic Receiver Scene

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Traditionally our October issue must include a review of domestic receivers and this one is no exception. This tradition stems from the days when Radiolympia, usually held in the autumn, was the annual focal point of the British radio industry. Those hey days of the U.K. radio trade have long since passed and manufacturers now satisfy themselves, and presumably the traders, with a multiplicity of individual trade shows held in London hotels. Not so in Germany, however. Instead of the biennial national show, which was reintroduced a few years after the war, Germany has this year held its first international show. This, as did Radiolympia, had the unstinting support of the broadcasting organizations and the Post Office and the radio industry put on as big a show as ever—some individual companies taking the whole of one of the many halls at the exhibition centre in West Berlin. A staff report on the Berlin show, included in this issue, is devoted mainly to the subject of quadraphonic reproduction which stole the show.

Our review of domestic receivers on the U.K. market, this year surveys only television sets; there being little, if anything, new in sound receivers.

In this issue we also publish a letter from a reader who complains, as others have done from time to time, of the appalling lack of quality in the sound output of television receivers. He also mentions manufacturers' apparent disregard of the desire of many viewers to enjoy a standard of sound quality compatible with the vision quality and comparable with that of their audio equipment.

Designers, or perhaps more correctly the marketing men, have adopted the attitude that the audio output of a television receiver is secondary and, therefore, any cost pruning must be carried out in the audio circuits and the transducer.

No one is unmindful of the fact that television manufacturers are in business to sell sets at a profit and the pruning of what are considered non-essentials in order to market equipment at a competitive price is understandable. What we cannot understand is why set manufacturers, or at least most of them, do not cater for the discerning minority who would be willing to pay for something above average. As is well known, there are manufacturers who produce receivers in period cabinets, at a price, for those who want to camouflage the ubiquitous 'goggle box', but it is generally a standard chassis which is used and few, if any, make any pretence of giving a superior performance.

Our correspondent complains that the manufacturer—incidentally the one with the largest output of receivers in the U.K.—was unwilling to modify his set to provide an improved audio output. We can fully appreciate that to undertake such modifications for an individual set owner would be economically unacceptable—we would ourselves be shocked if we accurately calculated what it costs to answer an individual reader's technical enquiry let alone undertaking to modify equipment! What we cannot understand, however, is why provision is not made in at least some receivers for the audio output to be fed to a viewer's own audio equipment. We know there are problems of isolation etc, but they are not insurmountable.

We return to our opening remarks regarding the present state of the British radio and television industry. We believe it is the apathetic attitude of the industry which is responsible for the present recession and has opened the gates for the ever-increasing flood of imported equipment. The industry seems to rely on temporary boosts, such as that being given by colour television, to maintain its momentum. Something much more stable is required. Could not Britain's undoubted international reputation in the field of hi-fi be used on which to build a new image for the industry as a whole—high quality in sound and vision.

This new 'image' might provide the justification for reviving Radiolympia.

Receiving Weather Pictures from Satellites

1. A very simple receiving station

*by J. M. Osborne**

There are several American weather satellites in orbit and, at the time of writing, one is continuously transmitting weather pictures. It is possible for an amateur to receive these signals and make pictures from them.

There is no mystery about orbits as a brief description should make clear. Common sense and arithmetic should enable anyone to predict satellite transits for weeks ahead. The satellites which concern us are in simple circular orbits at a height of 1400 km above the surface of the earth. From Newton's Law of Gravitation it follows that the time to circle the earth at this height is 115 minutes.

A satellite will circle in the same plane indefinitely. The orbit has been chosen to make about 10° with the earth's axis of rotation. Hence the satellite crosses the equator at an angle of 80° and so reaches polar latitudes of 80° as shown in Fig. 1. As the earth rotates, each point on its surface between 80°N and 80°S will pass twice through this plane at the same time each day, e.g. once by day and once by night. In the example of Fig. 1 a point on the equator will cross three hours (45°) after passing the sun (after noon), that is 15.00 hr local time by the sun, e.g. 16.00 hr B.S.T. To within about 15 minutes this also holds for all points on the earth's surface between 50°N and 50°S.

A satellite is always somewhere on the circle of its orbit. Since 115 minutes per orbit is not an exact number per day, each day it will be at a different place in the orbit at the time the given point on the earth's surface passes through the plane. As an example let us consider London and a typical satellite NOAH 1 on 8th June 1971. At 11.26 hours the satellite crosses the latitude 52°N going north. As shown in Fig. 1 London at this time is in position A. For an observer in London the satellite is below the eastern horizon. 115 minutes later, at 13.21 hours, the satellite will again be crossing latitude 52°. The earth having rotated 29° in the meantime (since it rotates 360° in 24 hrs), London will now be in position B in Fig. 1. For the observer the satellite is now high in the eastern sky moving from south to north and it will be above the horizon from about eight minutes before this time until about eight minutes later when it sets in the north.

115 minutes later, at 15.16 hours, the satellite will again cross latitude 52°N but by now London will be in position C in Fig. 1 and the satellite will be high in the western sky. A set of predictions for these two transits has been extracted from those prepared by the Radio and Space Research Station and is reproduced in Table 1. From these the latitude and longitude positions of the satellite have been plotted for an area corresponding to Europe (Mercator's projection) at two minute intervals in Fig. 2.

While an observer could never 'see' a satellite 1500 to 3000 km away, he can

* Westminster School

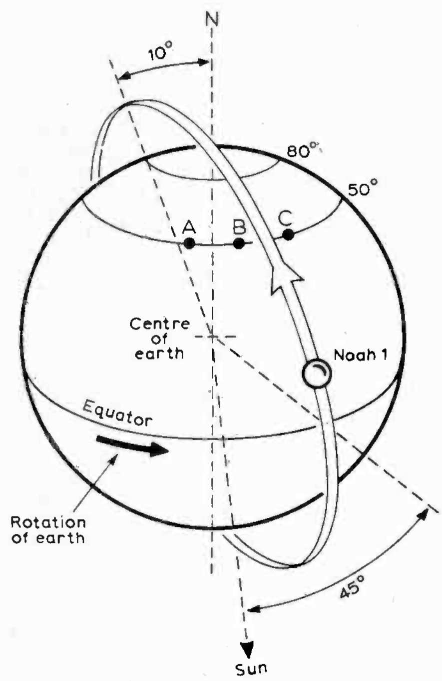


Fig. 1. The satellite's orbit shown relative to the earth. The orbit and the sun remain fixed while the earth rotates about its axis. As the satellite orbits every 115 minutes, a point on the earth's surface (London) moves successively from A to B and then C. From B the satellite is high to the east; from C high to the west.

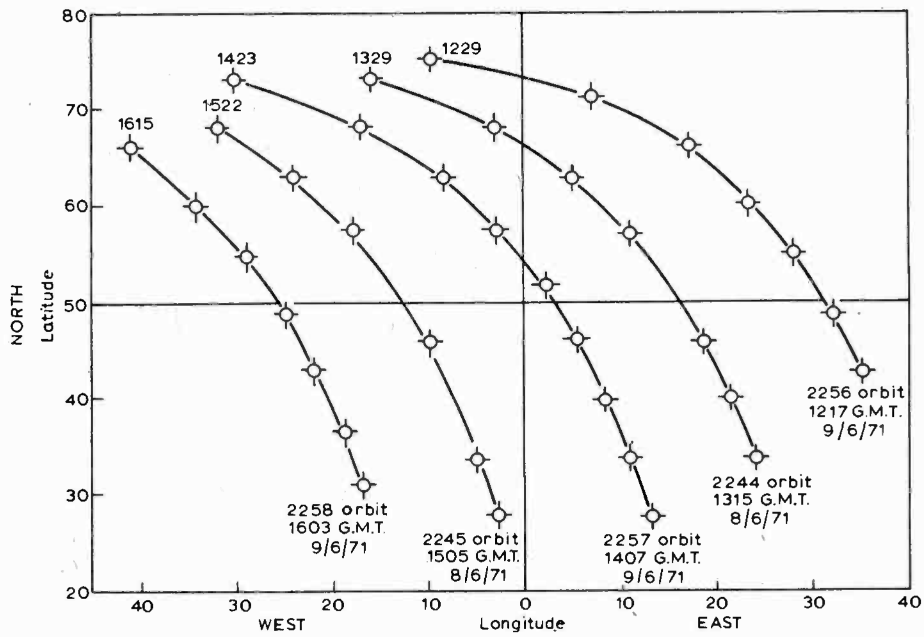


Fig. 2. The two orbits from Table 1 together with three orbits from the next day plotted at two-minute intervals which give an idea of where to point the aerial. The nearer the satellite the higher the aerial elevation needs to be.

receive signals from the satellite's 5W solar-powered v.h.f. transmitter. As the beam width of a simple aerial may be 50° tracking is not a critical process.

The two orbits discussed for 8th June were numbers 2244 and 2245 from launch. Also shown in Fig. 2 are orbits 2256 to 2258 on the following day. Orbit 2256 occurs 12 × 115 minutes after orbit 2244 and so on.

To generalize, this satellite will always move from south to north and be to the east of the observer between 12.00 and 14.00 each day and to the west between 14.00 and 16.00. Each day the transit will be about 1 hour (earlier or later) different from the day before. Assuming that one knows the time of crossing a given latitude, the track can be seen or interpolated on Fig. 2.

Everything said about the orbits applies to local time throughout the world. Furthermore the 80° inclination of the orbit (to the equator) is chosen because this results in a precession of the orbit of 1° per day; that is 360° or one revolution each year like the sun. So the times given apply to solar time throughout the year.

Pictures of the ground below the satellite are sent every few minutes by a slow-scan television system known as automatic picture transmission (a.p.t.). Each picture takes about three minutes to send at four lines per second. There is a short interval between pictures during which NOAH 1 sends infra-red pictures as it does also during the night. The pictures taken during orbits 2244 and 2245 are shown in Fig. 3. Each picture overlaps with its neighbours as can be seen on close inspection. As the camera is looking at a spherical earth and as the orbits converge towards the poles, the overlaps are not exact. By sticking the photographs together carefully, a best fit can be obtained as shown in Fig. 4. Europe from the Mediterranean to Scandinavia is clearly visible. Countries are often shown by cloud cover or snow on the mountains, but if the sky is clear coastlines can also be seen at lower contrast.

These pictures were taken with the very simple apparatus described in this article and are not of good quality due to receiver noise and low definition presentation. However, they might be good enough for an amateur weather forecaster. The block diagram is shown in Fig. 5. Working from left to right, the aerial is a home-made six-element Yagi for 137MHz, which is light enough to be held in the hand. A proper aerial for satellite tracking would be either a helical or a crossed Yagi to accept a rotating plane of polarization. However, a practised tracker using the portable aerial can rotate the aerial about its long axis at about a quarter of a revolution per minute to keep the signal strength meter reading maximum.

Aerial and receiver

I described a very simple aerial for satellite signal reception in the February 1971 issue of *The Short Wave Magazine*, essential details of which are reproduced in Fig. 6. Readers who require a full constructional description should refer to the original article.

The receiver is a cheap domestic f.m. tuner, type TCC A1005, which has to be modified to cover 137MHz. The receiver may be obtained from G. W. Smith Ltd for a little under £7. The modification consists of removing one turn from the r.f. and oscillator coils and removing 25% of the turns on the r.f. choke as shown in the

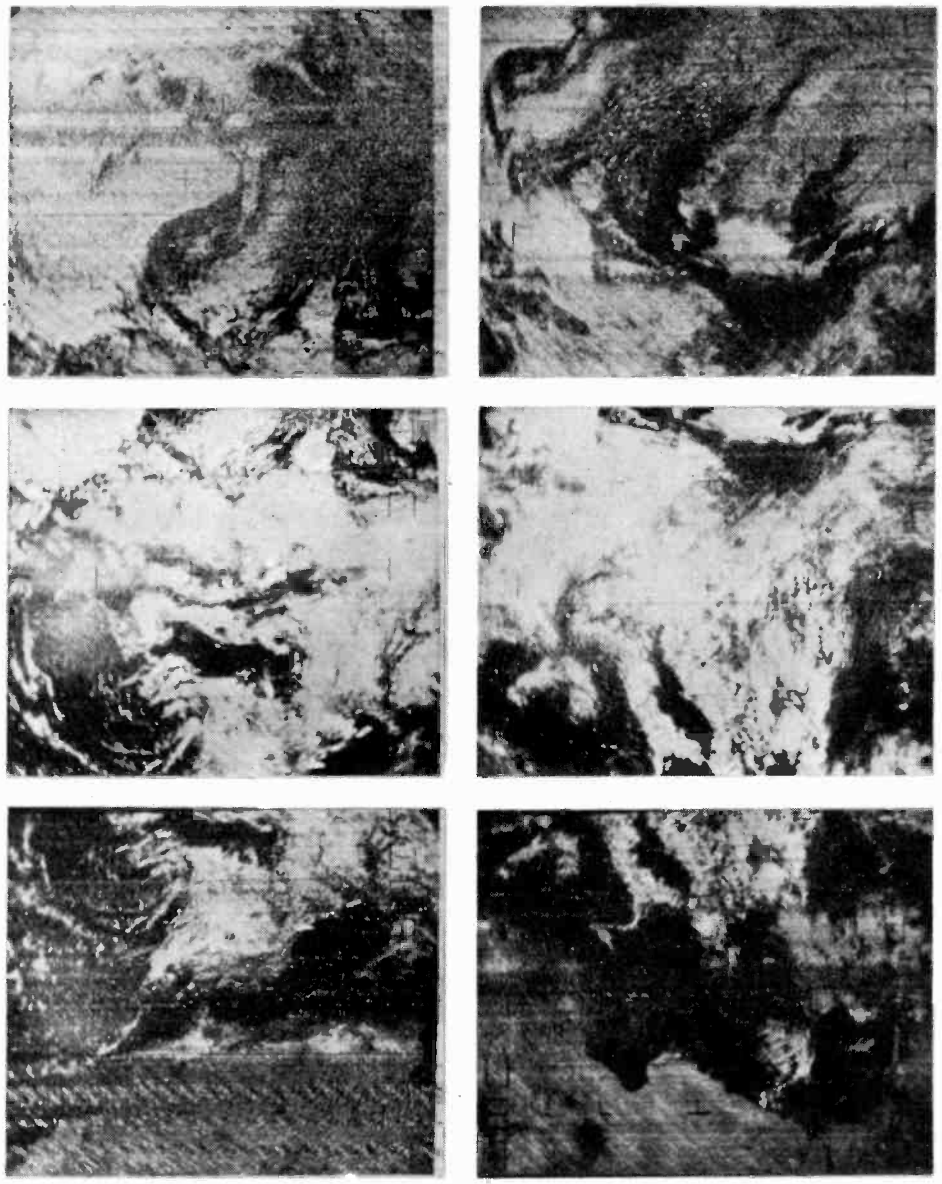


Fig. 3. Pictures taken, using the simple equipment described, during the orbits 2244 and 2245 tabulated in Table 1 and plotted in Fig. 2. They show, bottom right, the Nile delta and Italy; top right, Scandinavia and the Baltic; bottom left, Spain, Gibraltar and North Africa; and a practised eye could spot Scotland emerging from the cloud over the U.K. in the top left picture

TABLE 1. Satellite Predictions

time	azimuth	elevation	lat. N	long. E	height	range
Orbit No. 2244 date 8-6-71					km	
13.15.1	125	12.3	33.73	23.99	1,472	3,419
13.17.1	118.3	21.7	39.77	21.47	1,476	2,800
13.19.1	106.3	33.4	45.76	18.58	1,480	2,271
13.21.1	82.4	45.4	51.68	15.12	1,484	1,921
13.23.1	43.4	48.3	57.49	10.78	1,488	1,858
13.25.1	12.6	38.5	63.13	5.02	1,491	2,108
13.27.1	357	26.2	68.47	356.81	1,493	2,579
13.29.1	348.8	16	73.25	344.18	1,495	3,171
Orbit No. 2245 date 8-6-71						
15. 8	183.8	14.4	27.65	357.5	1,467	3,265
15.10	190.8	24.5	33.73	355.26	1,472	2,652
15.12	203.7	37.3	39.77	352.74	1,476	2,135
15.14	231.3	50.6	45.76	349.85	1,480	1,809
15.16	276.8	52.1	51.68	346.39	1,484	1,783
15.18	308	39.8	57.49	342.05	1,488	2,068
15.20	322.6	26.6	63.13	336.29	1,491	2,559
15.22	330.4	16.2	68.47	328.08	1,493	3,156

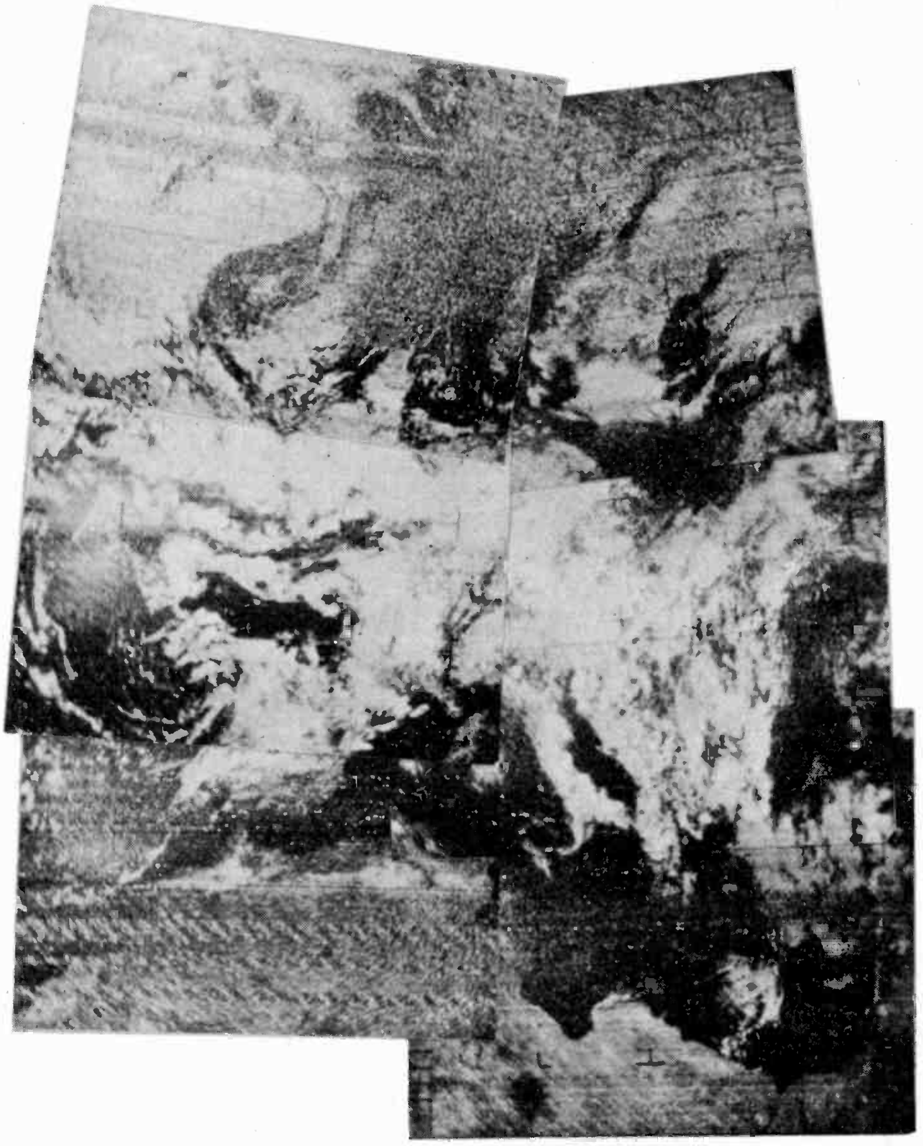


Fig. 4. *The pictures of Fig. 3 overlapped to make a best fit mosaic, showing Europe and the Middle East from Suez to Iceland.*

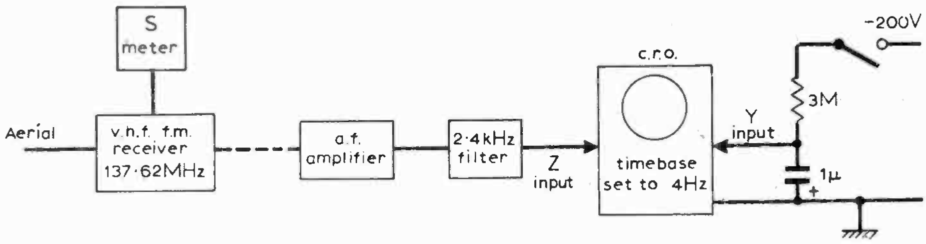


Fig. 5. *Block diagram of the apparatus used for taking the pictures given in Figs. 3 and 4. The one-shot vertical sweep circuit is shown in full.*

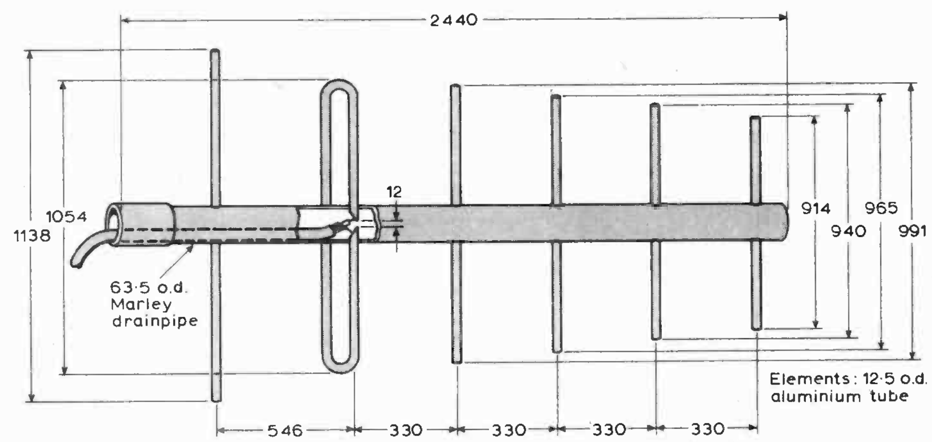


Fig. 6. *Aerial constructional details.*

circuit diagram in Fig. 7. It is useful to have some way of checking that the frequency of the tuned circuits is correct and a dip oscillator is a useful tool for this purpose. The only satellite transmitting at present, ESSA 8, operates on 137.62 MHz. It is desirable to have this point marked on the dial with some precision, possibly by using harmonics of a crystal oscillator as markers. The satellite is in range for only fifteen minutes at a time so tuning cannot be left to chance. The discriminator in addition to demodulating the f.m. signal provides a signal-dependent voltage which is connected to a signal-strength meter. An AVO Multiminor on the 2.5V range or any 10k Ω/V meter will do. It is an advantage to have a large scale instrument so that it can be easily seen by the person operating the aerial.

Oscilloscope Z modulation

As implied, the picture information is conveyed by means of frequency modulation of the carrier so that its strength is independent of the varying range and attitude of the satellite. The modulation is carried out at a fixed frequency of 2.4kHz and this sub-carrier is easily recognized on the monitor speaker as an audible note. Its intensity, but not its frequency, fluctuates as the picture information is used to amplitude modulate the sub-carrier. A typical line of this amplitude modulated 2.4kHz sub-carrier is shown in Fig. 8. To improve the signal-to-noise ratio a tuned audio filter is used following the audio amplifier as shown in Fig. 9. This audio is sufficient to modulate the spot brightness on a standard school oscilloscope (Telequipment S51E). Because the cathode of the oscilloscope is at negative e.h.t. the Z modulation is applied via an internal capacitor. As d.c. coupling is not possible, the raw audio frequency is fed to the Z input, only the positive half of each cycle brightening the spot.

Line time-base and synchronization

The internal time-base of the oscilloscope can provide a 4Hz line sweep. It is just about possible to get recognizable pictures with a free running time-base and an example is given in Fig. 10. The white edge of the picture appears at random and wanders from line to line. There is no synchronizing in the picture signal and this raises the biggest technical problem for the amateur. The solution which I have adopted is to use a 100kHz quartz oscillator followed by i.c. dividers to produce a very stable 4Hz source of trigger pulses. These are injected into the Y input of the scope at the base of a 1 μF capacitor and used to trigger the sweep as shown in Fig. 12. The inductance is in no way critical and a winding of a small a.f. transformer suffices. With the trigger control on the S51E set correctly perfect synchronization is possible.

The crystal clock consists of a 100kHz quartz crystal oscillator followed by an

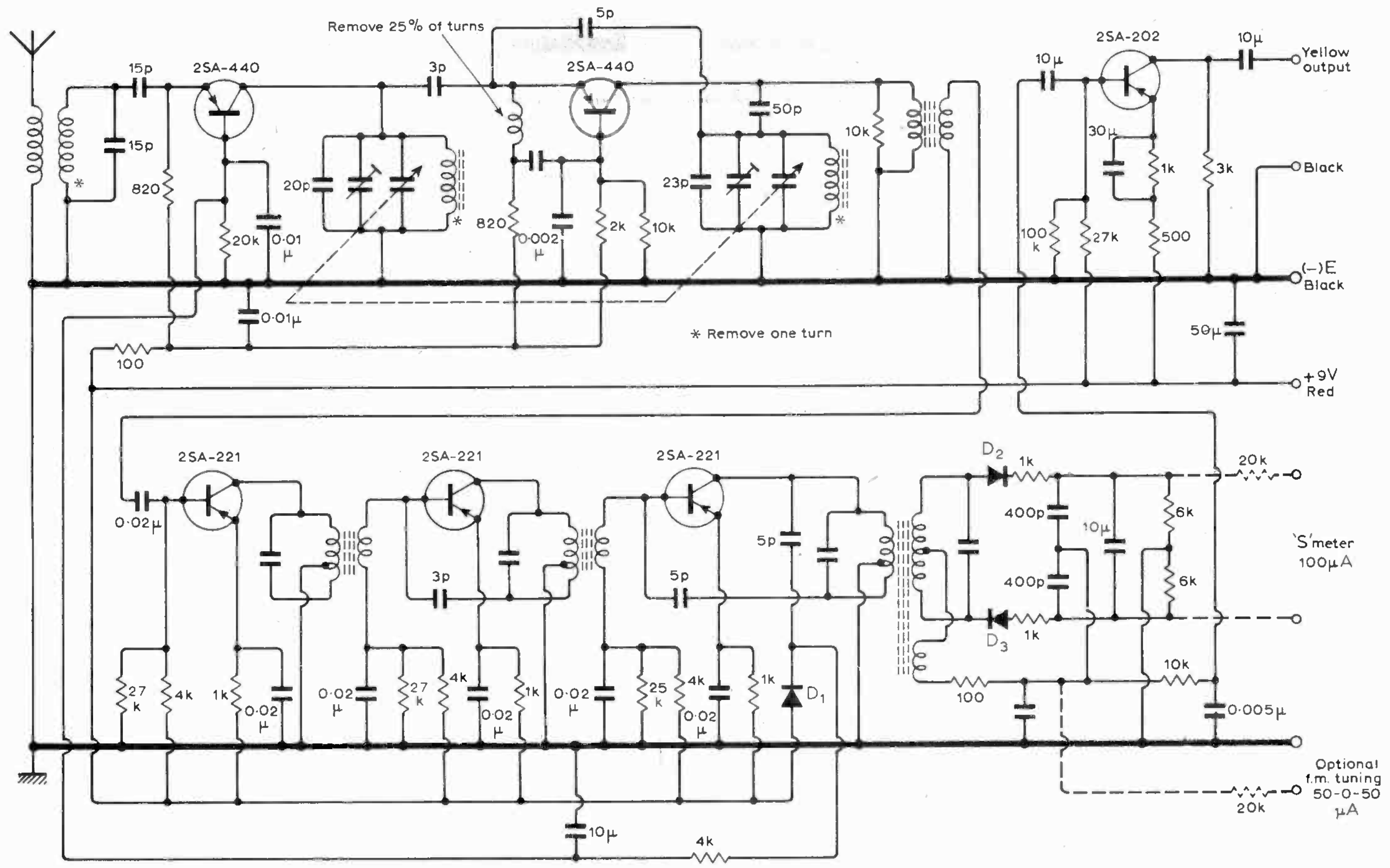


Fig. 7. The circuit diagram of the f.m. tuner showing how the S meter is connected and which coils to alter. Transistor types are given as a guide; alternative types may be fitted. Extra parts are shown dotted.

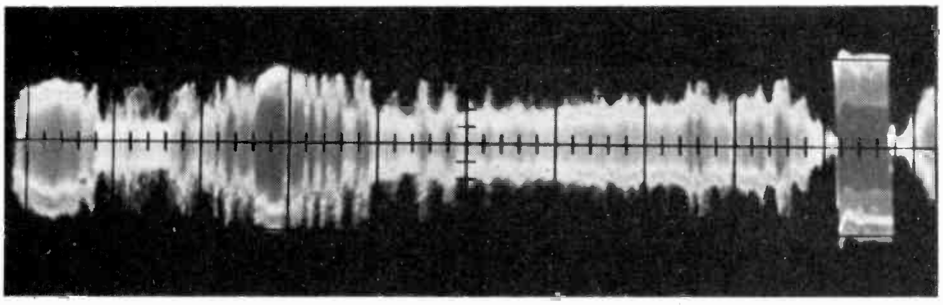


Fig. 8. An oscilloscope trace showing a typical line (250ms) of the amplitude modulation of the 2.4kHz subcarrier. The rectangular section near the end is the 12.5ms white edge of the picture.

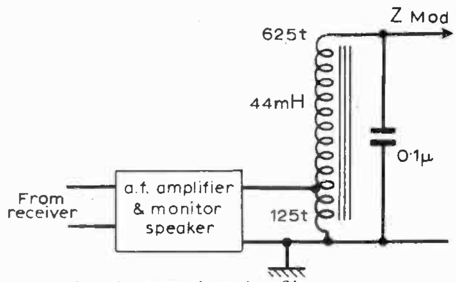
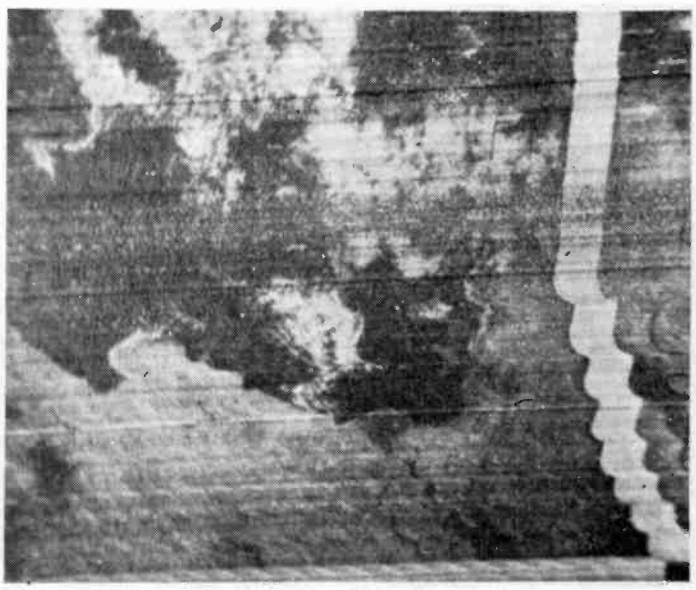


Fig. 9. The tuned audio filter is a simple device which steps up the signal voltage but, more important, gives considerable improvement in the signal-to-noise ratio.

i.c. divider chain (Fig. 11). The oscillator circuit is conventional but a high beta transistor should be selected for easy starting. The crystal frequency is adjusted by the trimmer *TC*. The simplest and completely effective calibration relies on the use of a radio with a long-wave band. This is tuned to the standard frequency 200kHz Radio Two transmitter. If the radio is placed near the crystal oscillator enough second harmonic exists to beat with the 200kHz signal. The trimmer is set to give one beat per second or better. The radio should be orientated to give a weak signal from the broadcast station. The receiver noise, as the a.g.c. operates on beats, and is helpful in making the final setting. A beat frequency of 0.2Hz is possible and the long term stability is probably better than 1 in 2 × 10^5. Once set the crystal clock needs no further attention. The second transistor is also a

Fig. 10. This shows the picture at the bottom right of Fig. 3 as it appears without synchronization and a free running time base. The white wavy line is the edge of the picture.



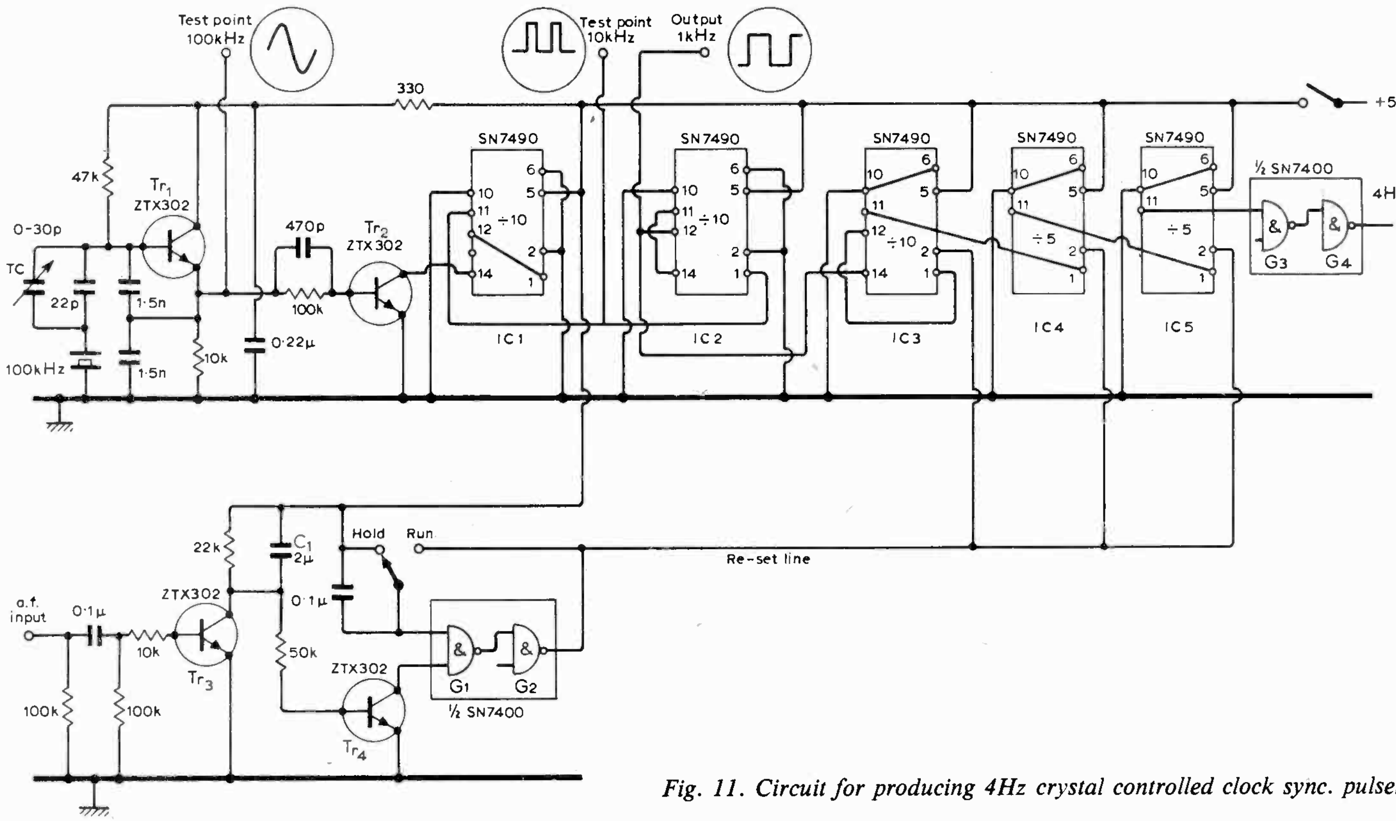


Fig. 11. Circuit for producing 4Hz crystal controlled clock sync. pulses.

high beta type to switch the i.c. decade divider without noticably loading the crystal oscillator.

The divider chain provides outputs at 10kHz and 1kHz which may be used as test points or as frequency standards in other equipment.

A gate on the reset line of the counters is operated by the sync. pulse train which is transmitted before the picture information. This resets the divider to start in time with a gap in the pulse train (the gaps occur at 4Hz). Hence the first sync. pulse occurs in the next gap and, as the clock is accurate, the synchronization of the whole picture will be correct.

The starting procedure is as follows. Just before the sync train arrives the transmitter sends a few seconds' warning burst of a 600Hz tone. This warning that the picture is about to begin is easily recognized. The operator at this time throws the reset switch up, thus taking the reset line from all three dividers to the positive line. This sets and holds all counters to zero. At the end of the tone the sync. train arrives. The operator now moves the switch to the run position. In the meantime the signal arriving has charged C_1 which holds Tr_4 off so counting does not start. On the arrival of the next gap in the carrier C_1 discharges and so switches on Tr_4. This puts the input 1 of gate 1 to ground causing the output of the gate to go positive. This causes the output of gate 2 to go down taking the reset line to zero and counting starts. The reset line also goes to input 2 of gate 1 thus holding the situation after the end of the gap and indeed indefinitely until the reset switch is next raised.

The line time-base is triggered by a negative-going pulse. This could be obtained directly from the last divider. However, these dividers show a small step down in output voltage during the 'on' stage. This does not affect the logic but could conceivably produce a false negative trigger pulse. As a safety precaution the output is taken via the two remaining gates of the SN7400; as the final gate is either on or off no ambiguous pulses can occur.

Vertical time-base.

The frame time-base is a one-shot device and consists of two components only. A switch connects a 1µF capacitor to a −200V supply via a 3MΩ resistor. The Y input to the oscilloscope is arranged to give a 1V/cm sensitivity so that 10V across the capacitor gives full vertical deflection, this takes about 200 seconds and is adjustable by varying the supply voltage or the 3M resistor. It is important to turn off the switch at the end of a sweep to avoid exceeding the working voltage of the capacitor. The circuit of the vertical time-base can be seen in both Figs. 5 and 12.

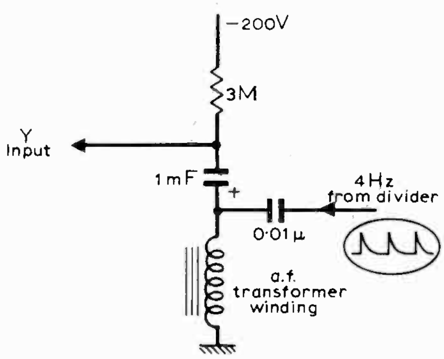


Fig. 12. The circuit used to introduce the synchronizing pulses from a quartz crystal clock into the Y input of the 'scope.

Photography

The slow scan picture can be seen on the screen of the oscilloscope and a general idea of the cloud cover in Europe could be estimated by watching the scan, line by line. Unless one has a very long-persistence screen, i.e. 3 minutes, it is necessary to integrate the picture by photography. The camera is focused on the c.r.t. with the shutter open while the picture is being made. Almost any camera will do but a supplementary lens is generally needed to focus down to 20cm. Almost any lens of about 20cm focal length will do and it can be held over the camera lens with insulating tape. The camera must be fixed in a rigid mount in front of the screen with the stop wide open, say f2.8, and the shutter on bulb. It is more convenient to black out the room than to exclude light from the camera and 'scope. One can have very subdued lighting while making the picture and so do the switching etc. and also see what is going onto the film. The camera used by the writer is a Kodak Retina employing Tri-X film.

An idea of the layout can be obtained from the photograph, Fig. 13. The camera faces the c.r.t. screen, the supplementary lens being held in a piece of wood just visible in front of the camera. Behind is the h.t. unit which supplies −200V d.c. adjustable, while in the foreground is the tuned filter passing the picture signal to the Z modulation on the 'scope.

One operator outside tracks the aerial

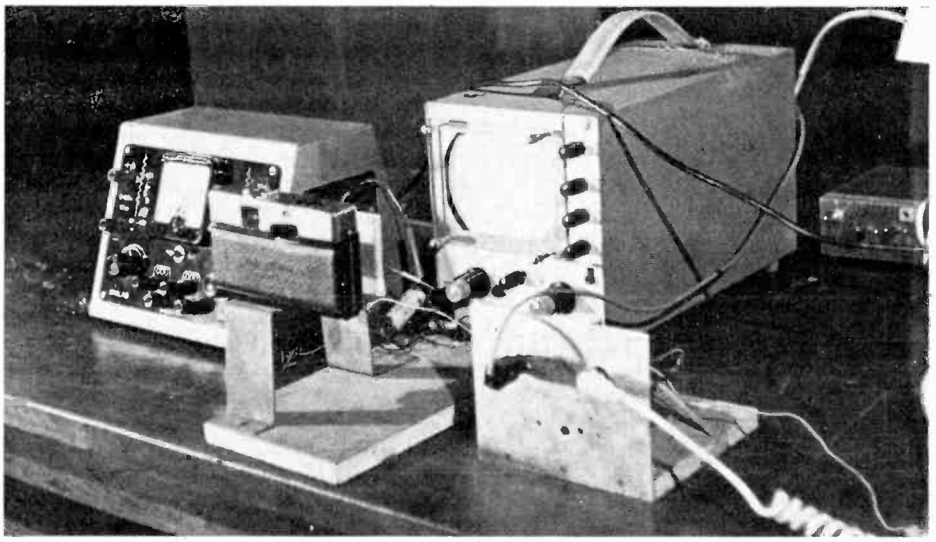


Fig. 13. The picture making end of the apparatus set up ready for use. The camera facing the screen is in the centre of the picture. To the right is the audio filter and to the left the 200V supply. The capacitor and resistor of the vertical sweep are attached to the Y input of the 'scope.

watching the S meter and monitoring the audio signal on a loudspeaker. The first audio amplifier and loudspeaker is seen near the feet of the operator in Fig. 14. Indoors, in a darkened room, the audio signal arrives via a screened cable, is amplified and fed to the 2.4-kHz filter and the 'scope Z input. The brightness control is set so that the sweep is just visible with no Z input. The modulation brings up the brightness to a value which will make an image on the film. The vertical deflection control is used to set the sweep at the top of the screen with the capacitor discharged.

A 3-second burst of a 600-Hz tone warns the operators that a picture sequence is about to start. The aerial operator concentrates on keeping the signal steady. The indoor operator switches on the vertical sweep and opens the camera shutter. At the same time phasing of the line sync. dividers is carried out as previously described. As soon as the picture finishes the shutter is closed and the vertical time-base switched off. The film is wound on ready for the next picture and the capacitor discharged through a 1kΩ resistor to bring the sweep back to the top of the screen. After the transit the film is cut off the cassette in a photographic darkroom and loaded into a tank, developed and printed in the usual way. A Polaroid camera can be used to give instant pictures.

My thanks are due to Dereck Slater, of Kettering Grammar School, for the original suggestion to use an S51E, to Geoffrey Perry of the same establishment for information on earlier satellites, to the Radio and Space Research Station at Slough for current prediction and the Met Office Tracking Station Operator for up-to-date information on new satellites and dead ones. My thanks also to the National Aeronautics and Space Administration of America, that mammoth organization capable of putting such sophisticated machinery into orbit, who are still able and willing to send me information directly.

ESSA-8, the only satellite transmitting at present transmits on 137.62MHz and transits north to south in the mornings. We pass through the plane of the orbit around 11.00 hours. It operates in daylight only and sends a continuous note between pictures. Next month a more advanced station will be described.

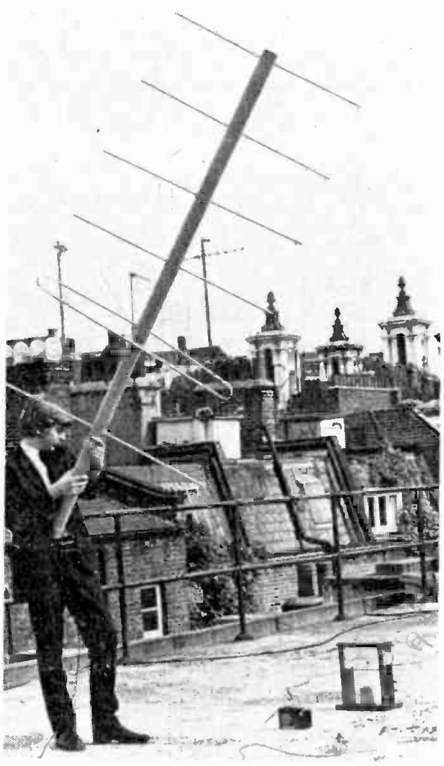


Fig. 14. The aerial and S meter. The coaxial cable leads to the aluminium box containing the receiver. The black box contains the first audio amplifier and monitor speaker.

Conferences and Exhibitions

LONDON

Oct. 12-15 — R.H.S. New Hall
Engineering Inspection & Control Exhibition & Conference
(Business Conferences & Exhibitions, Mercury House, Waterloo Rd., London S.E.1)

Oct. 25-28 — Olympia
Research & Development Exhibition & Conference
(R. W. Boardman (Exhibitions), 8 Leicester St., London WC2H 7BN)

Oct. 25-30 — Olympia
Audio Fair
(International Audio Festival & Fair, Dorset House, Stamford St., London S.E.1)

BRIGHTON

Oct. 19-21 — Hotel Metropole
Inter/Nepcon
(P. G. Saville, 21 Victoria Rd, Surbiton, Surrey)

BRISTOL

Oct. 12-14 — New Bristol Centre
Electronic Instruments Exhibition
(Industrial Exhibitions, 9 Argyll St., London W1V 2HA)

MANCHESTER

Oct. 5-8 — City Hall
MELEX—Manchester Electronics Exhibition
(Industrial Exhibitions, 9 Argyll St., London W1V 2HA)

NEWCASTLE

Oct. 5-7 — Exhibition Centre
Engineering Exhibition
(Engineering Industries Assoc., 15 Walker Tce., Prince Consort Rd., Gateshead-on-Tyne 8)

OVERSEAS

Oct. 4-6 — Toronto
Electrical & Electronics Conference
(Conference Office, 1819 Yonge St, Toronto 7, Ontario)

Oct. 6-8 — Washington
Electronic & Aerospace Systems
(M. B. Thorpe, Bell Aerospace, 1000 Connecticut Ave., Washington, D.C. 20036)

Oct. 6-9 — Mexico City
Seminar on Telecommunications
(J. Alberty, Siemens Mexicana, S.A., Poniente 116, 590, Col Industrial Vallejo, Mexico 16)

Oct. 7 & 8 — Montreal
Video Cartridge, Cassette & Disc Player Systems
(S.M.P.T.E., 9 East 41st St, New York, N.Y. 10017)

Oct. 11-13 — Washington
Electron Devices
(I.E.E.E., 345 East 47th St, New York, N.Y. 10017)

Oct. 11-13 — Chicago
One World of Microelectronics
(International Society for Hybrid Microelectronics, Suite 102, 1410 Higgins Rd, Park Ridge, Illinois 60068)

Oct. 12-17 — Ljubljana
Modern Electronics Exhibition
(Gospodarsko Razstavisce, Ljubljana, Titova 50, Yugoslavia)

Oct. 14-20 — Düsseldorf
Interkama
(Düsseldorfer Messegesellschaft mbH—Nowea—4 Düsseldorf 10, Postfach 10203)

Oct. 15-24 — Prague
Audio, Video & Radio Exhibition
(AVRO Praha '71, 10 Rimska, Praha 2)

Oct. 18 & 19 — Chicago
Consumer Electronics Symposium
(W. Luplow, Zenith Radio Corp., 1851 Arthur Ave., Elke Grove Village, Ill. 60007)

Oct. 18-20 — Chicago
Fall Electronics Conference
(I.E.E.E., 345 East 47th St, New York, N.Y. 10017)

Oct. 18-20 — Lausanne
Eurocon 71—I.E.E.E. Convention
(Eurocon 71, 24 Chemin de Bellerive, CH-1007 Lausanne)

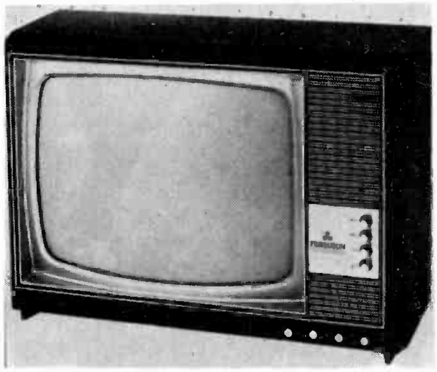
Television Receiver Review

Circuit developments in new sets

If one had to sum up the trend in television receivers since our last report (October 1970) one might reasonably say that it has been the year of the *smaller* set. Not small set, for these have been with us for a long time—the use of transistors and integrated circuits having made it possible to design neat mains/battery portable monochrome sets with screen sizes from 10in (Sanyo) down to 3in (Standard). It would seem that British and European tube and receiver manufacturers have decided that the 26in screen is about as large as they can go with the present technology, and are now concerned with fostering an apparent demand for lower-priced receivers with smaller screens. (This demand may well have been started by the influx of the Japanese portables.) The 'smaller set' category might well be identified by a range of screen sizes of 17in (monochrome and colour), 15in (colour), 13in (monochrome only). Most of these receivers are described by their makers as 'portable', but some people might consider this applicable only to the smallest sets, which can be powered from batteries as well as from the mains.

Meanwhile existing designs of large (20in-26in) hybrid receivers have been continuing in production because they have been found successful both in price competitiveness and reliability. G.E.C., ITT-KB, Philips, Pye Group and Rank-Bush-Murphy are among the major groups which have reported 'no change'. A newcomer to Britain with hybrid receivers is Grundig, a firm which claims to be Germany's largest television set manufacturer. They have introduced three monochrome receivers and one 26in colour set, which uses integrated circuits for sound i.f. colour decoding and tuner stabilization.

Technically the most interesting of the smaller sets is the Sony 13-in colour receiver type KV-1320UB. This has a new type of tri-colour tube called the Trinitron which, as we reported in our March 1971 issue, p.108, uses, instead of a shadow-mask and phosphor-dot pattern, a metal plate with vertical slits and vertical phosphor stripes. The three electron beams emerge from a single electron gun in a 'horizontal-in-line' formation, as distinct from the triangular formation of a shadow-mask tube. Apart from this the receiver has a type of colour decoder which operates on



Example of this year's new sets—a Ferguson 17-inch colour receiver using the B.R.C. type 8000 chassis mentioned in the text.

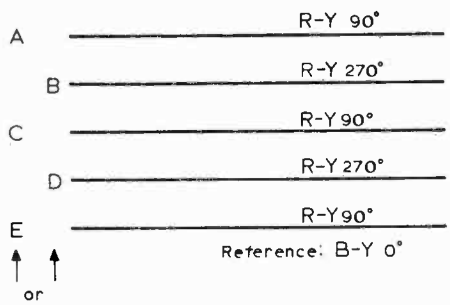


Fig.1. Successive lines of a television field, showing the phase of the R – Y colour information alternating between 90° and 270°.

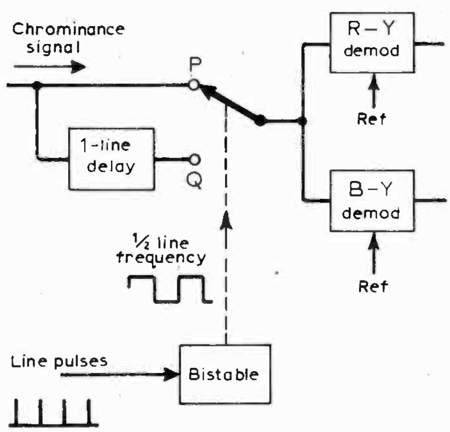


Fig.2. Basic principle of decoder used in Sony 13-inch colour receiver.

a different principle from that of a conventional PAL receiver and therefore, according to the manufacturers, does not infringe the AEG-Telefunken patents on PAL. (Sony do not have a licence from AEG-Telefunken to make PAL receivers.)

What in fact this decoder does is to convert the PAL chrominance signal available at the detector into an N.T.S.C. type of chrominance signal—that is, one without phase alternation line by line by the R–Y component. Thus the receiver does not make use of the essential feature which distinguishes the PAL system from N.T.S.C.—the cancellation of phase (and hence hue) errors introduced in the transmission path.

The phase reversal of the R – Y component on alternate lines of the transmitted signal is cancelled by the simple expedient of omitting the colour information in every other line of each field. Thus in Fig.1, if the R – Y information in lines A, C, E, etc., is omitted, the R – Y information in lines B, D, etc., is retained and always has the same phase angle (270°) with respect to the B – Y phase reference (0°). Alternatively, if the R – Y information in lines B, D, etc, is omitted, that in A, C, E, etc, is retained and again always has the same phase angle (90°) with respect to the reference. This process is achieved electronically by the system shown in Fig.2. An electronic switch is operated by a bistable circuit giving a square wave at half the line scanning frequency. Thus if the switch is in position P at the beginning of line A (Fig.1) the chrominance signal is passed directly to the R – Y and B – Y demodulators throughout line A. At the end of line A the bistable moves the switch to position Q, but the chrominance information transmitted during line B does not reach the demodulators because it is held back by the 64μs (one line period) delay unit. Instead, while the switch is at Q, the demodulators receive a delayed version of line A chrominance information. Before the line B chrominance information starts to emerge from the delay unit the electronic switch has moved back to position P where it remains for the duration of line C . . . and so on. In practice it does not matter which position the switch starts from when the set is turned on, the R – Y chrominance information will always have the same phase (permanently 90° or permanently 270°). The phase of the B–Y component is not changed in the PAL transmitted signal, so this fixed phase information is passed to the demodulators in both positions, P and Q, of the electronic switch; but, as with the R–Y component, the demodulators receive the B–Y component directly when the switch is at P and then a delayed version of it when the switch is at Q. Thus the demodulators receive the chrominance information as transmitted only during alternate lines (e.g. lines A, C, E, etc.) and during the 'between' lines (e.g. lines B, D) they receive repeated versions of that information.

R–Y and B–Y demodulation is achieved in the normal way by synchronous detectors using local reference oscillators in phase quadrature operating at the colour subcarrier frequency. The phases of these reference oscillations are controlled by the colour sync bursts in the transmitted signal, and these swing $\pm 45°$ in phase (with respect to the B–Y phase reference, 0°, plus 180°), in synchronism with the R–Y component phase reversals. The controlling burst is used in the normal way for the B–Y reference oscillator, but because of the signal switching system described above the burst phase must be reversed for the R–Y reference oscillator on one line out of two to obtain the 90° shift in the mean burst phase. This is achieved by a further electronic switch, operated by the bistable, which switches in a phase inverter when the Fig.2 switch is at position P.

A simplified version of the actual circuitry is shown in Fig.3. It will be seen that the electronic switch in Fig. 2 is formed by two diodes which are turned on and off by positive and negative d.c. voltages from the bistable (the points equivalent to the switch terminals are shown at P and Q). The 220pF capacitors are simply to isolate the d.c. operating voltages from the previous signal paths. A similar two-diode circuit is used for switching the phase of the burst. As can be seen the 'phase inverter' referred to in the previous paragraph is obtained by means of a centre-tapped transformer, the two signal voltages between the c.t. and the secondary terminals being always 180° out of phase.

It would seem that the use of the non-PAL decoder has two main disadvantages. First, because of the omission principle of Fig.1, half of the transmitted chrominance information in the vertical direction is not displayed. (However, there is also a loss of vertical chrominance information in a standard PAL delay line decoder, because the colour information from any two adjacent lines is averaged by the action of the delay line.) Secondly, because the PAL signal is converted into an N.T.S.C. type of signal, hue errors introduced by phase shifts in the transmission path are not automatically cancelled (and in fact the Sony receiver is provided with a manual hue control for this very reason). On a 13-in screen the first disadvantage does not show up to any extent, but it will be interesting to see what is the picture quality of a forthcoming receiver using an 18-in Trinitron tube.

Another new colour receiver is the British Radio Corporation's type 8000 chassis, which has a 17-in (shadow-mask) colour tube. This set is interesting in a number of respects. First the price is below £200 (in fact £189.75); secondly it has an all solid-state circuit; thirdly the designers have dispensed with the e.h.t. voltage tripler used in most colour sets and reverted to an overwind on the line scanning transformer and single rectifier to provide the 21kV e.h.t. for the colour tube; fourthly the detector is a synchronous type instead of the usual envelope detector, and finally the power supply uses a thyristor voltage stabilizer.

The makers have abandoned the e.h.t. tripler mainly on grounds of cost, thereby helping to keep the price of the set down. Although in the past overwinds for 20kV or more have been found prone to breakdown through shorting of turns, sometimes starting fires, the designers of the receiver state that they have achieved better relia-

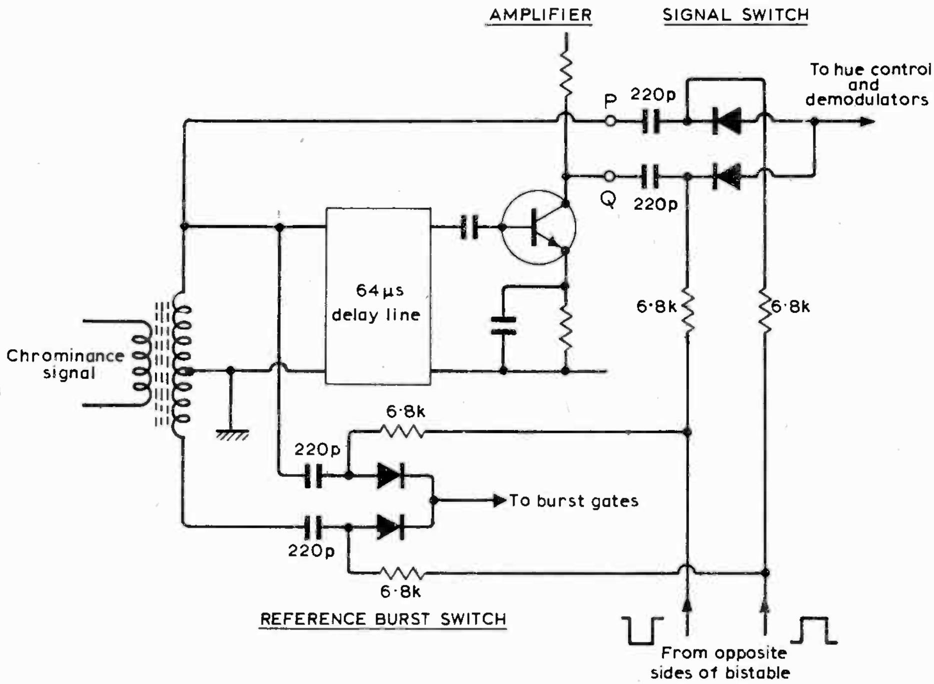


Fig.3. Simplified circuitry of the Sony colour decoder shown in Fig.2. The points P and Q correspond to the "switch contacts" P and Q in Fig.2.

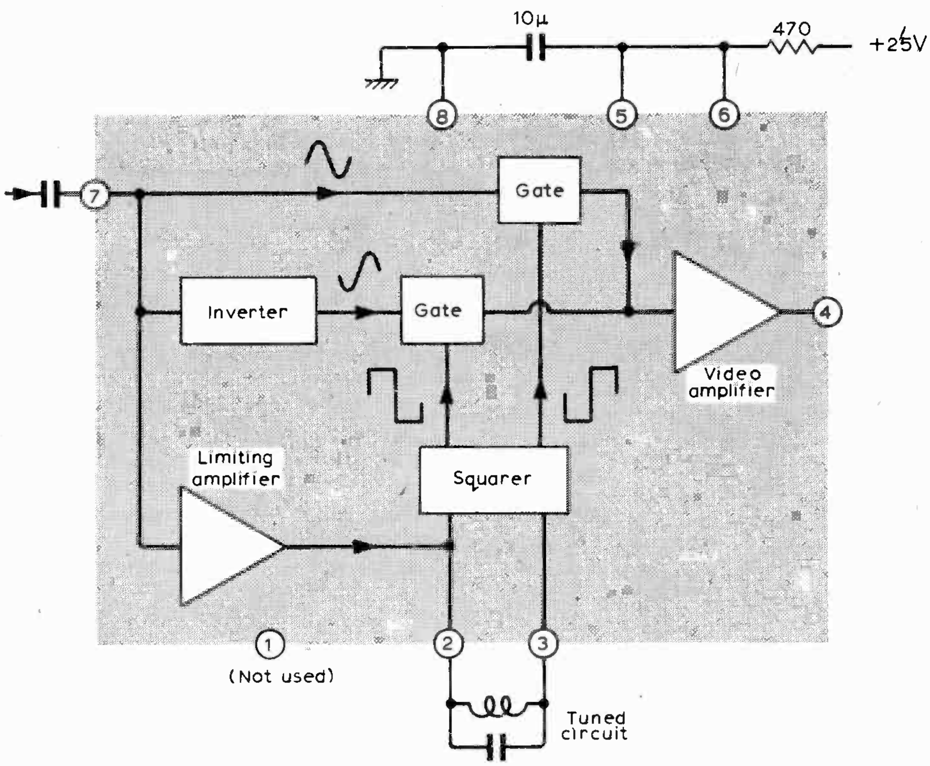


Fig.4. Functions and terminals of integrated circuit synchronous detector used in B.R.C. 17-inch colour receiver and Decca 12-inch monochrome set (Motorola MC1330P)

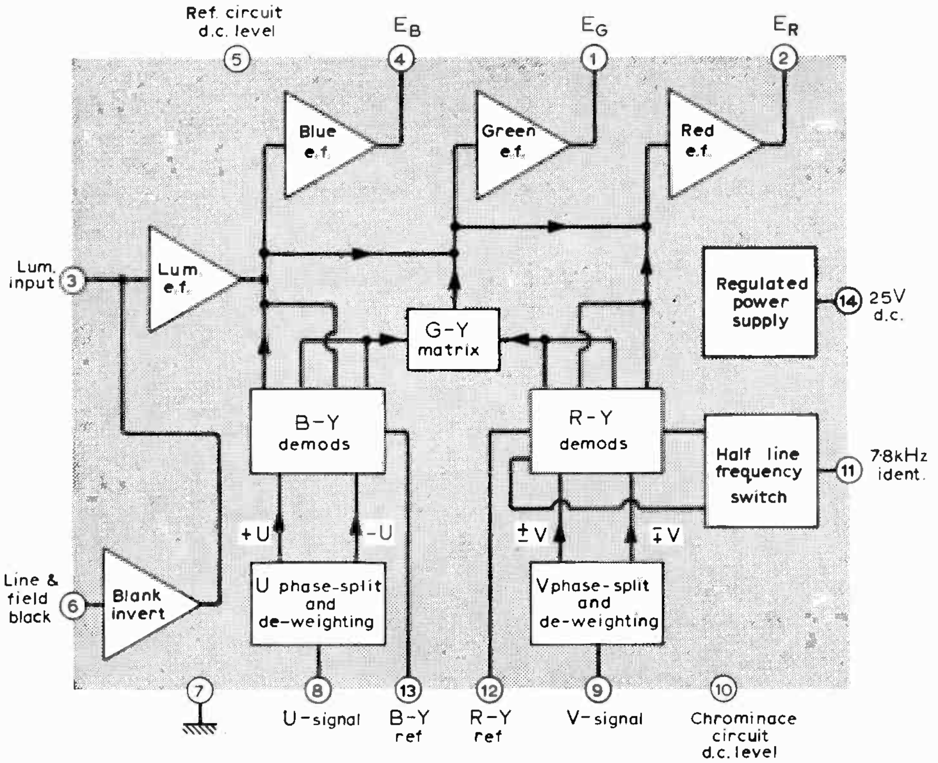


Fig.5. Functions and terminals of chrominance decoding integrated circuit (Motorola MC1327) used in B.R.C. and Decca 17-inch colour receivers.

bility by a winding technique involving impregnation with silicone rubber insulation. Decca, in their latest 17-inch colour receiver, the CS1730, have decided on an intermediate arrangement, by using a 10kV overwind and a voltage doubler. This doubler has selenium rectifiers and is housed near the bottom of the chassis to keep it cool.

A synchronous detector, operating at the low signal voltage of 50mV, is used in the B.R.C. set, and in a Decca monochrome receiver to be described later, because of its inherently high linearity in comparison with the simple diode envelope detector. The advantages of this high linearity include less need for sound trapping, less critical tuning and more stable i.f. performance at high receiver sensitivities,

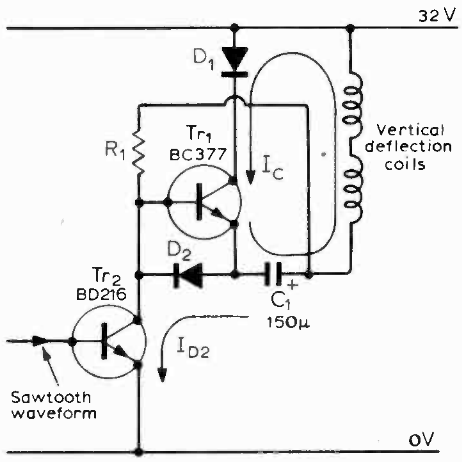


Fig.6. Simplified vertical deflection circuit of Decca 12-inch monochrome set.

as the i.f. and video gain partitioning can be re-apportioned to reduce the need for high gain at i.f. The synchronous detector is certainly more complicated, but it is available in integrated circuit form and so is not unduly expensive or difficult for the set maker to use. Fig. 4 shows the internal functions of the Motorola MC1330P used by B.R.C. and Decca. To provide the fixed local oscillation required for synchronous detection the incoming i.f. signal is passed through a limiting amplifier, removing the modulation, to an external tuned circuit (connected to terminals 2 and 3) which is tuned to the carrier frequency 39.5MHz. The resulting oscillation is applied to a squaring circuit which produces the square waves needed for opening and closing the gates. With the arrangement shown, two gates with an inverter in one signal path, the input signal is chopped at 39.5MHz and one half cycle is inverted. The result is a train of uni-directional, half-sinewave pulses proportional in amplitude to the carrier level and hence to the modulation. This is passed through a video amplifier within the i.c. and the result is an output (at terminal 4) with a d.c. component of about 7V and a video signal component of up to 4V peak-to-peak.

In the B.R.C. receiver the line timebase works at the high supply voltage (for transistor circuits) of 180V, and this allows a fairly simple regulated power supply to be used. In this a thyristor acting as a triggered switch is inserted between one mains input terminal and the 180V terminal to be voltage regulated. The time during the positive half cycle of the mains supply, when the thyristor is triggered is varied in accordance with the load on the regulated supply, so that the energy removed by the load is balanced by the energy restored to the reservoir capacitor during the period of thyristor conduction. The time of triggering is determined by the rate of rise of ramp voltage across a capacitor, this rate being made a function of the output voltage of the supply.

In both this set and Decca's 17-inch colour receiver the chrominance decoding circuitry is greatly simplified by the use of an integrated circuit. This is the Motorola MC1327, and the functions it performs are shown in Fig.5. It accepts luminance and chrominance signals, the 4.43MHz reference oscillations for demodulation, the 7.8kHz identification signal and line and field blanking pulses. The chrominance signals are demodulated and matrixed so that the i.c. produces R, G and B signals.

Another new solid-state receiver is a 12-inch mains/battery monochrome set just introduced by Decca, the type MS1210. This receiver uses four integrated circuits: the MC1352 giving i.f. amplification and a.g.c., the MC1330 synchronous detection and video amplification, the TBA750 intercarrier sound detection and a.f. pre-amplification, and the TAA611B audio power amplification. The last two devices, in fact, provide the whole of the sound channel—no discrete active devices being used. The TBA750 intercarrier sound i.f. receives its input signal from the MC1330 vision detector via a ceramic filter. An interesting point about the power supplies is that a 120V rail required for the vision amplifier is obtained from a winding on the line output transformer.

An unusual circuit in the scanning section is the vertical deflection output stage. This is similar to a class B complementary symmetry output stage but does not in fact use a p-n-p power transistor, which would be unduly expensive to perform the functions required of it. Instead the output stage uses two ATES n-p-n transistors as shown in Fig.6, the lower one of which, the BD216, although it has a high breakdown voltage, is a low cost device. The two phases of the class B type of operation are: 1st phase, Tr_1 producing one half of the output waveform with Tr_2 acting as its driver; 2nd phase, Tr_2 alone producing the other half of the output waveform. The positive going ramp of the sawtooth waveform applied to the base of Tr_2 in both the phases produces an increasing collector current via R_1. This in turn causes the base current of Tr_1 to fall,

$$I_b\,(Tr_1) = I_{R1} - I_c\,(Tr_2),$$

and hence the collector of Tr_1 falls, going from a maximum to a minimum. The path of I_c is as shown by the loop. Eventually a point is reached when V_{be} of Tr_1 goes negative, no further base current flows in Tr_1 and D_2 is now forward biased. This is the end of phase 1 and the start of phase 2 in which Tr_2 acts on its own as the output transistor with R_1 as its collector load; the waveform at the collector passing through D_2, C_1 and the vertical deflection coils. The sawtooth waveform applied to the base of Tr_2 drops off rapidly at the end of the ramp, cutting off Tr_2, and as a result the back e.m.f. generated by the deflection coils appears across Tr_2.

Turntable Design for Home Construction

by R. Ockleshaw

In three articles the author describes a turntable, pickup arm and wow and flutter meter for home construction. The turntable, believed to be the first complete design for home construction and described in this issue, has a rumble level of −36dB relative to 1cm/s r.m.s. recorded velocity and peak wow and flutter of ±0.25%. Ready-turned parts are available for those without access to a lathe. Detailed drawings show how the parts are made and assembled and the article also shows how the mechanical filtering system is derived. Cost of the turntable and pickup arm is between £20 and £25. The second article will describe the construction of the pickup arm and the third will show how to check turntable performance and describes a novel wow and flutter meter using a phase-locked loop.

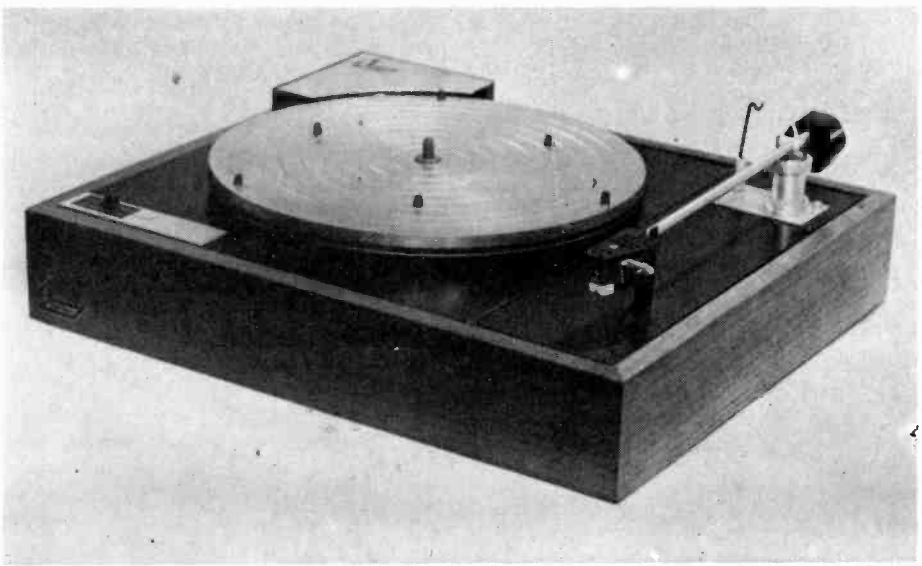
Although several designs for pickup arms have been published, I do not know of a constructional project that included a turntable. Perhaps the reason for this is obvious—it is mechanics on the grand scale, not normally suitable for the amateur with a limited range of tools.

To produce certain parts for this project within a satisfactory tolerance a lathe has to be used, but I have been careful to ensure that lathe-work can be accomplished on medium-sized or even small machines, the type most likely to be available. Provided one has the basic ability to use a lathe, gaining access should be easy. Model societies may have one—almost certainly some of the members—local schools or colleges that run evening metal-work courses might be persuaded to allow the occasional use of a lathe, or may even encourage it. Those that do may charge a nominal fee. There are only three parts for which the use of a lathe is essential. Use of a lathe for certain other parts simplifies their manufacture, but if made by other means will only affect the finish and not the performance. (Ready-made turned parts can be obtained from the address given in the parts list.)

Filtering wow and rumble is discussed towards the end of this article where it may be better appreciated in the light of practical knowledge.

Styling is functional and in keeping with modern design, and performance, in relative terms, should satisfy all but the most critical. Although the design contains most features normally desired in a 'transcription' unit it is essentially simple both in concept and in detail.

The unit features a 10-in diameter machined cast-aluminium turntable driven by a self-starting synchronous motor through a resilient rubber belt. There is a choice of two speeds using a simple manual change. The matching pickup arm is protected against vibration and acoustic pick-up by integral mechanical filters. A pickup-arm lowering device is featured. Provided instructions are followed, wow and flutter will be 0.5% pk-pk and rumble −36dB relative to a recorded velocity of 1cm/s r.m.s.



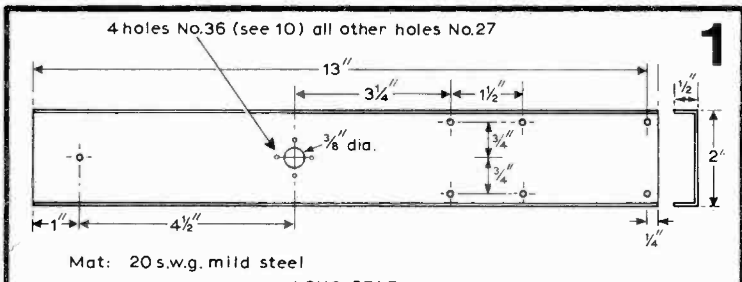
Construction

Motor board. The motor board should be to hand when assembling the plinth as it can be used as a jig to ensure that the plinth is square. Make from ½-in plywood, or blockboard, the apertures being cut by jig-saw, coping saw, etc. In following the accompanying diagrams, note that the area around the aperture for the switch body is recessed to accommodate the switch mounting plate and screws. Veneer or paint the top surface. Other ideas are matt-black Formica, or if you paint the plinth, a contrasting colour. Finish also the exposed edge adjacent to the pickup-arm board.

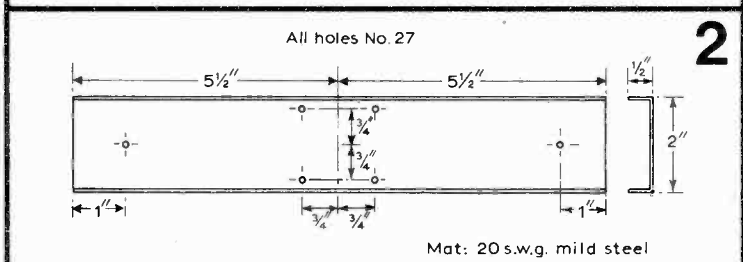
Plinth. Make the three duplicated parts in the plinth from ½-in high-density plywood to the dimensions indicated and assemble as shown together with fillets and blocks. Use a good-quality synthetic glue (Evode Resin W, Cascamite, etc.) for the joints, these being held by veneer pins (use motor board as jig) while the glue sets. Rubber feet, obtainable from hardware or do-it-yourself shops, can be screwed or glued underneath. Finish as desired.

Next, make the motor plate, adjustment plate and pickup-arm board. Although a captive nut (hank bush) is specified for the adjustment plate, in practice a shakeproof washer and nut may be a useful alternative. Evostik impact adhesive can be used to fix the motor to the motor plate.

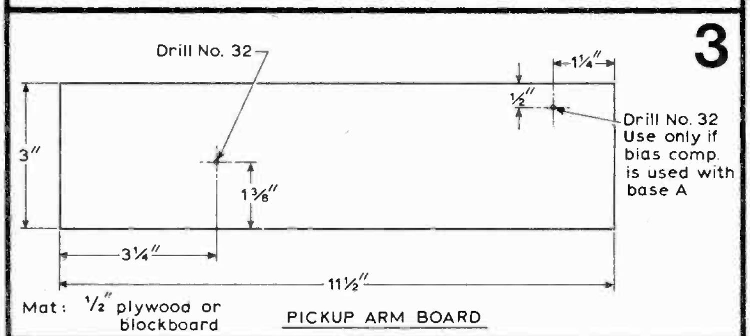
Turntable. The 3-lb turntable is a faceplate for an industrial sanding machine. It is produced by Picador Engineering Co. Ltd, a well-known firm of tool makers, and can be obtained through tool shops. It is essentially a sandcasting and may have slight casting flaws when received but these will be generally of little consequence. Complete the turntable by inserting the main bearing sleeve (see later) thrust bearing assembly (see later) and turntable mat. As a cheaper alternative to the mat, glue six rubber pips (mine came from a moulded rubber car mat) onto the turn-table—preferably into drilled recesses.



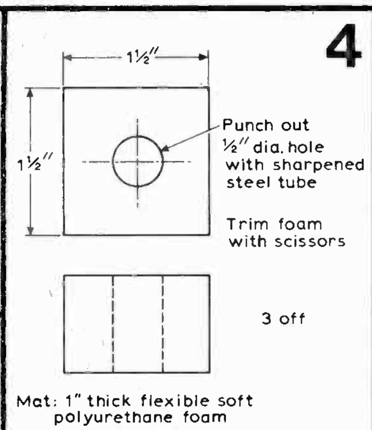
LONG SPAR



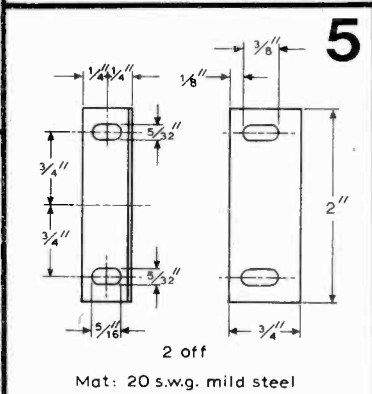
SHORT SPAR



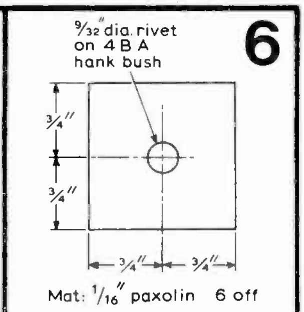
PICKUP ARM BOARD



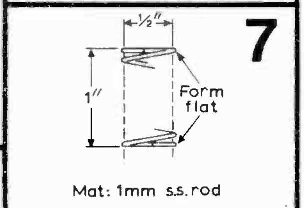
DAMPING PAD



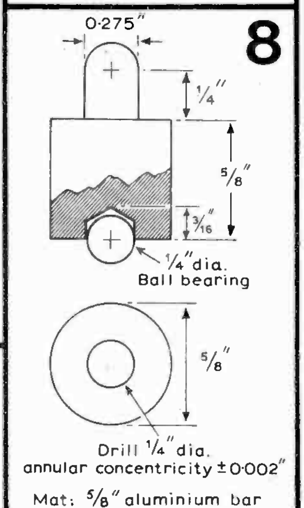
PICKUP ARM BOARD BRACKET



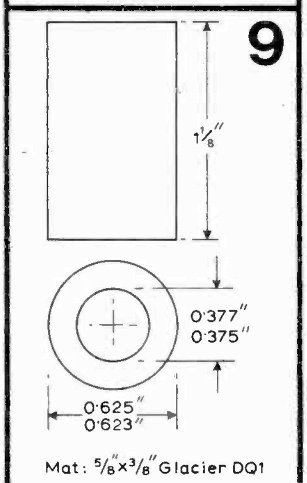
PAD CHEEK



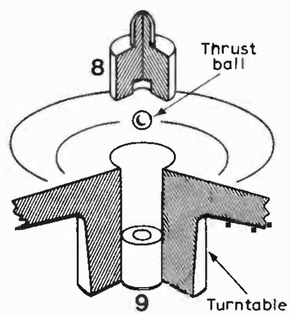
SUSPENSION SPRING



SPINDLE

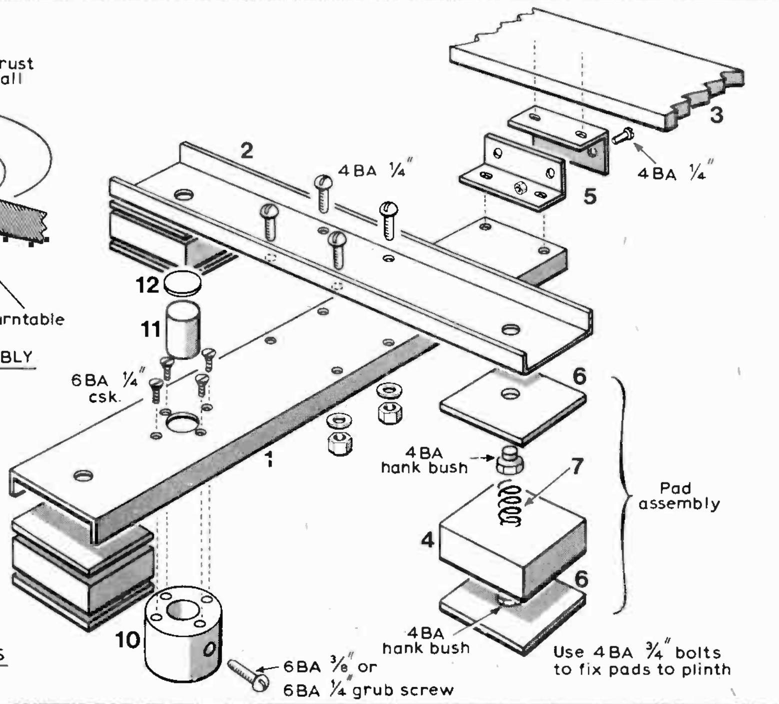


MAIN BEARING SLEEVE

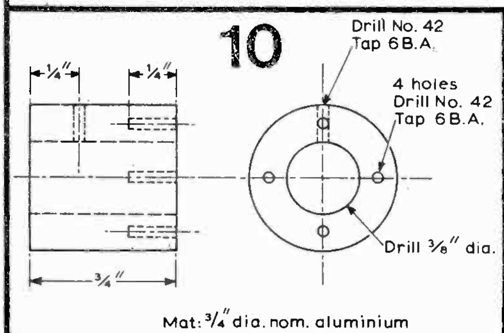


TURNTABLE ASSEMBLY

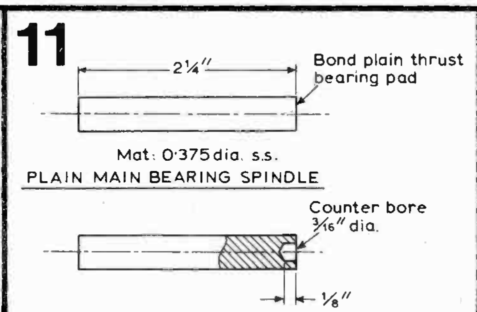
All drawings not to scale



ASSEMBLY OF INTERNAL DETAILS

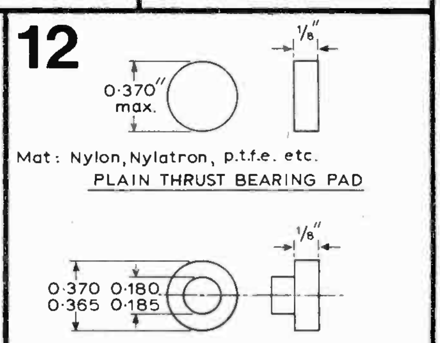


MAIN BEARING SPINDLE HOLDER



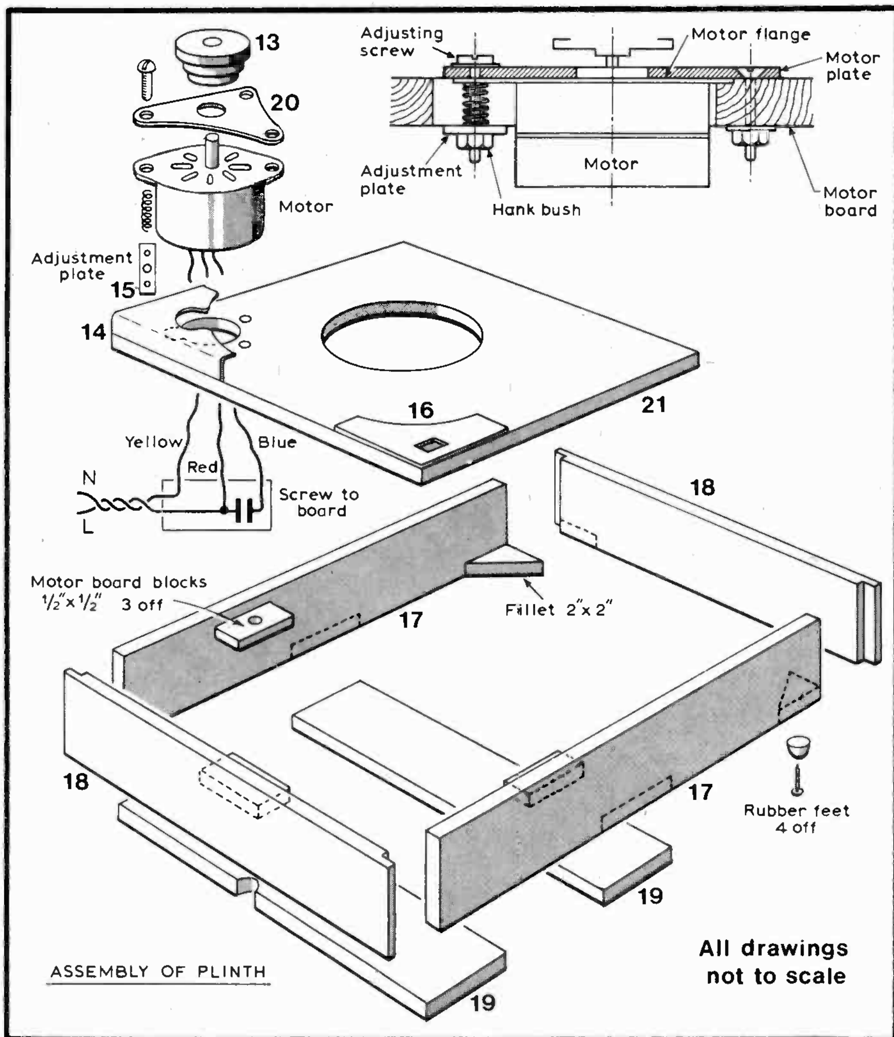
PLAIN MAIN BEARING SPINDLE

ALTERNATIVE MAIN BEARING SPINDLE FOR LUGGED THRUST BEARING PAD

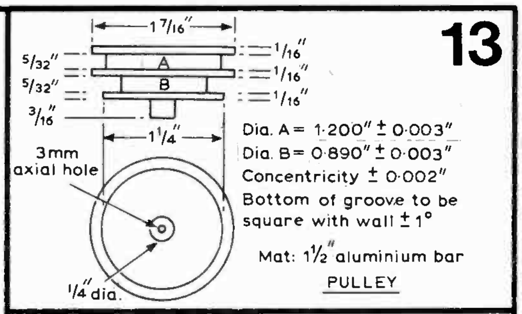


PLAIN THRUST BEARING PAD

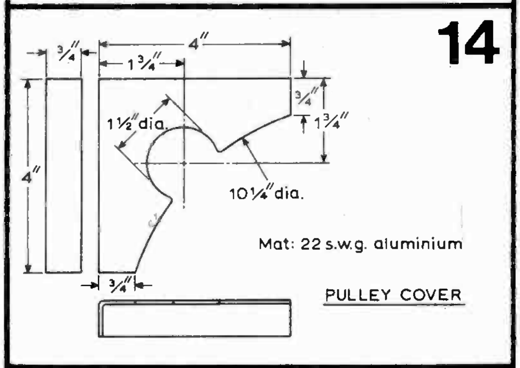
LUGGED THRUST BEARING PAD



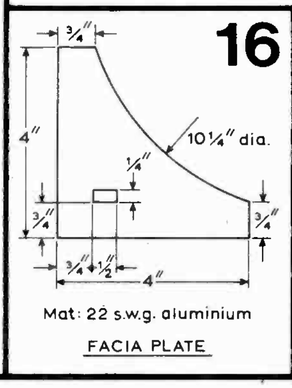
ASSEMBLY OF PLINTH



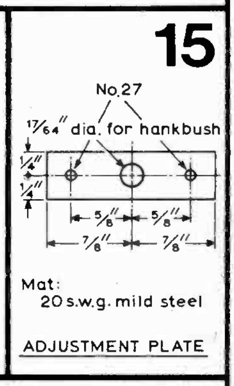
PULLEY



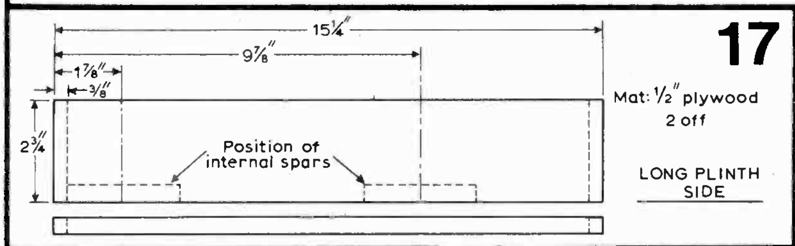
PULLEY COVER



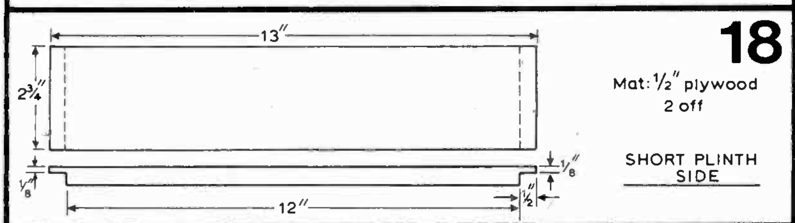
FACIA PLATE



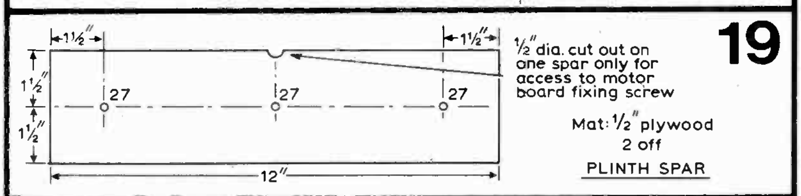
ADJUSTMENT PLATE



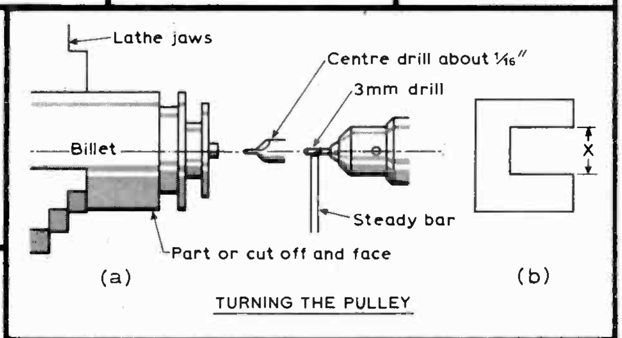
LONG PLINTH SIDE



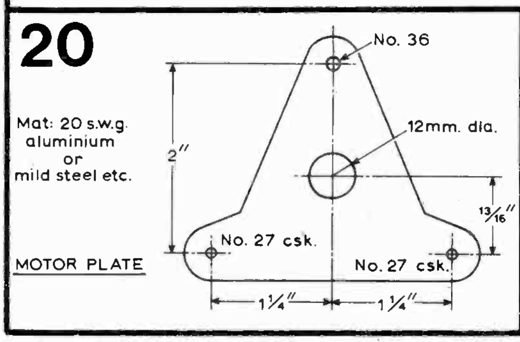
SHORT PLINTH SIDE



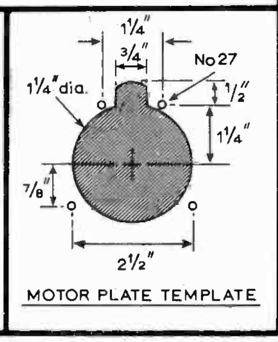
PLINTH SPAR



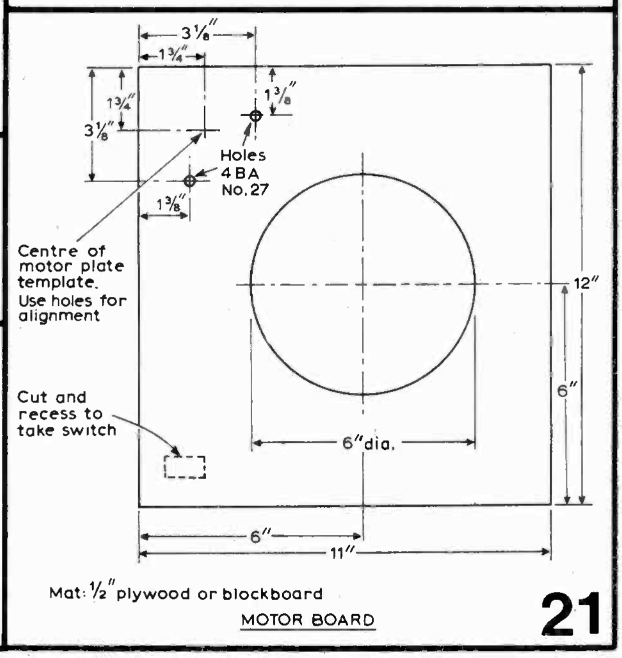
TURNING THE PULLEY



MOTOR PLATE



MOTOR PLATE TEMPLATE



MOTOR BOARD

(The inner three pips in the photograph are for 7-in discs.)

Main bearing spindle. Silver steel is supplied to a high degree of tolerance: ±0.0005-in of the nominal size. It is ground to this accuracy giving a finish considered more suitable for bearing surfaces than a turned one. After cutting to size, face the ends on a lathe. If a lathe is not available, rough file one end and grind with a rolling jig and oil stone.

Harden the spindle by heating to cherry red and then quenching in water. Polish with fine emery cloth and finally metal polish while rotating the spindle in the lathe or drill chuck. Carefully preserve the spindle surface prior to hardening as any attempt to remove blemishes by polishing may prove futile. These blemishes will cause excessive bearing wear. Round off top edges to prevent the bearing sleeve being scored when placing the turntable over it.

It is more important that the top surface of the nylon thrust-bearing pad is square than the top of the spindle. In this case bond the nylon thrust bearing pad to the top of the spindle with Araldite after hardening and grind square if necessary.

Main bearing sleeve. The main bearing sleeve is made from a p.t.f.e.-compound dry bearing material. This retains most of the desirable features of p.t.f.e. but is much easier to machine. The material is quite soft and convenient to use, if a trifle dirty, but care should be exercised to prevent bearing surfaces being damaged. This compound, in common with many plastics, has a high coefficient of linear expansion. Indeed, p.t.f.e. at 20°C exhibits a so-called phase change resulting in a sharp dimensional increase, which may be used to advantage. The bearing material is supplied as a tube with nominal $\frac{3}{8}$-in inside and $\frac{5}{8}$-in outside diameter. As the inside hole is a little too small, use successive reamers to bore the material to correct size. Hold the reamers in a tail-stock chuck (the work in the main chuck of course) and rotate the work by hand or at least at a very low speed. Then carefully turn down the outside of the bearing sleeve to the correct size.

Fit the bearing sleeve into the turntable. At this stage the main bearing spindle may still not fit the hole or it may be too stiff. This may be because of the squeezing action of a tight fit of the sleeve into the turntable. In this case carefully run-through the reamer to bring it to the correct size. If the tolerance of the main bearing spindle is on the high side this still may not be sufficient to give a perfectly free-running bearing. (Test at normal room temperatures, not straight from the lathe or after being held in the hand.) To give increased bearing clearance place the turntable together with the fitted bearing sleeve in a refrigerator for a few minutes, followed by reaming. Use a reamer in reasonable condition—it is important that the surface should be free from scores. Always feed the reamer with a rotating action.

Thrust-bearing spindle. Construction of the thrust-bearing spindle is more straightforward. No tight tolerances apply except that it is as well to check that the spindle fits the hole in the middle of a new record as these rapidly wear. The thrust ball may be held in the assembly by overswaging with a centre punch or with Araldite. The thrust-bearing ball should rest on the exact centre of the nylon thrust bearing pad to reduce rumble. No difference in performance should result if this part is made in other materials, like nylon or p.v.c.

Long and short spars. Bend the two spars from 20 s.w.g. mild steel (galvanized or passivated if possible) to give adequate stiffness. If a bending machine is not available careful work with a mallet and vice should be adequate remembering that this part is unseen and finish is unimportant.

Pulley. The pulley is possibly the most difficult part to make. The tolerances given must be strictly adhered to if performance is not to be impaired. Measuring the internal diameter of the grooves when turning the pulley is facilitated by using a simple gauge (see drawing 'Turning the pulley'), the groove being too narrow for a normal micrometer. (Set dimension X with a template.) To start the hole in the pulley, use a centre drill and ensure the drill does not deviate inside the pulley by using a bar to steady the drill.

The pulley cover (drawing 14) can alternatively be made without the angled sides, instead using $\frac{1}{2}$-in thick wood for the two sides (as in the photograph). By making the height slightly greater than the pulley height, the $1\frac{1}{2}$-in dia. cut can be avoided.

Damped suspension pads. For the suspension pads, three springs are required, made by winding 13in of 1-mm silver-steel wire on a $\frac{1}{2}$-in dia. former. After removing from the former, even out the spring and form as shown. Compress with fingers until it 'bottoms'. After removing pressure it should be 1-in long. To give a clean $\frac{1}{2}$-in hole in the pads to take the springs, punch out using a sharpened piece of thin-walled $\frac{1}{2}$-in stainless-steel pipe (as used in the lifting device). Make the pads larger than necessary and trim on assembly. Use Evostik for bonding.

Assembly

Assemble the main bearing spindle with its bottom flush with its holder. Use the grub screw to lock it in place temporarily as adjustment will follow. Place the suspension cruciform comprising the long and short spars, with the pickup-arm board fixed by brackets, in the plinth before screwing on the motor board from underneath. Additional pad cheeks can be used as packing to make the turntable top parallel with the motor board.

Assemble the bonded motor plate and motor to the motor board together with the adjustment plate and spring. (The spring must be strong enough to allow the end of the motor plate to rise above the board.) Screw the capacitor holder to the underside of the motor board.

Wire the motor to the switch before screwing the motor board to the plinth, earthing the motor casing. Assembling the pulley to the motor may require a little persuasion as it has been designed as an 'interference' fit. Heat the pulley in hot water for a few minutes—expansion should then allow a fit. Do not ream the hole to size and do not unnecessarily pull off the pulley once fitted as this may cause enlargement of the hole and consequent slipping. Lower or raise the main bearing spindle to align the top of the pulley with the top of the turntable.

Designing to avoid rumble

Rumble generally is generated by two sources in a turntable unit—the motor and turntable main bearing—and may be described as noise the spectral content of which lies within the range of about 10 to 200Hz. Apart from a comparatively small amount of noise due to mechanical displacement in the motor bearings, its contribution arises from 'stepping' or 'cogging'—the tendency to rotate in discrete steps rather than in a uniform way. If a synchronous motor is held loosely in the hand and allowed to rotate this 'cogging' vibration is felt quite strongly. Thus if the motor is coupled to the turntable it must always be through some kind of mechanical vibration filter—for example a resilient belt or rubber-tyred wheel.

Unfortunately it is more difficult to mechanically filter rumble generated by the turntable main bearing. This kind of rumble is generally random (except perhaps when the turntable is blessed with ball bearings) unlike the discrete motor vibrations that are related to mains frequency. It is caused by imperfections on the bearing surfaces.

Motor rumble

In this design, vibrations from the motor can be transmitted to the turntable by two paths—the drive belt and the motor mountings—and a mechanical filter is necessary in both paths (Fig. 1).

The electrical equivalent—Fig. 2—shows the motor as a two-dimensional

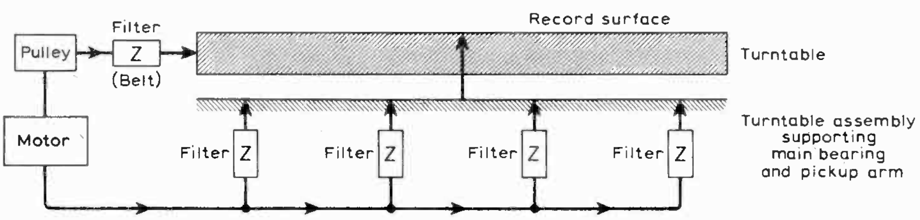


Fig. 1. Rumble from the motor is transmitted to the turntable by two paths (motor mounting and pulley) which must be separately filtered.

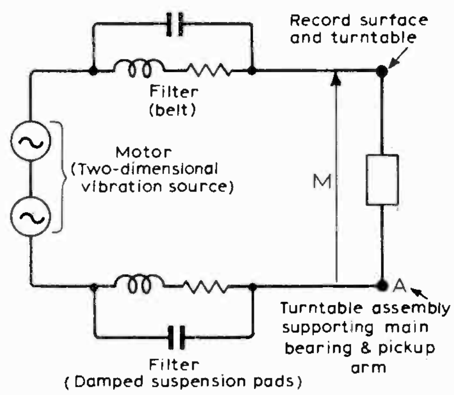


Fig. 2. Electrical equivalent of Fig. 1. Motor produces rumble through the belt in a lateral plane and through the mounting in a vertical plane. The lateral vibration can produce vertical vibration if the turntable is not stiff enough.

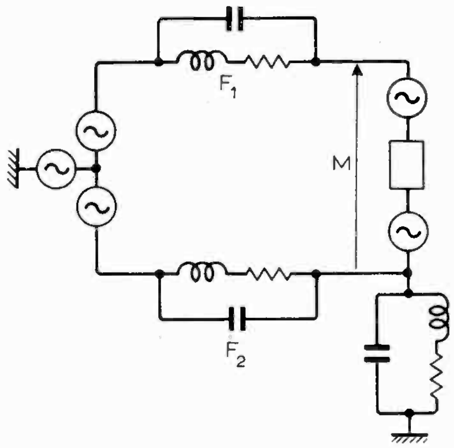


Fig. 5. In the belt-driven unit, F_2 can be made effective enough to eliminate F_3 and the motor casing can be grounded.

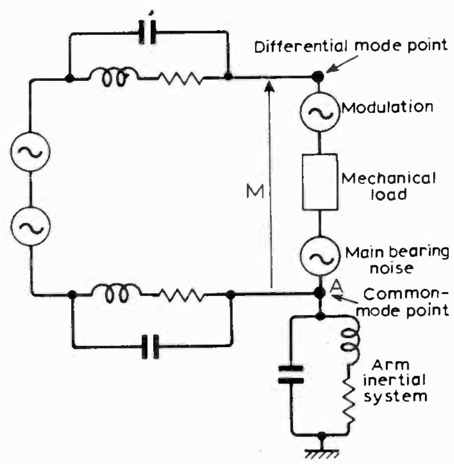


Fig. 3. Inertial grounding effect of pickup arm creates common and differential-mode points. Common-mode response can be eliminated by grounding point A.

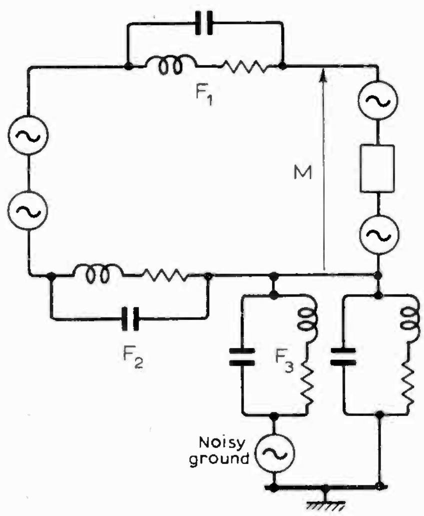


Fig. 4. Mounting a turntable unit on a 'noisy ground'—a non-rigid shelf for example—introduces noise and one solution is to use a 'lockable in transit' type of spring mounting for F_3.

vibration source. Relative to the ground plane, vibration through the turntable mountings will be in a vertical plane while that from the belt will be predominately in a lateral plane. However, this lateral vibration can give rise to vertical vibrations if the turntable is not sufficiently stiff or adequately damped.

The main responses of a stereo cartridge will be at 45° to the plane of this vertical displacement and will thus reproduce a component of any vertical displacement relative to the pickup-arm mounting point. This is why it is always desirable to mechanically couple the pickup arm as close to the turntable as possible to reduce as much as possible any differential movement.

But, however much we may reduce the differential displacement, the common-mode displacement may still have an effect on the pickup output because the pickup is essential an inertial system and will therefore have a common-mode response. What response it does have obviously depends on the design of the pickup arm.

We therefore should modify the electrical model to that of Fig.3 and it is obvious that any common-mode response can be eliminated by grounding (literally!) at point A. Unfortunately, if the ground is noisy due to the unit being placed on a shelf, then the pickup will produce an output in sympathy with the displacement. This is one common cause of acoustic feedback.

Many turntable units are grounded at this point but the manufacturers are always careful to ensure that effective filtering eliminates any displacement that might excite the common-mode response of the pickup arm Fig. 4.

The design of belt-drive units is not so mechanically restrictive as some jockey-wheel-driven types, and allows the use of more efficient filters for F_1 and F_2 (Fig. 4)—the belt and turntable suspension pads respectively—and it becomes possible to combine F_2 and F_3 and ground the motor casing (mechanically). The resulting, chosen, arrangement is shown in Fig. 5.

Main bearing rumble

The prime cause of bearing rumble is imperfection of bearing surfaces. The

Parts List

All parts, including cover, for both pickup arm and turntable are available as raw materials or ready-turned where appropriate from Longdendale Technological Products, Hadfield, Hyde, Cheshire.

Part	description/material	source
motor	Berger RSM 50/8	Longdendale Technological Products (LTP)
turntable	Picador 10-in sanding disc $\frac{5}{8}$-in shaft	most good tool shops
belt	rubber	LTP
main bearing sleeve	Glacier DQ1 $\frac{5}{8} \times \frac{3}{8}$-in nom.	Glacier Bearing Co. Ltd.
main bearing spindle	$\frac{3}{8}$-in dia. silver steel	sold in most tool shops & engineers' suppliers in 13-in lengths
suspension springs	1-mm dia. silver steel	" " "
motor alignment spring	$\frac{3}{4} \times \frac{1}{4}$-in o.d.	LTP
damping pads	1-in thick polyurethane foam	upholstery dealers
long and short spars	20-s.w.g. mild steel	ferrous metal dealers
turntable mat	rubber	Metrosound, C. Watts radio hobby shops
pad cheeks	$\frac{1}{16}$-in Paxolin	radio hobby shops
pulley	$1\frac{1}{2}$-dia., 2-in long aluminium bar	non-ferrous metal dealers
facia plate, pulley cover, motor plate, adjustable slate	20-s.w.g. aluminium	non-ferrous metal dealers
switch	2-pole c/o slider	Radiospares etc.
thrust bearing pad	$\frac{1}{4}$-in dia. $\times$ $\frac{1}{2}$-in long nylon	LTP
thrust ball	$\frac{1}{4}$-in dia. ball bearing	cycle shops, motor accessory shops
spindle	$\frac{5}{8}$-in dia. p.v.c. rod $\times$ $1\frac{1}{2}$-in	LTP
main bearing spindle holder	$\frac{3}{4}$-in dia. $\frac{3}{4}$-in long aluminium rod	non-ferrous metal dealers

Miscellaneous
Captive nuts (hank bushes, six 4BA one 6BA), screws (six 4BA $\frac{1}{4}$-in cheesehead, four 4BA $\frac{3}{4}$-in countersunk head, four 6BA $\frac{1}{4}$-in cheesehead, six 4BA $\frac{1}{2}$-in cheesehead), nuts, rubber feet. From usual sources or LTP.

obvious approach is to make them as perfect as possible. This is quite reasonable but there is a limit and mechanical filtering techniques must be used to reduce the effect further.

It is well known that the less dense a material the greater is the attenuation to the passage of sound and noise. Here in lies the key. The bearings should be made of a material with a density that is as low as possible. The energy then generated, which can be quite high, suffers a great deal of attenuation in its passage to the stylus. The reproduction of rumble can also be affected by resonance phenomena in the pickup arm, about which more later.

Most modern plastics fall into the low-density category but not all are suitable bearing materials. Of those that are, nylon and p.t.f.e. are most common. Unfortunately p.t.f.e. is virtually impossible to machine, nylon is difficult but machinable, and p.v.c. while not an ideal material from the wear viewpoint is easier still to machine. Better still are some compound materials that have p.t.f.e. as a base. They retain all or most of the desirable properties but are easy to machine. They are known under proprietary names like Glacier DQ1, used in this design.

Wow and flutter

Wow is caused by slow variations in record speed, flutter by fast variations. Like rumble, it cannot be eliminated completely, merely reduced to an acceptable level. In the simple arrangement of a slow-speed motor directly driving a revolving turntable, wow and flutter could be caused by sticky main bearing, belt slip, motor cogging and pulley eccentricity. (Wow can also be caused by a badly eccentric or warped record but this is outside our control.) But note that only one of these points really indicates a design problem, that is motor cogging, and this is really tied up with rumble. If the belt is an efficient filter this source of flutter is eliminated.

The most usual way of preventing wow and flutter is to prevent the remaining three imperfections occurring due to bad manufacture, or dirt and grease being smeared on the belt, and to provide a turntable with a high inertia. Care must be taken that any turntable inertia is not overcome by too tight a coupling of the drive motor. This most certainly would occur if a synchronous motor was used with a rim-drive jockey-wheel system. The speed of a synchronous motor is fixed and does not depend on the load as with an asynchronous motor.

A second article will describe construction of a pickup arm.

Correction

R. J. Ward, author of the article **'Swept-frequency audio oscillator'** in the September issue, has asked us to point out that the 4.7-nF capacitor in Fig. 11 should be omitted. We regret omitting the label F, to correspond to E in the multivibrator of Fig. 5. There was a printer's omission on p.417–'Power supplies are required at +10V and −10V' should have appeared in the text gap.

October meetings

LONDON

6th. IERE—"Components—past, present and future" by G. W. A. Dummer at 18.00 at London School of Hygiene, Keppel Street, W.C.1.

7th. RTS—"Satellite broadcasting" Part 1: Basic satellite technology by G. Lewis at 19.00 at I.T.A., 70 Brompton Road, S.W.3.

12th. AES—"Developments in audio instrumentation" by J. Kuehn at 19.15 at the Mechanical Engineering Dept., Imperial College, Exhibition Road, S.W.7.

13th. IERE/IEE—"A blood analyser using the PDP-8/L" by E. T. Oram at 18.00 at 8-9 Bedford Sq., W.C.1.

14th. SERT—"The BRC 8000 television receiver" by A. Martinez at 19.00 at I.T.A., 70 Brompton Road, S.W.3.

18th. BCSR Statistical Soc.—Babbage memorial lectures at 14.30 at I.E.E., Savoy Pl., W.C.2.

20th. IERE—"Application of satellite relayed communications to civil aviation and maritime use" by D. Hirst and J. D. Parker at 18.00 at 8-9 Bedford Sq., W.C.1.

21st. RTS—"Satellite broadcasting" Part 2: Satellite design by G. K. C. Pardoe at 19.00 at I.T.A., 70 Brompton Road, S.W.3.

27th. IERE—"Innovation in industry—a factor for growth" by R. H. Jones at 18.00 at 8-9 Bedford Sq., W.C.1.

ABERDEEN

13th. IERE/RTS—"Colour film for television" by Dr. Boris Townsend at 19.30 at Robert Gordon's Institute of Technology, St. Andrews Street.

20th. IERE—"Hi-Fi tape recording" by R. West at 19.30 at Robert Gordon's Institute of Technology, St. Andrews Street.

BATH

13th. IERE—"Signal processing and computation using pulse rate techniques" by J. D. Martin at 18.00 at The University.

BIRMINGHAM

5th. IERE—"World competition in the electronics industry of 1970—a challenge for the engineer" by Dr. F. E. Jones at 19.15 at the Department of Electronic and Electrical Engineering, The University, Pritchetts Road.

21st. SERT—"Video tape, the manufacture and requirements" by R. Waldie at 19.30 at University of Aston, Gosta Green.

BOLTON

14th. IERE—"Computer-aided design" by E. Wolfendale at 18.15 at the Institute of Technology, Deane Road.

BOURNEMOUTH

5th. SERT/IEETE—"Radar ornithology—the engineer's point of view" by H. R. J. Smith at 19.45 at College of Technology, The Lansdowne.

BRISTOL

21st. SERT—"Curve tracers" by R. Watson at 19.30 at the Polytechnic, Ashley Down.

27th. IERE—"The continuing education and development of professional engineers" by Dr. K. G. Stephens at 19.00 at The Polytechnic, Ashley Down.

CAMBRIDGE

28th. IERE—"The problem of addressing new display materials" by A. Colchester at 18.30 at the University Eng. Labs., Trumpington St.

CARDIFF

6th. SERT—"Demonstration and lecture on the Sony Trinitron television tube" at 19.30 at Llandaff Technical College, Western Avenue.

20th. IEETE—"Electronic variable speed drives" by C. J. Teece at 19.30 at University of Wales Institute of Science & Technology, Cathays Park.

CHATHAM

28th. IERE—"Electronic video recording and reproduction" by B. T. Pickstock at 19.00 at Medway College of Technology.

CHELMSFORD

13th. IERE—"Comparison of p.c.m. and f.d.m./f.m. microwave radio relays" by S. G. Allen at 18.30 at the Civic Centre.

COVENTRY

28th. IERE—"Reliability" by R. C. Winton at 19.15 at Lanchester Polytechnic.

DUNDEE

7th. IEETE—"Technician engineers and technicians—their role, their status, their future" by E. A. Bromfield and "The Engineers Registration Board and composite register" by M. W. Leonard at 19.00 at the University, Fulton Bldg.

DURHAM

13th. IEETE—"Modern telecommunications" at 19.30 at University Science Labs, South Rd.

EDINBURGH

6th. IERE—"The development of a colour TV service" by J. Dunlop at 19.00 at Carlton Hotel, North Bridge, 1.

12th. IEE—"Setting up an educational micro-electronics laboratory" by N. Milne at 18.00 at Carlton Hotel, North Bridge, 1.

GLASGOW

7th. IERE—"The development of a colour TV service" by J. Dunlop at 19.00 at The Institution of Engineers and Shipbuilders, 183 Bath Street, C.2.

11th. IEE—"Setting up an educational micro-electronics laboratory" by N. Milne at 18.00 at The Institution of Engineers and Shipbuilders.

HARLOW

22nd. IERE—"Fibre optics in telecommunications" by Dr. N. Chown at 19.30 at Harlow Technical College.

LIVERPOOL

12th. IERE—"Finance and engineering" by J. Cuckney at 19.00 at the Department of Electrical Engineering and Electronics, The University.

13th. IERE—"Electronics in Medicine" by Dr. D. W. Hill at 19.00 at the Department of Electrical Engineering and Electronics, The University.

MANCHESTER

21st. SERT—"Pulse width modulation" and demonstration of IVC colour video recorder by A. Parkinson at 19.00 at Renold Building, U.M.I.S.T., Sackville St.

MIDDLESBROUGH

26th. SERT—"Philips solid-state colour receiver" by N. Cunniff at 19.30 at Cleveland Scientific Institution.

NEWCASTLE-UPON-TYNE

6th. SERT—"Engineering development in colour TV" by K. R. Harris at 19.15 at Charles Trevelyan Technical College, Maple Terrace.

13th. IERE—"A new look at data logging" by T. Kinnear at 18.00 at Ellison Building, The Polytechnic, Ellison Place.

READING

21st. IERE—"Developments in transistor circuit design" by Prof. E. A. Faulkner at 19.30 at The University, Whiteknights Park.

SOUTHAMPTON

20th. IERE—"The design and application of digital filters" by Dr. D. R. Wilson, D. R. Corrall and B. D. Dollimore at 18.30 at Lanchester Theatre, The University.

STEVENAGE

20th. IEETE—"Electronics usages in commercial vehicles" at 19.30 at College of Further Education, Monkswood Way.

SWANSEA

20th. IERE—"Replanning aspects of medium-wave broadcast service" by Dr. R. C. V. Macario and J. F. Craine at 18.15 at Department of Applied Science, University College.

THURSO

19th. IERE—"Hi-Fi tape recording" by R. West at 19.30 at Thurso Technical College.

Digital TV Synchronizers and Converters

Advantages of field storage technique for synchronizing different picture sources and for standards conversion

by S. M. Edwardson, M.I.E.E., and A. H. Jones*, B.Sc.*

One of the ways in which the presentation of television programmes has improved in recent years is that, as far as possible contributions from a multiplicity of picture sources are now arranged to be synchronous. One reason for this is to provide an uninterrupted train of synchronizing pulses so that viewers are not disturbed by frame 'roll-overs' or other momentary synchronization defects when changes are made between different sources. Continuity of the synchronizing pulses is important to the broadcaster as well, particularly when the programme is being recorded on video tape, because the subsequent replay from a video tape machine can be seriously disturbed for several seconds following any discontinuity in the recorded synchronizing pulse train. A further advantage of synchronous sources is that special effects are possible, such as the so-called 'split-screen' technique (in which a single picture contains simultaneous contributions from two or more sources). In addition, source synchronism enables programme makers to wipe, mix and dissolve rather than simply cut between different sources.

When the different television sources are all located within a single building there is no great difficulty in achieving synchronism, since they all can be fed from a common pulse generator and, by adjusting the timings of the pulse feeds to individual sources, precise and virtually permanent synchronism of the video signals is obtained. This is not possible, however, when some sources are remote.

This article considers the ways used by broadcasters to achieve synchronism between relatively remote television sources. Emphasis is placed upon the most modern method—the field-store synchronizer—and the practicality of making a relatively cheap, high-performance version using digital techniques[1]. The article also considers the application of such techniques to standards converters.

Existing methods of source synchronization used by the B.B.C. fall into three main categories.

Genlock. Here the signal from the remote source is regarded as the 'master' signal and the synchronizing pulses at the studio centre are adjusted automatically to synchronize with the pulses of the master[2]. This is simple and convenient, but has the disadvantage that the synchronizing operation must be carried out slowly to avoid disturbance to viewers' receivers and other apparatus. Furthermore, only one remote source at a time can be used as master and it is necessary to use signals from a local source (e.g. a studio) for a period, while re-locking to a further remote source is carried out.

Natlock.† Here the central source (e.g. B.B.C. Television Centre) is the master, to which all other contributing sources are locked[3]. At the master, the phase of the synchronizing signals from one (or more) remote sources is compared with that of the master and digitized correction signals are fed back to each remote source so as to bring and maintain them in synchronism. The whole network is highly stable and uses narrow-band audio circuits for the correction signals.

The field-store synchronizer. This is essentially a variable video delay interposed in the path of a television signal, the value of delay being such that the output signal is in precise synchronism with a master signal. Precise synchronism between two television signals is achieved when the phases of their field synchronizing pulses, line synchronizing pulses and colour subcarriers are the same. Where a difference in frequency (changes of these phase relationships with time) exists between the television signal to be synchronized and the master signal, the delay in the synchronizer steadily increases or decreases to maintain synchronism; ultimately, the delay reaches a maximum or minimum value, at which point it is reset, to repeat its cycle of variation. A convenient value of maximum delay is equal to the duration of one field; thus, when the cycle of variation is repeated, one television field is omitted or duplicated according to the direction of delay variation. An interesting effect occurs in a field-store synchronizer when the cycle repeats, since the picture information carried by the train of output television fields, normally 'odd, even, odd, even, etc.' becomes, for example, 'odd, even, odd, odd, even, etc'. Two fields of the same kind, with regard to picture content, then occur successively and the output picture is seen to move vertically or 'hop' by one picture-line spacing. A hop in the other direction takes place at the next re-cycling. This effect is found in practice to be not very obvious and, in the majority of synchronizing applications, occurs only very rarely.

Only one field-store synchronizer exists at present and is in service at the B.B.C's Television Centre in London. Its variable delay is formed from a switched cascade of ultrasonic delay-lines similar to those in an electronic field-store standards converter—in fact, this synchronizer is a modified standards converter. Fig. 1 indicates one of the ways in which it is used.

Applications of synchronizers

PAL to PAL synchronization is the most common use of a synchronizer within the United Kingdom, where a colour television signal from a remote source is synchronized to, say, the signals at the studio centre. In most respects PAL to-PAL synchronization presents the simplest problem, because of the tight tolerance to which the subcarrier and scanning frequencies are held (± 0.45 part per million when the PAL signals originate in other countries using the PAL system). SECAM-to-PAL synchronization is particularly useful when importing signals from SECAM countries because, after processing by the synchronizer and transcoding, the signal conforms to the PAL specification in all respects, despite the wide range of scanning frequencies that the SECAM specification permits.‡

The synchronization of monochrome signals creates a special problem despite the simpler nature of the signals to be handled. The wide range of scanning frequencies likely to be encountered with imported monochrome signals can exceed the capacity of the present synchronizer

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† The National Slavelocking System used by the B.B.C.

‡ French exported SECAM signals are held to a tolerance of $\pm$ 0.5 part per million; this helps a great deal but would nevertheless result in a non-standard, transcoded PAL signal, unless a synchronizer were used.

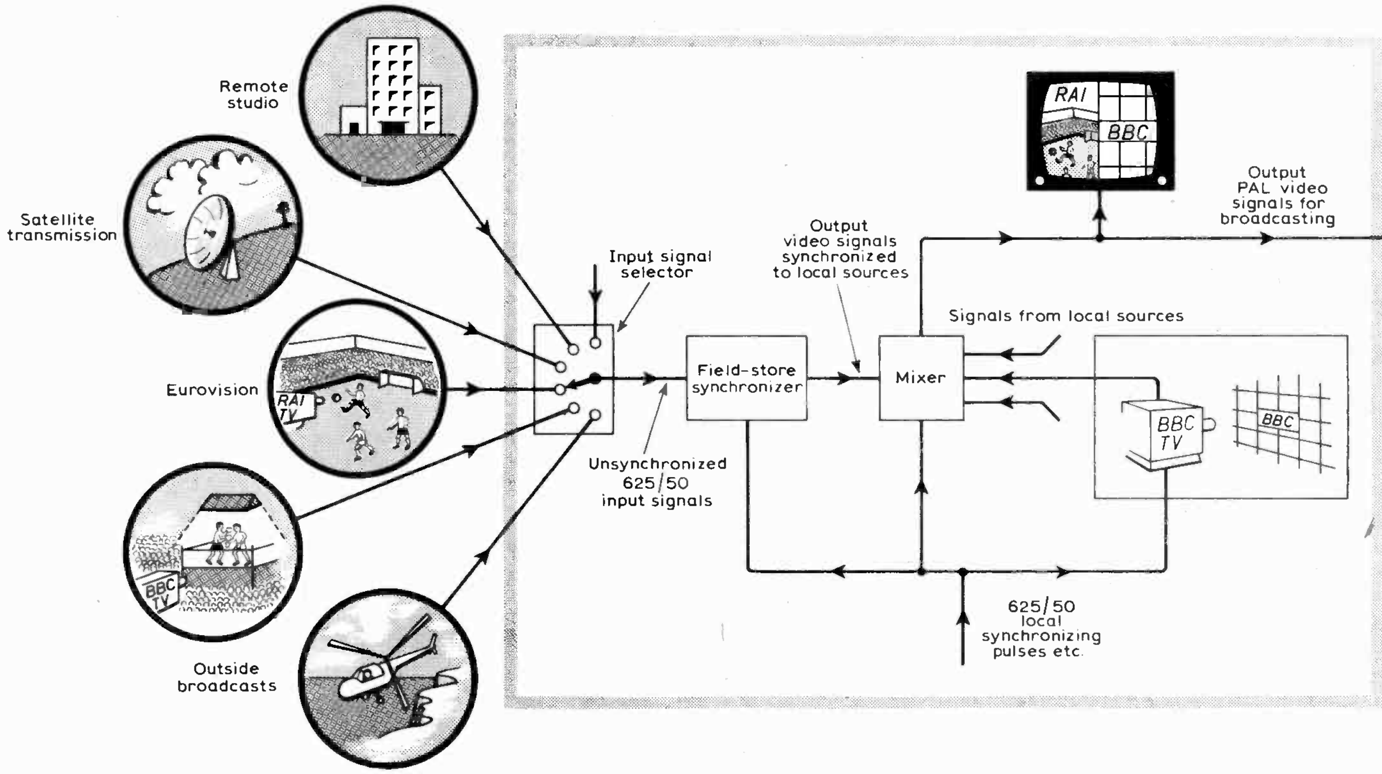

Fig. 1. Action of field-store synchronizer.

(±400 parts per million) and an optical standards converter must, at present, be used to achieve synchronism. Future non-optical synchronizers will occasionally be required to handle wide-tolerance monochrome signals. It was mentioned earlier that a vertical hop occurs every time the synchronizer's delay system re-cycles and, for input signals with scanning frequencies differing greatly from those of the output signal, hopping would occur very frequently and would be subjectively annoying. To handle such signals, therefore, additional storage capacity equal to one television field might be required, so as to ensure the emergence of an undisturbed train of 'odd, even, odd, even, etc.' fields from the synchronizer.** In this case re-cycling would occur half as frequently and a complete picture (i.e. two fields) would be omitted or duplicated each time.

Pros and cons of synchronizers

The field-store synchronizer has the advantages that a television source can be synchronized without disturbing the synchronizing pulses of the master station and without using feedback to the point of origination. It provides a continuous train of output synchronizing pulses (even with no input signal) and it permits rapid 'cutting' from one remote source to another, producing a correct output within a small fraction of a second of the arrival of a new input signal. The ability to synchronize without feedback is particularly valuable when overseas sources are considered.

** The 'hop' could also be removed by simpler means, but at the expense of impaired vertical resolution.

A disadvantage of the synchronizer arises from the fact that it operates by delaying the video signal and hence can cause video-signal distortions whereas, in the cases of Genlock and Natlock, synchronism is achieved through operations on only the synchronizing pulses. In the case of the synchronizer at present in service with the B.B.C., the distortion is small but is not imperceptible—an important consideration for a device intended to be used frequently in the television broadcasting chain.

Digital techniques now offer a solution to the problem of video distortion, as well as having other important advantages.

It is well known that the information contained in any analogue signal can be conveyed by sampling the signal at at least twice the highest frequency present; the magnitude of each of the samples may be sent as a binary number which is described by the presence or absence of each of a group of pulses. Fundamental work on the application of pulse-code modulation[4] to broadcast-quality colour television signals has concluded that a sampling frequency of three times the colour subcarrier frequency (i.e. about 13MHz) should be used and that each of the samples should be described by eight binary digits, corresponding to 256 equispaced quantizing levels; this leads to a serial bit-rate of about 100M-bits per second. However, the serial digit stream may be subdivided so as to use a number of parallel channels working at a correspondingly reduced bit-rate. It is possible, for example, to use 8 channels working at about 13M-bits per second, or 24 channels working at about 4M-bits per second. This subdivision transforms the digital signal into a form in which it can be processed by readily obtainable integrated circuits and storage devices. The advantages of digital processing are high accuracy and reliability, immunity to noise

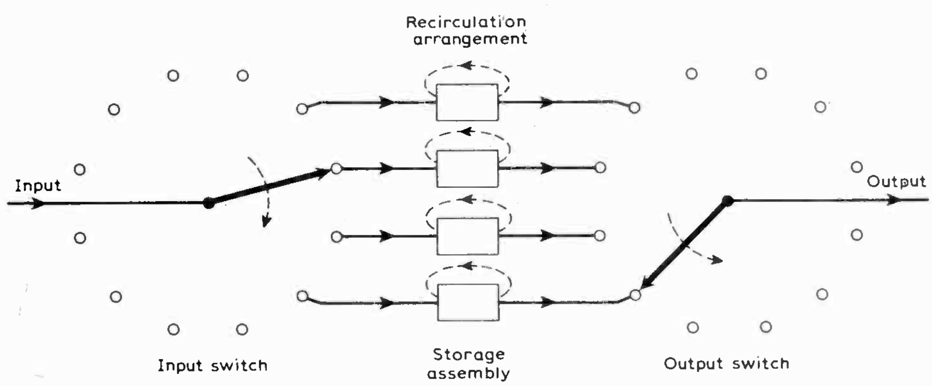

Fig. 2. Basic form of digital field store synchronizer.

and interference, with freedom from drift and from the necessity for careful setting-up and adjustment.

This last advantage makes digital processing particularly attractive for those parts of the television signal in which complicated processing is carried out. Experimental digital line-store converters have already been built[5] and it is reasonable to expect the practical application of digital processing to field-store synchronization and standards conversion. The costs involved in applying digital techniques have fallen in recent years to the extent that a digital solution to a requirement can now often compete, on economic grounds, with the analogue equivalent. It is estimated that the cost of a future digital field-store synchronizer will be appreciably less than that of the corresponding analogue equipment.

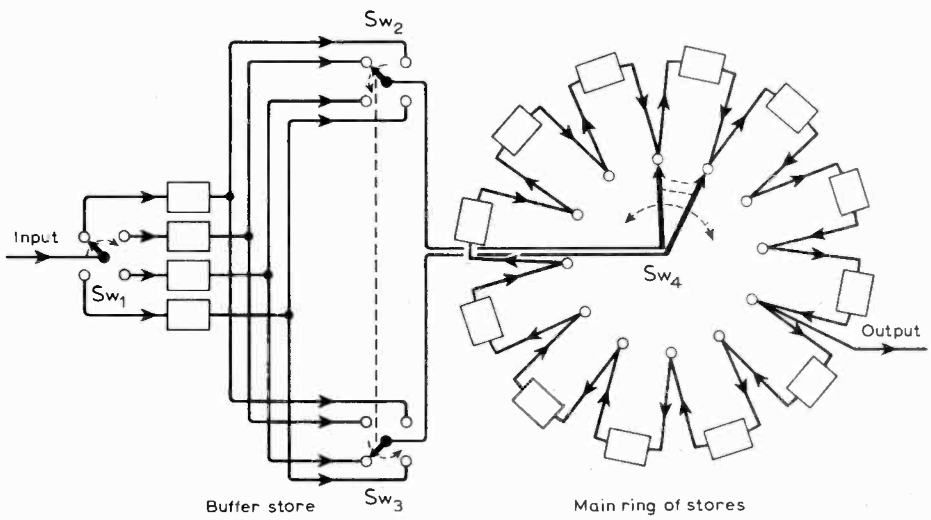

Fig. 3. Alternative form of synchronizer.

Methods of digital synchronization

Present-day analogue synchronizers make use of ultrasonic delay-lines for signal storage. These lines have the property that a signal inserted into them emerges at the output terminal after a specified time interval. For synchronization, and a number of other applications, however, it would be preferable to use devices into which 'blocks' of signal may be written and stored for a variable interval depending on the relative phasing of the input and output synchronizing pulses. Fortunately, the storage devices used in digital systems are generally of this type and their application to the television synchronization problem, in place of delay-lines, leads to a considerable simplification in the ancillary circuits.

Thus with a storage system consisting of a series of 'pigeon-holes', which can be filled and emptied as required, it is possible to envisage field-store synchronizer whose basic form is shown in Fig. 2.

The storage assembly is subdivided into a number of individually accessible units; these may have any convenient size, but it is desirable that the information contained in a television field should be accommodated within a whole number of units. The total capacity of the storage assembly must be at least equal to that required for one television field.

Writing and reading from the storage units is effected by means of the input and output switches shown diagrammatically in Fig. 2. The stores are emptied in sequence via the output switch which is controlled by the output synchronizing-pulse train. The input switch is controlled by the input synchronizing pulses and directs each block of incoming information to the storage unit to which the output will be connected when that particular information is required; the stores are controlled by input clock-pulses during writing and by output clock-pulses when reading. The reading process is preferably made non-destructive (perhaps by 'read-restore' action), the stored information remaining available until replaced by the writing-in ('overwriting') of new information.

By this overwriting technique it is possible to deal with non-synchronous cuts in the input signal without causing any visible disturbance at the output.* If the position on the raster of the beginning of a new signal were known, say by indicating the 'line-number' to the input switching system, the signal could immediately be routed to the appropriate store location. In practice, this cannot occur and it will be necessary to arrest the writing process until the first of the new field-synchronizing pulses arrives; in this case, that part of the input signal which was written into the stores during the field immediately preceding the cut would be repeated at the output. If the writing process were stopped altogether, say by the removal of the input signal, the output would produce a stationary picture.

In general, however, the input and output switches provide access to the storage units in an orderly sequence but, of course, at slightly different rates. Now digital storage arrays are generally constructed in such a way that the writing and reading processes are carried out by the same circuits. Thus writing and reading cannot take place simultaneously in any one storage unit, if the two clock rates are different, as indeed they may have to be in a synchronizer.

This restriction can be overcome by incorporating more storage units than are necessary to accommodate only the information corresponding to a field. Then if, say, writing 'catches up' with reading, the reading switch can be arranged to omit a field. If reading catches up with writing, the reading switch will correspondingly cause the previous field to be repeated. This process is identical to the delay re-cycling process mentioned earlier. In practice, it may be advantageous to use a number of extra storage units sufficient to provide backlash; in this way frequent vertical picture hops may be avoided in the circumstances when the phase difference between the input and output signals wanders about zero.

* This assumes that the fact that a cut has been made is conveyed to the synchronizer; if not then, between the time of the cut and the appearance of the next field synchronizing pulse at the input, information may be displayed in the wrong position on an otherwise standard output raster.

At present, the obvious choice of storage device for a synchronizer of this type is the m.o.s. dynamic shift-register. This device will not store information reliably for more than a short time interval, but this problem can be overcome by recirculating the information within each storage unit, at either input or output clock rate, during the interval between writing and reading. Another way of coping with the problem posed by dynamic registers is to cycle the information through the storage units connected as a ring. If this were done under the control of, say, the output clock it would be possible to derive the output from a fixed point in the ring of stores, with the signal inserted at an appropriate point. In this form, the ring may be regarded as a tapped delay with the addition of a recirculation path to allow for the repetition of information when required. A subsidiary buffer store would be required at the input, however, so that new information could be inserted into the appropriate point of the ring at the appropriate time, under the control of the output clock pulses. This leads to arrangements of the type shown in Fig. 3. Each of the storage units comprising the buffer store on the left-hand side of this diagram has a capacity equal to that of each of the units in the main ring of stores. Sw_1 directs input information into the buffer store as it arrives; this process is, of course, clocked at input rate. The reading of the buffer store and all subsequent switching and clocking operations are locked to the output standard. Sw_2 and Sw_3 are ganged; their purpose is to provide access, during the period of each signal block, to information that has been written into the buffer and is ready to be transferred to the ring. During any one such period, signals flow down one or both, or neither of the two wires leading to Sw_4. The wipers of Sw_4 are ganged and are positioned, at the beginning of each signal block, to feed information into the appropriate (adjacent) pair of terminals on the ring so as to replace the signal block(s) that would, otherwise, have circulated through that particular section of the ring. Information is discarded or repeated at the output when the wipers of Sw_4 move past the output connection. The size of the buffer store, and the motion of Sw_2 and Sw_3 may be arranged so that frequent discarding and repeating of information is avoided when the input and output synchronizing waveforms are hovering near synchronism. If the main ring holds only one field, ancillary circuits can be connected at the output to ensure that the output signal is presented in correct phase during successive fields.

Other arrangements can be envisaged; for example, it would be possible to connect the input signal to the main storage ring, with a subsidiary buffer store at its output. The final choice of block diagram will depend on detailed design considerations.

Complications arise when field-store synchronization is attempted with a storage capacity limited to about one television field. The properties of a PAL colour signal are such that an 8-field cycle is involved; this arises because of the interlaced fields, the V-axis (PAL) switching at half-line frequency, and the arithmetical relationships between the colour subcarrier and the scanning frequencies. Each of the eight fields is separately identifiable and a synchronizer would, ideally, have a storage capacity sufficient for eight fields, in order to match precisely any incoming field to one from the master signal; even the synchronization of monochrome signals ideally requires two-field storage. There is no need, however, for such storage capacity in practice since the difficulties can be overcome without serious penalties. There are two main effects involved.

First, when the timing of the input signal requires that 'odd' fields at the input be displaced to become 'even' fields at the output, or *vice versa*, picture information will be absent from half of one television line at the bottom or top of the output picture.

A second, and more serious, problem arises in connection with the polarity of the V-axis (PAL) switching. Once the corresponding lines of the nearest incoming field have been aligned, there is a 50% chance that the polarity of the PAL switching sequence will be wrong. During the development of the present-day synchronizer, various methods of overcoming this problem were examined and the method finally adopted was to change, when necessary, the synchronizer, delay by one complete television line so as to bring the V-axis switching sequence into step†. This method, known as 'line-slipping', results in a picture that has been moved bodily up or down by one line and means that a further loss of one line of video information can occur; this was considered less serious than the degradation of picture quality which would accompany alternative solutions. It is likely that a similar method will be necessary in a digital synchronizer.

Extension to field-store conversion

A field-store converter is required to produce an output signal whose field phasing is constantly varying relative to the input. A field-store synchronizer must, of course, be capable of dealing with such variations. However, in the case of the converter, the variation is much more rapid, and the conversion process, in general, also involves a change in the number of lines per picture. These requirements may be satisfied by arrangements similar to those given in Figs 2 and 3 with the addition of circuits that interpolate between a number of input lines (possibly derived from successive input fields) to produce information suitable for display on the output raster, together with the additional storage capacity required for interpolation.

Fig. 4 is an extension of Fig. 2 to provide these extra facilites. In this example the interpolator takes information from one line in each of two successive fields, and the two output switch wipers are driven accordingly. The total storage capacity required would somewhat exceed that corresponding to two fields. Circuits already developed[5] could be used to carry out the processing required in a digital interpolator of this type.

The presence of the colour subcarrier complicates the interpolation process, however, as it does for analogue field-store standards conversion. A problem arises because the phase of the colour subcarrier changes from line to line and field to field in a manner which can prevent information being taken directly from different lines and fields of the signal. Analogue standards converters avoid this difficulty by using an intermediate system of colour signal coding, rather like N.T.S.C., having a specially chosen colour subcarrier frequency which is an integral multiple of the input line frequency. This means that, for a given colour, the phase on any line of any field is always the same and interpolation is thereby simplified. It is possible that a similar kind of intermediate colour system may be necessary in digital field-store standards converters.

† Since PAL switching occurs at half-line-frequency rate, the opposite switching polarity must always exist on adjacent lines.

Acknowledgements

The authors wish to acknowledge the contributions and help received from their colleagues in the B.B.C. Research Department; they also wish to thank the Director of Engineering of the B.B.C. for permission to publish this article.

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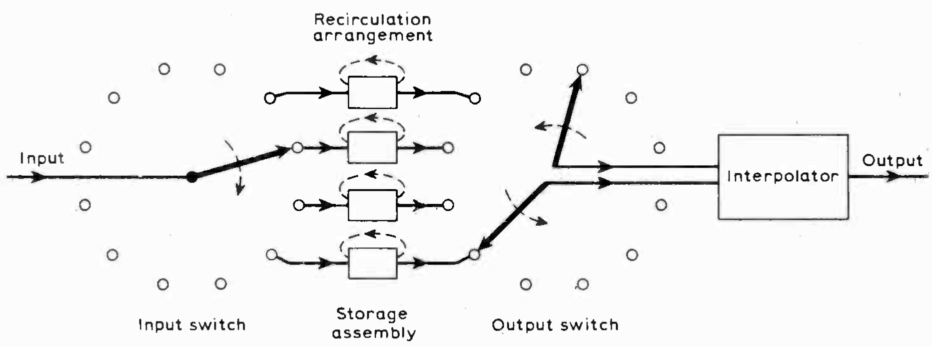


Fig. 4. Extension of Fig. 2 to provide facilities for field-store standards conversion.

Communication 72

This is the title of an international radio and data transmission conference being organized for 13th–15th June next year in the Metropole Convention Centre, Brighton. It is being jointly sponsored by *Electronics Weekly* and *Wireless World* and will provide a meeting ground for the manufacturers and users (both military and civil) of communications equipment. A steering committee including representatives of Government Departments, the industry and user organizations has been set up and a call for papers will be issued shortly.

Considerable interest has already been shown by manufacturers in the supporting international exhibition which has the backing of the Electronic Engineering Association and is being organized by P. Gordon Saville, 21 Victoria Rd., Surbiton, Surrey. Present plans provide for about 150 stands.

Letters to the Editor

The Editor does not necessarily endorse opinions expressed by his correspondents

Dual-trace oscilloscope unit

I would like to comment on some of the points made by W. T. Cocking in his article 'Dual-trace Oscilloscope Unit'.

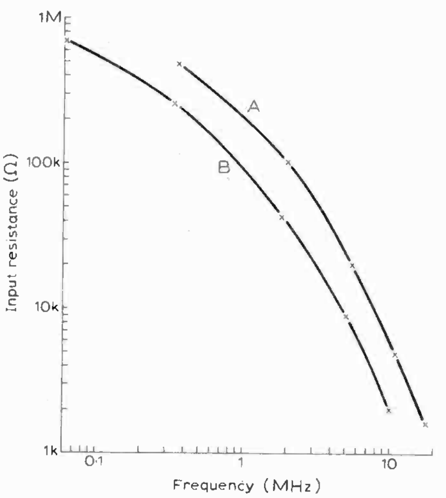
A continuously variable gain control I consider unnecessary and I do not use it on an ordinary oscilloscope in which the gain varies in steps of 1:2:5:10. On the other hand, I would not consider the purchase of an oscilloscope which lacked direct coupled amplifiers. There are rare occasions when the a.c. and d.c. components differ so much that I have to put a dry battery in series with the input, but this is acceptable for experimental work.

Most people believe that the input resistance of an oscilloscope is about 1MΩ shunted by a capacitance of 30 to 50 pF because this is stated in the instruction manual. In fact this is true only at low frequencies. At high frequencies the shunt resistance falls to perhaps 2kΩ. This may not be important when used with switching circuits but it will probably be disastrous if connected across the tuned circuit of an oscillator.

The graph shows the resistive component of the input impedance measured with a Q meter. Above 100kHz the resistance is inversely proportional to the square of the frequency. The resistance will vary slightly from one attenuator position to another but the two curves are representative. One oscilloscope (B) uses valve amplifiers and the input resistance varies only slightly when the mains supply is switched off. There are series resistances such as grid stoppers in the input attenuator and these probably cause the very low equivalent shunt resistance. Measurements were made with short (approx. 6 inch) wires between oscilloscope and Q meter.

I must emphasise that the graphs do show the shunt resistance. They are not curves of capacitive reactance.

M. D. Samain,
University of Salford.



Input resistance of oscilloscopes. (A) Advance OS2100 (transistor amplifier); (B) Telequipment D53, amplifier C2 (valve).

The author replies:

The points about gain control and a d.c. response are surely personal ones. I am used to a continuous gain control and would not willingly do without one. On the other hand, I have rarely found any use for the d.c. input of an oscilloscope.

I am most interested in the figures for the input resistance of oscilloscopes at high frequencies. I made a rough measurement on an oscilloscope at 10MHz and found the resistance to be of the order of 7kΩ only. The c.r.o. so loaded a tuned circuit, however, that the resulting Q was too low to measure accurately with the meter available and I would not rely on my figure to better than $\pm 50\%$! It does, however, give confirmation of a low input resistance at high frequencies.

The suggestion that it is caused by the use of series stopping resistors is probably the chief cause. At 10MHz, 22Ω in series with 30pF has a parallel equivalent of 12.8kΩ in shunt with 30pF.

W. T. Cocking.

Television sound quality

I recently purchased a new 24-inch single-standard TV set. I have subsequently found that although the picture quality is very good the sound is dreadful, speech quite frequently being unintelligible and music invariably not worth listening to. When I complained to the retailer I was told that the poor sound was common to most sets and was due to the fact that the manufacturers had provided more for the money on the vision side. I said that the sound quality was as important as the visual quality to my enjoyment and that I was prepared to pay either to have the sound taken through my high-fidelity amplifier and speaker system, or, alternatively to buy an entirely separate tuner to use with my high-fidelity system. I was told that they were forbidden by the manufacturers to do the former (it was done on a previous TV set), and that there was no such thing as a separate tuning unit for TV sound.

I then communicated with the manufacturer (B.R.C.) pointing out that the sound quality was much worse than on one of their own portable transistor sets I had bought for a little over £20. They said that they were sure my TV set was faulty and should be returned to their factory. I perforce went through the lengthy procedure of doing this, at the same time stating that I would much rather put the sound through my other equipment either from the TV set or a separate tuning unit, or failing that, and since the set was being returned to them anyway, would willingly pay anything within reason for them to fit a better quality amplifier and/or speaker. In the event they insisted that none of these things was possible and returned my set with a note that a capacitor had been changed.

The quality of the sound reception is minimally improved but remains quite unacceptable by any reasonable standard.

In common with many other families, we use our television set for more hours of the week than either the radio or record player. Despite the fact that I have very expensive equipment for sound reproduction, I am obliged to tolerate sound on our major source of entertainment which spoils our pleasure in the programmes. Although I am prepared to spend whatever additional money is necessary to obtain good sound quality I am told that this is not available at any price.

R. Sear,
London N.W.3.

Optimum scale integration

In 'News of the Month' in your July issue (page 340) you comment on the use by Plessey of the term 'Optimum Scale Integration'.

When designing complex linear integrated circuits – for example colour processing systems – the limit to the amount that may be integrated is rarely set by chip size. The factors controlling chip complexity are usually stability (when high gains are involved) and overall system price – bearing in mind that the cost of an integrated circuit increases very rapidly with the number of external connections that are made to it. A digital system may well have less connections if it is integrated on a single huge l.s.i. chip than on several smaller chips but the same does not apply to linear systems, which need coupling, decoupling and tuning, most of which are accomplished with non-integrated components.

Thus, several years ago, Plessey Microelectronics coined the term 'optimum scale integration', or o.s.i., to describe the integration of linear systems into the most economic number of functions per chip. It was a contrast with digital l.s.i. where the most economic number of functions per chip is usually the largest.

JAMES M. BRYANT,
Plessey Company,
Components Group,
Swindon, Wilts.

In reply:
Mr. Bryant quite rightly points out that the problems of designing linear and digital i.cs are different but to imply that digital i.cs do not have to be optimized is stretching things a bit. Minimizing the number of interconnecting leads can be done only if the chip is being designed for a particular system. In most cases the chips (digital) are intended as building bricks in some system to be designed by the customer and not known to the i.c. manufacturer. Digital i.cs, like most other manufactured products, are the result of a process of optimization and compromise. The term o.s.i. seemed to stem from the need to make the devices sound different for publicity purposes—hence our quip.—ED.

The asymmetric long-tailed pair

The long-tailed pair is, arguably, the most versatile basic circuit scheme ever conceived—all credit to the perceptive genius of A. D. Blumlein—and the advent of monolithic silicon integrated circuit technology, with its active device oriented circuit design philosophy, has vastly extended its use. So far, however, attention has concentrated on the 'symmetric' long-tailed pair, i.e. a balanced scheme in which the active devices are made, intentionally, as near-identical as possible. As far as I am aware no attention has been paid to the case where the devices are intentionally fabricated with a significant, controlled, asymmetry, i.e. the asymmetric long-tailed pair. It is the purpose of this letter to point out briefly, the possible advantage of such a configuration; in the case discussed here bipolar junction transistors are dealt with.

Consider the circuit of Fig. 1 in which transistors Tr_1 and Tr_2, made in close proximity on the same semiconductor wafer, have emitter areas A_1, A_2 units respectively. If, (i) the saturation current density of the emitter base junctions of both devices is J_o, (ii) operation is at a current level $\gg I_{CBO}$ (typically < 1nA), and (iii) the common-base d.c. current gain of each device is α, then

$$I_{C1} = \alpha I_{E1} = \alpha A_1 J_o \exp\{(V_1 - V_E)/V_T\} \quad (1)$$

$$I_{C2} = \alpha I_{E2} = \alpha A_2 J_o \exp\{(V_2 - V_E)/V_T\} \quad (2)$$

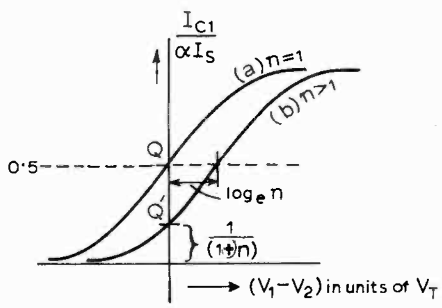


Fig. 2. Long-tailed pair transfer characteristics.

where V_T = thermal voltage = $KT/q \approx$ 25 mV at T = 300°K.

Furthermore, $I_S = I_{E1} + I_{E2}$ (3)

Routine algebraic manipulation of (1), (2), (3) gives,

$$(I_{C1}/\alpha I_S) = 1/[1 + n \exp\{-(V_1 - V_2)/V_T\}] \quad (4)$$

where $n = (A_2/A_1)$. A similar expression holds for $(I_{C2}/\alpha I_S)$.

A more convenient form of (4) is,

$$(I_{C1}/\alpha I_S) = 1/[1 + \exp\{(V_{OS} - V_1 + V_2)/V_T\}] \quad (5)$$

in which,

$$V_{OS} = V_T \log_e n \quad (6)$$

Equation (5) is sketched in Fig. 2. Curve (a) corresponds to $n = 1$ (symmetric case): curve (b) corresponds to $n > 1$ (asymmetric case). Clearly the effect of area difference is to shift the transfer characteristic parallel to itself along the horizontal axis by the amount of the offset voltage, V_{OS}. (In the intentionally symmetric case there is always the possibility of some undesired small offset voltage because of fabrication tolerances: thus a 2% area difference between Tr_1, Tr_2 yields, via (6), V_{OS} = 0·5 mV).

For the linear amplification of small signal voltages bipolar with respect to a specified reference level V_2 a symmetric scheme is suitable. With the quiescent point at Q the transfer characteristic is substantially linear for $\Delta V_1 = \pm V_T$. Suppose, however, that it is required only to amplify signals positive going with respect to V_2. In such a case the choice $n \neq 1$ would appear preferable: in fact, the input signal range for linear amplification is extended by a factor of 2 if the transistors are designed so that,

$$V_{OS} = V_T \log_e n = V_T \quad (7)$$

or, $n \approx 2{\cdot}7$.

For this condition the quiescent point is Q'. Obviously, the configuration is equally suitable for the amplification of negative going signals only if they are applied to the base of Tr_2.

B. L. HART,
London E.15.

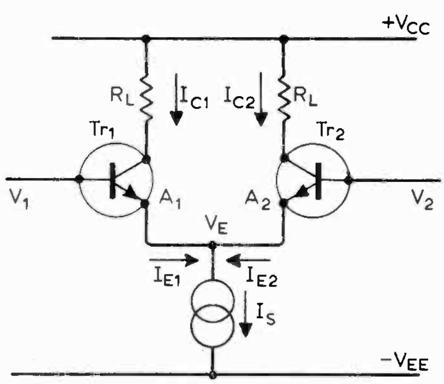
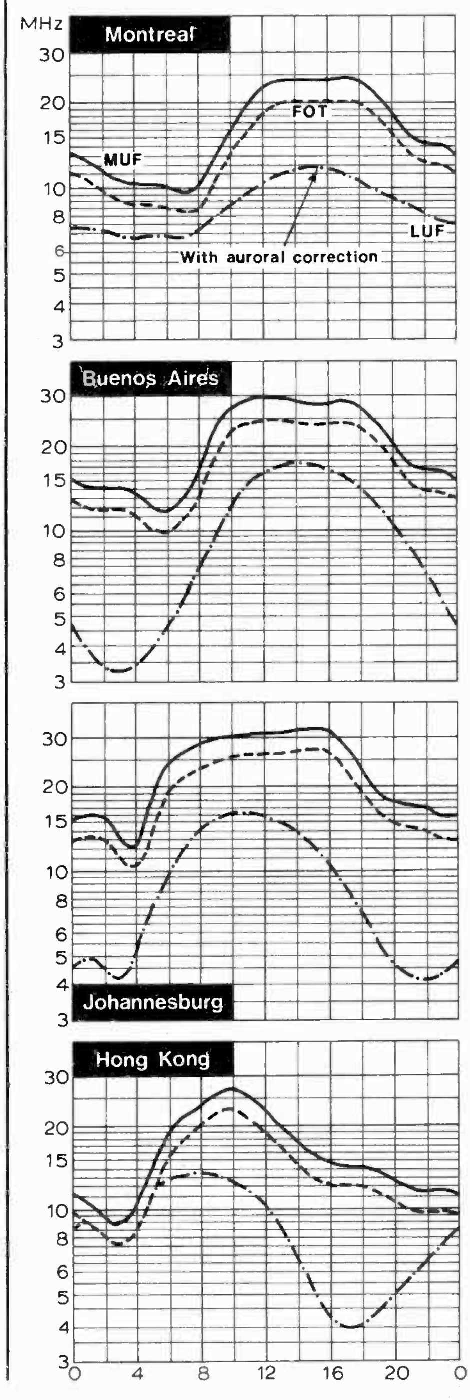


Fig. 1. Basic long-tailed pair.

H.F. Predictions—October

Path MUFs are determined by the two-control-point method of calculating MUFs for 4000km range from each terminal along the great circle between them and taking the lower value as the MUF for the path. When the terminals are widely separated in latitude the MUF difference can be considerable, for example on Hong Kong/London during 00.02 to 00.04 G.M.T. it is 23MHz. Operation above path MUF is often observed under these conditions accompanied by a change in direction of arrival away from the great circle bearing towards the equator. Similar effects, due to ground reflection scattering and ionospheric layer tilts, are observed on many long-distance circuits and have diurnal and seasonal variations.



News of the Month

New radio-telescope

A detailed design for a radio-telescope, to be known as the Mark VA, is to be commissioned by the Science Research Council at a cost of some £250,000. In 1967 the Council announced two preliminary design studies for a large steerable radio-telescope to be operated by remote control from the Nuffield Radio Astronomy Laboratory of Manchester University, at Jodrell Bank. The new design announced by the Council will carry these preliminary studies a stage further and lead to the consideration of tenders for construction of all the major components of the telescope in about a year's time. The Engineering Division of the United Kingdom Atomic Energy Authority Reactor Group will be the S.R.C's agent; Husband and Company, of London and Sheffield, will be the consulting engineers. The specification is for a telescope of about 114m aperture, with a solid membrane, the elements of which can be adjusted by remote control during operation. The membrane will be carried on a large steel structure pivoted in elevation on bearings carried on a beam supported from a reinforced concrete turntable. It is planned that the site of the telescope, if approved, will be at Meifod in Montgomeryshire in Wales. If constructed the Mark VA would operate at wavelengths down to a few centimetres and be used in conjunction with the existing Mark I, currently being repaired and modified, to form an interferometer with a base-line some fifty miles long.

Automatic buoy

Europe's first fully-automatic unmanned navigational buoy has replaced the Shambles lightship off Portland Bill, Dorset. Lanby (large automatic navigational buoy) has just undergone a year of intensive testing which followed its delivery by the manufacturers, Hawker Siddeley Dynamics, to Trinity House. The buoy consists of a main light beacon 12m above sea level which can be seen for sixteen miles and a powerful fog signal which can be heard more than three miles away. At a later date radar and radio beacons may be fitted, and there is provision for accommodating meteorological or oceanographic data-reporting equipment if required. The automatic operation of the buoy and its power supplies, three 5kW diesel-powered generating sets, is monitored every thirty minutes by a shore station via a radio telemetry link. Should any failure occur, standby services operate automatically, and indication of the fault is relayed to the shore station. Shore control can carry out 40 separate checks on the equipment and can control 22 different operations. It is estimated that the buoy will cost 90% less to operate than the £29,000 per year required to keep a light vessel at sea.

Small airfield 'control tower'

A compact equipment (NP8) designed by Rohde & Schwarz for small airfields is not only an accurate direction finder but also provides two-way v.h.f. communication on any one of up to six channels. A technique known as the wide aperture Doppler method is used for the direction finding process.

The pilot of an aircraft wishing to land at an airfield equipped with the NP8 selects the airfield approach frequency on his normal v.h.f. transmitter and calls the control tower. The NP8 receives the signal and provides the controller with a digital indication of the airfield's bearing from the aircraft (QDM) to within one degree and also gives a rough indication (within 10°) of the aircraft's bearing from the airfield (QDR). The controller also hears the transmission and reply using the NP8's transmitter.

The direction finder aerial consists of 16 dipoles arranged in a circle of 3.3m diameter which are electronically commutated at 170Hz and simulate a single aerial rotating around a circle of 3.3m diameter. The communications aerial is a single dipole mounted at the centre of the 16 d.f. dipoles.

The outputs of the two aerial systems are fed to two separate receivers which have a common crystal-controlled local oscillator. The output of the communications receiver is detected and used to feed an audio amplifier and speaker. It is also used to compensate for frequency differences between transmitter and receiver and to prevent an f.m. signal from upsetting the d.f process by comparing the communications receiver output with the d.f receiver output to obtain a correction signal.

The d.f. receiver's output is frequency modulated by a 170Hz signal which is caused by the 'rotation' of the aerial relative to the aircraft's transmitter and has a phase which when compared with the original 170Hz commutating signal yields the bearing of the aircraft.

The phase shift of the bearing signal is averaged over a period of 180 simulated aerial rotations before being displayed but for a very short transmission a bearing indication is available after 36 rotations.

Naval gun used to produce ferrite parts

New ferrite components are being developed at the Billericay factory of Marconi Communication Systems using an unusual production process. The basis of the new process is a 6-inch naval gun with the barrel cut short and sealed. Soft rubber moulds, containing powdered ferrite material from which all the air has been evacuated, are immersed in a hydraulic fluid in the gun barrel, and the breach of the gun is closed. The fluid is then pumped up to a pressure of over 15 tons per square inch, and the powder is forced into a solid block inside the moulds. Since the pressure is applied evenly in all directions by the fluid in the gun barrel, the compressed powder is almost completely free from stresses which might distort the block of ferrite in the furnace.

The ferrite is then fired at a high temperature in an electric furnace, during which time it becomes nearly molten, and shrinks by one fifth of its size. At the end of the process the component is hard enough to cut glass, and is accurate in size to within 0.5%. This unusual method of compressing ferrite powders eliminates lengthy cutting and grinding operations, which normally have to be carried out using diamond cutting tools on the finished ferrite blocks. It also saves a considerable wastage of off-cut material, which cannot be re-used after it has been fired. In the case of the more expensive ferrites, this saving can be considerable.

I made it myself

The communications division of Motorola have taken a step in the right direction by adding an important commodity to one of their radio paging receivers. Each receiver is assembled, tested and packed by one assembly technician. Gone is the production line where each worker did the same job over and over again with little idea of what the final product looked like. The assembly workers are now completely involved. They are responsible for the quality and reliability of the receivers they have each made and an extra something is added which is called pride in one's work. A signed note with the receiver tells the customer who made it.

The receiver in question, called the Pageboy-2, uses only 80 components (if a hybrid i.c. can be called a component) and makes the one-person production technique possible. Motorola are so pleased with the results of the exercise they are now looking at other areas where the idea could be applied.

Quadraphony and Home Video steal the Berlin Show

The 27th German-based radio and television exhibition, held this year in Berlin (Aug. 27-Sept. 5), was international for the first time. So we are justified in presenting some developments from outside Germany this time. The enlarged exhibition area held 263 exhibitors, with nearly half from countries other than Germany. There were 14 British manufacturers represented, 20 from the U.S.A. and 38 from Japan. Main developments were in quadraphonic sound systems and home video equipment.

Four-channel systems

There was a lot to see in four-channel equipment. If you're confused by what's happening in four-channel sound systems, we don't blame you. The situation is confusing because of the variety of systems and in particular a lack of agreement about which to use for what purpose. The jargon doesn't help the outsider to four-channel thinking either.

As well as the basic four-channel arrangement of four microphones feeding four speakers independently ('4-4' system) there are simulated systems–which can be merely ambience-enhancing techniques–for creating four speaker signals from two channels ('2-2-4' system) and '4-2-4' systems for processing four-channel information over two-channel links (e.g. discs). Then there is the question of what to do about compatible tapes, discs and broadcasts for four channels of information (at least ten systems have been proposed for broadcasting).

Some are tempted to dismiss it all as commercial gimmickry, if not trickery, but out of all this comes a theme we have heard before with mono *vs* stereo and monochrome *vs* colour television–those who have heard the better four-channel systems say they don't want to go back to conventional stereo.

Ambience is what is mostly lost through stereo reproduction, and is the reverberant sound of the playing room which arrives later than the direct sound and with an almost random directionality. To get an impression of this one has to perceive sound in the listening room on the same basis as in the original room. To do this means arranging to get sounds in the room which follow on from the original sound in an incoherent way but at the same time do not reduce the stereo directional property. Using the findings of Haas (which incidentally related to *speech* pulses) it is maintained that delays of about 1 to 30ms do not reduce directionality–the first-heard sound locating the source—and the delayed pulses merging to reinforce the first sound (provided the level difference is less than 10dB). Thus it has been proposed to introduce delays (of around 10ms) between front and back speakers (in a two-channel stereo system), arranging the back speakers to get the best ambience effect–level with the ears. Getting these delays can be inconvenient because of the delay mechanism needed, e.g. displaced tape heads, sound propagation tubes, etc. The alternative of using four appropriately spaced microphones can achieve the required delay, but requires the co-operation of the recording director and a 4-2-4 system. Consequently simpler ways of achieving an ambience effect have and are being adopted.

The Körting Multisound 600, Siemens RS172 and RS302, a unit by Audioson, and the Elac 3400T are based on the old argument that the difference between two stereo channels carries reverberant sound (which is less masked than in the sum signal) and can be used to reproduce an enhanced reverberation effect. Körting use a differential amplifier to produce antiphase difference signals, ($\pm L-R$), which are fed through separate amplifiers to two rear speakers. The 180° phase difference is intended, the makers say, to prevent a sound image being formed midway between the rear speakers. But the effect of this may be disturbing to some in a similar way to the effect of anti-phase speakers in a conventional stereo setup, and can give reduced l.f. response through cancellation. Although these two signals could be provided more economically using either one extra amplifier with antiphase speakers or by matrixing the L and R signals, Körting –in common with many other manufacturers of such black boxes–are anticipating availability of four-channel discs or tapes.

Pioneer equipment shown had two modes of operation–one using a matrix for four-channel discs (coded stereo discs) and one using a phase difference circuit for ordinary stereo discs. The phase difference method provides a differential $L-R$ signal for the rear speakers with a 90° phase difference to provide a diffused rear sound source. The matrix mode is intended to be used with coded discs, i.e. two-channel discs derived from four main microphone channels. The Sansui QS-500 also includes a matrix and it is interesting that makers have decided to adopt a particular kind of matrix before there is any agreement on what system will eventually be used for disc coding.

The Sansui equipment is unique in that it includes phase modulators to give a presence effect which acts on each of the rear channels to give 'randomly' varying phase differences between 0 and 180°. Both rear channel signals, derived by matrixing, are phase shifted prior to this phase modulation–the specification shows 90° at 300Hz for the left and 90° at 600Hz for the right. The significance of these frequencies is not explained.

A '4-2-4' system proposed for use with such units has a four-microphone arrangement feeding a linear matrix coder to produce two channels from the four. The resulting left channel output comprises mainly signals from the left front and back microphones together with a difference signal from the right front and back microphones, and conversely for the right output. These two composite signals can then be applied to a stereo disc cutter in such a way as to rotationally modulate the groove by appropriate choice of coefficients in the matrix, rotation of the cutter x-y axes corresponding in theory to 'panning' a sound source around 360°.

In practice of course the cutter–or pickup stylus–is not physically rotated, the desired effect being achieved by giving suitable coefficients to the cutter signals. When the matrixed or 'coded' signals are retrieved from a disc, and 'de-matrixed' it turns out that when, say, the left front microphone only is providing a signal, three speakers are energized, the left front with a full signal and the two adjacent speakers with a signal 3dB down. As it stands, this system is clearly not a 'discrete' system, and it would seem there is a reduction in front left-right separation.

But it is argued that most programmed material would not demand four discrete channels. When discrete reproduction is important it is possible to apply gain control to the two flanking channels to reduce their effect using circuitry which recognizes the appropriate kinds of signals. This basic idea, similar to that of Scheiber, is the basis of a variety of commercial four-channel playback units, including those by Pioneer, Sansui, Electro-Voice, Lafayette.

While it may be true that conventional stereo discs can be reproduced with added realism, such a coded disc will not be very compatible–a two-channel stereo setup will have reduced separation. Also, to improve this front right-left separation means an expensive decoder because of the need for additional gain control circuitry. As a centre-back signal corresponds to a vertical stylus motion, this would be lost when playing such a disc in the mono mode. A way round this is to provide a 90° phase difference (actually $\pm 45°$) between the two composite channels and thus their sum is equal to the square root of the sum of the squares of the two signals, thus giving mono compatibility.

Bauer* has pointed out that there is directional ambiguity as a result of using a one-dimensional matrix i.e. one in which the output signals are linearly related to the input with real coefficients, claimed to be overcome in the CBS system by using a two-dimensional matrix with complex coefficients–see later.

One method of putting four channels of information onto a disc is the modulated subcarrier technique used by the Victor Company of Japan. In this a matrix produces the signals L_F+L_B, L_F-L_B, R_F+R_B, R_F-R_B. The two difference signals are separately angle modulated onto a subcarrier of 30kHz with a total passband of 20-45kHz. (Difference signals below 800Hz are frequency modulated and above 800Hz are phase modulated onto the carrier.) The two sum signals are then added, so the two composite signals (representing the left channels and the right channels) are modulated onto the disc groove in the normal way. Fig. 1(a) shows a typical groove modulation. The level of the modulated difference signals is kept to 20dB less than the maximum level of the sum (audio) channels. By this means crosstalk figures of 20dB (both front-to-back channels) and 25dB (both left-to-right channels) are obtained.

This kind of system was investigated by CBS—except that the carrier was at 22kHz with an a.m. upper sideband extending to 38kHz–but a number of snags were found. So that the stylus can trace the finer groove modulations the base-band signal has to be reduced in level resulting in a 6 to 8dB drop in s/n ratio in the stereo mode. Also there are difficulties in tracking which would mean restricting the inner groove radius to about 15cm. Then there is the cost of pick-ups designed for use up to 40kHz.

The system eventually adopted by CBS–called SQ (stereo/quadraphonic) and recently demonstrated in London as well as in Berlin–uses a linear matrixing technique which gives improved performance in some respects over other matrixing methods. Starting with the disc cutter, the method of getting the additional directional information onto the disc is similar to the system already discussed. The front signals are as for a conventional stereo disc. The left back channel is associated with a clockwise circular motion in the groove and the right back channel with an anti-clockwise motion. The left back signal is applied equally to both groove walls with a 90° phase lag on the right, and the right back signal is applied equally with a 90° phase lead on the right. The back channels are thus orthogonal–as are the front channels–signals in one back channel being unaffected by a signal in the other back channel. Thus, in theory, infinite separation is available between the front pair and the back pair of channels. (Not so between the left and right pairs, where separation can be as little as 3dB.) Equal front signals give a lateral groove modulation, equal back signals give a vertical modulation and a source at other points around a microphone square would give elliptical modulation. Fig. 1(b) shows four 45-45 grooves with modulation by each channel. The 90° phase difference between the two wall modulations is clearly seen.

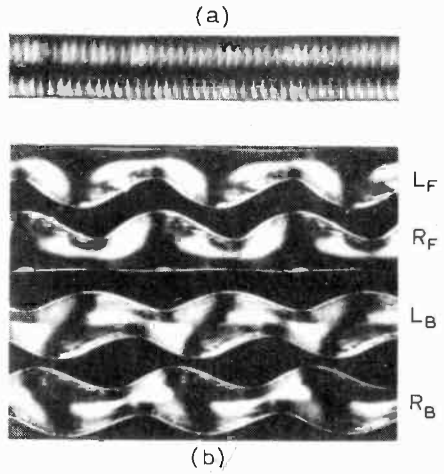


Fig. 1. Grooves of four-channel discs using subcarrier technique (a) and using CBS matrix technique (b).

The matrixing process has the following relation:

$$L=L_F+aR_B-jaL_B$$

and $R=R_F-aL_B+jaR_B$

where $a=\sin 45°=\cos 45°=\frac{1}{2}\sqrt{2}=0.707$.

(The terms prefixed with j are formed with wideband 90° phase-shift circuits.)

In the 'de-matrixing' process (Fig. 2) the outputs will be:

$$L'_F=L_F+aR_B-jaL_B$$
$$R'_F=R_F-aL_B+jaR_B$$
$$L'_B=L_B-aR_F+jaL_F$$
$$R'_B=R_B-aL_F-jaR_F$$

Thus the front-left speaker, for example, produces no front-right signal, but has an in-phase back-right component and a back-left signal shifted in phase by −90°. By inspection of the other equations it can be seen the front and back pairs have the theoretically infinite separation while front signals are transferred with reduced amplitude in the rear and *vice versa*. High front separation is most useful for maintaining compatibility with two-channel stereo equipment and is a distinguishing feature of the system–Fig. 3(a). This figure also shows the signal amplitudes resulting from a front left signal in the other systems for comparison at (b). (It is achieved at the expense of slightly more power being radiated from the opposite direction of the dominant sound source than in the system using all real coefficients in the matrix–Fig. 3). Using a different kind of matrix with the system will reduce separation and alter sound distribution.

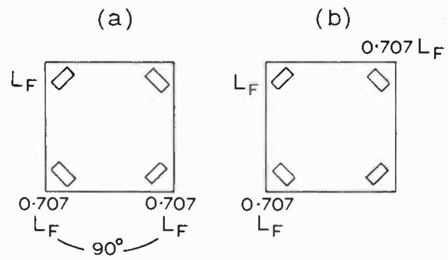


Fig. 3. Speaker outputs when a front-left microphone only is energized using the CBS matrix method (a) and typical output using other matrices (b).

In the example of Fig. 3(a), the rear signals have negligible effect on perceived direction, only contributing to the total loudness. The human hearing system favours sounds from the front, and as sounds for the back reach the ear largely by reflection (in a room) and are therefore delayed, the Haas effect prevents any effect of reflected sound on directionality. This rule doesn't seem to apply when the back

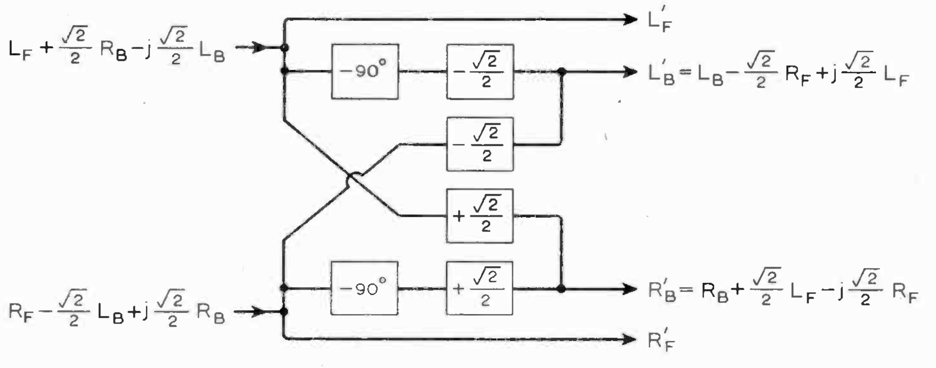


Fig. 2. Simplified decoder matrix used in CBS SQ system using wideband 90° phase-shift circuits. Modified form of matrix can give improved separation between centre front and back signals at the expense of left-right separation.

* Letter to the editor, *J. Audio Eng.Soc.* vol.19 1971 pp.315/6.

signals are dominant. In the case of a back left signal, the signals in the front speakers are in quadrature and it has been shown that the image from two such signals is displaced toward the leading signal (front left). It turns out that this is at about the same angle as the perceived sound from the back speaker—which is about $\frac{1}{3}$ of the angle between two speakers. (Perceiving incoherent stereo signals from behind narrows the separation angle.) So the front image tends to 'blend' with the back image, and because the back signal is the stronger the sound is perceived from the back. A feature of the system is that the same effect occurs if the listener turns round and faces the back.

When playing a four-channel disc on a two-channel system, the sounds corresponding to equal signals in quadrature are shifted towards the leading phase speaker. Thus a back left signal appears displaced toward front left, which helps to convey some sense of identification between the four and two-speaker reproductions.

The reduced-amplitude (or 'side-effect') signals are perceived when a listener turns through 90°, reducing apparent front-back separation. A refinement to the system therefore is to use controlled-gain amplifiers in each of the four channels, whose action is to attenuate the side-effect signals whenever they have equal amplitudes and a 0, 90 or 180° phase difference in adjacent channels. (Gain of the remaining two amplifiers is correspondingly increased to maintain constant power.) Given such a system, performance is claimed to be virtually identical to that of the original master tape.

CBS say that the first quadraphonic discs –about 20 titles–will be released in the U.S.A. in November, costing about $1 more than two-channel discs. Sony are the first licensee for hardware outside the U.S.A. and showed two decoders at the exhibition. They are expected to be available in Europe early in 1972, when no doubt CBS will start pressing discs in the U.K. Cost of decoders is expected to range from about £20 for a matrix-only type to around £60 for a model with gain control circuitry. Other manufacturers and record companies are being licenced in Europe, and we expect announcements to be made later this year.

Home video

The Philips VCR video cassette recorder had its premiere at the exhibition. Demonstration models using this system (under licence) were seen on a number of stands—Bosch/Blaupunkt, Loewe Opta, Grundig, Nordmende and Philips—and other companies have also agreed to use the system, including Telefunken, Saba, Lenco, Zanussi (Italy), Revox and Thorn. A feature of the VCR machines is the inclusion of a u.h.f. receiver, enabling broadcasts to be recorded independently of the playback receiver. On some models, a timer is included to operate the recorder at a preselected time. Philips machines are expected to cost about £290 and are now planned to be marketed in April or May 1972. Despite the wide agreement on the VCR system for the PAL system, there still does not appear to be a standard for N.T.S.C., 60Hz areas. In Japan and the U.S.A. ten different tape systems have been announced.

Most of the proposed domestic video machines are running behind schedule–our table (page 529 November 1970 issue) showing dates of introduction of the competing systems is now out of date. The Teldec video disc is now expected in 1973 and problems with RCA's Selectavision mean that a launch date cannot be given.

Nordmende demonstrated their CCS Super 8-mm film system. Like the EVR system this uses the flying-spot technique to convert film pictures for display on a television receiver.

The most interesting system technically is the video disc, and the colour version of the Teldec (Telefunken-Decca) video disc player was demonstrated for the first time. To get picture information onto a disc with a reasonable playing time clearly needs a revolutionary technique not only in pickup design but also in getting the required information density. Information theory shows that for a 3-MHz bandwidth with a signal-to-noise ratio of 40dB, a channel capacity of 4×10^7 bit/s is required, which amounts to a storage density of 500,000 bit/mm^2 at 1500 rev/min–two orders of magnitude greater than a microgroove disc!

To get this kind of density means that normal lateral groove modulation is out of the question and constant-width grooves are used less than 8μm wide. The sound and picture information is frequency modulated onto a carrier of between 3 and 4MHz, with a ratio of minimum to maximum wavelength of 1:2.66. The signal is cut into the 150° grooves in hill and dale fashion. In retrieving this modulation from the disc the wave crests are impressed against the piezoelectric pickup (fixed in relation to the groove, thus avoiding the problem of pickup inertia) by an air film no greater than 50μm (see illustrations in "The video disc" by J. C. Gilbert, *Wireless World* vol.76 1970 pages 377/8). Pickup output is proportional to wavelength, and as the disc is rotating at constant speed, the wavelength-frequency 'constancy' varies as the pickup traverses the disc because of increase in groove velocity. The resulting fall in output is equalized prior to demodulation and subsequent u.h.f. modulation. Pickup response is limited to about 5MHz by a resonance which occurs when the acoustic half-wavelength in the transducer is comparable with its dimensions. Transducer mass and compliance of the elastic mounting give a low-frequency resonance at about 100kHz. This allows a pickup-arm bandwidth of five to six octaves to be achieved, presumably necessary because of the low modulation index, producing sidebands outside the deviation band.

The big question is how has colour been added to this system? Teldec engineers argued that vertical resolution is unnecessarily high and to match the horizontal resolution, considerably less than 625 lines per frame can be used. Hence, the red, green and blue picture content is recorded in sequence, so that red information is given every three lines. On playback, delay elements are used so that all three signals are available at the same time. This mixing process is used only for low-frequency picture information–up to 1MHz–so sharpness is not lost. Only two kinds of disc are necessary, a 1500 rev/min type for 625 lines, 50Hz and a 1800 rev/min type for 525 lines, 60Hz. Differences within the 625-line standard are catered for in the processing circuitry.

Although playing time per disc is short, about 5min, cartridges have been developed to take a stack of discs, which are automatically removed from their covers. Both monochrome and colour versions of the equipment are now scheduled for marketing in 1973.

Tape noise reduction

Philips showed a prototype cassette 'hi-fi' recorder (model N2510) whose performance is claimed to meet DIN45 500 standards. Using high-coercivity-tape cassettes, improved magnetic heads and their dynamic noise limiter technique (see *Wireless World* July 1971 issue pp.339/40) it is scheduled for release mid-1972.

While in Berlin we thought we would follow up a rumour that three Japanese companies–Sony, Matsushita (National) and Victor–had jointly developed a rival to the Dolby system. Sony dissociated themselves from this and said they were still negotiating with Dolby.

National, who have been using a noise reduction circuit on their cassette tape recorders (rather like the Sanyo type), claim to have developed a new 'double-ended' system, i.e. one which requires signal processing prior to recording. According to National literature, they obtain a 6-dB improvement in signal-to-noise ratio with this and together with their 'noise-free device' single-ended circuit they claim an overall improvement of 20dB! It seems they have not yet decided whether to market this, one governing factor being development of the Philips system. They have also been involved in discussions with Dolby Laboratories over the B-type system.

The Victor company (Japan) claim to have a system competitive and compatible with the Dolby system–their published curves in fact are identical to Dolby's–without patent infringement. A possible reason for the emergence of these other systems may be the royalty price Dolby is asking. According to Dolby Laboratories it has recently been reduced to about four pence per processor as a result of an increased number of licensees. There are now 63 licensees of consumer Dolby products, including 22 in the USA, 13 in Japan and 12 in the U.K. Latest cassette machines seen using the Dolby system are made by Hitachi and Sansui.

Dual-trace Oscilloscope Unit

3. Bipolar transistors

by W. T. Cocking, F.I.E.E.*

The two previous parts of this article have dealt with the requirements for a dual-trace oscilloscope unit and have discussed in detail the design of an amplifier incorporating a field-effect transistor for its input stage. It was shown that the main practical difficulty with an f.e.t. arises out of the very large tolerances on this type of semiconductor. Additionally, however, there is a lack of definite information on the temperature coefficient. In view of the gain control requirements, this makes it impossible to be sure that a design is satisfactory without lengthy tests on a great many f.e.ts.

It is a fact that the provision of a continuous control of gain is a major design problem. It was clear from the start that the most satisfactory solution would probably be to use a differential amplifier with the gain control resistor connected between the two emitters. This is a well-known circuit, but for good maintenance of the balance it requires complete symmetry. This means, in particular, that as far as d.c. is concerned everything connected between one base and the bias source must be duplicated between the other base and its bias source.

This virtually rules out the use of the f.e.t. as an input device, for a matched pair would be required to achieve the necessary symmetry and with their normal large tolerances this is more easily specified than secured. How then otherwise can we achieve an adequately high input resistance? It must be around 5 MΩ as a minimum and is better 10 MΩ, so that it causes negligible error by its shunting effect on the 100 kΩ resistor which is supposed to define the input resistance.

An emitter-follower has an input resistance of approximately $h_{fe}R_E$ and a typical transistor, such as the BC107, has a minimum h_{fe} of about 100. To obtain an input resistance of 10 MΩ, therefore, an emitter load of 100 kΩ is needed. Now the input resistance of a differential stage is unlikely to be much more than 10 kΩ, so a second emitter follower is needed. A second stage with an emitter load of 1 kΩ, which is small compared with 10 kΩ, will have an input resistance of 100 kΩ to form the emitter load of the first stage.

Thus, a preliminary check indicates that a double emitter follower is needed to obtain the required input impedance, and for symmetry, it must be duplicated on the other side of the differential amplifier. This solution thus requires rather a large number of transistors. This was why initially we investigated other arrangements and we returned to it only when we found those other arrangements to be unsatisfactory for gain control.

According to the text-books the input resistance of the double emitter follower is lower than one expects because the input resistance of Tr_2 is shunted by the collector-emitter differential resistance of Tr_1 (Fig. 1.) Further, it is usually advised that a coupling resistor be connected from the emitter of Tr_1 to $-V_{CC}$, which provides a further reduction of the emitter load. The reason for providing this coupling resistance is to ensure that Tr_1 is not cut-off by the I_{CO} of Tr_2. This is possible even with silicon transistors under some conditions.

However, I_{CO} is unlikely to exceed 0·05 μA even at high temperature and the trouble is most simply avoided by making I_{B2}, and hence I_{C1}, large in comparison. The BC107

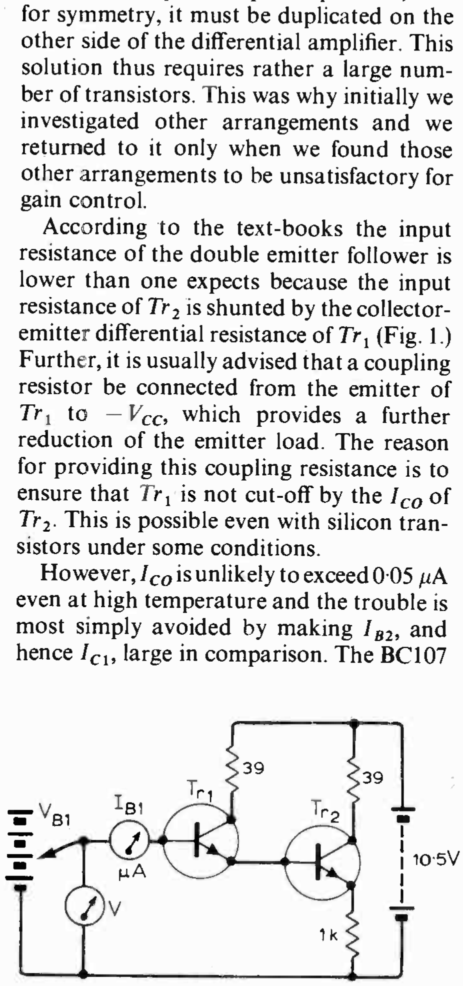


Fig. 1. Circuit for measuring the input current-voltage relation for a double emitter follower.

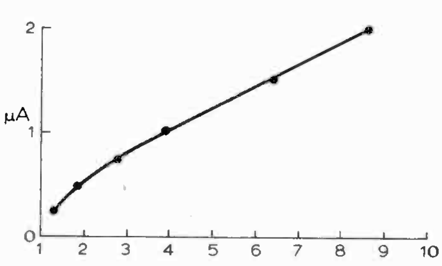


Fig. 2. Plot of current-voltage for the circuit of Fig. 1.

is rated for an h_{FE} of 110 to 450. In the worst case, if I_{C2} is at least 3 mA, I_{B2} is not less than 3/450 = 0·00665 mA = 6·65 μA, and this is adequately large in comparison with any likely value of I_{CO}. A current of 3 mA or more is also desirable to minimize the risk of the emitter follower cutting off on negative-going signals. There is always shunt capacitance to any coupling and it cannot change its charge instantly.

In order to assess the input resistance we need to know the collector a.c. resistance of Tr_1 at a collector current of the order of 6–30 μA, the latter figure being appropriate for h_{FE2} = 110. The published transistor data is of no help here and so we resorted to experiment. We rigged up the circuit shown in Fig. 1 using a pair of 2N3706 transistors. These are not the most suitable, for they have a minimum h_{FE} of only 30, but they happened to be at hand. We varied the base bias in steps and noted the base current and plotted the figures as a curve (Fig. 2). Above about 8·6 V the base current rose very rapidly because of the approach of Tr_1 to saturation. For V_{B1} = 8·6 V, I_{B1} = 2 μA and for V_{B1} = 2·8 V, I_{B1} = 0·75 μA; thus, the a.c. input resistance is

$$(8{\cdot}6-2{\cdot}8)/(2-0{\cdot}75) = 4{\cdot}63\ \text{M}\Omega.$$

Similar measurements with a pair of BF194 transistors gave a resistance of 7·2 MΩ. This showed it to be practicable to obtain an adequately high input resistance from a double emitter follower.

The general form of the circuit follows almost automatically and is shown in Fig. 3. Transistors Tr_1 and Tr_2 form the input emitter follower; Tr_3 and Tr_4 are the differential pair; and Tr_5 and Tr_6 are a duplicate emitter follower. The output stage is Tr_8 with Tr_9 to switch it on and off. Because the base voltage of Tr_8 is much lower than the collector voltage of Tr_3, the p-n-p stage Tr_7 is interposed. It also enables a shift control to be provided which does not affect the gain. This is R_8 acting as a variable resistance. The free end is connected into the other amplifier so that the component acts as a differential shift control, moving one trace upwards and the other downwards at the same time. This is necessary because independent shift controls can lead to grossly incorrect bias on Tr_8.

The bias supplies for Tr_1 and Tr_6 are obtained from R_2 and R_3 which are fed

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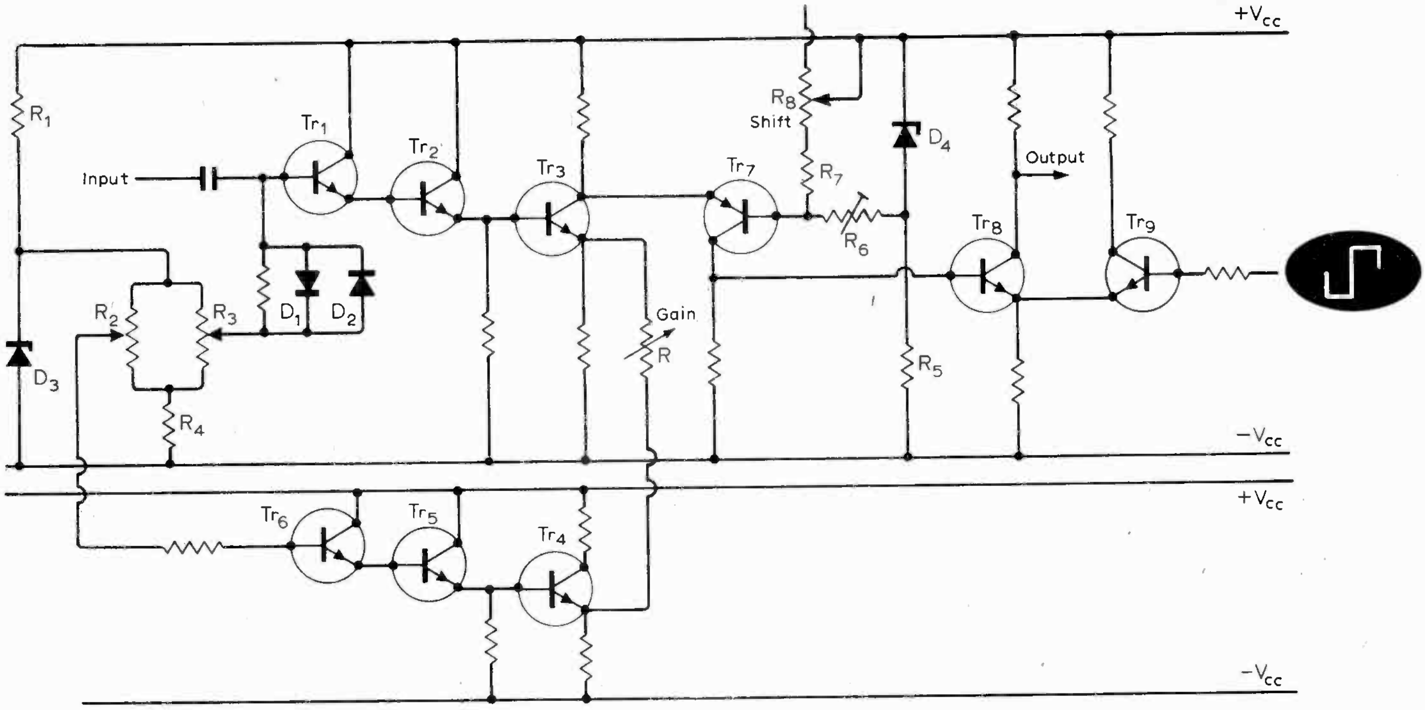

Fig.3. Basic circuit of amplifier. Tr_3 and Tr_4 form a differential amplifier with the gain-control resistor R between the emitters. Tr_1 and Tr_2 have a high input resistance, so that the actual input resistance of the amplifier is defined by R_{B1} (see text for explanation of the terminology). Tr_5 and Tr_6 are a duplicate emitter follower and are necessary only to preserve the balance of the differential stage. Tr_7 is used primarily to give a change of d.c. level between Tr_3 and Tr_8 but it also enables 'shift' to be obtained without affecting gain. Tr_8 is the output stage which is switched on and off by Tr_9.

from the zener diode D_3. Stabilized bias supplies are essential unless the main supply is stabilized; even if it were, the bias supply resistors would have to be of $\pm 1\%$ tolerance. In practice, R_3 is adjusted to bring the voltage across R_{E3} to a design value and then R_4 is adjusted for zero voltage across R; R_7 is adjusted with R_{10} at its mid position for a design value of $V_{C7} = V_{B8}$.

Before proceeding further, it may be as well to clarify the nomenclature and conventions used. To simplify the diagram base, emitter and collector resistors are not labelled in Fig. 3; they are all R_B, R_E or R_C with a numerical subscript for the particular transistor to which they belong. Thus, R_{E3} is the resistor between the emitter of Tr_3 and $-V_{CC}$. The resistor between the collector of Tr_3 and $+V_{CC}$ can be designated as R_{C3} or R_{E7} as desired; similarly, the one between the collector of Tr_7 and $-V_{CC}$ can be called R_{C7} or R_{B8}.

For n-p-n transistors, all voltages which have a single letter subscript (e.g., V_B, V_E, V_C) have also a numerical subscript to indicate the particular transistor, and the voltages are measured with respect to $-V_{CC}$. If measured with respect to some other point, there is a double letter subscript. Thus V_{C8} is the collector voltage of Tr_8 with respect to $-V_{CC}$; V_{CE8} is the collector voltage with respect to the emitter of Tr_8.

In the case of p-n-p transistors, the voltages are normally measured with respect to $+V_{CC}$. They should, therefore, strictly have a minus sign, but this is inconvenient. V_{C3} is the collector voltage of Tr_3 and is also clearly the emitter voltage of Tr_7 with respect to $-V_{CC}$. However, V_{E7} is the emitter voltage of Tr_7 with respect to $+V_{CC}$. Collector voltage V_{C3} is positive, V_{E7} is actually negative (because of the different point from which it is measured) but is referred to here without the minus sign.

After this explanation, we can return to Fig. 3. The diodes D_1 and D_2 are essential protective devices. They ideally have no effect on the normal signal performance. Their purpose is to prevent damage to the equipment if the probe is accidentally connected to a high voltage. We take this high voltage to be the supply mains, which can reach ± 360 V peak. For 10:1 input attenuation of the probe and R_{B1} together, the probe resistance is 900 kΩ and even without the diodes the maximum input to Tr_1 is ± 36 V peak. With the diodes, the base voltage of Tr_1 is limited to at most a volt more than the diode return voltages. Because of component tolerances a close control of voltages is impracticable and it is necessary to design so that safe conditions exist throughout the amplifier, not merely in the first stage. In particular, V_{EBO} for any transistor must not exceed 6 V for the BC107 type.

In the development, we naturally omitted D_1 and D_2 initially and we rigged up the circuit of Fig. 3 on the bench to check its performance. This did, in fact, prove admirable. We found it readily possible to obtain a −6 dB bandwidth of 10 MHz, a gain of 10 times, a gain control range of 3·5:1, and good stability of the d.c. balance. Although not perfect, this last was far superior to that of any other circuit tried. When we came to add protective diodes, however, we found that Tr_3 and Tr_7 were in some danger and we had to do some redesign to avoid this. This is why we now take them into account from the beginning.

Before considering the design in detail, it is advisable to be clear about a few important facts about transistors. The first is that for d.c. V_{BE} is virtually a constant except for tolerances and temperature. For the BC107 it is 0·55 to 0·7 V as a manufacturing tolerance, and it decreases with rising temperature at the rate of 2 mV/°C. For the BC157 p-n-p transistor V_{BE} is 0·6 to 0·75 V and decreases in magnitude at 2 mV/°C.

Because of this, when there is appreciable external emitter resistance, the emitter voltage bears an almost constant relation to the base voltage. It is a very low impedance point. In Fig. 3, for example, if V_{B7} is fixed, V_{E7} is also fixed at a magnitude lower by V_{BE7}. This means that the total current in $R_{C3}(R_{E7})$ is constant; therefore, if I_{C3} increases I_{C7} decreases by the same amount.

For a.c., the internal differential resistance of the base-emitter junction must sometimes be taken into account. This is designated r_e and has the rough value of $26/I_c$ ohms with I_c in mA. It is usually additive to the external emitter resistance R_E and we shall call r_e+R_E the total effective emitter resistance R_e. The voltage amplification is then R_C/R_e and the input resistance measured between base and earth is $h_{fe}R_e$.

The maximum normal output required from Tr_8 (with Tr_9 off) is 1 V peak-to-peak. With two traces on the c.r.o. fully separated it can be only one-half of this. To allow a large factor of safety for drift and to obtain good linearity we shall design for an output of 2 V peak-to-peak. We previously chose $R_{C8} = R_{E8} = 330\,\Omega$ on the grounds of nominally unity gain and the required frequency response. We also decided on $V_{B8} = 2{\cdot}7$ V.

Deducting V_{BE8} (= 0·55 to 0·7 V), V_{E8} is 2 to 2·15 V. The collector current (assuming the base current to be negligibly small in comparison, as is usually the case) is V_{E8} divided by R_{C8}, which is 330 Ω nominal. With a ±5% tolerance, the resistance lies between the limits of 314 and 347 Ω. Therefore, the limits on collector current are 2/0·347 = 5·75 mA and 2·15/0·1314 = 6·84 mA.

The internal emitter resistance $r_{e8} = 26/I_C$ and so ranges from 3·8 Ω to 4·5 Ω. From the signal point of view, this plus R_{E8} equals R_{e8}, the effective total emitter resistance, which is thus 318·5 to 350·8 Ω. The collector resistance R_{C8} is also nominally 350 Ω, but ranges from 314 to 347 Ω. Now R_{e8} and R_{C8} are uncorrelated and the limits are with one high and the other low. Therefore, the voltage amplification R_{C8}/R_{e8} is 347/318·5 = 1·09 to 314/350·8 = 0·895.

The input resistance is

$$h_{fe8}R_{e8} = 125 \times 0{\cdot}3185 = 40\,\text{k}\Omega$$

as a low limit with $h_{fe} = 125$. In fact, h_{fe} may be as high as 500 for the BC107 transistor, so the input resistance may be as high as 160 kΩ. We can do nothing to prevent this variation, but we can make its effect trivial by making R_{C7} small compared with its lowest value. As we shall see later, R_{C7} is 1·2 kΩ. With a ±5% tolerance its value is 1·16 to 1·26 kΩ. Now 1·16 kΩ shunted by 40 kΩ is 1·13 kΩ and 1·26 kΩ shunted by 160 kΩ is 1·25 kΩ. These are the values which should strictly be taken in assessing the gain of the Tr_3, Tr_7 combination. The maximum error caused by ignoring it is only 3%, however.

The calculations for Tr_8 have been given in detail to illustrate the method employed. The same procedure is followed for the other stages but it would be tedious to give it in full. The results only are, therefore, summarized in Table 1.

In general, we need not in this case calculate V_{CE} nor the collector dissipation, because they are so far below the limits that it is unnecessary. However, as an example, we shall do so for Tr_8. We assume

$$V_{CC} = 12\text{ V} \pm 1{\cdot}5\text{ V},$$

making V_{CC} = 10·5 to 13·5 V. From the point of view of V_{CE}, the worst case is when R_C and R_E are off tolerance in the same direction. The collector-emitter circuit resistance is thus 628 to 694 Ω and I_{C8} is 5·75 to 6·84 mA so that the voltage drop is 5·75 × 0·694 = 3·89 V to 6·84 × 0·628 = 4·3 V.

The currents and voltages are taken this way because low current results from high resistance and *vice versa*. The minimum V_{CE} is thus 10·5 − 4·3 = 6·2 V and the maximum is 13·5 − 3·89 ≈ 9·5 V. The collector dissipations are 6·2 × 6·84 = 42·5 mW and 9·5 × 5·75 = 54·6 mW. The latter is not necessarily the maximum dissipation, but in this case it probably is. It is so far below the limit of 400 mW for the transistor that we need not worry about it.

The figures are for continuous operation. However, Tr_8 is switched on and off for equal periods. As a result, the mean current and the mean dissipation are one-half of the above figures.

Table 1

	Low	Normal	High	
V_{B8}	—	2·7	—	V
V_{BE8}	0·55	0·625	0·7	V
V_{E8}	2	2·075	2·15	V
I_{C8}	5·75	6·27	6·84	mA
r_{e8}	4·5	4·14	3·8	Ω
R_{e8}	318·5	334·1	350·8	Ω
R_{C8}	314	330	347	Ω
A_8	0·895	0·985	1·09	
R_{C7}	1·14	1·2	1·26	kΩ
I_{C7}	2·15	2·25	2·37	mA
$V_{E3} = V_{E4}$	—	2·7	—	V
V_{B1} and V_{B6}	4·35	4·575	4·8	V
R_{E3} and R_{E4}	2·09	2·2	2·31	kΩ
I_{C3} and I_{C4}	1·17	1·23	1·29	mA
R_{C4}	1·14	1·2	1·26	kΩ
$I_{C4}R_{C4} = V_{B10}$	1·34	1·475	1·63	V*
$I_{C3}+I_{C7}$	3·32	3·48	3·6	mA
R_{C3}	446	470	494	Ω
V_{E7}	1·485	1·64	1·78	V*
V_{BE7}	0·6	0·675	0·75	V
V_{B7}	2·085	2·515	2·53	V*
r_{e7}	12·1	11·6	10·95	Ω
r_{e3} and r_{e4}	20·1	21·1	22·2	Ω
V_{B10}	1·35	1·48	1·63	V*
V_{E10}	0·75	0·8	0·88	V*
$I_{C10}+I_{C11}$	1·52	1·7	1·97	mA
I_{C10}	0·26	0·284	0·358	mA
I_{C11}	1·162	1·416	1·71	mA
R_{C11}	1·425	1·5	1·575	kΩ
$I_{C11}R_{C11}$	1·66	2·12	2·7	V
V_{C11}	2·41	2·92	3·58	V*
V_{CE11}	11·09	9·08	7·12	V

* Voltage below $+V_{CC}$

Our next concern is the input capacitance Tr_8. The stage gain is about unity, so the portion of the input capacitance due to Miller effect is only twice C_{bc}. Because of R_{E8}, the portion caused by C_{be} will be only a small fraction of C_{be}. Values of these elements are not quoted for the BC107. Nor is C_{ce} for the BF157 used for Tr_7. We have to guess that the total capacitance across R_{C7} is unlikely to exceed 5 pF.

When considering the output stage Tr_8 in Part 1 we found that the combination of 330 Ω and 55 pF gave a response down by 3·61 dB at 10 MHz. For the same response here with 5 pF, R_{C7} can be

$$330 \times 11 = 3{,}630\,\Omega.$$

For R_{C7} = 1·5 kΩ, the response will be −0·87 dB; for 1·2 kΩ it will be −0·6 dB. This is, therefore, the sort of value which we should use on a frequency response basis, and is so low in comparison with the input resistance of Tr_8 that we can forget the latter.

From the point of view of frequency response the lower the value of R_{C7} the better, but there is clearly not much advantage in making it less than 1·2 kΩ. For a required gain, say, 10 times, $R_{E7}/R_{e3} \approx 10$, making R_{e3} = 120 Ω for R_{C7} = 1·2 kΩ. The input resistance of Tr_3 is $h_{fe}R_{e3}$ and this must be large compared with R_{E2} = 1 kΩ. We have thus to strike a balance between frequency response and a large enough input resistance for Tr_3. With h_{fe} = 125, the input resistance is 125 × 0·12 = 15 kΩ which is certainly large compared with 1 kΩ. As h_{fe} varies so much, it may actually be four times as large.

Before deciding on 1·2 kΩ for R_{C7} we have to check that I_{C7} will be sufficient to handle the signal. The current is

$$I_{C7} = V_{B8}/R_{C7} = 2{\cdot}7/1{\cdot}26 = 2{\cdot}15\text{ mA}$$

minimum with a high tolerance resistor. For a 1 V peak signal, the signal current will be 1/1·26 = 0·794 mA. There is thus adequate signal-handling capacity and we can decide definitely to make R_{C7} = 1·2 kΩ.

The next step is to estimate the gain of the input emitter follower Tr_1 and Tr_2. We saw earlier that for the required input resistance R_{E2} must be about 1 kΩ and that I_{C2} should be something like 3 mA. Taking these figures, r_{e2} = 26/3 = 8·6 Ω. The gain of Tr_2 is thus 1000/1008·6 ≈ 0·99. Now Tr_1 works into a load h_{fe} times as great and has $1/h_{FE}$ times the current; h_{fe} and h_{FE} are usually similar in magnitude, although not necessarily equal. It follows that the gain of Tr_1 will be about the same as that of Tr_2 and the overall gain about 0·98.

Since the gain of Tr_8 is 0·895 to 1·09, the overall gain apart from Tr_3 and Tr_7 is 0·879 to 1·07. We require the overall gain to be 10 times, therefore Tr_3 and Tr_7 together must provide an amplification of 9·35 to 11·4 times. This gain is actually

$$\frac{R_{C7}}{R_{e3}} \cdot \frac{R_{C3}}{R_{C3}+r_{e7}}$$

Here r_{e7} is the internal emitter resistance of Tr_7 and depends on I_{C7}; it is given in Table 1 and is around 11 Ω. The requirement for R_{C3} is that it be very large compared with r_{e7}, but not so large that it drops too much voltage with I_{C3} and I_{C7} in it. A value of 470 Ω suggests itself. If I_{C3}, which we do not yet know, is about the same as I_{C7}, the drop will be about 2·1 V, which seems reasonably low. The factor

$$R_{C3}/(R_{C3}+r_{e7})$$

is thus about 470/481 = 0·975. It is not worth while here to bother taking tolerances into account. We now find that R_{C7}/R_{e3} must be 9·62 to 11·7.

Before we can proceed further we have to consider the input conditions and, in particular, how we can protect the amplifier against an accidental overload. As mentioned earlier we are taking the maximum input at the probe to be ±360 V. The probe resistance is 900 kΩ and so the maximum possible overload current is 0·4 mA. At this current, the forward drop of a diode is unlikely to be more than 1 V at most and is more probably 0·5–0·6 V. If the diodes are unbiased, as shown in Fig. 3, they will limit the input to Tr_1 to ±1 V about its bias voltage. This will certainly do no harm in the early stages.

Now the normal maximum signal at the output is 0·5 V peak and with a gain of 10 times this becomes 0·05 V at the input. The gain control range is 3·33:1 minimum and so to obtain full output at low gain, the input must be 0·05 × 3·33 = 0·167 V peak. The diodes are in shunt with R_{B1} and must have a resistance very large in comparison if the input resistance is to be well-defined by R_{B1}. This resistance should be 20 MΩ per diode when forward biased by 0·167 V, the peak signal.

The normal diode data does not help in selecting a suitable type, nor in deciding whether bias is necessary or not. The BZY145 appears to be suitable but it is necessary to resort to experiment. A trial quickly showed bias to be essential. This raises problems of how to obtain it. Trial showed about 0·5 V back bias to be sufficient.

It is practicable to connect one diode

between the base of Tr_1 and $-V_{CC}$. On overload V_{B1} will then be taken to $-0{\cdot}5$ V or thereabouts. This will cut-off Tr_1, Tr_2 and Tr_3, but this need not harm any of these three transistors. We cannot, however, safely return the other diode to $+V_{CC}$, for this will result in V_{B1} reaching about $V_{CC}+0{\cdot}5$ V on overload. At least Tr_1 will saturate and probably Tr_2 also. There is a a probability that the base current would be dangerously high.

We now assume that the back bias on the diode should not be less than 0·5 V. If we use a BZY88/C5V6 zener diode for D_3 its voltage will be 5·3 to 6 V. If the diode is returned to this, V_{B1} must not exceed 4·8 V for 0·5 V or more back bias on the diode. With maximum tolerances on V_{BE} for Tr_1, Tr_2 and Tr_3, V_{E3} must be at least 2·1 V lower. Thus, $V_{E3} = 4{\cdot}8 - 2{\cdot}1 = 2{\cdot}7$ V as a maximum. It is a coincidence that this is the same as V_{B8}, but a convenient one if it is otherwise satisfactory.

For a forward voltage drop of 0·5 V, V_{B1} will rise to 5·8 to 6·5 V above—V_{CC} depending on the zener used. With low tolerance V_{BE}, V_{E3} will rise at most to $6{\cdot}5 - 1{\cdot}65 = 4{\cdot}85$ V.

Tests which were later carried out with $V_Z = 5{\cdot}6$ V and $V_{B1} = 4{\cdot}7$ V ($V_{E3} = 2{\cdot}7$ V), which corresponds to a back bias of 0·9 V on the diode, were quite satisfactory. It was noticed that changing the diode bias affected the frequency compensation of the probe appreciably. This is to be expected because diode capacitance changes with voltage. The practical variations, however, are caused by tolerances and are taken up by initial adjustments. The main changes in the life of the equipment are caused by temperature and are likely to be very small.

When the equipment was completed, the adequacy of the protection was tested by connecting the input across the 240-V supply mains. Naturally, nothing on the equipment was earthed. No harm whatever resulted. Having thus chosen

$$V_{E3} = V_{E4} = 2{\cdot}7\text{ V},$$

we can proceed to design the Tr_3 stage. The first thing to notice is that if signals are applied in the same phase to Tr_3 and Tr_4, there is ideally no current in R and R does not affect the gain for these signals. Such signals are those resulting from the effects of temperature on Tr_1 to Tr_6. The in-phase gain is approximately R_{C7}/R_{E3} and can be made less than unity if R_{E3} is greater than R_{C7}. However, for fixed V_{E3}, I_{C3} falls as R_{E3} is increased and it must be large enough to handle the signal. We previously found the signal current in R_{C7} to be 0·79 mA and allowing for the small loss in the coupling to Tr_7 we can take it as being 0·8 mA in Tr_3. The collector current of Tr_3 should thus be 1·2 mA or more for reasonable linearity. This means that R_{E3} should not exceed 2·25 kΩ. We thus choose 2·2 kΩ for R_{E3} and, (Table 1) I_{C3} is 1·17 to 1·29 mA.

We have now chosen the main circuit values except for the gain control R. Before we do this, which is a little complicated, let us check the overload conditions after the first stage. It is quite possible to have a condition in which the first stage is safe, but some later stage is not.

On overload, V_{B1} goes to a maximum of $+6{\cdot}5$ V or a minimum of $-0{\cdot}5$ V. In the first case V_{E3} rises to a maximum of $6{\cdot}5 - 1{\cdot}65 = 4{\cdot}85$ V and if R is small it pulls the emitter of Tr_4 up to almost the same voltage. Now V_{B6} will be at its normal 4·38 to 4·8 V and V_{B4} will be 3·25 to 3·4 V, therefore Tr_4 will be cut off. Considering R as negligibly small, we then have

$$V_{E3} = V_{E4} = 4{\cdot}85\text{ V}$$

with an emitter load comprising R_{E3} and R_{E4} in parallel. This is 1·1 kΩ nominal, 1·045 kΩ minimum. Therefore,

$$I_{C3} = 4{\cdot}85/1{\cdot}045 = 4{\cdot}64\text{ mA max.}$$

Because I_{C3} increases above its normal value, I_{C7} will decrease. The increase of I_{C3} is $4{\cdot}64 - 1{\cdot}17 = 3{\cdot}47$ mA at most, while I_{C7} is 2·37 mA (a little more because of shift conditions yet to be discussed). It follows that Tr_7 will be cut-off and V_{B8} will be zero. The drop across R_{C3} will be

$$4{\cdot}64 \times 0{\cdot}494 = 2{\cdot}3\text{ V}$$

and so the IR drops of Tr_3 will be

$$4{\cdot}64 + 2{\cdot}3 = 6{\cdot}94\text{ V},$$

making $V_{CE} = 9{\cdot}5 - 6{\cdot}94 = 2{\cdot}56$ V as a minimum. Thus Tr_3 will not saturate and this makes the calculations valid ones. It is clear also that Tr_4 will not have excessive reverse base-emitter bias. It is well under the 6 V limit.

To make everything safe all we have to do is to ensure that Tr_9 cannot pull the emitter of Tr_8 more than 6 V above $-V_{CC}$.

Now consider a negative overload. This takes V_{B1} to about $-0{\cdot}5$ V and Tr_1, Tr_2 and Tr_3 are cut off. If there is no R_{E1}, as in Fig. 3, the potential of the emitter of Tr_1 and base of Tr_2 is indeterminate. It is wise, therefore, to fix it at $-V_{CC}$ by a resistor of 1 MΩ or so. With Tr_3 cut-off, Tr_7 acts as a common-emitter stage with R_{C3} as its emitter resistor. As V_{B7} has its normal value, so will V_{E7} have a normal value. Therefore, the total current in R_{C3} does not change, but I_{C7} rises to the normal $I_{C3}+I_{C7}$, or 3·6 mA maximum. This increases V_{B8} to 4·55 V maximum, and so V_{E8} is 0·55 V less, or 4 V.

An additional shift of $\pm 0{\cdot}5$ V is required on V_{B8} and V_{E8}, which makes the maximum emitter voltage of Tr_8 4·5 V. When Tr_9 has its base at $-V_{CC}$, this is reverse base-emitter bias on Tr_9. It is under the 6 V rating and so is safe.

We can now return to consider the gain control. We require a minimum range of 3.33:1 and a gain of 9·62 to 11·7 times. With low tolerance R_{C7} is 1·14 kΩ and R_{e3} must be $1140/11{\cdot}7 = 97\,\Omega$; with high tolerance it must be $1260/9{\cdot}62 = 131\,\Omega$. To reduce the gain to 1/3·33, these values must be 3·33 times or 323 Ω to 437 Ω.

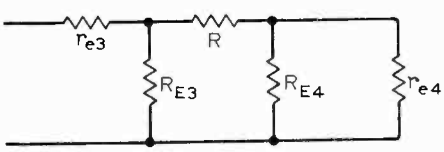

Fig. 4. This shows the equivalent circuit of the emitter circuit of Tr_3.

Now R_{E3} is the complex network shown in Fig. 4. As r_{e3} and r_{e4} vary only by $\pm 1\,\Omega$, it is good enough to take $r_{e3} = r_{e4} = 21\,\Omega$ constant. The elements apart from r_{e3} must thus be 77 to 111 Ω and 303 to 417 Ω. Since R_{E4} is 2·2 kΩ it can be neglected as a shunt on r_{e4} of 21 Ω.

The required figures are thus to be given by R_{E3} and $R+r_{e4}$ in shunt; whence

$$R + r_{e4} = \frac{R_{E3}R'}{R_{E3} - R'}$$

where R' is the required resistance. Working this out for $R_{E3} = 2{\cdot}09$ kΩ, we get for $R+r_{e4}$, 80–117 Ω and 355–522 Ω; with $R_{E3} = 2{\cdot}31$ kΩ, we get 79·6–116·5 Ω and 348–509 Ω. Deducting $r_{e4} = 21\,\Omega$, we get for R, 59–96 Ω and 334–501 Ω in the first case, and 58·6–95·5 Ω and 327–488 Ω in the second. It is thus clear that R can consist of 100 Ω and 500 Ω variable resistors in series, one as a preset to fix the maximum overall gain at unity, and the other as a panel gain control. Variable resistors usually have a tolerance of $\pm 10\%$, so the maximum values may be only 90 Ω and 450 Ω. The latter is a little low, but if we include a 22 Ω fixed resistor we have for the preset a minimum range of 22–112 Ω and the minimum required values of 58·6 Ω plus the 450 Ω of the gain control gives 508·6 Ω which is greater than the maximum of 501 Ω needed.

We shall not here go into detail about the bias networks. They are straightforward and the only difficult thing is to obtain the required range of control, despite tolerances, with standard value components. Two controls are provided for Tr_7; R_6 is a preset which is adjusted to bring V_{B8} to 2·7 V with the shift control R_8 at its mid-setting. The required output shift is $\pm 0{\cdot}5$ V to separate the traces fully. At the base of Tr_7 it is under $\pm 0{\cdot}2$ V because it is subject to the gain of Tr_7 as a base-input amplifier, which is about 2·5 times.

It will be realized that d.c. shift is permissible in spite of a.c. coupling to the oscilloscope because the switching process breaks up the different levels on the two output stages into a square wave which is passed by the a.c. coupling. Nothing has so far been said about temperature and we shall now deal with this.

It is very laborious to do this taking all tolerances into account and, in any case, we have not sufficient information to do it accurately. We take all transistors as having a temperature coefficient of 2 mV/°C which acts to increase the collector current. At 5·6 V, the zener diode D_3 will have a coefficient of $-0{\cdot}2$ mV/°C. The mean value of $V_{B1} = V_{B6}$ is 4·575 V (Table 1). This is $4{\cdot}575/5{\cdot}6 = 0{\cdot}816$ of the zener voltage and the effective temperature coefficient of V_{B1} and V_{B6} is $-0{\cdot}2 \times 0{\cdot}816 = -0{\cdot}163$ mV/°C. The combined coefficients of Tr_1, Tr_2 and Tr_3 are 6 mV/°C and so the coefficient of V_{E3} is $6 - 0{\cdot}163 = 5{\cdot}837$ mV/°C. Both sides of the differential amplifier are alike and so it is the same for V_{E4}. At all temperatures, therefore, V_{E3} and V_{E4} move together and there is no current in R. Balance is maintained. Notice, however, that this demands equal temperatures and temperature coefficients on the two sides, and this may not be achieved in practice.

Because there is no current in R, the effective gain for temperature effects is not the signal gain of R_{C7}/R_{e3} but

$$R_{C7}/R_{E3} = 1200/2200 = 0{\cdot}545.$$

This is a very great advantage of the differential stage; the gain for in-phase signals can be small while the gain for push-pull or single-sided inputs can be large. The effective temperature coefficient, due to the circuits prior to Tr_7, at the base of Tr_8 is thus $5{\cdot}84 \times 0{\cdot}545 = 3{\cdot}18$ mV/°C. In Tr_3, an increase of temperature increases the current, but this reduces the current in Tr_7 and so a negative sign is required, to make the voltage at Tr_8 base $-3{\cdot}18$ mV/°C.

Now in Tr_7, the temperature coefficient of V_{BE7} is 2 mV/°C acting to increase I_{C7} and so acting at the base of Tr_8 in opposition to the previous one. If D_4 is a 4·7 V zener its temperature coefficient is $-1{\cdot}55$ mV/°C. The normal value of V_{BE7} is 2·515 V (Table 1). The bias reduction factor is $2{\cdot}515/4{\cdot}7 = 0{\cdot}535$ and so the effective temperature coefficient of the zener diode at the base of Tr_7 is

$$-1{\cdot}55 \times 0{\cdot}535 = -0{\cdot}83 \text{ mV/°C}.$$

This acts to reduce the collector current and so the total effective temperature coefficient of Tr_7 referred to its base is $2 - 0{\cdot}85 = 1{\cdot}15$ mV/°C.

This is subject to the gain of the stage, which is $1200/470 = 2{\cdot}55$ times, making the contribution of Tr_7 at the base of Tr_8 $1{\cdot}15 \times 2{\cdot}55 = 3{\cdot}05$ mV/°C. Combined with the $-3{\cdot}18$ mV/°C from the early circuits the total resultant is $-0{\cdot}13$ mV/°C. Virtually, therefore, we have a nominally zero temperature coefficient at the base of Tr_8. This is partly a happy chance, but only partly, for although we have not mentioned it, we chose a zener voltage for D_4 which would lead to a temperature coefficient suitable for theoretical overall cancellation. Of course, Tr_8 itself has the usual 2 mV/°C coefficient affecting its collector current.

The tolerances on the zener temperature coefficients are actually quite large. However, the major factors in achieving a low overall coefficient remain. These are the differential stage which attenuates rather than amplifies the combined coefficients of the early stages and the fact that Tr_7 temperature coefficient acts in opposition. We have not worked it out in detail, but in the worst case we should not expect the coefficient at the base of Tr_8 to exceed ± 3 mV/°C, which we consider to be reasonably small.

The switching process prevents 'internal sync' from being used. For the Marconi Instruments oscilloscope used in development the minimum signal at up to 1 MHz for 'external sync' is 0·2 V peak. The normal maximum output for fully-separated traces is 0·25 V peak. Clearly a sync output signal of around 1 V is desirable. An additional sync amplifier with a gain of about four times is needed.

Ideally, the collector loads of Tr_3 and Tr_4 do not affect the balance of this stage. In practice, they have some small effect. Tr_3 has a very low impedance load to a.c. for it is mainly the emitter input resistance of Tr_7, about 11 Ω. This is important in that signal voltages on the collector of Tr_3 are negligible and Miller effect is absent, which keeps the input capacitance of Tr_3 low.

In the interests of simplicity we have chosen to make R_{C4} give about the same voltage drop as R_{C3} and it turns out that this requires 1·2 kΩ, so that the signal on the collector of Tr_4 is of the same amplitude as that on the base of Tr_8. As Table 1 shows the IR drops in the collector of Tr_4 are a little lower than those in the collector of Tr_3 (compare V_{E7} with V_{B10}). The amplifier which follows is of the type described in Part 2, but using a p-n-p transistor followed by an n-p-n, and its circuit is shown in Fig. 5.

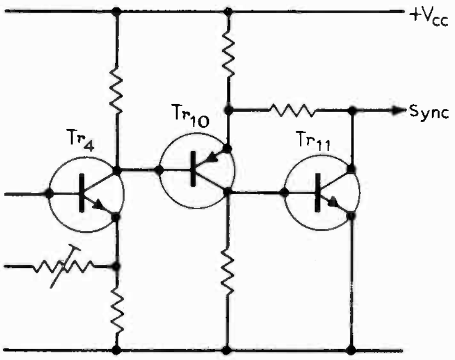

Fig. 5. An extra two-stage amplifier is used and fed from Tr_4 to provide a greater output than the main amplifier and one which is isolated from the switching signals for synchronizing the oscilloscope timebase.

Values of V_{E10} and $I_{C10} + I_{C11}$ are readily found and appear in Table 1. If $R_{C10} = 2{\cdot}2$ kΩ and $V_{BE11} = 0{\cdot}625$ V, the current in R_{C10} must be

$$0{\cdot}625/2{\cdot}2 = 0{\cdot}284 \text{ mA},$$

and, neglecting the base current, this is I_{C10}, whence $I_{C11} = 1{\cdot}7 - 0{\cdot}284 = 1{\cdot}416$ mA. The remaining figures are worked out in Table 1.

It is now necessary to consider what happens on a severe overload. In one sense of overload Tr_4 is cut-off. Then V_{B10} is zero and both Tr_{10} and Tr_{11} are cut-off, and no harm is done. In the other sense, Tr_3 is cut-off, so effectively Tr_4 has normal bias to keep $V_{E4} = 2{\cdot}7$ V, but the effective emitter resistance is $R_{E4}/2$, or 1·045 to 1·16 kΩ and it passes 2·33 to 2·59 mA. The drop across R_{C4} is then 2·66 to 3·39 V. Therefore, V_{B10} can be 3·39 V below $+V_{CC}$. In the worst case with $V_{BE10} = 0{\cdot}6$ V, V_{E10} must be 2·79 V below $+V_{CC}$ and the current in R_{C10} can be $2{\cdot}79/0{\cdot}146 = 6{\cdot}25$ mA.

Let us assume that Tr_{11} saturates, so $V_{CE11} = 0{\cdot}2$ V. Then with $V_{CC} = 10{\cdot}5$ V the drop across R_{C11} must be

$$10{\cdot}5 - 0{\cdot}2 - 2{\cdot}79 \approx 7{\cdot}5 \text{ V},$$

and the current in it may be only

$$7{\cdot}5/1{\cdot}575 = 4{\cdot}76 \text{ mA}.$$

This leaves a balance of

$$6{\cdot}25 - 4{\cdot}76 = 1{\cdot}49 \text{ mA}$$

for I_{C10}. Now V_{BE11} will change but little and so the current in R_{C10} will not change much, so the difference

$$1{\cdot}49 - 1{\cdot}16 = 0{\cdot}33 \text{ mA}$$

must be I_{B11}.

With $V_{CC} = 13{\cdot}5$ V, the drop across R_{C11} is 10·5 V, and the current in it can be 7·35 mA. This is greater than the 6·25 mA total in R_{C10} and so in this case Tr_{11} will not saturate. In either case, the conditions seem safe ones.

We have still to consider the possibilities of danger arising in the connections to the oscilloscope, the attenuator details and, of course, the switching waveform generator. Space prevents their discussion here, and these matters will be deferred to Part 4.

Announcements

For the fourteenth year a 27-lecture evening course on **colour television engineering** is being held at the Polytechnic of North London, Holloway N.7, beginning on 4th October. Fee £6. a good fundamental knowledge of monochrome techniques is assumed.

A post-graduate evening course entitled **Integrated Circuit Electronics** (Application Techniques) is to be held at North East London Polytechnic commencing 21st October. Details from The Registrar, Faculty of Engineering, North East London Polytechnic, Longbridge Rd, Dagenham, Essex RM8 2AS. Fee £5.

The following weekly evening courses are to be held at **Hendon College of Technology,** The Burroughs, London N.W.4. Electronics for non-electrical engineers, 16 meetings commencing 12th October; the construction and operation of digital computers, 16 meetings commencing 13th October; and hi-fi sound reproduction, 9 meetings commencing 11th October.

Two ten-evening courses entitled **'Basic Electronics'** are to be held at Twickenham College of Technology, commencing 14th October this year and 13th January 1972. Fee £10 per course. Further details from Twickenham College of Technology, Egerton Road, Twickenham, Middx.

An evening course of eight lectures on **microelectronic design techniques** will be held at Enfield College of Technology, Queensway, Enfield, Middx. commencing 5th October. Fee £6.

The Plessey Company Ltd have acquired the **instrument landing systems** interests of Standard Telephones and Cables Ltd which will consolidate Plessey's activities in the navaids field.

Marconi International Marine Co. Ltd are to supply a complete **v.h.f. radiotelephone network** to link the ferries, pier offices and head office of the Caledonian Steam Packet Co. Ltd of Gourock, Renfrewshire. The system comprises 18 Corvette 20S v.h.f. radiotelephone transceivers and a 20W v.h.f. base station.

Standard Telephones and Cables Ltd have been awarded orders by the British Post Office to the value of £400,000, for installation of eight TXE2 **electronic telephone exchanges.**

F.W.O. Bauch Ltd, 49 Theobald Street, Boreham Wood, Herts, announce that hiring facilities are now available for the ARP 2600 **electronic music synthesizer.** The rate is £25 per day including instruction which takes place on the Bauch premises.

FR Electronics, Wimborne, Dorset BH21 2BJ, have announced a marketing and technical collaboration agreement with Hathaway Instruments Inc., of Colorado, U.S.A.

International Audio Fair

Olympia, October 26th-30th

On this page is a list of product names which will be seen at the Audio Fair, and a list of the 20 lecture demonstrations arranged as last year but taking place in a specially built 'hi-fi theatre' on the second floor of the Empire Hall.

Wireless World will be sponsoring five events—four lectures and one recital of recorded music.

The lectures will be further explorations of ever-important questions relating to audio engineering, and may well help in establishing a more honest connection between engineering specifications and the listening experience.

The recital (4 p.m. on the Saturday) will consist of selected gramophone recordings played over a pair of small corner-horn loudspeakers based on a design published in *Wireless World* last year. The Fair is open from 10 a.m. to 9 p.m. each day.

Lecture demonstration programme

Tues. 26th Oct.

2 p.m. Acoustics of rooms by Roger Driscoll
4 p.m. Processing of gramophone records by E. B. Pinniger
6 p.m. The musical value of synthesizers by Tristram Cary (*W.W.* presentation)
8 p.m. Live, recorded, dead or alive? by Adrian Hope

Wed. 27th Oct.

2 p.m. Producing classical recordings by Christopher Bishop
4 p.m. Tape troubles by H. W. Hellyer
6 p.m. The progress of sound reproduction by Ralph West (*W.W.* presentation)
8 p.m. Women and Hi-Fi. (A bird's eye view 'brains trust'!)

Thurs. 28th Oct.

2 p.m. The development and practical use of dynamic and electrostatic headphones by Howard Souther
4 p.m. Loudspeakers—why the weakest link? by Arthur Bailey (*W.W.* presentation)
6 p.m. An eccentric look at the record repertoire by Donald Aldous
8 p.m. Silence and music by R. Berkovitz

Fri. 29th Oct.

2 p.m. Multi-channel recording by Robert Auger
4 p.m. Record rejuvenating by A. C. Griffith
6 p.m. Design problems in audio amplifiers by J. L. Linsley Hood (*W.W.* presentation)
8 p.m. 'Feed-back chat'. (A 'brains trust')

Sat. 30th Oct.

2 p.m. Audio tape cassettes and cartridges by Walter Woyda
4 p.m. Recital of recorded music (*W.W.* presentation)
6 p.m. From all directions. Microphone problems discussed by R. H. Fisher

Readers who hope to attend one or more of the *Wireless World* presentations may care to send questions on the subjects to be explored. A selection of queries received will be put to each lecturer at the end of his discourse. Submissions should be brief, preferably broadly based, and addressed to The Editor, *Wireless World*, Dorset House, Stamford St., London S.E.1.

On the *Wireless World* stand at the Fair will be working demonstrations of audio equipment built to designs published in the journal. It is planned to interconnect the various items and provide a rank of good quality headphones for the use of visitors.

AKG
Agfa-Gevaert
Akai
Amstrad
Armstrong
Audio Technica

BSR MacDonald
Bang & Olufsen
BASF
Bell & Howell (AR)
Bib
Brahms/Medway
Bush (Arena)

Celestion
Connoisseur

Decca
Dynatron Radio

EMI
Emco
Enquiry Recorder Systems

Ferguson
Ferrograph

Garrard
Goldring
Goodmans
Grosvenor
Grundig

HMV
Hacker
Harman-Kardon
Heathkit
Howland-West

ITT/KB

KEF
Keletron
Kellar
Koss

Lansing
Leak
Luxor

MB Mikrofonbau
Marconiphone
Markovits
Metrosound
Musonic

National Panasonic
Nivico

Onkyo
Ortofon

Paddock Tidy Recorders
Philips
Pickering
Pioneer
Precision Tapes
Pye

Quad

R.C.A.
Reslosound
Revox
Rota
Rotel

SME
STE-MA
Sansui
Sanyo
Scotch
Sennheiser
Sharp
Shure
Sinclair
Sonotone
Sony
Stax

Tandberg
Tannoy
Telefunken
Thorens
Trio

Uher
Ultra
Unlimited Sound

Wharfedale
Wien

Field-sequential Colour Television Receiver

2—Circuit details

by T. J. Dennis, B.A.

The automatic phase control system used for synchronizing the rotation of the colour wheel is straightforward in operation. Its circuit is shown in Fig. 1. The design finally adopted is heavily dependent on the motor used and the torque it is required to produce; that shown here should be used only as a guide.

The prototype motor came from a piece of domestic equipment, and was intended for series operation from a.c. mains. Access to field and armature windings separately was obtained, and tests showed that the motor would produce adequate torque at 1000r.p.m. with 12V on the field winding and 19V on the armature, at 600 and 200mA respectively. The control circuit (Tr_{6-11}) was therefore designed to give the latter output voltage for an input at the base of Tr_5 of 6 volts. Silicon diodes D_{5-7} are voltage droppers, giving a total drop of approx. 2 volts.

In operation either field sync or flyback pulses (negative going) trigger the emitter-coupled astable (1)*, consisting of Tr_1 and Tr_2, at 16.75Hz. The emitter-coupled variant was chosen as it enables large mark-space ratios to be obtained, and gives a current output which can be heavily loaded without affecting frequency.

The negative going output pulse of approx. 8ms duration is fed to a phase splitter (6) consisting of Tr_3 and Tr_4. Complementary transistors are used to ensure that when the output is on 'sample' both are saturated, with the result that the pulses fed to the four-diode discriminator (7) through R_{13} and R_{14} are truly symmetrical. The negative edge of the pulse from Tr_4 is also used elsewhere in the system.

The pick-up coil L_1 (12) should consist of 500-1000 turns of 28 gauge enamelled wire wound on a U-shaped limb. Construction is not critical, provided a peak-peak output of at least 1V is obtained. The actual magnitude (in fact dV/dt on the edges) of the voltage affects the gain of the system, and therefore its transient response: excessive amplitude will cause hunting, while a low level will result in a weak and sloppy phase lock.

In operation, the output from L_1 is taken in series with a variable d.c. from R_{22} for speed control to emitter follower Tr_5, which provides a low impedance feed to the discriminator.

On receipt of the 8ms gating pulses, all four diodes of the discriminator conduct, and by balanced bridge action a path exists between Tr_5 emitter and Tr_6 base. Over a small number of cycles, C_8 charges to the potential of Tr_5 emitter, and preserves it–more or less–over the non-sampling period of 52ms. This is because the input impedance of the next emitter follower, Tr_6, is very high (approx. 600kΩ assuming Tr_6 beta= 50, which gives an 8% loss over 52ms). A further emitter follower, Tr_7, reduces again loading effects on C_8.

Next come the voltage adjusting diodes, followed by a voltage amplifier with gain 2, whose main purpose is to provide the working voltage for the motor armature plus the V_{be} drops of the three impedance-reducing emitter followers, Tr_{9} $_{10\ \&\ 11}$. As Tr_{11} has to handle appreciable current, particularly on starting, a 2N3055 is used.

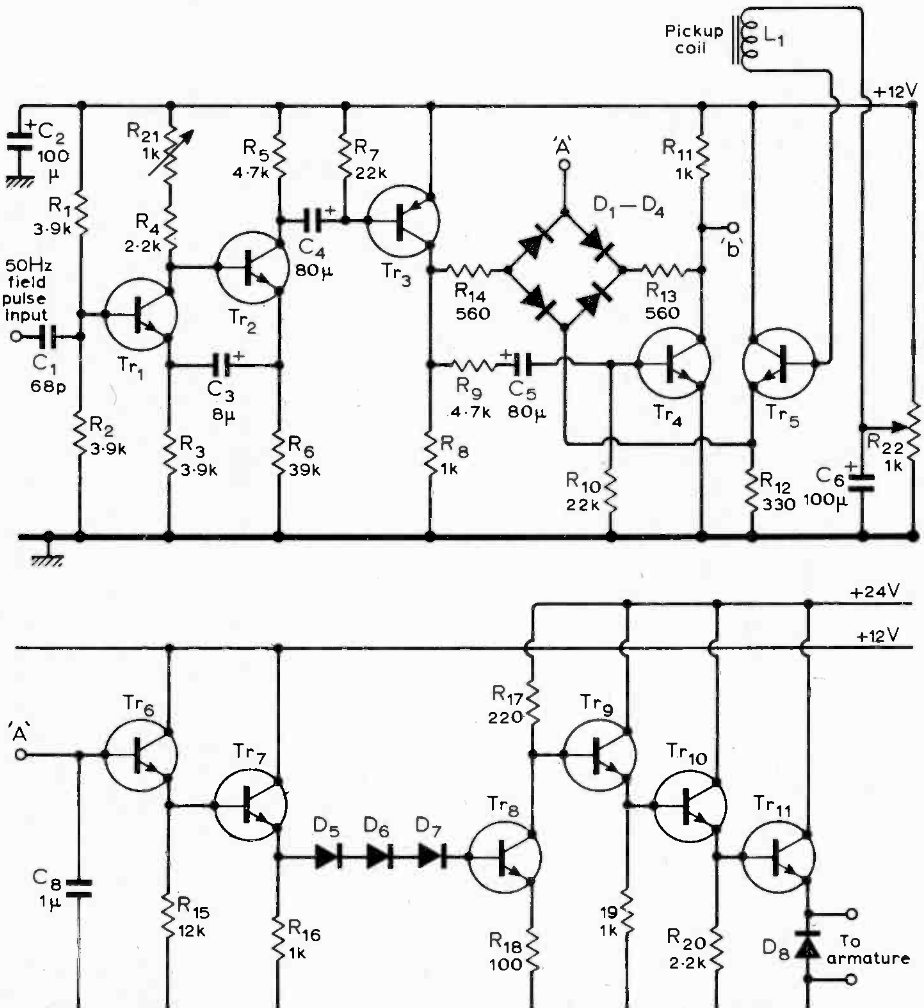

Fig. 1. Motor control system. Motor field winding is connected across 12V. Tr_1, Tr_2, Tr_4, Tr_6, Tr_7, Tr_9, ZTX300; Tr_3, ZTX500; Tr_5, Tr_8, Tr_{10}, 2N697; Tr_{11}, 2N3055; D_1-D_7 1N914; D_8, BY100.

*Numbers in brackets refer to the block diagram of Fig. 1, Part 1.

Diode D_8 is essential to suppress the negative voltage transients which will appear across the largely inductive armature at switch-off.

It should be pointed out that the above circuitry is suitable only for relatively small motors driving colour wheels of the simple type described last month. Once the diameter of the disc becomes much greater than, say, 15 inches, windage accounts for a considerable power loss, and a larger motor is required. The problem was overcome in the case of the writer's 23in. wheel by the use of a d.c. shunt-wound motor, intended for 220V at 0.5A. This is supplied with 300V for its field, while the armature is fed from a typical variable series-regulated feedback-stabilized high-voltage power supply. The lower limb of the voltage controlling potentiometer on this unit is replaced by a pentode valve whose grid is fed directly from Tr_8 collector, Fig. 1. Adjustment of R_{22}, and the cathode resistor of the pentode enables a mean output of 160 volts to be obtained, which will run the motor at 2000 r.p.m. Coupling to the colour wheel shaft is effected by means of a 2:1 reduction belt drive.

The low level parts of the a.p.c. system are retained unchanged.

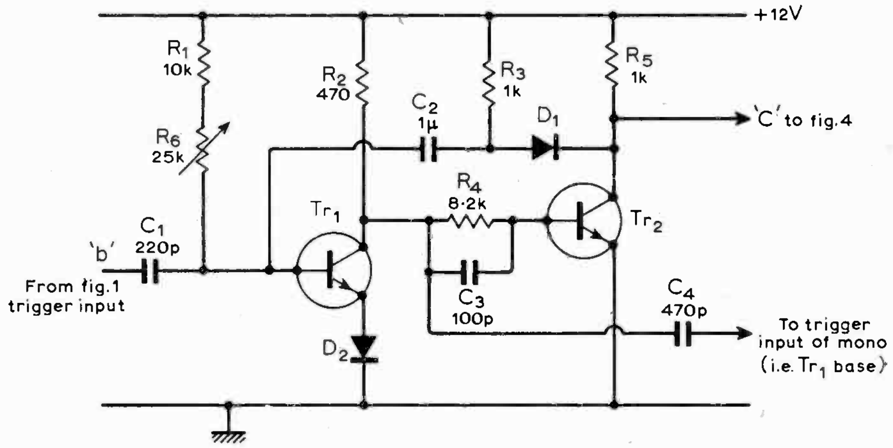

Fig. 2. Red gating pulse generator. Tr_1, Tr_2, ZTX300; D_1, OA91.

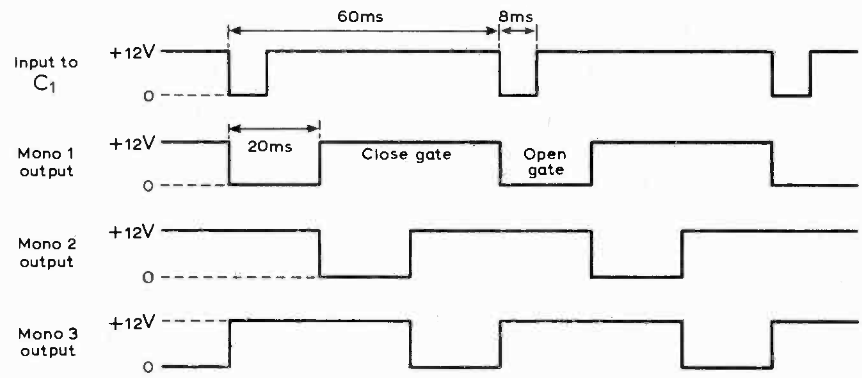

Fig. 3. Ideal monostable outputs.

Colour switching circuits

The gating pulses generator consists of three identical monostable multivibrators, the circuit of the first being shown in Fig. 2 (2R). On receipt of a negative edge from TR_4, Fig. 1, the circuit produces complementary pulses at its outputs, of width dependent on the time constant of $R_6 + R_1$ and C_2. Variable resistor R_6 is adjusted to obtain pulses of as near as possible 20ms. Diode D_1 is included to sharpen up the trailing edge of the negative going output from Tr_2, which would otherwise be partially exponential as C_2 would have to recharge, once Tr_2 turns off after the quasi-stable period of 20ms, through R_5. This task is now performed by R_3, D_1 being immediately cut off by the positive excursion of Tr_2 collector.

The trailing edge of the positive pulse from Tr_1 collector is differentiated by C_4 and used to trigger the following monostable, which in turn, on completion of its 20ms pulse triggers the third, the resulting waveforms being as shown in Fig. 3. The next input edge then appears at Tr_1 base, and the sequence is repeated.

Fig. 4 shows the circuit of one of the three gate units and the output circuitry.

The colour difference inputs come directly from the collectors of the first stage amplifiers of the May 1969 *W.W.* article, Fig. 1. These amplifiers are operated at full gain, independent gain control being provided at the gate inputs.

Emitter follower Tr_1 is mounted on the decoder board with R_{19} on a small panel nearby, as are the other two colour-difference gain controls. Its main purpose is to isolate the matrixing stages. As the d.c. levels of the decoder outputs are rather high, 12V zener diodes provide a suitable drop. The amplitude controlled input is a.c. coupled to emitter follower Tr_2 which sets up the correct mean d.c. condition for the gate proper, $Tr_{3\ \&\ 4}$ and provides a low-impedance source.

When the gate is closed, Tr_3 base is forward biased through R_8 from the relevant monostable, now in its stable state. The bias of approx 1mA is suffi-

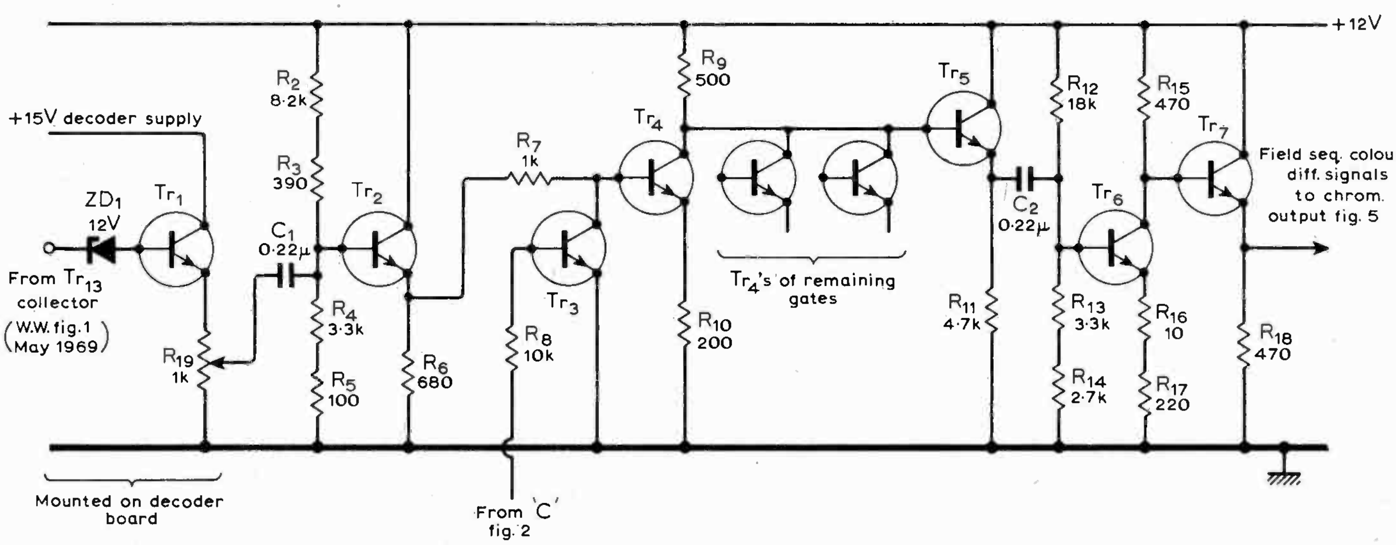

Fig. 4. Colour gating circuitry (only R – Y gate shown in full). Tr_1, Tr_2, Tr_3, Tr_4, Tr_6, ZTX300; Tr_5, Tr_7, 2N697.

cient to cause Tr_3 to bottom, with its collector load of R_7 fed from a 2.7V source. The base of Tr_4 is thus clamped at zero volts and the transistor is cut off. No signal can then reach the common load R_9. Once the monostable changes to its 20ms quasi-stable state, Tr_3 is cut off, and Tr_4 behaves as a conventional series feedback amplifier, with collector load R_9 and theoretical gain 2.5.

It should now be clear how the complete system operates: the Tr_3s are switched off in turn, enabling the required colour difference signal to appear at the output.

Theoretically there should be no change in the d.c. level at Tr_5 emitter as colour changeover occurs, as the gate circuits are identical. However, some differences are unavoidable due to component tolerances. Small potentiometers of the order of 100 ohms can be included in the d.c. setting bias chains at the inputs, and adjusted for minimum pedestals on the output waveform with no signal input.

An effect which will almost certainly occur is that due to incorrect setting of the pulse width controls in the monostables. This results in a positive or negative pulse at Tr_5 emitter according as the total period of the monostables is less than or greater than 60ms. The pulse will occur between the completion of one colour sequence and the initiation of the next; its effect may be eliminated by ensuring that the period is slightly too long, when the negative pulse is inverted twice, by Tr_6 and the valve chrominance output stage, to cause beam cutoff at the c.r.t. grid.

Long term stability of the monostables has proved sufficient for the application, provided a stabilized power supply is used; logic circuits to generate the gating pulses were considered, but rejected in favour of the simplicity of the above arrangement.

Fig. 5 shows the chrominance output circuit to drive the c.r.t. grid and is based on that of the June 1969 *W.W.* article, Fig. 1. The choice of valves is purely because they were to hand. An ECL84 or PCL84 could replace either.

The chief modification is in the facility for varying the clamping potential of the triode for brilliance control by means of R_9, this system has proved more efficient in operation than that described in the relevant *W.W.* article, and enables a conventional 'video amplifier' to be used in the luminance channel.

The luminance output stage is the original monochrome circuit with the addition of the luminance delay line. Fig. 6 shows the circuitry round the latter.

Transistor Tr_1 is a phase splitter, with 1kΩ collector load to match the delay line impedance. Chrominance is taken from the emitter circuit, which includes a 4.43MHz trap, *L*, C_2. Video is also taken from this point to the additional sync separator providing PAL switching pulses and timing for the burst gating pulse.

Losses in the unit are counteracted by inclusion of networks R_4, C_3 and R_{11}, C_6 which adjust the gains of the two amplifiers. D/C. restoration is provided at the video amplifier grid by C_7, R_{12} and D_1.

The circuit of Fig. 6 was inserted directly in the feed to the v.f. output stage of the monochrome receiver after the existing 6MHz sound take-off coil.

Auxiliary sync separator

It is not feasible to use the existing receiver sync separator in place of what is to be described, since the pulses extracted therefrom carry the 600ns delay imposed by the luminance delay line.

Fig. 7 shows the complete burst-gating pulse generator, used to operate a four-diode bridge placed in series with C_7 and Tr_3 base of Fig. 2, *W.W.* April 1969. P_3 is then connected to a decoupled potential divider at approx 4 volts. Capacitor C_9 is then connected to the C_7 side of the bridge.

Referring to Fig. 7, Tr_1 is an inverting amplifier feeding the sync separator proper, $Tr_{2\ \&\ 3}$. Transistors Tr_4 and Tr_5 constitute a monostable giving a pulse (of width sufficient to encompass the colour burst) triggered from the trailing edge of the line sync pulse. This pulse is amplified to 15V, and phase inverted twice to provide gating current for the burst gating bridge.

The negative pulse at Tr_9 emitter is also used for triggering the PAL bistable in the decoder, and gating *out* the burst at D_1 of Fig. 1, *W. W., May 1969.*

Power supplies

For simplicity it was decided to operate all solid-state sections of the system from rail voltages of 12 and 24V, deriving all other levels from these as required.

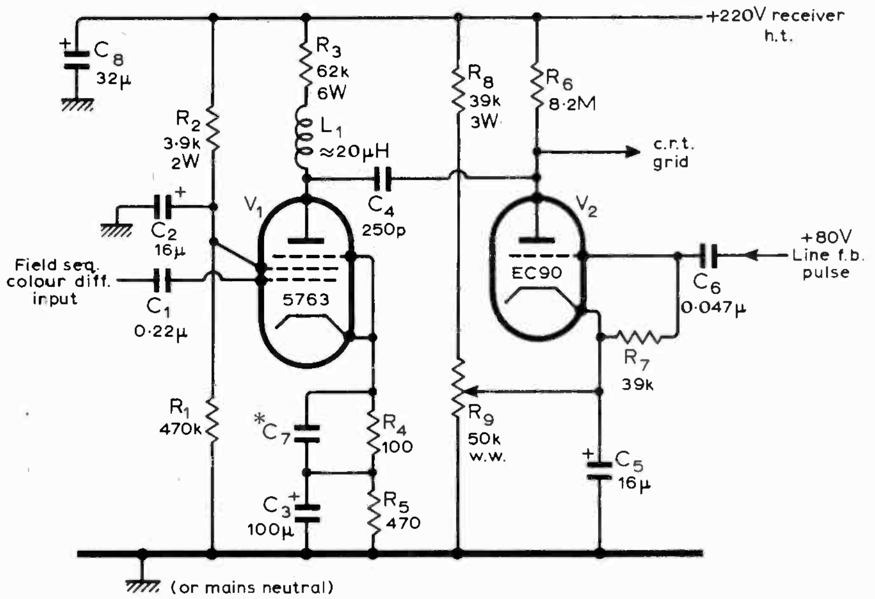

*Fig. 5. Colour difference output stage. The +80V line pulse can be obtained from a winding of about six turns of p.v.c. insulated wire on the line output transformer. *C_7 should be adjusted for optimum frequency response.*

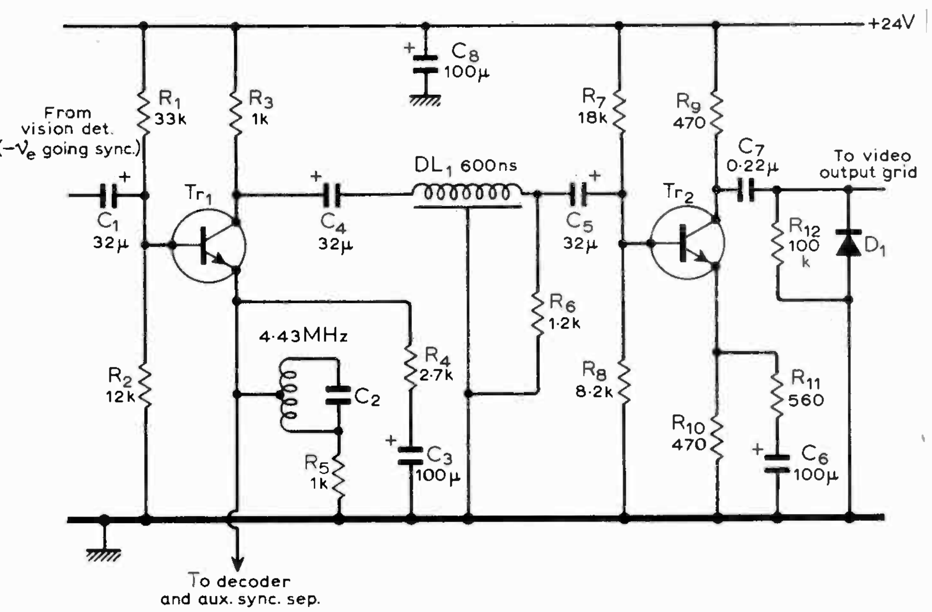

Fig. 6. Luminance delay line. Tr_1, ZTX300; Tr_2, 2N697; D_1, 1N914.

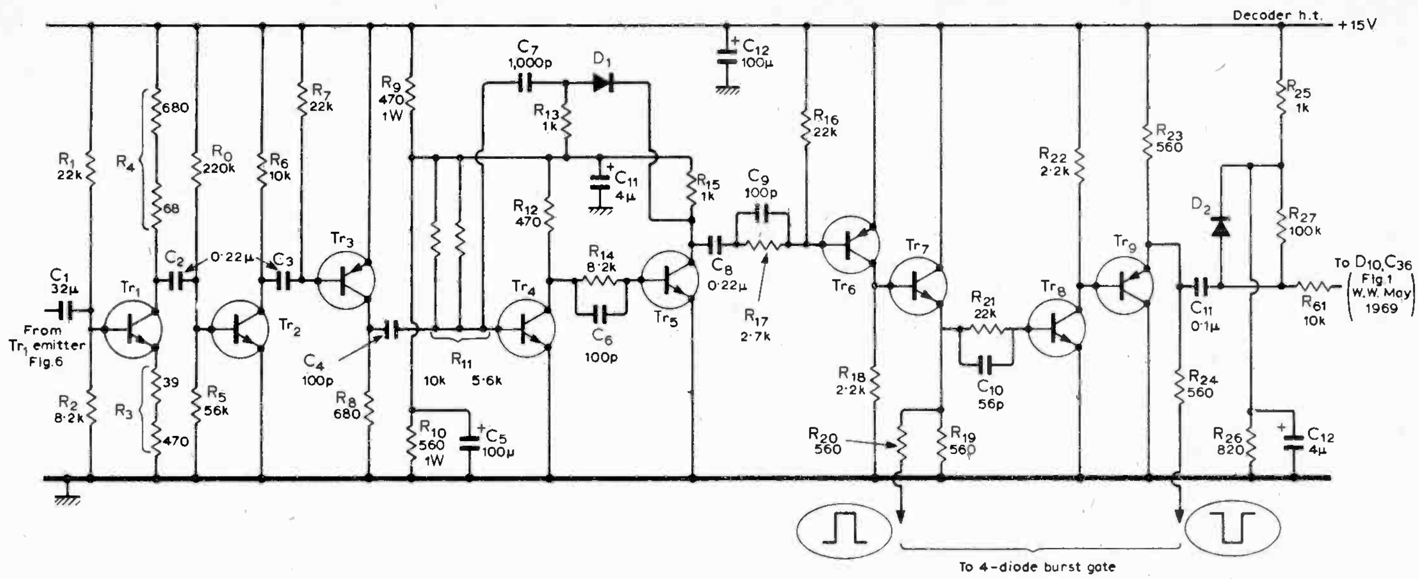

Fig. 7. Auxiliary sync separator and burst gating pulse generator. Tr_1, Tr_2, Tr_4, Tr_5, Tr_8, ZTX300; Tr_3, Tr_6, ZTX500; Tr_7, 2N697; Tr_9, MM1614; D_1, 1N914; D_2, OA91.

The basic voltages came from two 12-V series stabilizers, in series and fed from isolated windings on one transformer.

Fig. 8 shows the circuit, based on a Ferranti 'E-line' transistors application report, of one of the supplies; it is conventional in form, the output voltage sets itself to that defined by the zener voltage plus the 0.7VV_{be} of Tr_1.

Transistor Tr_5 is a crude, but adequate, current limiter operating at approx 2.1A; i.e., that current required to drop 0.7V across 0.33 ohm. The 2N3055 (Tr_4) must be mounted on a suitable heat sink.

The +15V supply for the decoder is derived from the +24V rail by a third series stabilizer, identical to that of Fig. 8, but with the omission of Tr_4, Tr_5 and R_4. ZD_1 (now a 15V specimen) and the load are connected to the emitter of Tr_3.

The +20V supply for the decoder was obtained from a single 20V zener fed via a 470Ω resistor from +24V.

The −20V necessary for the colour difference amplifiers and other parts of the decoder circuit presented some problems, however. The rather complex solution of Fig. 9 was finally adopted. It consists of an astable multivibrator running freely somewhere below line frequency, its complementary outputs being buffered by two emitter followers, Tr_3 and Tr_4, from a pair of peak rectifying circuits, D_{5-8}. The circuit provides a no-load output of 24V, the internal impedance being set by the 560Ω emitter loads of Tr_3 and Tr_4. No physical zener series resistance is therefore provided for ZD_1, which stabilizes the output at −20V: the demanded current is approx 3mA.

Setting-up

The basic assumptions made here for setting-up are that the constructor has access to a double-beam oscilloscope and a reliable source of colour difference signals, as well as line flyback, composite video and field sync.

(1). The master astable, Tr_1 and Tr_2 of

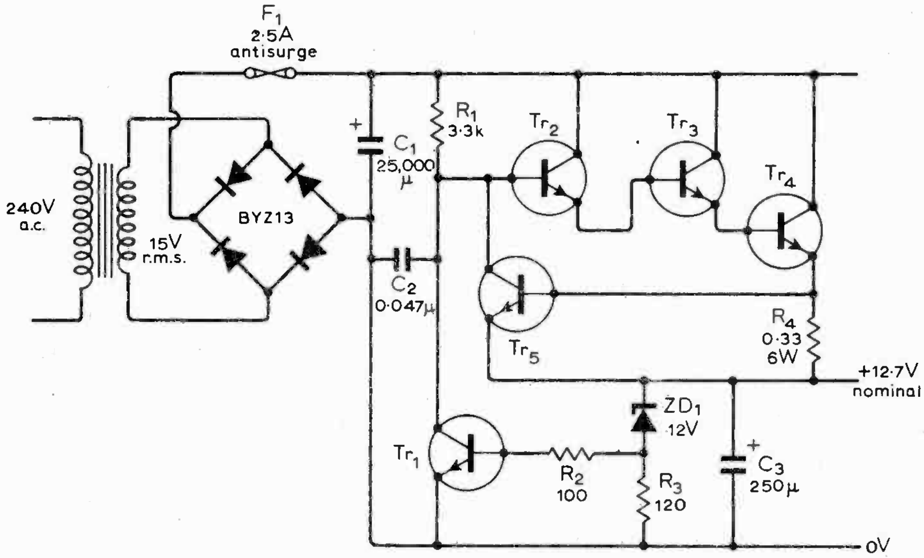

Fig. 8. 12V stabilized power supply. Tr_1, Tr_5, ZTX300; Tr_2, Tr_3, 2N697; Tr_4, 2N3055.

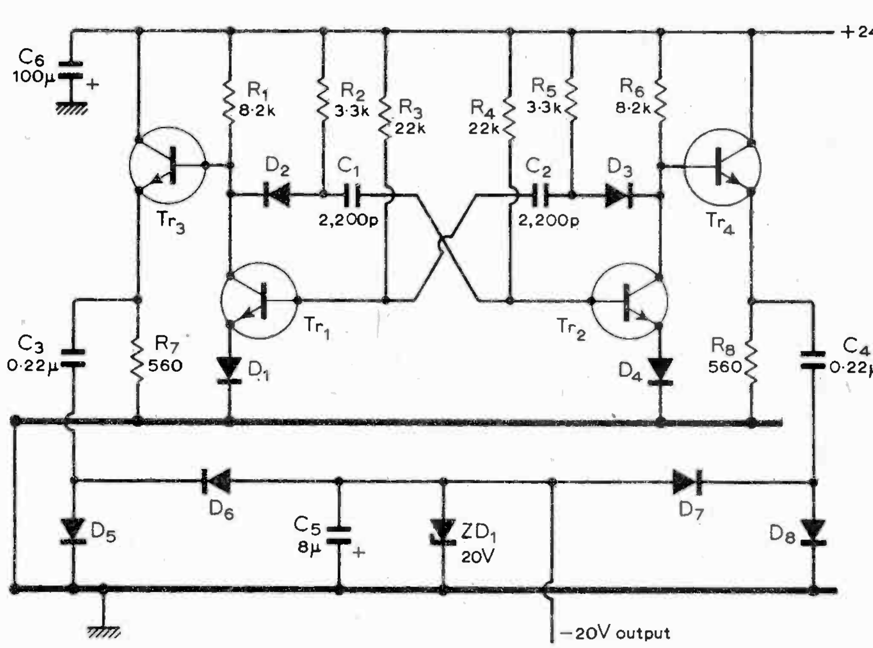

Fig. 9. −20V power supply. Tr_1, Tr_2, ZTX300; Tr_3, Tr_4, 2N697; D_{1-8}, OA91.

Fig. 1 must be set to divide by three the incoming 50Hz field frequency. Operation in a division mode depends on the amplitude of the sync pulse used, and this should be adjusted experimentally to obtain the maximum range on R_{21} within which the division ratio is maintained. The input pulses must also be entirely free from line frequency transients, which will seriously impede synchronization.

The best method is to take the separated field sync pulse from the monochrome set used through a simple *RC* low-pass filter to a limiting amplifier, thence (negative going) to the astable.

(2). Check that Tr_3 and Tr_4 produce positive- and negative-going 8ms 12V pulses respectively at their collectors, and that both transistors remain saturated during the pulse period.

(3). With R_{22} set to give 6V at Tr_5 base, check the voltage at Tr_7 emitter, where it should be approx 3.9V. Also check that this voltage varies with variation of the setting of R_{22}.

(4). Having previously tested the motor under operating conditions for the voltages required for running at 1000 r.p.m., make suitable variations in R_{17} and R_8, and the presence or absence of D_{5-7} to obtain the required armature voltage at Tr_{11} emitter. *Note 1.* A rheostat can also be included in series with the field winding if necessary, but remember that a reduction in field current, while increasing the speed of an ideal shunt wound motor, also increases the armature current proportionately. Torque remains constant.

Note 2. The velocity of the motor can best be determined by making use of the waveform from L_1. Trigger the oscilloscope from the $16\frac{2}{3}$Hz pulses from the master astable (itself running correctly) and display them on one trace. The second trace carries the coil waveform which is visually compared in period and phase with the 60ms of the timing trace.

(5). With L_1 disconnected and R_{22} slider (Fig. 1) connected directly to Tr_5 base, adjust R_{22} until the motor runs as nearly as possible in synchronism (using the method of Note 2.). L_1 should then be brought into circuit, when the motor phase should move to a locked position after a few damped oscillations. If oscillations continue experiment with the gain of the control circuit, and the value of C_8. A convenient means of reducing the effective gain is to move the pickup coil away from the rotating magnet.

(6). The angular position of the magnet relative to the coil must be adjusted to ensure that the correct coloured filter is moving past the c.r.t. at the correct time. A rough positional guide is to place the bar magnet so that one of its ends points to an angular position on the wheel just ahead of the commencement of the first colour in the sequence, which in the prototype is the red. See also step 13.

(7). Adjustment of monostable periods. With one trace of the oscilloscope displaying at least three field flyback or sync pulses, and the other the quasi-stable period of the first monostable, trigger the 'scope on the $16\frac{2}{3}$Hz pulses.

Adjust R_6, Fig. 2, until the pulse period of the monostable is equal to that between two field sync pulses.

Check that the second monostable is being triggered reliably by the trailing edge of the first, and repeat the adjustment for width. If triggering is unreliable or absent, increase the value of C_4 to 560pF.

The 'scope should then be reconnected to display the first monostable output on trace (1) and the third on trace (2). Trigger from the trailing edge of the first monostable output. Adjust the period of the third monostable so that it overlaps with the beginning of the next sequence by an amount not greater than the field blanking period of the incoming video. This ensures that there is no interference with the picture between sequences.

(8). With the decoder switched on, and the transmitter carrying colour bars, check that the waveforms at the emitters of the Tr_2's transistors (Fig. 4) for R−Y, B−Y and G−Y are as they should be, and not distorted or clipped, up to full settings of the saturation control on the decoder, and R_{19}.

During this test, the free ends of the R_8s should be taken to +12V to ensure that all gates are cut off.

(9). Connect the R_8s of the three colour gates to the relevant monostable outputs and with the R_{19}s at minimum, check the waveform at Tr_5 emitter for pedestals as colour change-over occurs; this is apart from the negative pulse which will be obtained between sequences if the monostables have been set up as above. If marked pedestals are obtained, suitable adjustments should be made to the bias chains at the Tr_2 bases.

(10). With the R_{19}s at full gain and a moderate saturation adjustment, the 'scope being triggered from a line frequency source, check the waveform at Tr_7 emitter, where all three colour difference signals should be visible simultaneously, with a marked flicker.

(11). With the input to C_1, Fig. 5, disconnected, check the operation of R_9 as a brilliance control with +80V line-flyback clamping pulses on V_2 grid.

(12). Check the operation of the luminance delay line circuit, Fig. 6, and that the video waveform is not clipped by Tr_1 or Tr_2 when contrast is high. With the 'scope input on d.c., check that the waveform is being d.c. restored correctly by D_1.

(13). Connect C_1 of Fig. 5 to Tr_7 emitter, Fig. 4, when coloured areas of the picture will flicker with an intensity proportional to their saturation. View the picture through the locked colour wheel, when if colours are incorrect (e.g., blue faces), re-check step 6 and reverse the connections to the pickup coil. Once the wheel is in roughly the correct phase, make fine adjustments of the relative angular positions of magnet and coil. The direction of movement necessary will become apparent through experience or common sense.

(14). With the decoder saturation control set to give a reasonable signal output, preferably with colour bars, adjust the R_{19}s of Fig. 4 to obtain colours which 'look' right. These adjustments are uncritical and straightforward.

It is best to have the saturation control high and the R_{19}s low rather than vice-versa, as this arrangement ensures a good s/n ratio in the displayed colour picture.

(15). If the circuit of Fig. 7 is incorporated in the decoder, the operation of the sync separator, Tr_2 and Tr_3, should be checked to ensure that line pulse output continues independently of picture content. Trouble will occur if Tr_1 clips the incoming waveform on highlights, with the result that burst gating pulses are lost.

The gain of Tr_1 has to be a compromise, in that it must provide adequate gain for clean sync separation on low contrast settings, but must not clip when contrast is high.

(16). The only problem likely to be encountered in setting-up the power supplies is with Fig. 9. Astables of this type sometimes fail to start oscillating on switch-on, since a stable state exists with both transistors saturated. This effect was encountered when the prototype was powered from two 12-V car batteries, the astable being started then by shorting one of the bases of Tr_1 or Tr_2 to earth. The effect does not occur with the mains power supplies of Fig. 8.

Conclusions

These articles have been written to present sufficient information on a field sequential colour TV system built by the writer to enable interested readers to do the same.

Although quite a considerable amount of circuitry is involved, none of it is particularly critical in design or construction, and is no doubt amenable to criticism, modification and improvement.

The only specialized electronic components required are the two delay lines, and the 4.43MHz crystal for the decoder.

The filters were purchased as 21 × 49 × 0.01in sheets (smaller areas are available) from Rank Strand Electric, Ltd., of 250 Kennington Lane, London, S.E.11, and are their "Cinemoid" stage lighting filters, numbers 6, 20 and 39, primary red, green and blue. This size cost 63p per sheet.

Perspex sheet is obtainable from any good builders' merchant, and can sometimes be cut to shape on request. Suitable motors were, in the author's case retrieved from the yard of a local scrap dealer.

The basic monochrome receiver used was a home-built affair, which, however, contains commercial u.h.f. tuner and i.f. plus sound and vision output units.

It is suggested that the monochrome receiver be used initially with its existing c.r.t., and a simple colour wheel, to gain experience of the behaviour of the system, before the necessary tube replacement and remounting is carried out for a larger spiral wheel. Suitable small 110° tubes are the A28-14W, giving an 11in picture, or any portable set tube. These will take the existing scan coils without modification, although width, and e.h.t. may need adjustment.

Thanks are due to the Department of Electrical Engineering Science at the University of Essex, particularly Dr. J. A. Turner.

Electronic Building Bricks

16. The Quantizer

by James Franklin

Signals originating from analogue transducers—such as a television camera or an electrical strain gauge—sometimes have to be converted, for information processing purposes, into digital form. This means that the successive values of the signal become represented by numbers (Part 4), which might be decimal, binary or based on any other radix. We have already met the idea of considering a signal as a sequence of separate values (Part 2) and the use of this concept for measuring information (Part 15).

Now a practical requirement of an analogue-to-digital converter is that it needs a certain amount of time to produce each number. Electronically each number is represented by a pattern, either in time (e.g. a sequence of pulses), or in space (e.g. an array of on/off states of electronic switches), and some interval of time, however small, is necessary to enable each pattern to be formed and distinguished from those preceding and following it. Clearly such a converter cannot operate directly on an analogue signal, which is a continuously varying quantity (i.e. has infinitely small time intervals between successive values). The best that can be done, to keep the digital representation as close as possible to a continuously varying quantity, is to convert values of the signal to numbers at a very high rate—say a million conversions per second. In practice we use the rate necessary for the job.

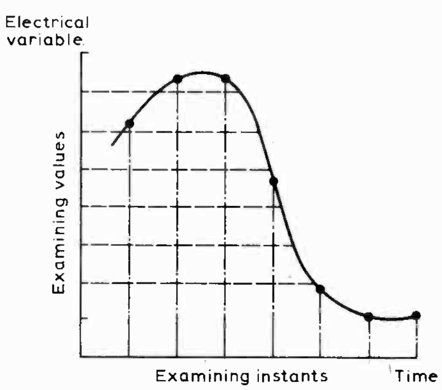

Fig. 1. Showing how a signal can be examined at regular intervals of time (indicated by dots on graph) or regular intervals of the variable which constitutes the signal.

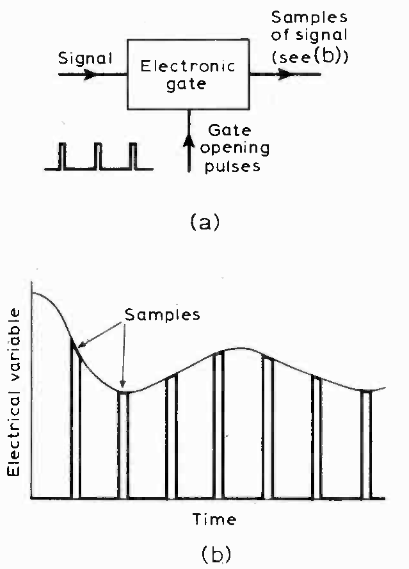

Fig. 2. Quantization by sampling, using an electronic gate (a) which is opened and closed to the signal by short duration pulses. The resulting output waveform is shown by the thick line in (b).

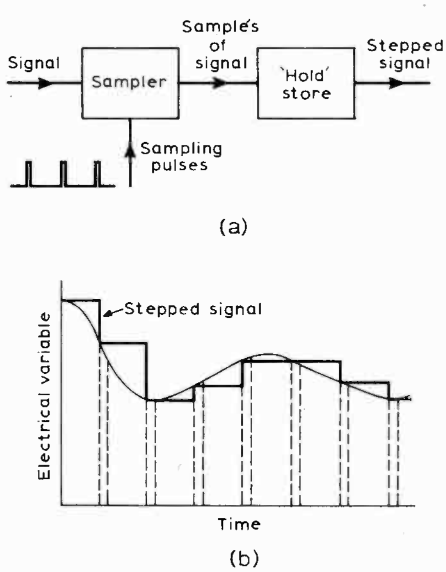

Fig. 3. Quantization by the 'sample-and-hold' method. The 'sampler' in (a) is an electronic gate as in Fig. 2. The resulting output (b) is a series of steps roughly following the original signal.

What this is depends on the accuracy of digital representation of the signal we need for a particular application. Any clock using an escapement mechanism does not indicate time continuously but it is near enough to continuous for most human purposes.

Thus the continuously varying signal must be examined at intervals. This examination could be at regular intervals of time or at regular intervals of value, e.g. voltage, of the signal (in which case the time intervals will be irregular). Both methods are illustrated in Fig. 1. This general process is known as quantization, because what was originally continuously varying is now represented as a series of discrete quantities, or quanta.

Two methods of achieving quantization of a signal are shown in Figs. 2 and 3. In Fig. 2(a) the signal is passed through an electronic 'gate' which is opened for short periods by regularly occurring pulses (from an electronic 'clock' or oscillator). What emerges from the gate, shown in (b), is a train of pulses of different amplitudes—thin 'slices' or 'samples' of the original signal. These samples may be usable as such in information processing equipment even though the tops of the pulses are sloping. If not—perhaps because the samples are of too short duration—the method shown in Fig. 3(a) may be used. Here the signal waveform is sampled as before but the initial value of each sample is stored* until the next sample is taken. Thus the information available from the store is in the form of a series of steps roughly following the graph of the original analogue signal, as can be seen in (b). This is known as the 'sample-and-hold' method.

How accurately the quanta—the samples in Fig. 2 or the steps in Fig. 3—follow the original signal graph depends on the fineness of quantization, that is, the time intervals or value intervals between samples. We have already discussed this idea in terms of the number of levels required for measuring the information in a signal in bits (Part 15). Generally speaking it is more difficult and costly to sample rapidly than to sample slowly, so engineers use the slowest rate of sampling that will define the signal to the accuracy they need for a particular purpose. To obtain the maximum possible accuracy of signal definition the sampling rate required is given by a simple formula based on mathematical analysis† of the shape of the signal graph.

One example of the use of quantizers is in an advanced type of telephone trunk transmission system now being introduced in various parts of the world. This is called pulse code modulation and it requires that the voice signals be quantized to enable them to be coded into digital form.

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*e.g. as charge in a capacitor

†Fourier analysis of the signal into component sinewaves. For full accuracy of definition the sampling rate must be at least twice that of the highest frequency sinewave that is a component of the signal.

Elements of Linear Microcircuits

12: Television receivers

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

In the 1960s transistors ousted valves from most circuit positions in domestic television receivers and now we are seeing linear microcircuits in their turn displacing transistors.

Although the U.S.A. has led the world in development of military and industrial i.cs, Western Europe has led in consumer i.cs (at least in monolithics, since in hybrids Japan has forged ahead). In Europe the main stream of i.c. development for television receivers has come from Western Germany with devices from Valvo (Philips), Siemens, Telefunken, and Intermetall (I.T.T.). Plessey in the U.K., S.G.S. in Italy and Secosem in France have also entered the field, while across the Atlantic Motorola, R.C.A., Texas Instruments and Fairchild are active.

To date the different semiconductor manufacturers have tended to adopt different approaches to partitioning the television receiver for linear i.c. substitution. As a result, second source supplies are not usually available to the set maker.

Good receiver partitioning aims at using the advantages of monolithic techniques up to a point where the replacement cost of any microcircuit is not prohibitive. A single microcircuit covering all the electronics of the receiver is possible but economically prohibitive. It looks as if the number of microcircuits in a receiver will ultimately settle at between four and eight.

Until now linear i.cs have been most widely used in the sound channel, the post-video-detector signal processing, and the colour decoder. Limited frequency, voltage and power handling capabilities have restricted their applications in other areas. Your understanding of the problems of the change-over to i.cs might well be helped by a study of my book 'Transistor Television Receivers' (Iliffe Books, 1963).

Sound channel

A natural development of the early op-amp linear i.c. was an amplifier microcircuit which gave the typical 66dB voltage gain needed in an f.m. intercarrier sound i.f. strip (200kHz bandwidth round 6MHz). The Mullard TAA350, with four current-driven, balanced, long-tail pairs giving efficient limiting and high a.m. rejection, was an example of this.

Fig. 1 (a) is a practical circuit (from the Pye 691 single-standard 625-line colour chassis) using the TAA350. The input is from an AA119 intercarrier sound detector via two 6MHz tuned circuits. Output is via an OA90 sound detector to a volume control and an a.f. amplifier.

It is relatively easy to integrate a detector stage into a monolithic amplifier, and we find many commercial examples of this such as the Mullard TAA380, Plessey SL432A and Telefunken TAA930. All the basic f.m. detector types (discriminator, ratio, quadrature, differential peak, pulse counting and phase locked loop) have been tried. Anyone interested in the merits (or demerits) of the different detector systems should consult 'A Comparison of Integrated-circuit Television Sound Systems by L. Blaser and D. Long in *I.E.E.E. Transactions on Broadcast and Television Receivers,* Feb., 1971, Vol. BTR-17, No. 1, pp. 35-43.

The long-tail pair makes it simple to

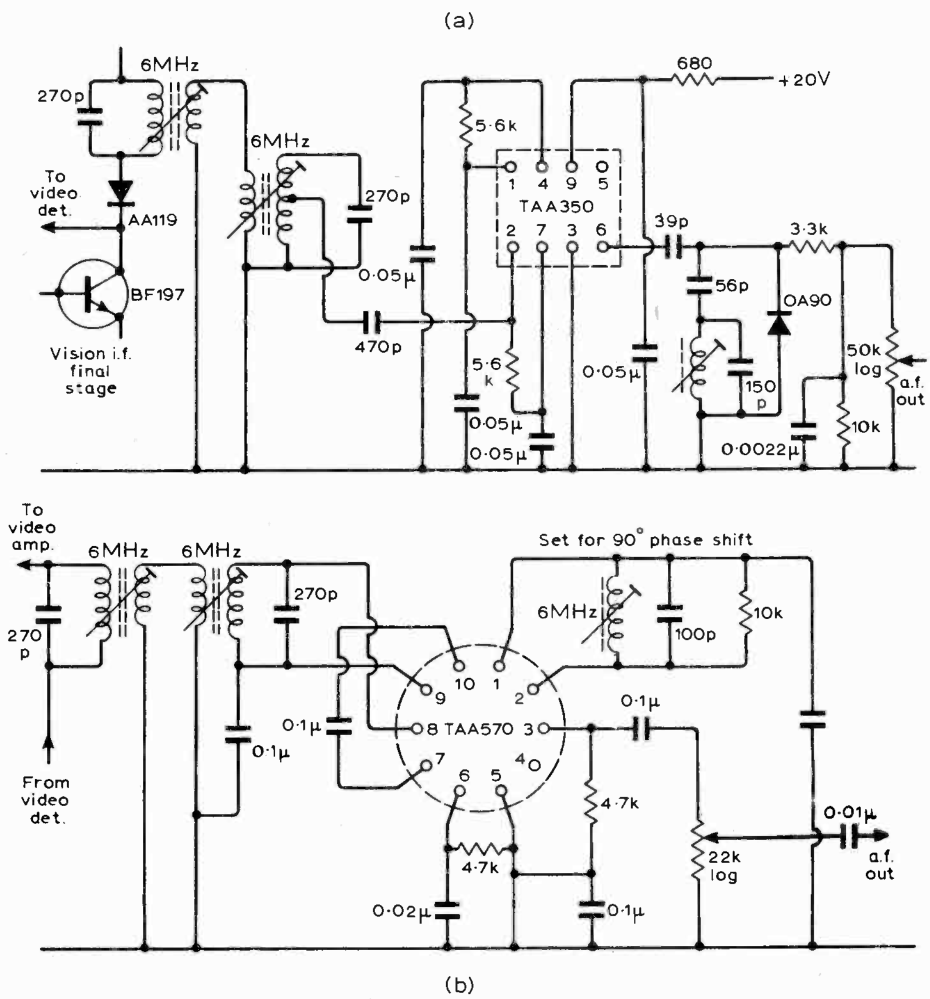

Fig. 1. Typical sound channel microcircuits. (a) Connections used with the Mullard TAA350 amplifier-limiter; (b) use of the TAA570 with integral detector.

* Newmarket Transistors Ltd

vary voltage gain by varying the d.c. bias voltage on the base of one of the transistors of the pair, and we find a group of amplifier-limiter-detector i.cs with a d.c. volume control facility that enables the volume control potentiometer to be located some distance from the microcircuit. Typical of this type of i.c. are the Mullard TAA450 and TAA570 (Plessey pin-compatible SAA570), Siemens TBA120, and SGS TBA261. Fig. 1 (b) shows how the TAA570 has been used in the Pye 169/769 monochrome (625-line only) television chassis. Sound i.f. input comes via two 6MHz tuned circuits from the video detector, detection is by a single-tuned quadrature detector, and the audio output drives a two-stage valve amplifier. (The remote d.c. volume control available at pin 4 of the TAA570 has not been used in this case.)

Extra transistors are easy to fabricate in monoliths, so that the next development was to add an audio pre-amplifier stage to the limiter amplifier. This extra stage you will find in the Mullard TAA640, TAA750 and TBA480, and in the RCA3065.

Two audio stages (a pre-amplifier and driver) appear in such amplifier-limiter microcircuits as the SGS TBA581 (to drive class AB complementary transistor power output stages) and TBA591 (for class A transistor or valve output).

All the intercarrier sound i.cs described above require some form of external audio amplifier to complete the drive to the loudspeaker. These outboard audio amplifiers are still usually discrete transistor or valve designs, but microcircuit versions are available.

Monolithic audio amplifiers up to 3W output are now fairly common. Typical examples are the Telefunken TAA900 (2W) and SGS TAA621 (3W). By suitable heat-sinking, conventional monolithic designs can be pushed up to 5W, and we are already seeing new designs (e.g. from Sony) capable of 20W r.m.s. output.

Thick film add-on audio power amplifiers from 3-50W output are now produced by many Japanese firms such as Mitsubishi, N.E.C., Sanken, Sanyo and Toshiba, and will compete strongly with monoliths.

One interesting development that seems to point the way to the final solution to integrating into a single package the whole intercarrier sound channel is the SGS monolith TBA631, which combines the functions of limiter-amplifier, detector and 3W audio amplifier into a single chip with an integral heatsink.

Jungle chips

The post-video-detector circuitry of the television receiver has received much attention from i.c. manufacturers. It has been found possible to integrate in one chip the following video signal processing functions: video pre-amplification, keyed a.g.c. detection, a.g.c. amplification for both tuner and vision i.f. control, noise cancellation for a.g.c. and sync. circuits, sync. separation, automatic horizontal sync. and, finally, vertical sync. pulse separation. This video signal processing i.c. is variously known as the 'signal processing circuit' or, affectionately and obviously, as the 'jungle chip'.

The best known example is the Mullard TAA700 (now superseded by the set out in detail here but Mullard can supply data to prospective users.

The TAA700 is designed for TV receivers equipped with transistors or valves in the deflection and video output stages, with n-p-n transistors in the tuner and i.f. amplifier, and with negative modulation. It works on a nominal 12V d.c. supply rail.

Sound/vision i.f.

Sound/vision i.fs present special problems in applying i.cs because the first i.f. stage must have a.g.c., and the requirement for many tuned bandpass and rejector circuits has tended to give the monolithic i.c., for sound/vision i.f. only applications, no advantage over discrete transistor assemblies. Away back in 1967 Fairchild brought out the μ A 717 for just such a purpose, but it was never widely adopted at least on this side of the Atlantic.

An i.c. combining the sound/vision i.f. amplifier with some later stages of the receiver can, however, make integration an economic proposition. One interesting example of this is the RCA CA3068 shown in section block diagram in Fig. 2.

The CA3068 provides a high gain (75dB typical) 45MHz wideband i.f. amplifier with 50dB a.g.c., a video detector, a 12dB video pre-amp., an impulse noise limiter, keyed a.g.c. with noise immunity, delayed a.g.c. for the tuner, buffered automatic fine tuning for varicap tuner control, separate sound i.f. amplification, sound carrier detector, 4.5MHz sound intercarrier pre-amplifier and isolated zener reference diode for regulated voltage supply. The connection diagram of Fig. 2 illustrates the simplicity of use of this i.c., particularly when the needs of the serviceman are remembered.

Another interesting approach to sound/vision i.f. microcircuitry was described in 'A Thick-film Television Video I.F. Amplifier Using Compatible Components' by R. Weber and J. Prabhakar in *I.E.E.E. Transactions on Broadcast and Television Receivers,* Nov. 1967, Vol.BTR13, No.3, pp.7-12. In this, thick film techniques were used with printed capacitors and surface mounted toroidal coils, both capacitors and coils being adjustable on test by abrasive (powder jet blast) techniques. While this approach has not been widely adopted, it has attractions because it can produce a pre-aligned plug-in i.c. requiring no adjustment by the set maker or serviceman.

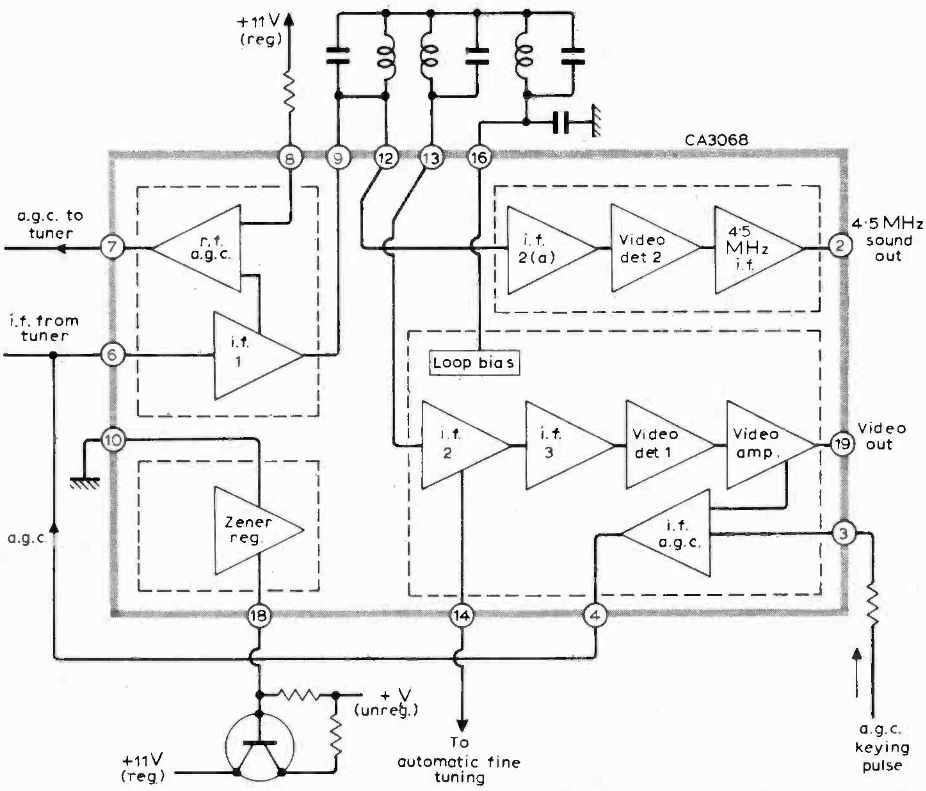

Fig. 2. Combined sound/vision i.f. microcircuit type CA3068.

Tuner

The frequencies (up to 900MHz) handled by the tuner are well beyond current monolithic i.c. capabilities. Hybrid (thick or thin film) techniques show some promise as explained in 'The New Thick-film Hybrid Integrated Circuit Module for V.H.F. Television Tuners' by K. Williams in *I.E.E.E. Transactions on Broadcast and Television Receivers,* July, 1968, Vol. BTR-14, No. 2, pp. 111-115. Plugged into the appropriate passive tuning networks, the resultant i.c. provides

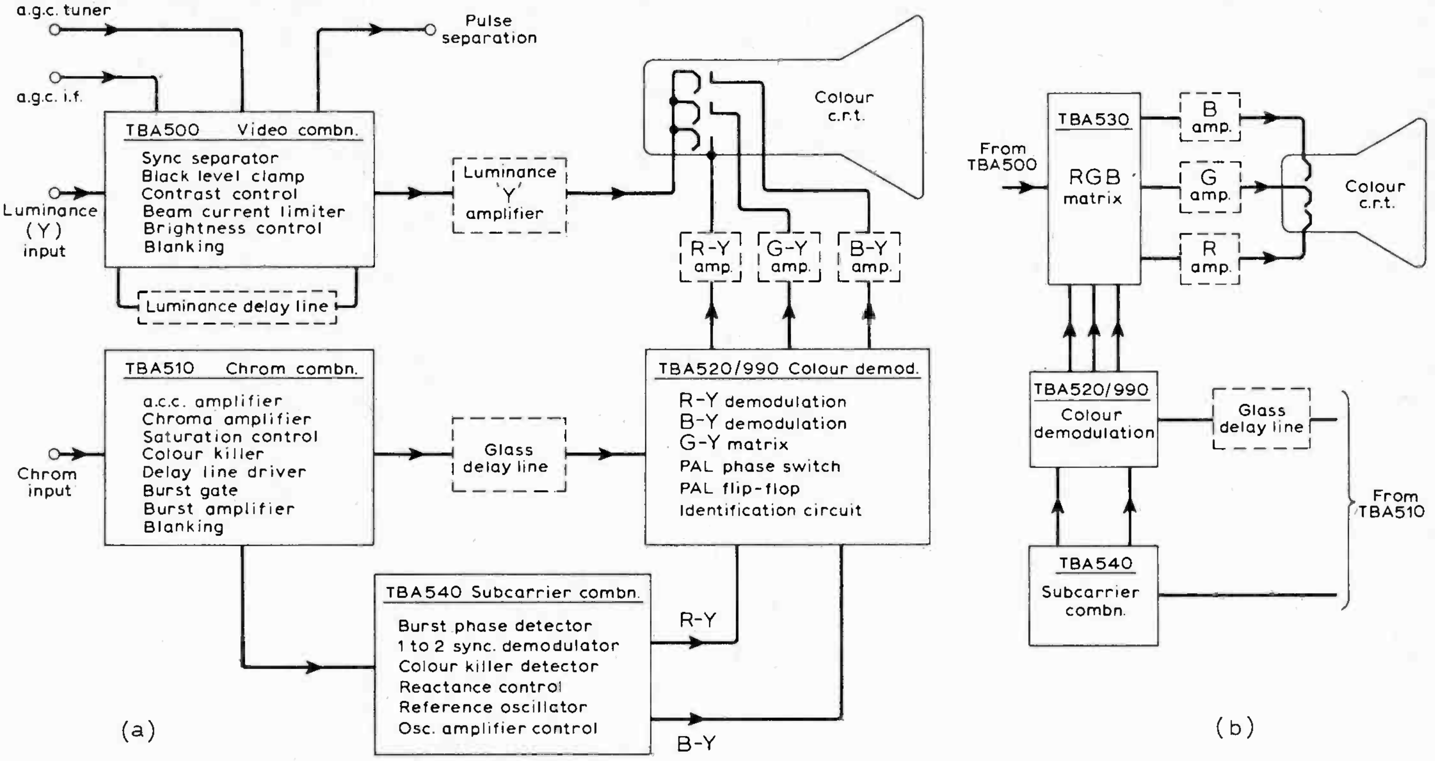

Fig. 3. Using the Mullard TBA500 series in colour receivers. (a) Colour difference arrangement; (b) RGB drive.

all the active circuitry for a v.h.f. tuner which is competitive with discrete device assemblies on the score of both performance and cost.

Most new European television receivers are now varicap-tuned, and although it has not been possible to produce a commercially viable tuner i.c., several firms have produced a self-contained voltage regulator i.c. to provide the very stable 30V or so required for varicap tuning. Typical of these is the Mullard TAA550 and Telefunken TBA940.

Colour television receivers

Some of the microcircuits described earlier, such as the tuner-varicap regulated supply, the sound/vision i.f., the sound channel, and the video processing jungle i.c., can be used in monochrome or colour sets. But a special breed of microcircuits has also been developed for colour signal processing.

There are several different approaches to the problem of handling colour signals with i.cs. The Mullard set of i.cs consists of the TBA500 video combination, TBA510 chrominance combination, TBA520 (TBA990) colour demodulator, TBA530 RGB matrix and TBA540 colour subcarrier combination. Space prevents a full description here of the internal circuitry and design problems of this family which is constantly being updated. However, for conventional colour difference drive to the c.r.t. grids, a practical system uses four of the i.cs . . . the TBA 500, 510 520 and 540 . . . . as shown in Fig. 3(a). Essentially, the luminance (Y) input to the TBA500 (which could come from the TAA700 described earlier) is amplified, delayed and fed into the Y amplifier to drive the c.r.t. cathodes. The TBA510 takes the chrominance input, centred about 4.43MHz, separates off the chrominance (R−Y. B−Y) information and feeds it via a 64 s glass delay line to the colour synchronous demodulator, TBA520. At the same time it isolates the 4.43MHz colour subcarrier information and feeds it to the TBA540 where it controls the 4.43MHz crystal carrier reinsertion local oscillator to produce a correct phase and frequency output to feed the synchronous demodulator TBA520, also taking into account the PAL phase reversal on alternate lines. In the TBA520, the demodulated R−Y and B−Y inputs are combined (matrixed) to give a G−Y signal. The three colour-difference signals are then fed through separate discrete-component amplifiers to the c.r.t. grids.

Where an RGB drive to the separate c.r.t. cathodes is desired, the fifth i.c. of the set, the TBA530 is interposed between the luminance and colour-difference outputs on the one hand and the c.r.t. RGB drive amplifiers on the other as shown in Fig. 3(b).

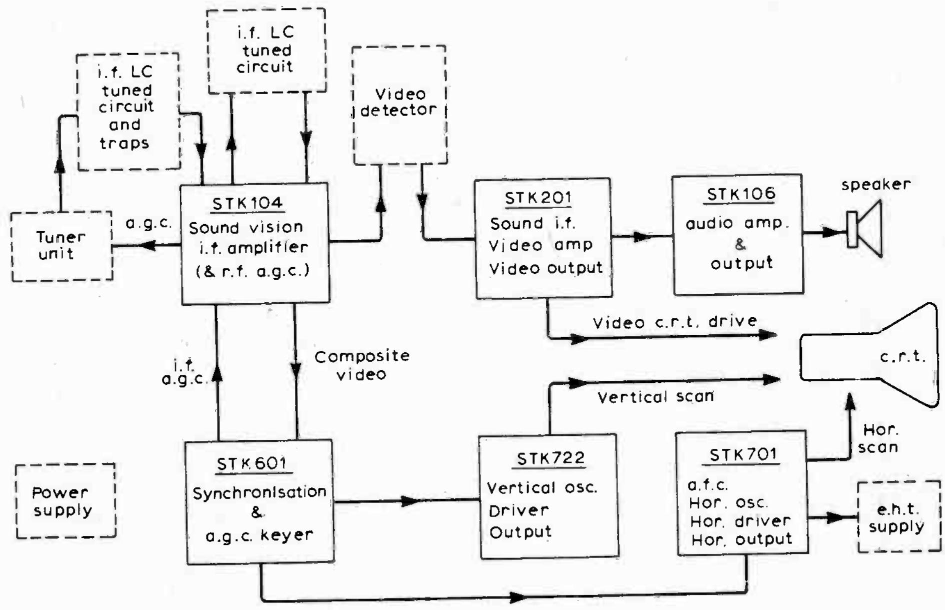

Fig. 4. Six thick film hybrid microcircuits from Sanyo provide most of the circuitry for this 17in receiver.

Interesting alternative approaches to colour signal processing can be found in 'Integrated M.T.O.S. Circuits for Colour TV Applications' by M. M. Mitchell and W. Sheets in *I.E.E.E. Transactions on Broadcast and Television Receivers,* July, 1968, Vol. BTR-14, No. 2, pp. 28-33, and in 'Colour Command—A Digital Method for Extracting the Colour Information from the N.T.S.C. Signal' by R. Weber and T. T. Fu in the same journal, July 1968, Vol. BTR-14, No. 2, pp. 52-57.

Going back to Fig. 3, it will be seen that the drive circuits to the c.r.t. are discrete component, transistor or valve. Thick film hybrids are now available to replace these, as for example in the 'Accucircuit' plug-in microcircuits produced by RCA.

Future of i.cs in television receivers

Monolithic i.cs predominate in the microcircuits for TV receivers described so far, but thick-film hybrids are beginning to offer strong competition. Fig. 4 shows in block form the use of six thick-film i.cs which provide most of the circuitry for a 17in v.h.f. receiver designed by Tokyo Sanyo Ltd. Using an insulated-metal-substrate, Sanyo can meet the high voltage and power requirements of output stages without separate amplifiers. As a result, the count of 25 transistors, 246 other parts and 553 solder joints for conventional discrete assembly is reduced to 6 i.cs, 58 other parts and 198 solder joints. For fuller discussion, you should consult 'Development of All-i.c. 17in Black-and-white Line-operated TV Receiver' by Sadao Kondo, et. al. in *I.E.E.E. Transactions on Broadcast and Television Receivers,* May, 1971, Vol. BTR-17, No. 2, pp. 98-104.

The shape of things to come can also be seen in the Matsushita (Panasonic) pocket-size receiver using eight thick film hybrids providing the functions sound i.f. and detector, audio and a.g.c., vision i.f., video detector and amplifier, sync. separator and a.f.c., vertical deflection, horizontal deflection and power supply filtering.

Finally we can expect to see a mixing of i.c. technologies as foreshadowed in a colour TV design developed at the Kansai Electronic Industry Development Centre in Japan and organized by five TV manufacturers, seven component producers, four universities and two institutes in the Osaka area. While the design uses a discrete u.h.f. tuner, the v.h.f. tuner uses a thin film r.f. amplifier and a monolithic mixer/oscillator. The 3W audio amplifier is monolithic, as are the vertical and horizontal oscillators. In the colour section, thick film is used for the chrominance bandpass amplifier, the chrominance demodulators, the matrix pre-amplifier and the subcarrier reactance oscillator, with monolithics for the colour killer, and colour burst amplifier. Both thick and thin film are used in the colour phase detector circuit.

Development is now so rapid that a pundit in the U.S.A. has been quoted as going on record that in five years time 75% of the circuitry of the televison set will be integrated in only three i.cs.

Personalities

Professor J. F. Coales, O.B.E., M.A., appointed president of the I.E.E. for 1971/2, is professor of engineering, Cambridge University, where he has been in charge of post-graduate studies in control engineering since 1952. Professor Coales, who is 64 and a graduate of Sidney Sussex College, Cambridge, held various appointments in the Admiralty Department of Scientific Research and Experiment from 1929 until 1940 when he took charge of the development of naval gunnery radar. Six years later he became research director of Elliott Brothers Ltd where he stayed until his academic appointment at Cambridge.

R. H. Barker, Ph.D., F.I.E.E., deputy director of the Royal Armament Research and Development Establishment, is the 1971/2 chairman of the Control and Automation Division of the I.E.E. Dr. Barker, a physics graduate of University of Hull, joined Standard Telephones and Cables as a physicist in 1938 and from 1941 to 1954 worked at the Signals Experimental Establishment (later the Signals Research and Development Establishment). He was made assistant director, Ministry of Supply, with responsibilities for airborne radar, navigational aids, maritime devices and air communications in 1954. Three years later he became superintendent of research at the Signals Research and Development Establishment and in 1959 was appointed deputy director of the Central Electricity Research Laboratory. Dr. Barker was technical director of R. B. Pullin & Company from 1962 until his appointment to his present position in 1965.

Peter E. Trier, M.A., M.I.E.R.E., director of Mullard Ltd, is the new chairman of the Electronics Division of the I.E.E. Mr. Trier, who is 52, graduated at Trinity Hall, Cambridge, and was on the staff of the Admiralty Signal and Research Establishment from 1941 until he joined the Mullard Research Laboratories in 1950. He became manager of the laboratories in 1953 and a director in 1957. His inaugural lecture, on October 20th, is on computer-aided design in electronics.

R. M. Hill, Ph.D., F. Inst. P., who was at one time head of the Electronics Department at the Electrical Research Association, Leatherhead, and is now reader in physics at Chelsea College of Science and Technology, is to supervise an investigation being undertaken at the College on conduction mechanisms in thick films. The work, for which a grant of £18,000 (renewable annually over three years) has been made, is being carried out on behalf of the Ministry of Defence (Aviation Supply). Dr. Hill, who is 38 and a graduate of the Royal College of Science and Technology, Glasgow, spent three years in Australia in the Commonwealth Scientific and Industrial Research Organisation and a further year as research fellow in the Clarendon Laboratory, Oxford, before joining the E.R.A. Electronics Department in 1962 as deputy head.

G. W. Mackenzie, M.I.E.R.E., has become chief engineer, B.B.C. Regions, in succession to **J. D. MacEwan,** B.Sc., F.I.E.E., M.I.E.R.E., A.Inst.P., who was recently appointed chief engineer, radio broadcasting. Mr Mackenzie joined the B.B.C. in 1941 and from 1954 until 1969 was on the staff of the Engineering Training Centre, latterly as head of technical operations section. Since September 1969, he has been in Northern Ireland, first as head of engineering and later head of programme services and engineering.

William A. Kinsman, F.I.E.E., is appointed managing director, Thorn Radio Valves & Tubes Ltd, and Thorn Colour Tubes Ltd. Until recently Mr. Kinsman was managing director of the Pressed Glass Division, Pilkington Brothers Ltd. At his own request, **C. C. McCallum,** who is 61, has relinquished the post of chief executive of both companies and will be retiring from full-time activities at the end of March 1972. After that, he will continue to serve on the boards in a part-time capacity. **J. C. King,** F.I.E.R.E., and **G. P. Thwaites,** B.Sc., F.I.E.E., F.I.E.R.E., have been appointed to the board of Thorn Radio Valves & Tubes Ltd., and Mr King, who has been engineering manager (products development), assumes the responsibility of general manager.

Arthur E. Crump, who has contributed several articles to *W.W.,* and **A. G. Witts,** B.Sc., have formed Custom Electronics (Poole) Ltd whose first product is a logic probe which can also be used as an analogue comparator and spike detector. Mr. Crump, who is managing director, was instrumentation manager at CETA Electronics and formerly principal engineer on remote control systems at Plessey Automation. Mr. Witts was also at CETA where he was responsible for design and production engineering, and previously was in the research laboratory of Plessey Automation.

E. Marland, F.I.E.E., has joined Dubilier Ltd as managing director in succession to **J. H. Cotton,** M.B.E., who has retired after over 40 years with the company. Mr. Marland was previously managing director A. H. Hunt (Capacitors) Ltd and a director of Erie Technological Products Ltd. The company has also announced the appointment of **B. V. Sargent** to the board as marketing director. He joined the company 14 months ago as marketing manager having previously held executive positions with Electrosil, M.E.C. and Plessey. The other members of the board, of which **S. Soames** became chairman earlier in the year on the retirement of **F. J. Hurn,** are **R. Davidson,** B.Sc., M.I.E.E., chief engineer and technical director, and **G. W. Wilks.**

New from Ferrograph

For the maintenance of professional recording equipment.

Now, for the first time, all the major parameters of a magnetic recording system can be measured on a single, inexpensive instrument. The Ferrograph RTS1 Recorder Test Set.

Consisting of 4 basic sections—variable frequency audio generator, millivoltmeter with associated attenuator, peak-to-peak wow and flutter meter, and distortion measuring network—this instrument will measure frequency response, distortion, crosstalk, erasure, input sensitivity, output power and signal/noise ratio.

Completely solid state and lightweight, it may be used in the field as well as the laboratory, operating on voltages of 100-120, 200-250 volts at 50 or 60 hz.

It is developed specially for those people who have to operate, maintain or service all types of tape recorders, sound-on-film equipment and audio apparatus.

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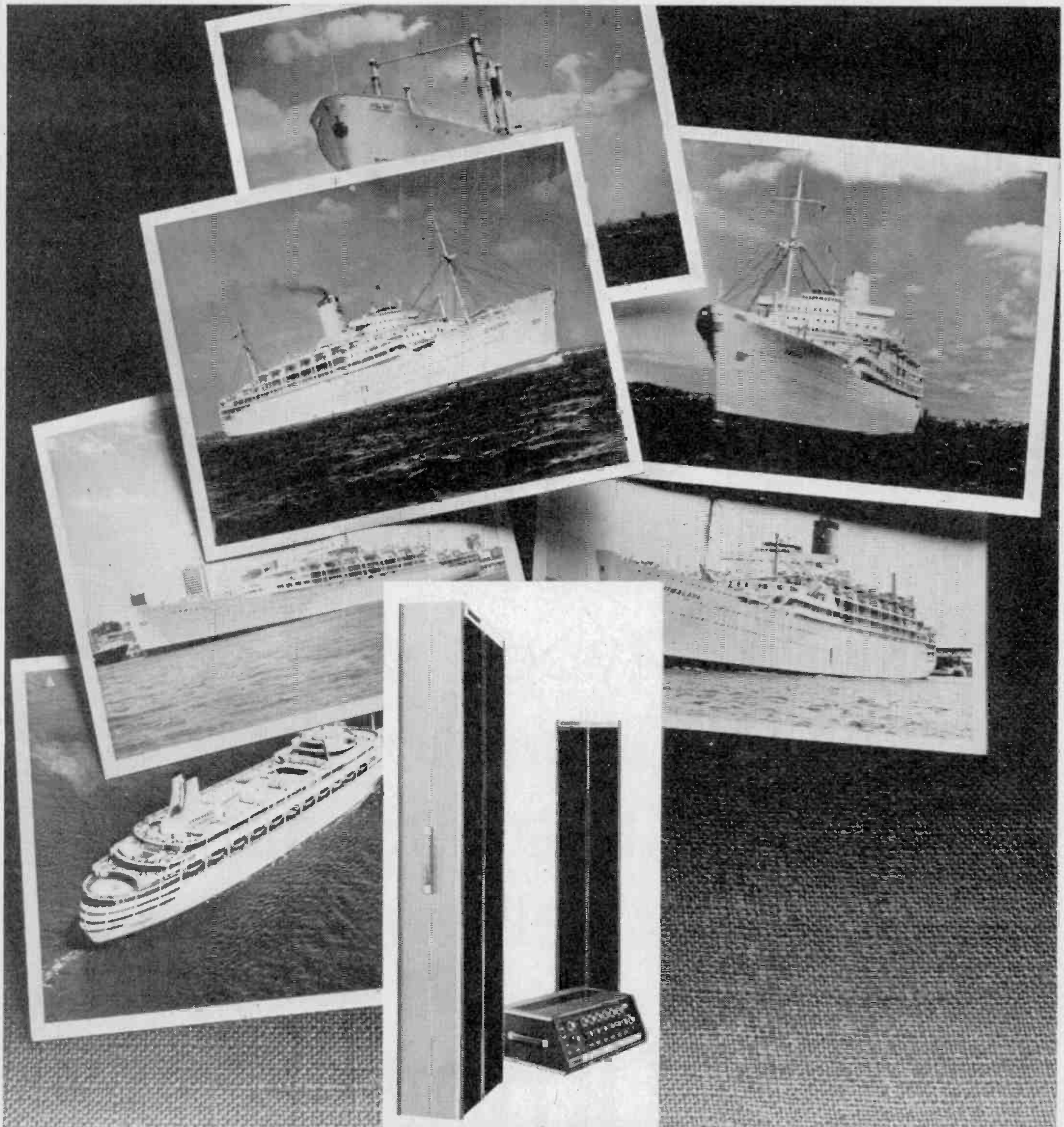

All sound and shipshape

P. & O. Lines provide top-grade artistes to entertain passengers in their luxury cruise liners. Now P. & O. have selected the Shure Vocal Master Sound System to enable the passengers to enjoy every nuance of the performances to the full. The Shure Vocal Master Vocal Projection System provides studio quality sound reproduction at sea or on land, indoors or outdoors, with completely flexible control and is fully portable. Send now for full information on the Shure Vocal Master Model VA302-E.

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WW—093 FOR FURTHER DETAILS

New Products

CCTV camera

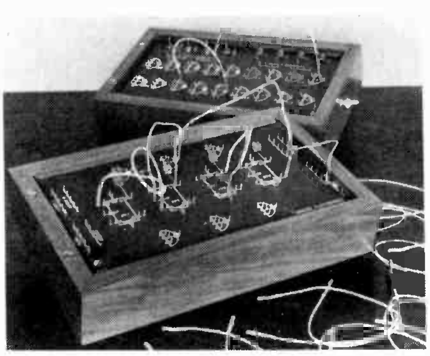
A solid-state television camera for closed circuit operation is now available from the Industrial Imports Division of Dodwell & Co. It can be connected directly to a domestic television set which is then used as a monitor. Automatic light compensation for varying light levels between 50 and 8000 lux provides stable operation over the range of 50 to 500 lux minimum. Type 7735A vidicon used in the camera has a resolution of 500 lines, and random interlace scanning is provided. The output signal is composite video/r.f. modulated at 1.5V peak-to-peak into 75Ω. Horizontal frequency is 15.75Hz, and the vertical frequency 50/60Hz. Ambient operating range is 32° to 104°F. A 220V, 50/60Hz operating voltage is required with a power consumption of 12.5VA. Weight is 6.8lb and the dimensions are 86 × 241 × 137mm. Price £101.90. A range of lenses is available. Remote control pan, tilt and zoom facilities can be provided. Viewing monitors are also available. Dodwell & Co. Ltd., Industrial Imports Division, 18 Finsbury Circus, London EC2M 7BE.

WW326 for further details

Logic tutors

A Combinational Logic Tutor from Limrose Electronics uses i.cs to provide a selection of AND, OR, NAND and NOR gates, together with input switches and output indicators, in a compact unit. Also new is the Sequential Logic Tutor designed for painless teaching of the principles of 'sequential' circuits such as binary and non-binary counters and shift registers. Both synchronous and asynchronous types of sequential circuits can be constructed on this unit. The unit also uses integrated circuits and consists of a selection of J-K flip-flops, NAND gates, a low-speed clock unit and a manual pulse generator. The outputs of the flip-flops are permanently connected to logic indicator lamps to continuously monitor their logical states. In both units, all electronic components and integrated circuits are mounted behind the front panel. This results in a 'student-proof' design which cannot be easily damaged mechanically or electrically in normal usage. Prices from £23.50. Limrose Electronics Ltd, Lymm, Cheshire.

WW327 for further details



Recorder with extra low tape speed

A multi-channel communications recorder which can record for 72 hours continuously on 31 separate channels simultaneously, is one of three new machines available from Pye TVT. Manufactured by Philips, the recorders are claimed to be the first to employ a standard tape speed of 15/32 i.p.s. Tape heads are of Ferroxcube, and there is a self-adjusting tape guide system. Three basic versions of the recorder are: (a) for 31 simultaneous channels on 1in tape; (b) for 15 simultaneous channels on $\frac{1}{2}$in tape; and (c) for 7 simultaneous channels on $\frac{1}{4}$in tape.

Each version is fitted with twin tape decks. A third deck can be added to 15- and 31-channel installations. An edge track is used to record a time reference signal as well as a pilot signal. The complete installation is normally housed in a standard 19-inch rack and has lockable glass fronted doors. Pye TVT Ltd, Coldhams Lane, Cambridge CB1 3JU.

WW 324 for further details

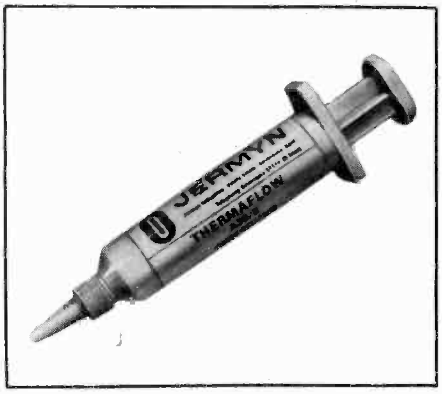
Digital audio delay system

The Gotham Delta-T 101 digital audio delay system converts audio information into digital form, stores it in this state and retrieves it at some later time controlled by switches on the front panel. Since there is no decay of the digital data while in storage, the delayed outputs maintain identical signal quality for all settings of the delay selector switches. The Delta-T101 is available as a single channel device, with the amount of time delay selectable in 5ms steps up to a maximum of 40ms. Additional plug-in output taps, up to a maximum of five, may be added at any time. Each of these will have its independent delay selection switches as well as a by-pass switch. Seven additional delay cards of 40ms each may also be plugged into the frame to bring the unit up to its maximum 320ms delay capability. Overall timing is controlled by a stable crystal oscillator. Integrated circuit operational amplifiers are used in the analogue portions of the unit. Except for the input and output transformers, direct coupled circuits are used with resultant intermodulation and harmonic distortion under 1%, even at maximum signal levels. Frequency response is 20Hz—12kHz ±2dB. Power requirement: 115/230V, 50/60Hz (100W max.) Size: standard 19in rack panel, 7in high and 17in behind panel. Gotham Audio Corporation, 2 West 46th Street, New York, N.Y. 10036, U.S.A.

WW316 for further details

Heat conducting compound

Thermaflow 2001 from Jermyn can be applied as a thin film between a heat dissipating device and heat sink to reduce the thermal resistance by as much as 50%. Electrically non-conductive, the compound will withstand a temperature of 200°C for 24 hours with a volatility of only 1%. The



compound is available in disposable syringes containing 14g (A30S—$52\frac{1}{2}$p each), and in jars containing 140g (A30J—£$1.62\frac{1}{2}$p). Jermyn Industries, Vestry Estate, Sevenoaks, Kent.

WW311 for further details

Tape noise reduction unit

The Dolby B tape hiss reduction system is now available from Kellar Electronics in the form of the KDB1 noise reduction unit. Its use as a record and replay tape signal processor results in 10% less tape hiss than the recorder would normally produce. This is achieved, it is claimed, without affecting frequency response or adding distortion. Such a system will make a large difference to cassette ($1\frac{7}{8}$ i.p.s.) and $3\frac{3}{4}$ i.p.s. reel-to-reel machines when reproducing a wide

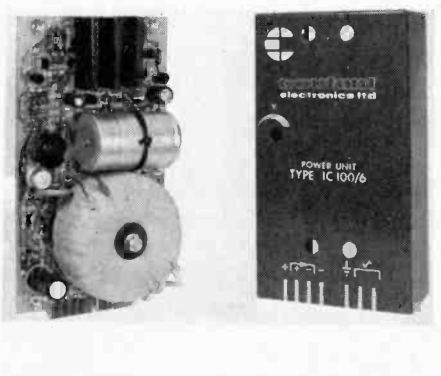
range of frequencies and dynamic levels. Inputs are 25mV into 20kΩ (record) and 25mV into 30kΩ (replay) for outputs of 580mV. Channel separation is quoted as 50dB at 1kHz and s/n ratio (including hum) better than 70dB referred to 580mV unweighted. Operation is from the a.c. mains. Price £49.50. Kellar Electronics Ltd, 6 Bycullah Avenue, Enfield, Middlesex.
WW318 for further details

Miniature resistors

A range of carbon film resistors, type Rsx 00 intended for miniaturized equipment, is available from Steatite Insulations. Each resistor measures only 0.7mm dia. × 2.5mm long. Values are from 10Ω—4.7MΩ, with tolerances of ±10% and ±20%. Steatite Insulations Ltd, Hagley House, Hagley Road, Birmingham 16.
WW317 for further details

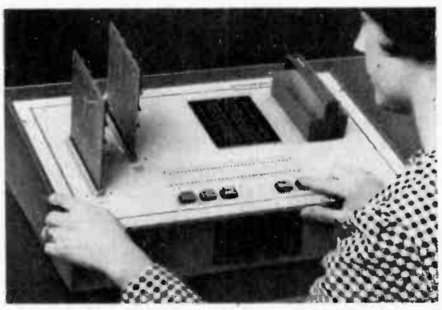
Power supply for logic circuits

IC100 miniature power supply from Coutant supplies an output adjustable between 5 and 6V at 1A. Over-voltage protection set at 6.8V is included, along with re-entrant circuitry for overload protection. Change in output is 0.02% for a ±10% input voltage change, and load regulation changes 0.1% (output voltage) for a no-load to full-load change. Ripple on the output is less than 1.5mV peak-to-peak and the unit operates over a temperature range of 0 to 55°C with a temperature coefficient of 0.03% change in output voltage for each °C change in ambient temperature. A.C. input is 100 to 132 or 200 to 264V. The unit measures 80 × 133 × 42mm. Connection to equipment is either by printed circuit edge connector or by 4mm fixing screws and soldered connections to turret lugs. Price is £14.50. Coutant Electronics Ltd, 3 Trafford Road, Reading RG1 8JR.
WW309 for further details



Swift digital tester

An 'in-house' need for a quick and simple means of testing logic circuit cards led to the design of this general purpose digital test set by the Test Systems Division of Honeywell. The equipment has its limitations and is mainly intended for tests on combinational circuits, but in certain circumstances sequential circuits can be accommodated. Testing is carried out by comparing a suspect circuit with a known good circuit. The 'master circuit' card is



plugged into a socket on the front panel. For 'one off' tests a patch panel is used to connect the d.c. power supplies and the test set outputs to the logic card inputs. All unspecified pins are assumed by the machine to be outputs. The suspect circuit card is plugged into a second socket on the front panel. The machine applies every possible binary combination to the card inputs and compares all the outputs of the two cards. If a difference occurs the sequence is stopped and a GaAs lamp display shows at which output pin an error was detected. The machine can be restarted if required whereupon it will cycle through the remaining tests. When a number of identical cards have to be tested, the patch cords can be replaced by a pre-wired plug which fits into a front panel socket. Cards to be tested can have up to 28 inputs and output fault patterns are indicated on a bank of 64 GaAs lamps. Various adaptors are available enabling different sized cards and single integrated circuits to be tested. Tests are carried out at a rate of one per μs and input and outputs are 5V t.t.l. Price is £890. Honeywell Ltd, Test Systems Division, Eton Rd, Industrial Estate, Hemel Hempstead, Herts.
WW301 for further details

Schottky barrier diode

Schottky barrier diode, type BAV46 from Mullard, has been developed for use in Doppler radar systems requiring a diode that has a low flicker noise at frequencies close to the carrier frequency, and a high conversion efficiency with or without d.c. bias when driven by low-level signals from the local oscillator. The overall noise figure is typically 10dB at 1kHz from the carrier frequency. Under typical operating conditions, forward current would be 30μA and the r.f. level 1μW at 9.375GHz. Its conversion efficiency is typically 1μA/μW. When operated as a microwave video detector with a forward bias current of 50μA and a video amplifier bandwidth of 2MHz, the BAV46 has a tangential sensitivity of −52dB and X-band frequencies (7-12 GHz). The device can be mounted across an X-band waveguide. If required, it can be supplied with a reversible end collet, type 56321, that makes the diode then conform to the DO-22 outline. The encapsulation is hermetically sealed. The operating temperature range is −55 to +150°C. Mullard Ltd, Mullard House, Torrington Place, London W.C.1.
WW308 for further details

Lightweight headset

A micro-miniature headset from Amplivox Communications, and called the Minilite, has an adjustable earphone housing which enables the user to receive incoming signals with the earphone unit resting lightly against the ear. The earphone housing is adjustable in all directions to enable the earphone to operate as a miniature speaker without physical contact. The housing rotates through 180° to enable the headset to be used on left or right ears. An acoustic tube-type microphone is used

which has telescopic adjustment for length, and also rotates for correct positioning near the mouth. The whole assembly is supplied complete with a new type of integral sliding headband. The headset can alternatively be mounted on spectacles. Weight with headband is 43.7g. Amplivox Communications Ltd., Beresford Avenue, Wembley, Middx, HAO 1RU.
WW333 for further details

High performance 42-track data recorder

An instrumentation tape recording system from SE Labs, designated SE data Series 5000, employs an eight-speed bi-directional tape transport, with a low mass integral capstan/motor assembly in a phase-lock servo. Arms produce sufficient tape tension around the capstan to dispense with pinch-rollers. These arms also act as sensors for the positional servo system controlling supply and take-up motors. Record and reproduce data amplifiers are common to all configurations of the Series 5000. Direct and f.m. modules are interchangeable. The direct reproduce module accepts up to eight plug-in equalizers which are switched automatically when the tape speed is changed. The f.m. system operates without adjustment in I.R.I.G. low, intermediate and wideband group 1 modes with eight-speed automatic switching. Flat amplitude or optimum transient filter response is selected manually by the position of the plug-in filter with respect to its socket. The 42-track recording heads of the 5000C maintain inter-track spacing at 3.81cm $\pm$ 2.54μm (1.5000in $\pm$0.0001in) and gap scatter 2.5 m (100 in). The basic price of the system is about £7,000. SE Laboratories (Engineering) Ltd, North Feltham Trading Estate, Feltham, Middx.
WW334 for further details

Reel-to-cassette duplicator

Series 235CS-1 reel-to-cassette duplicating system made by Telex, of Minneapolis, and available in the U.K. from Avcom Systems, comprises an open reel master transport and cassette slave modules. Frequency response is 30Hz –10kHz $\pm$3dB at $1\frac{7}{8}$ i.p.s, and t.h.d. less than 1% at 1kHz at '0' VU at $7\frac{1}{2}$ i.p.s. Bias frequency is 300kHz. Wow and flutter is given as 0.25% r.m.s. Crosstalk rejection at 1kHz: half track, two-channel, 50dB; quarter track, two-channel, 30dB stereo channel separation; and quarter-track four-channel, 30dB stereo-channel separation, with 45dB for adjacent stereo programmes. Signal-to-noise ratio is within 3dB of master tapes. All mechanical movements are solenoid controlled with operation from the master transport by momentary contact push buttons. Equalization for various combinations of tape speeds can be pre-set by clearly identified controls. This system, with six slaves, will produce 84 C-30 cassettes per hour. A typical duplication station, with six slaves, is priced at £1,295. Avcom Systems Ltd, Newton Works, Stanlake Mews, Stanlake Villas, London W12 7HA.
WW 320 for further details

25MHz storage oscilloscope

Oscilloscope type 2200 from Advance has a main frame with three operating modes: normal, with P31 phosphor; variable persistence; and store. A stored trace can be retained almost indefinitely and even displayed after the instrument has been switched off for a period. A range of plug-in X and Y modules are available for this new main frame:—

OS2001Y	Single trace unit.
OS2007Y	Dual trace unit–with a sensitivity of 10mV/cm from d.c. to full bandwidth.
OS2004Y	High gain differential unit–bandwidth d.c. to 2MHz–sensitivity 50μV/cm.
OS2001X	X amplifier unit–for X–Y operation.
OS2003X	Standard timebase unit.
OS2005AX	Sweep delay unit–sweep speeds 19 ranges from 200ms/cm to 40ns/cm.
OS2006X	Wide range/delay timebase unit–sweep speeds in 23 ranges from 2s/cm to 20ns/cm in 1.2.5.

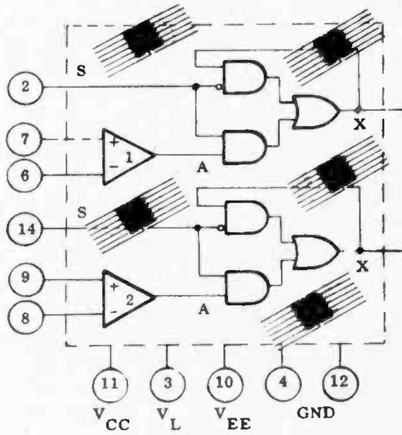
Advance Electronics Ltd, Raynham Road, Bishop's Stortford, Herts.
WW312 for further details

Range of trimmer pots

The Contelec T-84 series of single-turn, humidity-proof trimmers from Kynmore has a power rating of 0.5W at 70°C, with an operating temperature range −55 to +150°C. Size is TO-5. The standard version of the series has a dial printed on the top of the case, and an arrow on the adjuster, giving the location of the wiper on the track. Contacts are of precious metal. Solder pins are nickel- and gold-plated. Stops are provided at each end of travel. Screwdriver adjustment provides the electrical settings. The resistance range is from 10Ω to 20kΩ. Special resistance values and close tolerances are available to order. Kynmore Engineering Co. Ltd., 19 Buckingham Street, London W.C.2.
WW 307 for further details

Dual voltage comparator f.e.t.

A high-speed (90ns delay) dual-channel voltage comparator f.e.t. type L132, for analogue-to-digital conversion, has been announced by Siliconix. The device comprises two isolated comparison channels, each with a separate strobed latch on the output. Each latch is a t.t.l. type circuit, capable of driving t.t.l. inputs. The latch can change state only when the strobe is raised to the 1 level. Amplifier



comparison input error is 2mV. Common mode range is ±5V. Typical input current is 3μA, and differential input voltage 10V maximum. Supply current is 10mA maximum. The device is available as L132 CL in a TO-86 flat pack or L132 CK in a TO-116 dual in-line package. Siliconix Ltd., Saunders Way, Sketty, Swansea, SA2 8BA.
WW305 for further details

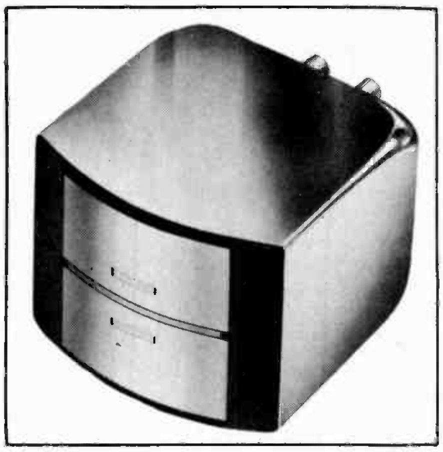
Capacitance and inductance meters

Model C1, capacitance meter, available from Sintrom Europe, has a measuring range of 0 to 30μF in twelve ranges. The ranges are in a 1-3-1 sequence with 100pF full scale as the lowest range. Nominal full-scale accuracy is 1%. The maximum voltage seen by the capacitor is 11V d.c.

Model L1, inductance meter (illustrated), has a measuring range of 100μH to 100H in twelve ranges. Nominal accuracy is 1% for inductances with a Q greater than 10. The voltage across the inductor is 50mV to reduce errors due to core magnetization. The instruments, made by Russell Laboratories in the U.S.A., are available in the U.K. from Sintrom Europe Ltd, 2 Arkwright Road, Reading RGS OLS.
WW304 for further details

Magnetic recording head

The Y28 recording head from Marriott Magnetics has been designed to meet the requirements of multi-track applications for use with standard recorded 8-track stereo cassettes. It has a rear plug suitable for interchangeable replacement with the standard of plug adopted in America. Outer dimensions of the head have also been standardized to facilitate interchangeability with other types. The head has a thick outer case of mumetal, and internal screening provides channel separation of 55dB. It is designed for a track width of 0.020in and is based on the X type using a nickel-silver headface.



Specification:

Inductance at 1kHz	400mH ±20%
resistance (d.c.)	450Ω
impedance at 1kHz	2600Ω
track spacing, centre-centre	0.127in

Output from Ampex ref. type 01-31331-01 120μs (uncompensated)

500Hz (reference level)	0.55mV ±2dB
1kHz (–10dB)	0.23mV ±2dB
7.5kHz (–10dB)	greater than +1dB above 1kHz level

The outputs of channel pairs are quoted as within 2dB of each other at any frequency in the range 100Hz to 7.5kHz.

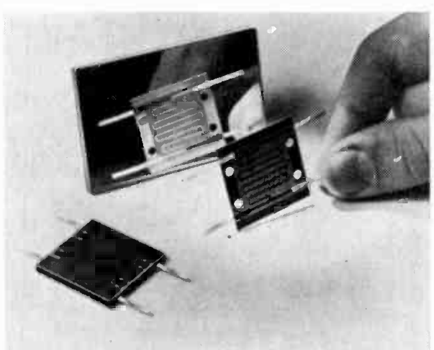
Output from own recording using 3M175 tape at 3¾ i.p.s.

bias current at 50kHz	0.25mA
record current	20μA
500Hz output	0.55mV ±2.5dB
1kHz	0.74mV ±2.5dB

7.5kHz better than 8dB below 1kHz level. Marriott Magnetics Ltd., Penryn, Cornwall.
WW 319 for further details

U.H.F. quadrature coupler

The outputs of several devices may be combined, transmission continuity retained and mismatches isolated using the quadrature coupler type MIC 5830-31 3-dB from Motorola. Mismatch problems are overcome because the application of a reflected signal at either of the output ports of the coupler results in signals at the input port attenuated by 20dB. Insertion loss is as low as 0.25 to 0.30dB, phase balance ±1.5° to 3.0°, amplitude balance 0.5 to 0.7dB, and the v.s.w.r. is 1.2:1. Transmission capability is maintained should one of a number of combined output r.f. transistors fail. Usable frequency ranges are 225-



400MHz, and 450-512MHz. The stripline devices are 31.8 × 31.8 × 3.6mm and are constructed from sealed fibreglass board. Price under £10 each. Motorola Semi-conductors Ltd, York House, Empire Way, Wembley, Middx.
WW 321 for further details

Double balanced mixers

Two sub-miniature double balanced mixers, types 1759 and 1760, from Hatfield Instruments occupy approximately one eighth of a cubic inch. The units can be used over the frequency range 100kHz to 500MHz (1759) and 10kHz to 150MHz (1760). Separate port earths are provided to reduce problems associated with common earth currents. Types 1759 and 1760 are priced at £19.80 each. Hatfield Instruments Ltd., Burrington Way, Plymouth, Devon. PL5 3LZ.
WW 303 for further details

Metal-oxide resistors

Metal-oxide films resistors, type WK, from Steatite Insulations are available horizontally or vertically preformed, with resistance values ranging from 1Ω to 100kΩ, with standard 2% and 5% tolerances. Temperature coefficients are either 200 or 400 p.p.m. Three body sizes are available: WK5, 6mm dia. × 16mm long; WK8, 9mm dia. × 20mm long; WK83, 9mm dia. × 32mm long. Power ratings at 70°C are 1.5, 4 and 6 W respectively. Steatite Insulations Ltd, Hagley House, Hagley Road, Birmingham, 16.
WW310 for further details

Marine communication receiver

Receiver HR 600-601/602 manufacturered in America by National Radio Company is available in the U.K. from Ericsson Marine. The main frame of the receiver contains all the signal path circuits—from aerial inputs to line and speaker audio outputs, including aerial attenuator, slot filter assemblies, frequency converters, i.f. amplifiers, i.f. filters, a.m. and product detectors and audio amplifiers. The main frame also includes a frequency synthesizer for first mixer injection, a beat-frequency oscillator and can operate from 115-230V a.c. 47-420Hz. Two frequency-control plug-in units are available, and when augmented by one of these units, the receiver is capable of operating at any frequency between 10kHz and 30MHz in a.m., c.w., s.s.b. and f.s.k. modes. Crystal filter i.f. bandwidths are automatically matched to the reception mode selected. A wide range of accessories will be available. Ericsson Marine, Crown House, London Road, Morden, Surrey.
WW328 for further details

World of Amateur Radio

Impact of integrated circuits

Amateurs in many parts of the world are now developing and describing construc-tional projects based on the use of linear and digital integrated circuits. One notes especially the wide use of the Plessey SL-600 series, the CA types (RCA) and the high-gain Motorola balanced mixer type MC1596G for communications re-ceivers and compact transceivers. The advantages of the SL621 a.g.c. generator have crossed the Atlantic, and is used, for example, in a recent 3.5-MHz receiver described in *Ham Radio* by the Canadian amateur Paul Hrivnak, VE3ELP, in con-junction with such linear devices as the SL610 r.f. amplifier, the MC1596G and the General Electric PA237 a.f. amplifier plus discrete field-effect transistors for the oscillators.

Crystal calibrators and digital frequency meters are using digital t.t.l. devices including the popular SN7490N decade dividers. Digital logic is also being used in electronic keyers and automatic senders. Also attracting increasing attention are the sophisticated integrated-circuit phase-locked loop synchronous demodulators such as the Signetics NE561 and NE565 (M565N) devices. The CA302A is proving useful as a combined speech amplifier and balanced modulator for s.s.b. generation and also as a linear amplifier providing up to about 1W p.e.p. output to drive a valve power amplifier.

A case for more power?

One of Britain's leading h.f. long-distance operators, Dr John Allaway, G3FKM, recently voiced the growing feeling that the maximum power limits of the British amateur licence need to be up-dated.

Since 1946, except for occasional special tests, the power limits imposed on all British stations have been 150W d.c. *input* for c.w. or a.m. operation or 400W peak envelope power *output* for s.s.b. (A3A or A3J) on the majority of bands. Most amateurs would agree that these limits are, in themselves, reasonable (although it is puzzling why s.s.b. should be given more power than c.w.). These powers permit regular DX operation with or without high-gain beam aerials.

The present problem is that much amateur DX operating is of a competitive nature: the rarer contacts tend to go to the stations which can put the strongest signals into the distant country. In these circumstances, the top power permitted in other European countries becomes of importance to British amateurs—and, in this respect, there is little doubt that Dr Allaway has grounds for asking for the subject to be reconsidered. Looking through recent pages of my log book, I find that more and more high power operation is being permitted in Europe (the limit in North America has always been 1kW). I have worked West German c.w. stations using 250, 500 and 750W, Swedish stations up to 500W, Swiss 400W, Polish 250W, French 175W, Italian 300W, many Russians using 200W, while the operator of a Hungarian club station recently gave his power as 1kW.

It must be admitted that it is widely believed that a number of British stations are using more than their permitted power (these operators may not be pleased to learn that in some regions the Post Office has restarted routine inspections). Much of the popular factory-built equipment has to be 'throttled back' to get down to the British power limits. It would surely be better to issue licences for higher power than to tolerate some amateurs obtaining an advantage by disregarding the licence terms. So while the majority of British amateurs would be happy to continue with present limits if only other European amateurs were similarly restricted, there is likely to be a growing desire that Minpostel should look again at the power restrictions.

70th anniversary of trans-atlantic radio

Plans are afoot to mark the 70th anniversary of the spanning of the Atlantic by Marconi (12th December 1901). These may include an international get-together of radio amateurs connected by history or location with the early days of radio. A special station, using the call VB1MSA, is reported to have begun operation in Newfoundland and is active on 3.5, 14 and 21 MHz. In this country, the event is being organized by the Cornish Amateur Radio Club (in whose county the 1901 transmitter was set up), and among those who have promised support is the Derby society, which, as the country's oldest radio society, is planning to run a demon-stration station during the weekend Dec-ember 11-12.

Death of a noted blind amateur

The death took place during August of a well known sightless amateur—James Illingworth, G3EPL, of St Bees, Cumberland. A former headmaster, he had held his licence for several years when, in 1956, he lost his sight. After only a short break he returned to his amateur operating and for many years has been a notable example of what can be done by the keen amateur to overcome physical handicaps, as well as encouraging other handicapped people to find satisfaction in this hobby. In 1963, Illingworth became the recipient of a Mullard Award, the citation for which recorded: "The courage which he has shown in overcoming his handicap has been a source of inspiration to amateurs everywhere. By his knowledgeable advice and persistent encouragement over the air, he has helped many other amateurs to modify and improve their own equipment."

In brief

A little-noted decision of the recent I.T.U. Geneva space conference (WARC-ST) may have a greater impact on amateur radio than the actual space allocations—this was the overwhelming rejection of a proposal by Argentina to reduce from 144 to 50 MHz the frequency above which licences may be issued without a c.w. test. . . . There was a record attendance of some 2500 at the R.S.G.B. 1971 Mobile Rally at Woburn Abbey . . . . A joint entry by the Surrey Radio Contact Club and the Croydon R.S.G.B. group (stations G3BFP/P and G6LX/P) gained the overall victory in the 1971 National Field Day, runners-up being Norfolk Amateur Radio Club. Stockport Radio Society won the Bristol Trophy for the leading single-station entry. Altogether 118 local clubs and groups competed, an increase of 14 on 1970. . . . A 144 MHz station, G3UGF/MM, is regularly active from the East Coast coastal tanker, *Esso Inverness*. . . . JY6RS is the station of the Royal Jordan Amateur Radio Society. . . . P. J. Smith, G3XJE, of Peterhouse, Cambridge, would welcome reports of long-delayed echoes (see 'W.o.A.R.' last month) as part of new Cambridge University research into this phenomenon. Reports should give delay period, strength of echo, date and time of observation, frequency of signal and any possible frequency shift of the echo. . . . The 70 MHz beacon station, ZB2VHF, at Gibraltar is again in operation and has been received in the U.K. . . . The prefix 8Q6 is now being used in the Maldive Islands.

PAT HAWKER, G3VA

Circuit Ideas

Variable astable multivibrator

The circuit was devised to fulfil the following requirements:

(a) Square wave generation in the range 1–30Hz.

(b) Operation from a 5V supply and t.t.l. compatibility.

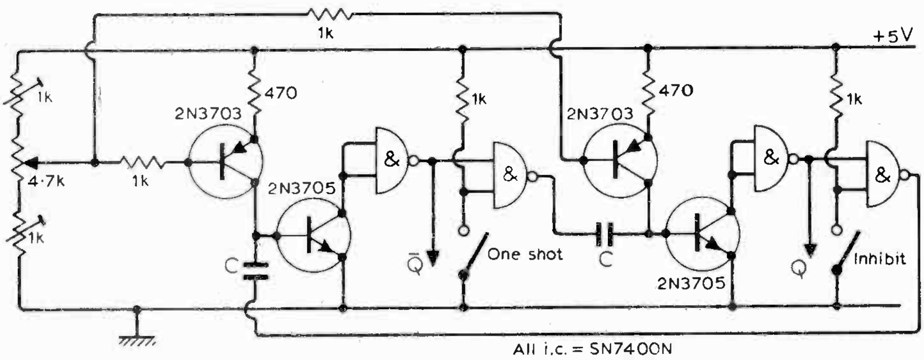
To obtain a wide frequency variation the conventional timing resistors of a multivibrator were each replaced by a p-n-p transistor whose currents are controlled by the linear single gang potentiometer. It was found possible to get a frequency variation of 500:1 by this method. The pre-set resistors were adjusted to get the required frequency range of 1–30Hz. With this coverage the relationship between frequency and rotation of the potentiometer is virtually linear. The prototype would oscillate in any frequency band between 0.167Hz and 350kHz by choosing suitable values of capacitor. At 0.167Hz $C = 33\mu F$ (tantalum) and at 350kHz $C = 5000pF$. The upper limit could probably be appreciably increased by using fast switching transistors, and selecting components to suit them.

The second requirement was met by using a quad two-input NAND as a twin 360° inverter. This considerably reduced the rise and fall times and enabled the incorporation of inhibit and single shot facilities as described later. The n-p-n transistors acted as current sinks for the NANDS.

The circuit proved very satisfactory for symmetrical square waves and for mark-space ratios of up to 10:1. Normal (Q) and complementary ($\bar{Q}$) outputs are available and the rise time of both outputs when driving a single t.t.l. load was measured to be 25ns.

When the inhibit line is switched to earth the oscillator stops. If the single shot button is then pressed a single square wave is generated at the normal output only. If the single shot button is operated when the oscillator is running this merely produces an inhibit function.

None of the components is at all critical.



All i.c. = SN7400N

The supply should be 5V ± 0.5V and for maximum frequency stability should be stabilized.

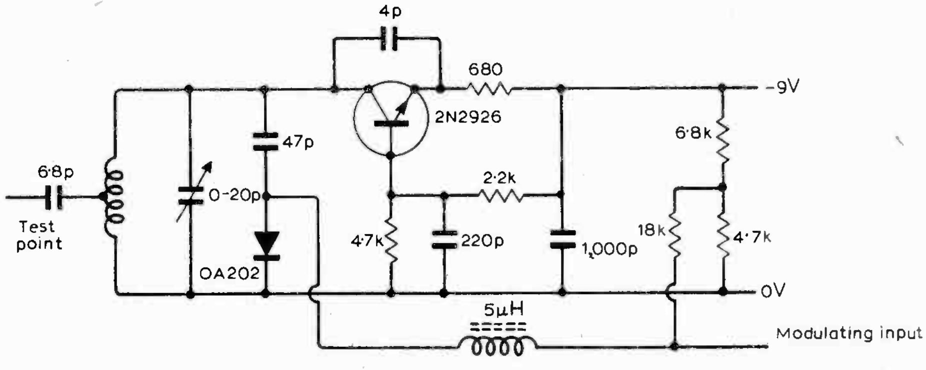
C. C. WARD,
University of Exeter.

Simple v.h.f./f.m. oscillator

A 2N2926 yellow-spot transistor oscillates readily in the circuit shown. The tuning coil consists of four turns of 16 s.w.g. tinned copper wire and is 0.4in dia. by 0.4in long. The variable capacitor can be a 20pF trimmer. An OA202 is used in place of a 'varactor'. An inverse polarizing voltage of 4V is about optimum and is obtained from a potential divider across the supply. To prevent shunting of v.h.f. voltages by the signal generator the modulating signal is applied to the diode via a 5μH miniature choke, and the collector end of the tuning circuit is connected to the diode by a capacitor of a value sufficiently small to 'block' currents at audio and somewhat higher frequencies. The components are mounted on a small piece of Veroboard having widely spaced strips of short length (to avoid undue self capacitance). This in turn is mounted on sheet aluminium bent to provide screening and to which earthy points are connected.

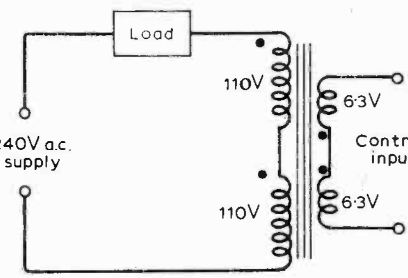
To check the functioning of the oscillator a low-voltage rectifier voltmeter, fitted with point contact diodes, may be connected through a small capacitor to a tapping on the tuning coil. Alteration of the collector/emitter capacitor will affect the amount of oscillation. Amplitude modulation may be achieved by applying the modulating voltage to the base of the transistor.

W. H. H. KELK,
Farnborough, Hants.



Variable power source using magnetic amplifier

Two mains transformers with 110V taps can be connected in series and in phase on the mains side, and in series but out of phase on the l.t. side, to provide a variable voltage supply. The l.t. windings are fed with a d.c. control of 1–3V, derived from a separate transformer. The amplifier can be used to supply a further transformer (as load) to provide a variable voltage supply.



W. B. PICKLES,
St. Albans,
Herts.

Literature Received

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

ACTIVE DEVICES

A folder is available from Sintrom Electronics Ltd, 2 Arkwright Rd, Reading, Berks., which contains data on analogue-to-digital converters, a fast follow-and-hold amplifier, eight-channel multiplexers and a range of operational amplifiers all manufactured by the Dynamic Measurements Corp., of Massachusetts WW401

British Brown-Boveri Ltd, Albany House, 41 High St, Brentford, Middlesex, have published a catalogue —and an associated price list—covering diodes, thyristors and triacs WW402

MCP Electronics Ltd, Alperton, Wembley, Middlesex HAO 4PE, have sent the following literature to us which describes products distributed by them:

- BF377/378. Data sheet dealing with transistors manufactured by Telefunken intended to replace the BFY90. Static characteristics are identical but the gain bandwidth product is 1.3GHz at 5V and 25mA. The 800MHz noise factor at 5V and 2mA is 5.5dB (200MHz, 2dB) WW403
- AHY10A/B. Data sheet for a germanium magnetic field sensitive diode for control applications (Telefunken) WW404
- CGY11/12/13, A/B. Data sheet describes a family of six GaAs Gunn-effect diodes for the X- and KU-band. Efficiencies are around 1.5 to 2% WW405
- BP300. Data and application information on a microelectronic two-pole active filter manufactured by TRW of America ($f = 0.1$Hz to 2kHz; $Q = 1$ to 200, stability $= \pm 0.005\%/°C$) WW406
- MV/MX Series (TRW). Hybrid v.h.f. and u.h.f. power microcircuits with outputs from 0.75 to 12W WW407

Microsystems International Ltd, 1 Great Cumberland Place, London W1H 7AL, have produced a short-form catalogue which lists operational amplifiers, m.o.s. memories and zener diodes WW408

GDS (Sales) Ltd, Michaelmas House, Salt Hill, Bath Rd, Slough, Bucks., have supplied us with data on two high-voltage avalanche rectifiers (S80HT1A and S100HT1A) manufactured by Westinghouse. (8 and 10kV at 1A at 25°C derating to 0.55A at 70°C, 50 to 400Hz, overload capability 45A for 10ms) WW409

PASSIVE COMPONENTS

Home Radio (Components) Ltd, 240 London Rd, Mitcham, Surrey, CR4 3HD, have published a new edition of their catalogue (the seventh) which contains 311 pages and lists a wide range of components and equipment mainly intended for the home constructor .... price 50p

We have received the following leaflets from GDS (Sales) Ltd, Michaelmas House, Salt Hill, Bath Rd, Slough, Bucks.:

- Painton trimmers WW410
- Eddystone die-cast boxes WW411
- Keyswitch relays WW412
- CGS Resistor Co. & Guest International. Resistors WW413

Pye TMC Ltd, Components Division, Roper Rd, Canterbury, Kent, have published a leaflet describing a range of illuminated push-button switches which are called type 1 .... WW414

Catalogue 102 from Cambion Electronic Products Ltd, Cambion Works, Castleton, Nr. Sheffield S30 2WR, lists solder terminals, r.f. chokes and connectors WW415

Henry's Radio Ltd, Edgware Rd, London W.2, have published the tenth edition of their catalogue. It contains 352 pages and gives details of electronic components, communications equipment and devices for producing electronic music and lighting price 40p

New product bulletin 671DL/1U available from Special Products Distributors Ltd, 81 Piccadilly, London W1V 0HL, describes a range of magnetic nut drivers manufactured in America by Xcelite Ltd. WW417

Pye TMC Ltd, Capacitor Division, Oldmedow Rd, Hardwick Trading Estate, King's Lynn, Norfolk, have a leaflet available which describes extended foil polystyrene capacitors WW418

An eight-page booklet gives the NATO stock numbers of oxide resistors to BS9111-N-002. Electrosil Ltd, Pallion, Sunderland, Co. Durham, SR4 6SU WW419

The components stocked by Lugton & Co. Ltd, Radio House, 209-212 Tottenham Court Rd, London W1A 2BN, are listed in the short-form catalogue of the Industrial Division WW420

The August/November catalogue of RS Components (formerly Radiospares), P.O. Box 427, 13-17 Epworth St, London EC2P 2HA, is available WW421

Handles, locks, catches, hinges, feet, ventilation rings, lifting eyes, castors, clips and other parts for equipment cabinets are described in the 'Handles and Accessories' catalogue from Imhof-Bedco, Colne Way Trading Estate, By-Pass, Watford, Herts WD2 4NE WW422

The Components Division of Ferranti Ltd, Dunsinane Ave, Dundee DD2 3PN, have supplied us with two catalogues:

- Radar systems components WW423
- Communications components WW424

We have obtained a great deal of literature from FR Electronics, Wimborne, Dorset BH21 2BJ:

- Reed switch catalogue (contains some useful applications information) WW425
- Reed switch price list WW426
- Reed switch accessories (coils and magnets) WW427
- Logcell data sheets. Very small mercury wetted relays available as basic switches or in monostable, latching, non-latching, i.c. compatible, coaxial, dual-in-line packaged and high-speed forms WW428
- Logcell price list WW429
- 'Pinlite' catalogue. Alphanumeric and other character display modules WW430

Solid-state relays capable of handling up to 7A manufactured by Darpan Controls Ltd, Bridge Mills, Derby Rd, Long Eaton, Nottingham NG10 4QA, are the subject of a catalogue. They are designed to be operated directly by logic i.cs and operational amplifiers; the operating power required being only 750μW WW432

Miniature incandescent lamps manufactured in Germany by Micro Gluhlampen Gesellschaft are described in a catalogue obtainable from H. F. Collison-Goodwell Ltd, Coleshill, Birmingham 338024 .... WW433

APPLICATION NOTES

Information sheet No. 209 from Integrated Photomatrix Ltd, The Grove Trading Estate, Dorchester, Dorset, describes how a dual-ramp digital panel voltmeter can be made using only four i.cs and a number of discrete components. Range and accuracy is 0 to 1.999V (positive or negative) $\pm 0.1\% \pm 1$ digit. The range can of course be extended using suitable multipliers WW434

A Multicore Solders leaflet (Bulletin P.C.1) which describes batch printed circuit soldering techniques is available from GDS (Sales) Ltd, Michaelmas House, Salt Hill, Bath Rd, Slough, Bucks. WW435

A paper, 'The versatility of the h.r.c. fuse in protecting semiconductor equipments' by J. Feenan, may be obtained from English Electric Fusegear Ltd, East Lancashire Rd, Liverpool L10 5HB .. WW436

The National Research Development Council, Kingsgate House, 66-74 Victoria St, London S.W.1, have sent us details of some patent applications:

- 41470/68. Band-pass filter sets WW437
- 51137/69. Low-noise tachometer generator WW438
- 56771/70. Out-of-circuit d.c. ammeter ... WW439
- 52193/69. A novel cycloconverter WW440

EQUIPMENT

We have received literature describing an audio equalizer which has a lift/cut control for each octave from 20 to 20,480Hz (10 in all) intended for matching audio systems to room conditions. Stereo versions are available. Soundcraftsmen, 1320 E. Wakeham Ave, Santa Ana, California 92705, U.S.A. WW443

The Quickdraw Company Ltd, 10 Beechdale, Winchmore Hill, London N.21, have produced a new protractor head for technical drawing which is described in a leaflet WW444

An American welder which electrically disassociates oxygen and hydrogen from distilled water and then uses these gases to produce a flame with a temperature of at least 3,316°C is described in a leaflet. The welder has to be connected to a mains power supply. The smallest model runs for twelve hours on 0.8 pints of water. Details from Special Product Distributors Ltd, 81 Piccadilly, London W1V 0HL WW445

GENERAL INFORMATION

'Catalog No. C13.10:350. Time and frequency: A bibliography of NBS literature published July 1955–Dec. 1970' published by the American National Bureau of Standards may be obtained from: Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, U.S.A. .... price (inc. p & p) U.S. $0.69

'About Patents' is a free booklet which describes the information retrieval services provided by the Patent Office. The Sales Branch, The Patent Office, Orpington, Kent BR5 3RD.

A 1971/72 prospectus may be obtained from The Registrar (Admissions), Cranfield Institute of Technology, Cranfield, Bedford.

The work of the National Economic Development Council (Neddy) and the 16 Economic Development Committees (Little Neddies) is described in a booklet 'What is Neddy?'. An associated catalogue 'Neddy in Print' gives a list of Neddy publications. Publications Dispatch, National Economic Development Office, Millbank Tower, Millbank, London SW1P 4QX.

'Approach and landing at Heathrow—a layman's guide' has been published by BEA and International Aeradio Ltd. It is a folder containing charts and explanatory matter which describes airline landing procedures, 'stacking', radio beacons, 'talkdowns', taxi-ing and parking at Heathrow. It is available from V. Windett, International Aeradio Ltd, Hayes Rd, Southall, Middlesex .... price 60p

Real and Imaginary

by "Vector"

Initial Suggestions

Periodically (if you will forgive the pun) the newspaper world experiences a silly season when nothing much seems to be happening and editors have to scrape the bottom of the barrel. At such times photographs tend to become larger and what is left of the sheet is filled with banner headlines.

The problem is much more acute for the hapless contributor to an electronics journal, for he has to grapple with an industry which has a perpetual silly season. At this particular moment, for example, nothing much is happening except that the Almighty Dollar has flipped to sabotage our export market, the Japs are hypnotizing our home market into committing hari-kiri and our microcircuit industry has fallen flat on its expensively-lithographed epitaxial (as predicted on this page in March 1967, though it gives me no joy to say so). Not to mention the circumstance that the Labour Exchange now has a decided leer on its stucco'd countenance whenever we steal past it.

In short, in the immortal words of the poet who wrote 'over the wire the message came, he is not better, he is much the same", the electronics industry is ticking over pretty much as usual and company chairmen with ruin staring them in the face are staring back and buying yet another estate in the Bahamas. So, upon the well-known precedent of fiddling while Rome is burning I thought I might do worse than pass away the time by setting you a quiz on the same general lines as those by L. Ibbotson which used to appear in *W.W.* under the heading "Test Your Knowledge". So here, without further ado, it is:—

(1) *What is AVRO?*
- *(a) A well-known multi-tester?*
- *(b) A famous name in aviation?*
- *(c) An estate agent's contraction for "average-sized-room"?*

(2) *What is MELEX?*
- *(a) A poultry food?*
- *(b) A Chinaman telling us his name is Rex?*
- *(c) A luncheon voucher for executives?*

(3) *What is ILMAC?*
- *(a) A Sassenach asking a Scotsman if he's under the weather?*
- *(b) A waterproof coat for invalids?*
- *(c) A brand of throat sweets?*

(4) *What is/are SEMINEX?*
- *(a) A new method of family planning?*
- *(b) The Old Boys' Association of a school of theology?*
- *(c) a breed of short-necked giraffes?*

(5) *What is SICOB?*
- *(a) A method of expressing the energy of a horse in S.I. units?*
- *(b) A mentally deranged male swan?*
- *(c) A computer language?*

(6) *What is INTERNAVEX?*
- *(a) An international trade union for belly dancers?*
- *(b) The medical term for solar plexus?*
- *(c) A NATO Navy Week?*

If you haven't had much luck so far, perhaps you might care to try the following for size:—IMAS, IMEX, EMCON, EASCON, INTER/NEPCON—come on that lad at the back, put some effort into it! All right then, I'll hand it to you on a plate with WESCON and EUROCON. No, Einstein Minor, the last-mentioned is not an organization dedicated to conning Britain into the Common Market. Full marks to all the others for twigging that these are all exhibitions, congresses, conventions, seminars or symposia. Incidentally, I have yet to find out the actual difference between events bearing the latter four titles.

This is the in-cult of the acronym to which the trendy boys in the exhibitions world have latched on. Bourgeois reactionaries may complain that these titles are not only meaningless but in some cases downright misleading, and enquire bitterly whether an electronics engineer must not equip himself with a crystal ball to find out that MELEX is the Manchester Electronics Exhibition. Such carping critics may count themselves lucky that they live in a tolerant democracy and not in an area where Luddite opposition to progress is short-circuited to the saltmines.

Personally, my only complaint is that the notion is rather *arriére-garde* and dated, for acronyms have been with us for a long time now. Couldn't the organizers of exhibitions and conferences take a leaf out of the book of those other natural disasters, hurricanes, and use given names for their functions? It would somehow make the thing so much more personal if we could go to an exhibition called Frieda or Janice or Laureen. Then if the organizers were fortunate enough to catch the ear of the Editor on one of his better days they might persuade him to publish a key in, say, the January issue or the Diary, so that even such an arrested mental development as mine could effect a translation.

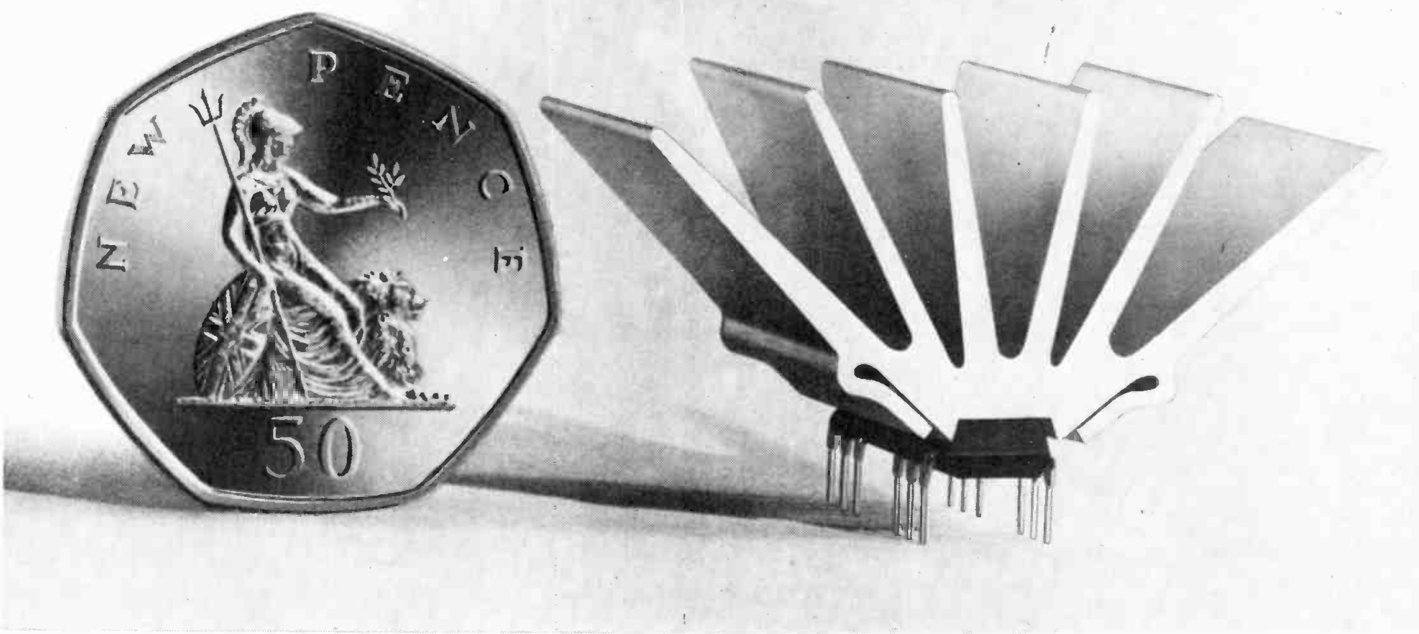
But of course even this is not the real McCoy (whoever he was). It was our own Post Office which was courageous enough to provide us with a clear directive by ditching those emotive telephone exchange names (and what fantasies could be woven concerning the girl operators at Bluebell. Cherrywood or Virginia?). But where was I? Oh yes—when they discarded those exchanges and paid us the compliment of expecting us to memorize a gaggle of ten-digit numbers. That was sheer good thinking on the part of some anonymous soul at the Ministry of Incomprehensibility and it behoves us one and all to benefit by example.

So, why not go the whole hog and sling out all these out-moded acronyms in favour of transistor-type codification? At the same time the electronics manufacturers should be urged to discard their trade names in favour of allocated serial numbers. Just think of the time saving effected by mentioning to a colleague that you were off to visit 123SE2095 instead of having to say 'I'm going to take a butcher's at the Semiconductor and Allied Technologies Seminar and Exhibition'. That's what I'd call Progress with a capital 'P'.

Even this need be only a halfway house toward the ultimate goal of scrapping the decimal system in favour of binary and digitizing not only exhibitions but everything else—railway stations, airports, strip-tease shows, Labour Exchanges—the lot. With all these in binary code stupendous new electronics markets would be opened up for portable back-pack computers for the general public who cannot be relied upon to recall, off-hand, that 1011101011 is Euston station. On a larger canvas the approach would give useful employment for all those highly expensive computers which the larger business houses have been conned into buying and which now serve no more useful function than providing rest homes for aged and infirm spiders.

new

Super IC-12



High fidelity Monolithic Integrated Circuit Amplifier

Two years ago Sinclair Radionics announced the World's first monolithic integrated circuit Hi-Fi amplifier, the IC.10. Now we are delighted to be able to introduce its successor, the Super IC.12. This 22 transistor unit has all the virtues of the original IC.10 plus the following advantages:

1. Higher power.
2. Fewer external components.
3. Lower quiescent consumption.
4. Compatible with Project 60 modules.
5. Specially designed built-in heat sink. No other heat sink needed.
6. Full output into 3, 4, 5 or 8 ohms.
7. Works on any voltage from 6 to 28 volts without adjustment.
8. NEW 22 transistor circuit.

Output power 6 watts RMS continuous (12 watts peak).

Frequency Response 5 Hz to 100KHz ± 1 dB.

Total Harmonic Distortion Less than 1%. (Typical 0.1%) at all output powers and all frequencies in the audio band.

Load Impedance 3 to 15 ohms.

Power Gain 90dB (1,000,000,000 times) after feedback.

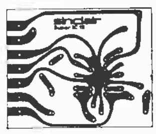
Supply Voltage 6 to 28 volts (Sinclair PZ-5 or PZ-6 power supplies ideal).

Size 22 x 45 x 28 mm including pins and heat sink.

Input Impedance 250 Kohms nominal.

Quiescent current 8mA at 28 volts.

With the addition of only a very few external resistors and capacitors the Super IC.12 makes a complete high fidelity audio amplifier suitable for use with pick-up, F.M. tuner etc. Alternatively, for more elaborate systems, modules in the Project-60 range such as the Stereo 60 and A.F.U. may be added. The comprehensive manual supplied with each unit gives full circuit and wiring diagrams for a large number of applications in addition to high fidelity. These include car radios, oscillators etc. The very low quiescent consumption makes the Super IC.12 ideal for battery operation.



Price, inc. FREE printed circuit board for mounting.

£2.98 Post free

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Should you not be completely satisfield with your purchase when you receive it from us, return the goods without delay and your money will be refunded in full, including cost of return postage, at once and without question. Full service facilities are available to all Sinclair customers.

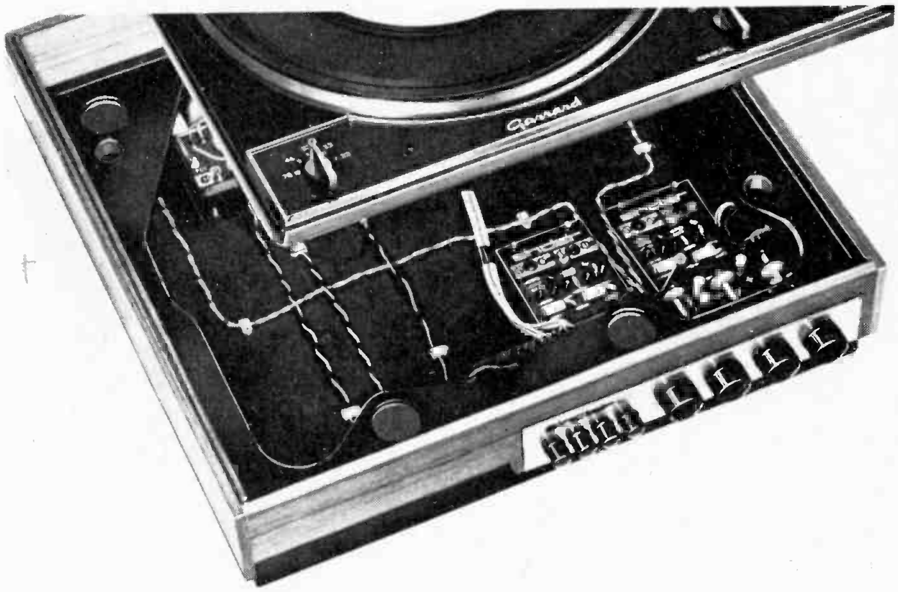
Sinclair Radionics Ltd, London Rd, St. Ives
Huntingdonshire PE17 4HJ
Telephone St Ives (048 06) 4311

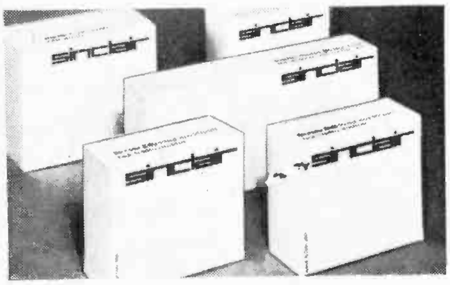
sinclair

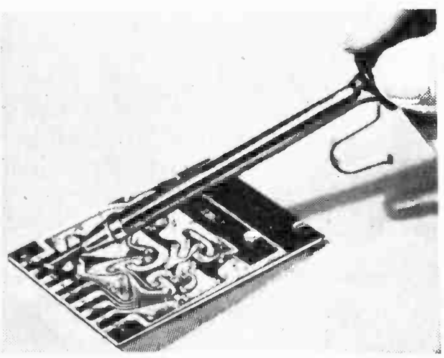
WW—094 FOR FURTHER DETAILS

Sinclair Project 60

The World's leading range of high fidelity modules







Project 60 offers more advantage to the constructor and user of high fidelity equipment than any other system in the world.
Performance characteristics are so good they hold their own with any other available system irrespective of price or size.
Project 60 modules are more versatile – using them you can have anything from a simple record player or car radio amplifier to a sophisticated and powerful stereo tuner-amplifier. Either power amplifier can be used in a wide variety of applications as well as high fidelity. The Stereo 60 pre-amplifier control unit may also be used with any other power amplifier system, as can the AFU filter unit. The stereo FM tuner operates on the unique phase lock loop principle to provide the best ever standards of sensitivity and audio quality. Project 60 modules are very easily connected together by following the 48 page manual supplied free with all Project 60 equipment. The modules are great space savers too and are sold individually boxed in distinctive white and black cartons. With all these wonderful advantages, there remains the most attractive of all – price. When you choose Project 60 you know you are going to get the best high fidelity in the world, yet thanks to Sinclair's vast manufacturing resources (the largest in Europe) prices are fantastically low and everything you buy is covered by the famous Sinclair guarantee of reliability and satisfaction.

Typical Project 60 applications

System	The Units to use	together with	Cost of Units
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40+40 W. R.M.S. de-luxe stereo amplifier	**2 x Z.50s, Stereo 60 PZ.8, mains trsfrmr**	As above	**£34.88**
Indoor P.A.	**Z.50, PZ.8, mains transformer**	Mic., guitar, speakers, etc., controls	**£19.43**

F.M. Stereo Tuner **(£25)** & A.F.U. Filter Unit **(£5.98)** may be added as required.

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BC 114	14p	12½p	2N1613	20½p	16½p
BC 115	16½p	14½p	2N2193	27p	20p
BC 116	15p	13½p	2N2218	23p	17½p
BC 116A	19p	16½p	2N2219	23½p	17½p
BC 118	10p	8½p	2N2221	23½p	17½p
BC 125	20½p	17½p	2N2222	23½p	17½p
BC 126	20½p	18½p	2N2369	15p	12p
BC 147	10½p	9½p	2N2369A	18p	13½p
BC 148	9p	8p	2N2484	27p	20p
BC 149	13p	12p	2N2904	31p	23½p
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BC 154	20p	17½p	2N2924	13p	9p
BC 178	26½p	23p	2N2925	14½p	9½p
BC 182	10p	9p	2N2926	8p	7p
BC 183	9½p	8½p	2N3011	15½p	12p
BC 184	11p	9½p	2N3053	18p	12½p
BCY 58	25p	20p	2N3055	78p	62½p
BCY 59	27½p	22p	2N3133	22p	17p
BCY 70	17p	12½p	2N3134	23p	18½p
BCY 71	22½p	15p	2N3135	23p	16p
BCY 72	12½p	10p	2N3136	27p	22½p
BF 115	18½p	15p	2N3390	30p	25½p
BF 167	21p	17p	2N3391	20p	17½p
BF 173	24½p	20p	2N3391A	22½p	19p
BF 180	35p	28p	2N3392	13p	11p
2N697	15p	12½p	2N3393	14p	12½p
2N699	29½p	22p	2N3414	14p	12½p
2N706	11p	9p	2N3415	16p	15p
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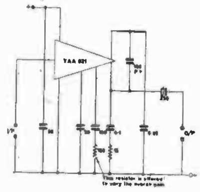

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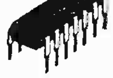

Check our 74 Series List before you buy any I.C's. Our prices are the lowest possible. All devices ex-stock. Full spec. guaranteed.

BI-PAK Order No.	Description	Price and Qty. Prices 1-24	25-99	100 up
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BP 01 = 7401	Quad. 2-input Pos. NAND Gate (with open collector output)	15p	14p	12p
BP 02 = 7402	Quad. 2-input Pos. NOR Gates	15p	14p	12p
BP 03 = 7403	Quad. 2-input Pos. NAND Gates (with open collector output)	15p	14p	12p
BP 04 = 7404	Hex Inverters	15p	14p	12p
BP 05 = 7405	Hex Inverter (with open-collector output)	15p	14p	12p
BP 10 = 7410	Triple 3-input Pos. NAND Gates	15p	14p	12p
BP 13 = 7413	Dual 4-input Schmitt Trigger	29p	26p	24p
BP 20 = 7420	Dual 4-input Pos. NAND Gates	15p	14p	12p
BP 30 = 7430	8-input Pos. NAND Gates	15p	14p	12p
BP 40 = 7440	Dual 4-input Pos. NAND Buffers	15p	14p	12p
BP 41 = 7441	BCD to decimal nixie driver	67p	64p	58p
BP 42 = 7442	BCD to decimal decoder (4-10 lines, 1 of 10)	67p	64p	58p
BP 46 = 7446	BCD-to-Seven-Segment Decoder Driver	£2·00	£1·75	£1·50
BP 47 = 7447	BCD-7-Seg. Decoder/Drivers (15-V outputs)	97p	94p	88p
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BP 50 = 7450	Expandable dual 2 Input AND-OR-INVERT	15p	14p	12p
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BP 53 = 7453	Quad 2 Input Expandable NAND-OR-INVERT	15p	14p	12p
BP 54 = 7454	4-Wide 2-Input NAND-OR-INVERT Gates	15p	14p	12p
BP 60 = 7460	Dual 4-Input Expander	15p	14p	12p
BP 70 = 7470	Single-Phase J-K Flip-Flop	29p	26p	24p
BP 72 = 7472	Master-Slave J-K Flip-Flop	29p	26p	24p
BP 73 = 7473	Dual Master Slave J-K Flip-Flop	37p	35p	32p
BP 74 = 7474	Dual D Type Flip-Flop	37p	35p	32p
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BP 91 = 7491	8-Bit Shift Registers	87p	84p	78p
BP 92 = 7492	Divide-by-Twelve Counters	67p	64p	58p
BP 93 = 7493	4-Bit Binary Counters	67p	64p	58p
BP 94 = 7494	Dual Entry 4 Bit Shift Register	77p	74p	68p
BP 95 = 7495	4 Bit Up-Down Shift Register	77p	74p	68p
BP 96 = 7496	5 Bit Parallel in Parallel out Shift-Register	77p	74p	68p
BP100 = 74100	8-Bit Bistable Latches	£1·75	£1·65	£1·55
BP104 = 74104	Single J-K Flip-Flop equiv. 9000 Series	97p	94p	88p
BP105 = 74105	Single J-K Flip-Flop equiv. 9001	97p	94p	88p
BP107 = 74107	Dual Master Slave Flip-Flops	40p	38p	36p
BP110 = 74110	Gates Master-Slave FlipFlops	55p	53p	50p
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BP118 = 74118	Hex Set-Reset Latches	£1·00	95p	90p
BP119 = 74119	Hex Set-Reset Latches 24 pin	£1·35	£1·25	£1·10
BP121 = 74121	Monostable Multivibrators	67p	64p	58p
BP141 = 74141	BCD-to-Decimal Decoder/Driver	67p	64p	58p
BP145 = 74145	BCD-to-Decimal Decoder/Driver. O/C	£1·50	£1·40	£1·30
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BP197 = 74197	Pre-settable 50MHZ Binary Counter	£1·80	£1·70	£1·60
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Devices may be mixed to qualify for quantity price. Larger quantities—prices on application. (TTL 74 Series only.)

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UIC01	= 12 × 7401N	50p	UIC50	= 12 × 7450N	50p	UIC82	= 5 × 7482N	50p
UIC02	= 12 × 7402N	50p	UIC51	= 12 × 7451N	50p	UIC83	= 5 × 7483N	50p
UIC03	= 12 × 7403N	50p	UIC60	= 12 × 7460N	50p	UIC86	= 5 × 7486N	50p
UIC04	= 12 × 7404N	50p	UIC70	= 8 × 7470N	50p	UIC90	= 5 × 7490N	50p
UIC05	= 12 × 7495N	50p	UIC72	= 8 × 7472N	50p	UIC92	= 5 × 7492N	50p
UIC10	= 12 × 7410N	50p	UIC73	= 8 × 7473N	50p	UIC93	= 5 × 7493N	50p
UIC20	= 12 × 7420N	50p	UIC74	= 8 × 7474N	50p	UIC94	= 5 × 7494N	50p
UIC40	= 12 × 7440N	50p	UIC75	= 8 × 7475N	50p	UIC95	= 5 × 7495N	50p
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DTL 930 SERIES

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BP932	Expandable dual 4-input NAND buffer	13p	12p	11p
BP933	Dual 4-input expander	13p	12p	11p
BP935	Expandable Hex Inverter	13p	12p	11p
BP936	Hex Inverter	13p	12p	11p
BP944	Dual 4-input NAND expandable buffer without pull-up	13p	12p	11p
BP945	Master-slave JK or RS	25p	24p	22p
BP946	Quad, 2-input NAND	12p	11p	10p
BP948	Master-slave JK or RS	25p	24p	22p
BP951	Monostable	65p	60p	55p
BP962	Triple 3-input NAND	12p	11p	10p
BP9093	Dual Master-slave JK with separate clock	40p	38p	35p
BP9094	Dual Master-slave JK with separate clock	40p	38p	35p
BP9097	Dual Master-slave JK with Common Clock	40p	38p	35p
BP9099	Dual Master-slave JK Common Clock	40p	38p	35p

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Q 5	4	OC 75 transistors	50p
Q 6	4	OC 72 transistors	50p
Q 7	4	AC 128 trans. P.N.P. high gain	50p
Q 8	4	AC 126 trans. P.N.P.	50p
Q 9	7	OC 81 type trans.	50p
Q10	7	OC 71 type trans.	50p
Q11	2	AC 127/128 Comp. pairs PNP/NPN	50p
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Q13	3	AF 117 type trans.	50p
Q14	3	OC 171 H.F. type trans.	50p
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Q17	3	NPN 1 ST141 & 2 ST140	50p
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Q22	20	NKT trans. A.F. R.F. coded	50p
Q23	10	OA202 Sil. diodes sub-min.	50p
Q24	8	OA 81 diodes	50p
Q25	6	IN914 Sil. diodes 75PIV 75mA	50p
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Q31	6	Sil. switch trans. 2N708 NPN	50p
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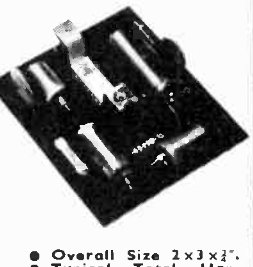

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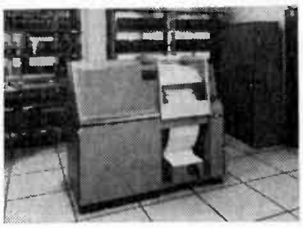

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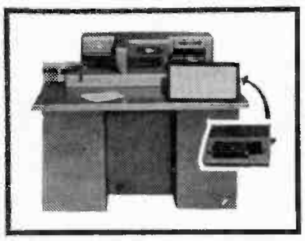

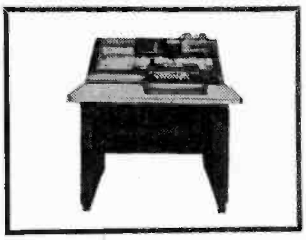

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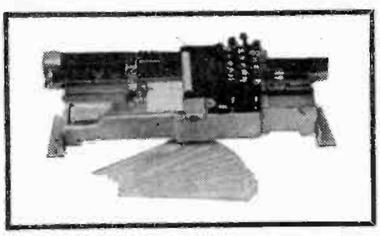

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2N3703	0·10	2N4058	0·13	MJ481	1·20	1S3062	0·25
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ACY40	15p	C9V1	15p	OA10	25p	2N706	10p
ACY41	15p	C10	15p	OA47	8p	2N706A	12p
AD140	55p	C11	15p	OA70	8p	2N708	16p
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AD162	37p	C15	15p	OA81	8p	2N911	50p
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AF117	25p	C22	15p	OA95	8p	2N1091	33p
AF118	44p	C24	15p	OA200	10p	2N1131	30p
AF124	25p	C27	15p	OA202	10p	2N1132	30p
AF126	17p	C30	15p	OC19	37p	2N1302	20p
AF139	37p	D13T1	45p	OC20	97p	2N1303	20p
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BC109	12p	NKT125	40p	OC44	15p	2N2160	62p
BC147	15p	NKT126	37p	OC45	15p	2N2368	17p
BC148	15p	NKT128	25p	OC71	15p	2N2369	17p
BC149	15p	NKT135	26p	OC72	23p	2N2369A	20p
BC158	17p	NKT137	32p	OC75	23p	2N2646	50p
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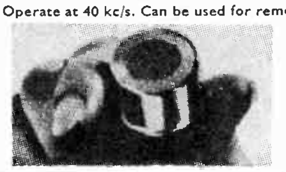

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NKT223	27p
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OC23	60p
OC24	60p
OC25	37p
OC26	25p
OC28	60p
OC29	60p
OC35	50p
OC36	60p
OC41	22p
OC42	25p
OC44	17p
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OC74	30p
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OC76	22p
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OC82D	15p
OC83	25p
OC84	25p
OC139	25p
OC140	32p
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SN7474	43p
SN7475	47p
SN7476	45p
SN7483	87p
SN7486	50p
SN7490	£1·00
SN7492	87p
SN7493	87p
SN7495	87p
SN7496	87p
SN74107	43p
SN74153	£1·40
SN74154	£2·20
SN74160	£1·80
SN74161	£1·80
SN74164	£2·20
SN74165	£2·25
SN74192	£2·25
SN74193	£2·25
TAA241	£1·62
TAA242	£4·25
TAA243	£1·50
TAA263	75p
TAA293	97p
TAA300	£1·75
TAA310	£1·25
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TAA350	£1·75
TAA435	£1·47
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TAA530	£4·95
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4002 100PIV	9p	11p	20p
4003 200PIV	10p	12p	22p
4004 400PIV	10p	12p	25p
4005 600PIV	12p	15p	26p
4006 800PIV	15p	17p	27p
4007 1000PIV	20p	20p	30p

50+ less 15%; 100+ less 20%

SILICON RECTIFIERS STUD MOUNTING

	6A	10A	17·5A	35A
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200PIV	25p	50p	55p	£1·42
400PIV	30p	55p	62p	£1·77
600PIV	32p	60p	72p	£2·12
800PIV	35p	75p	87p	£2·47
1000PIV	40p	85p	•1·05	£2·77

50+ less 15%; 100+ less 20%

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AA129	10p	BAY38	17p	OA9	10p
AAZ13	10p	BY100	15p	OA47	7p
AAZ15	12p	BY103	22p	OA70	7p
AAZ17	12p	BY122	37p	OA73	10p
BA100	15p	BY124	15p	OA79	9p
BA102	22p	BY126	15p	OA81	7p
BA110	32p	BY127	17p	OA85	7p
BA111	27p	BY164	57p	OA90	7p
BA112	70p	BY210	35p	OA91	7p
BA115	7p	BYZ11	32p	OA95	7p
BA141	32p	BYZ12	30p	OA200	7p
BA142	32p	BYZ13	25p	OA202	10p
BA144	12p	BYZ16	40p	OA210	17p
BA145	20p	FST3/4	22p		

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PIV	50	100	200	300	400
1A	25p	27p	37p	40p	47p
4A	—	47p	55p	57p	77p
5A	—	55p	65p	—	75p
7A	—	55p	65p	—	97p

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W-type	1·25″ × 5·1″	W-type	1·25″ × 5·1″
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1R5	30p
1S5	25p
1T4	25p
1U4	27p
1U5	50p
2D21	35p
3Q4	40p
3S4	35p
3V4	45p
5R4	60p
5U4	33p
5V4	42p
5Y3	32p
5Z4G	40p
6/30L2	75p
6AC7	25p
6AG7	40p
6AK5	30p
6AK6	57p
6AL5	20p
6AM6	33p
6AQ5	30p
6AS6	37p
6AT6	30p
6AU6	25p
6AV6	30p
6BA6	25p
6BE6	30p
6BH6	45p
6BJ6	45p
6BQ7A	40p
6BR7	85p
6BR8	65p
6BW6	85p
6BW7	70p
6BZ6	35p
6C4	33p
6CD6	£1·15
6CL6	50p
6CQ4	63p
6F1	62p
6F6G	30p
6F13	38p
6F14	65p
6F15	65p
6F18	45p
6F23	80p
6H6	20p
6J4	50p
6J5	20p
6J5GT	30p
6J6	20p
6J7	45p
6K8G	35p
6L6GT	45p
6LD20	40p
6Q7	40p
6SA7	40p
6SG7	35p
6SJ7	40p
6SK7	35p
6SL7	35p
6SN7	35p
6SQ7	40p
6U4	60p
6V6G	25p
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6X5GT	27p
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10P14	£1·10
12AT6	30p
12AT7	30p
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20D1	45p
20F2	75p
20L1	£1·10
20P1	50p
20P3	60p
20P4	£1·10
20P5	£1·20
25L6	45p

Type	Price
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25Z5	42p
25Z6	65p
30C15	80p
30C17	85p
30C18	75p
30F5	85p
30FL1	70p
30FL12	92p
30FL14	75p
30L15	85p
30L17	80p
30P12	80p
30P19	80p
30PL1	70p
30PL13	93p
30PL14	90p
35L6	50p
35W4	30p
35Z4	30p
35Z5	30p
50B5	45p
50C5	40p
80	50p
85A2	40p
807	50p
1625	50p
5763	70p
6146	£1·50
AZ31	50p
CY31	35p
DAF91	25p
DAF96	42p
DF91	25p
DF96	42p
DK91	35p
DK92	50p
DK96	42p
DL92	35p
DL94	45p
DL96	42p
DM70	32p
DY86	33p
DY87	35p
E88CC	65p
E180F	95p
EABC80	35p
EAF42	55p
EB91	20p
EBC41	55p
EBC81	30p
EBF80	40p
EBF83	40p
EBF89	32p
EBL21	60p
EC86	60p
EC88	60p
ECC40	60p
ECC84	30p
ECC85	60p
ECC88	40p
ECF80	35p
ECF82	35p
ECF86	65p
ECH21	57p
ECH35	60p
ECH42	70p
ECH81	30p
ECH83	40p
ECL80	40p
ECL82	35p
ECL83	65p
ECL86	40p
EF37A	60p
EF39	40p
EF40	50p
EF41	50p
EF42	70p
EF80	25p
EF85	35p
EF86	35p
EF89	28p
EF91	33p
EF92	40p
EF183	30p
EF184	35p
EH90	40p
EL34	50p
EL33	£1·25
EL41	55p
EL42	58p
EL81	55p
EL84	25p
EL85	43p
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Type	Price
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EM80	40p
EM81	50p
EM84	35p
EM85	£1·00
EM87	43p
EY51	40p
EY86	40p
EY87	42p
EZ40	45p
EZ41	45p
EZ80	25p
EZ81	28p
GZ32	45p
GZ34	60p
KT66	£2·05
KT88	£2·00
MU14	60p
PABC80	40p
PC86	60p
PC88	60p
PC97	45p
PC900	48p
PCC84	40p
PCC85	40p
PCC88	55p
PCC89	50p
PCC189	55p
PCF80	30p
PCF82	34p
PCF84	50p
PCF86	60p
PCF800	80p
PCF801	50p
PCF802	50p
PCF805	75p
PCF806	70p
PCF808	75p
PCL82	35p
PCL83	65p
PCL84	45p
PCL85	40p
PCL86	45p
PFL200	70p
PL36	55p
PL81	50p
PL82	45p
PL83	45p
PL84	40p
PL500	75p
PL504	80p
PY32	55p
PY33	63p
PY80	35p
PY81	30p
PY82	30p
PY83	38p
PY88	40p
PY800	50p
PY801	50p
U25	75p
U26	75p
U50	32p
U52	33p
U191	75p
U281	40p
U282	40p
U301	40p
U801	£1·00
UABC80	35p
UAF42	55p
UBC41	50p
UBC81	40p
UBF80	40p
UBF89	35p
UCC84	40p
UCC85	40p
UCF80	55p
UCH21	60p
UCH42	70p
UCH81	35p
UCL82	35p
UCL83	60p
UF41	60p
UF80	35p
UF85	40p
UF89	35p
UL41	65p
UL84	30p
UY41	45p
UY85	30p
VR105/30	38p
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400 MW	1·5 watt	10 watt
3·3-33 Volt	2·4-100 Volt	3·9-100 Volt
15p each	20p each	25p each

25 + less 15%; 100 + less 20%

2N3055	75p	AF239	37p
25+	62p	25+	32p
100+	50p	100+	28p
		500+	25p
		1000+	20p
BC113	15p	BC148	11p
25+	13p	25+	9p
100+	12p	100+	8p
500+	10p	500+	7p
1000+	8p	1000+	6p
BYZ13	25p	BC168C	15p
25+	20p	25+	12p
100+	17p	100+	10p
500+	15p	500+	8p
1000+	13p	1000+	6p
BC107/8/9	10p	BC169C	15p
25+	9p	25+	12p
100+	8p	100+	10p
500+	7p	500+	8p
1000+	6p	1000+	6p
OC71	12p	AD161/AD162	35p
25+	10p	25+	30p
100+	9p	100+	25p
500+	8p	500+	22p
1000+	7p	1000+	20p
OC72	12p	BF194	17p
25+	10p	25+	15p
100+	9p	100+	13p
500+	8p	500+	12p
1000+	7p	1000+	10p

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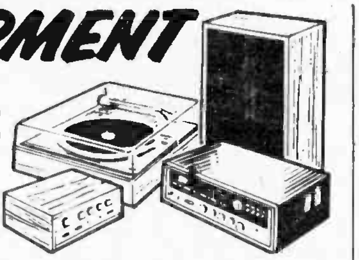

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Mini Mono‡	£4·97
C129*	£6·70
MP60	£11·30
610	£15·15
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310	£10·55
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‡ Mono * Stereo Cartridge
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Carriage 50p extra any model.

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Decks supplied ready wired in teak veneered plinth and cover fitted with cartridge.

Garrard 2025 T/C with Sonotone 9TAHCD	£13·95
Garrard SP25 III with Goldring G800	£18·95
(The above two models are also available in new metal plinth.)	
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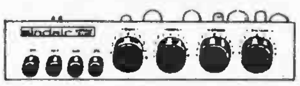

2 × Z30 amplifier, stereo 60 pre-amp, PZ5 power supply. £16·75. Carr. 37½p. Or with PZ6 power supply. £18·85. Carr. 37½p. 2 × Z50 amplifier stereo 60 pre-amp, PZ8 power supply. £20·25. Carr. 37½p. Transformer 4 PZ8, £2·97½ extra. Add to any of the above £4·87½ for active filter unit and £16 for a pair of Q16 speakers. PROJECT 60 FM TUNER £20·25. Carr. 37½p. All other Sinclair products in stock. IC12 £2·50. 2,000 amplifier £24·50. Carr. 37½p. 3,000 Amplifier £31·50. Carr. 37½p. Neoteric amplifier £45·97½. Carr. 37½p.

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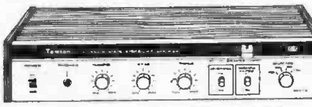

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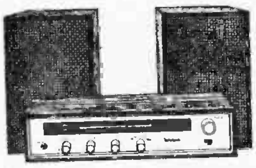

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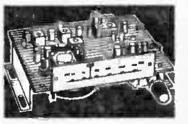

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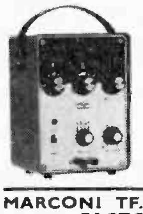

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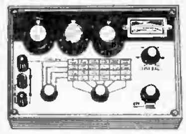

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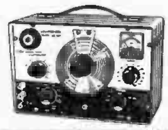

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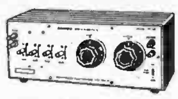

Variable range 0-111 db. Connections. Unbalanced T and Bridge T. Impedance 600 ohms. Range (0.1 db × 10) + (1 db × 10) + 10 + 20 + 30 + 40 db. Frequency: DC to 200 KHZ (—3db). Accuracy: 0.05 db. + indication db × 0.01. Maximum input less than 4 watts (50 volts). Built in 600 Ω load resistance with internal/external switch. Brand new £27·50 P. & P. 25p.

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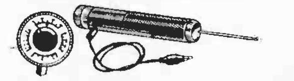

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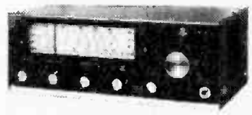

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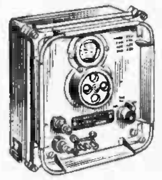

Small portable crystal controlled wavemeter. Size 7in. × 7½in. × 4in. Frequency range 500 Kc/s—10 Mc/s (up to 30 Mc/s on harmonics). Calibrated dial. Power requirements 300 V.D.C. 15mA and 12 V.D.C. 0.3A. Excellent condition. £4·47½. Carr. 37½p.

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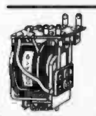

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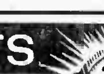

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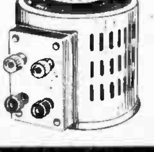

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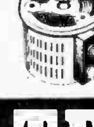

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2N1302	0·17½
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2N1304	0·22½
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2N1306	0·25
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2N1308	0·30
2N1309	0·30
2N1507	0·17½
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2N1632	0·30
2N1637	0·30
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2N2160	0·57½
2N2193	0·40
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2N2220	0·25
2N2221	0·25
2N2222	0·30
2N2297	0·30
2N2368	0·17½
2N2369	0·17½
2N2369A	0·17½
2N2410	0·42½
2N2483	0·27½
2N2484	0·32½
2N2539	0·22½
2N2540	0·22½
2N2613	0·35
2N2614	0·30
2N2646	0·52½
2N2696	0·32½
2N2711	0·25
2N2712	0·25
2N2713	0·27½
2N2714	0·30
2N2865	0·62½
2N2904	0·30
2N2904A	0·32½
2N2905	0·37½
2N2905A	0·40
2N2906	0·25
2N2906A	0·27½
2N2907	0·30
2N2923	0·15
2N2924	0·15
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2N3011	0·30
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2N3053	0·18
2N3054	0·46
2N3055	0·62
2N3133	0·30
2N3134	0·30
2N3135	0·25
2N3136	0·25
2N3340	0·97½
2N3349	1·30
2N3390	0·25
2N3391	0·20
2N3391A	0·30
2N3392	0·17½

Type	£
2N3393	0·15
2N3394	0·15
2N3402	0·22½
2N3403	0·22½
2N3404	0·32½
2N3405	0·45
2N3414	0·22½
2N3415	0·22½
2N3416	0·37½
2N3417	0·37½
2N3439	1·30
2N3440	0·97½
2N3570	1·25
2N3572	0·97½
2N3605	0·27½
2N3606	0·27½
2N3607	0·22½
2N3702	0·11
2N3703	0·10
2N3704	0·11
2N3705	0·10
2N3706	0·09
2N3707	0·11
2N3708	0·07
2N3709	0·09
2N3710	0·09
2N3711	0·12
2N3713	1·08
2N3714	1·15
2N3715	1·23
2N3716	1·30
2N3773	2·40
2N3791	2·06
2N3819	0·35
2N3823	0·97½
2N3854	0·27½
2N2754A	0·27½
2N3855	0·27½
2N3855A	0·30
2N3856	0·30
2N3856A	0·35
2N3858	0·25
2N3858A	0·30
2N3859	0·27½
2N3859A	0·32½
2N3860	0·30
2N3866	1·50
2N3877	0·40
2N3877A	0·40
2N3900	0·37½
2N3900A	0·40
2N3901	0·97½
2N3903	0·35
2N3904	0·35
2N3905	0·37½
2N3906	0·37½
2N4058	0·17
2N4059	0·10½
2N4060	0·12½
2N4061	0·12½
2N4062	0·12½
2N4244	0·47½
2N4245	0·42½
2N4254	0·42½
2N4255	0·42½
2N4284	0·17½
2N4285	0·17½
2N4286	0·17½
2N4287	0·17½
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2N4289	0·17½
2N4290	0·17½
2N4291	0·17½
2N4292	0·12½
2N4303	0·47½
2N5027	0·52½
2N5028	0·57½
2N5029	0·47½
2N5030	0·42½
2N5172	0·12½
2N5174	0·52½
2N5175	0·52½
2N5176	0·45
2N5232A	0·30
2N5245	0·45
2N5246	0·42½
2N5249	0·67½
2N5265	3·25
2N5266	2·75
2N5267	2·62½
2N5305	0·37½
2N5306	0·40
2N5307	0·37½
2N5308	0·37½
2N5309	0·62½
2N5310	0·42½
2N5354	0·27½
2N5355	0·27½
2N5356	0·27½
2N5365	0·47½
2N5366	0·32½
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3N141	0·72½
3N142	0·55
3N143	0·67½
3N152	0·87½
R.C.A.	0·52½
40050	0·55
40250	0·87½
40251	0·87½
40309	0·32½
40310	0·45
40311	0·35
40312	0·47½
40314	0·37½
40315	0·37½
40316	0·47½
40317	0·37½
40319	0·55
40320	0·47½
40323	0·32½
40324	0·47½
40326	0·37½
40329	0·30
40344	0·27½
40347	0·38
40348	0·52½
40360	0·42½
40361	0·47½
40362	0·57½
40370	0·32½
40406	0·57½
40407	0·40
40408	0·52½
40409	0·55
40410	0·62½
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40528	0·72½
40600	0·57½
40673	0·85
AC107	0·30
AC126	0·20
AC127	0·25
AC128	0·20
AC154	0·22½
AC176	0·25
AC187	0·62½
AC188	0·37½
ACY17	0·27½
ACY18	0·25
ACY19	0·25
ACY20	0·25
ACY21	0·25
ACY22	0·20
ACY28	0·20
ACY40	0·20
ACY41	0·25
ACY44	0·40
AD140	0·52½
AD149	0·57½
AD150	0·62½
AD161	0·37½
AD162	0·37½
AF106	0·42½
AF114	0·25
AF115	0·25
AF116	0·25
AF117	0·25
AF118	0·62½
AF119	0·20
AF124	0·22½
AF125	0·20
AF126	0·20
AF127	0·17½
AF139	0·37½
AF178	0·42½
AF179	0·72½
AF180	0·52½
AF181	0·42½
AD239	0·42½
AF279	0·47½
AF280	0·62½
AF211	0·32½
ASY26	0·25
ASY27	0·37½
ASY28	0·27½
ASY29	0·27½
ASY26	0·25
ASY50	0·25
ASY51	0·32½
ASY53	0·25
ASY54	0·25
ASY62	0·25
ASY72	0·17½
ASY83	0·25
ASY86	0·32½
ASZ21	0·42½
AU103	1·25
BC107	0·10
BC108	0·10
BC109	0·10
BC113	0·15
BC114	0·15
BC115	0·15
BC116	0·15
BC116A	0·15
BC118	0·10
BC121	0·20

Type	£
BC122	0·20
BC125	0·20
BC126	0·20
BC140	0·37½
BC147	0·10
BC148	0·10
BC149	0·12
BC152	0·17½
BC157	0·20
BC158	0·11
BC159	0·12
BC160	0·62½
BC167	0·11
BC168B	0·10
BC168C	0·11
BC169B	0·11
BC169C	0·12
BC170	0·12½
BC171	0·15
BC172	0·15
BC175	0·22½
BC182	0·10
BC183	0·09
BC184	0·11
BC182L	0·10
BC183L	0·09
BC184L	0·11
BC212L	0·13
BCY10	0·27½
BCY12	0·27½
BCY30	0·27½
BCY31	0·30
BCY32	0·50
BCY33	0·25
BCY34	0·30
BCY38	0·40
BCY39	0·60
BCY40	0·50
BCY42	0·15
BCY43	0·15
BCY54	0·32½
BCY58	0·22½
BCY59	0·22½
BCY60	0·97½
BCY70	0·20
BCY71	0·25
BCY72	0·17½
BCZ10	0·27½
BCZ11	0·42½
BD116	1·12½
BD121	0·65
BD123	0·82½
BD124	0·60
BD131	0·75
BD132	0·85
BDY10	1·37½
BDY11	1·62½
BDY17	1·50
BDY18	1·75
BDY19	1·97½
BDY20	1·12½
BDY38	0·97½
BDY60	1·25
BDY61	1·25
BDY62	1·00
BF115	0·25
BF117	0·47½
BF163	0·37½
BF167	0·18
BF173	0·19
BF177	0·30
BF178	0·30
BF179	0·30
BF180	0·35½
BF181	0·32½
BF184	0·25
BF185	0·42½
BF194	0·17½
BF195	0·15
BF196	0·15
BF197	0·15
BF198	0·15
BF200	0·52½
BF224	0·14
BF225	0·19
BF237	0·23
BF238	0·23
BF244	0·23
BFW61	0·47½
BFX12	0·22½
BFX13	0·22½
BFX29	0·30
BFX30	0·30
BFX43	0·37½
BFX44	0·37½
BFX51	0·20
BFX68	0·67½
BFX84	0·25
BFX85	0·32½
BFX86	0·25
BFX87	0·27½
BFX88	0·25
BFX89	0·62½
BFX93A	0·70
BFY10	0·32½
BFY11	0·42½
BFY17	0·22½
BFY18	0·32½
BFY19	0·32½
BFY20	1·60
BFY21	0·42½
BFY24	0·45

Type	£
BFY25	0·25
BFY26	0·20
BFY29	0·50
BFY30	0·50
BFY41	0·50
BFY43	0·62½
BFY50	0·23
BFY51	0·20
BFY52	0·23
BFY53	0·17½
BFY56A	0·57½
BFY75	0·30
BFY76	0·42½
BFY77	0·57½
BFY90	0·67½
BFW58	0·27½
BFW59	0·25
BFW60	0·25
BPX25	1·48
BPX29	1·38
BPY10	1·45
BRY29	0·47½
BSX19	0·17½
BSX20	0·17½
BSX21	0·37½
BSX26	0·45½
BSX27	0·47½
BSX28	0·32½
BSX60	0·82½
BSX61	0·62½
BSX76	0·22½
BSX77	0·27½
BSX78	0·27½
BSY10	0·27½
BSY11	0·27½
BSY24	0·15
BSY25	0·15
BSY26	0·17½
BSY27	0·17½
BSY28	0·17½
BSY29	0·17½
BSY32	0·25
BSY36	0·25
BSY37	0·25
BSY38	0·22½
BSY39	0·22½
BSY40	0·32½
BSY51	0·32½
BSY52	0·32½
BSY53	0·37½
BSY54	0·40
BSY56	0·90
BSY78	0·47½
BSY79	0·45
BSY82	0·52½
BSY90	0·57½
BSY95A	0·12½
BSW41	0·42½
BSW70	0·27½
C111	0·75
C424	0·27½
C425	0·55
C426	0·40
C428	0·37½
C744	0·30
ME0402	0·25
ME0411	0·22½
ME0412	0·25
ME0413	0·22½
ME1120	0·25
ME4001	0·15
ME4002	0·15
ME4003	0·20
ME4101	0·15
ME4102	0·17½
ME4103	0·15
ME6101	0·20
MJ400	1·07½
MJ420	1·12½
MJ421	1·12½
MJ430	1·02½
MJ440	0·95
MJ480	0·97½
MJ481	1·25
MJ490	1·00
MJ491	1·37½
MJ802	4·12
MJ4502	4·44
MJ1800	2·17½
MJE340	0·62½
MJE520	0·60
MJE521	0·73
MJE2955	1·37½
MJE3055	0·87½
MPF102	0·42½
MPF103	0·37½
MPF104	0·37½
MPF105	0·37½
MPS3638	0·32½
NKT0013	0·47½
NKT124	0·42½
NKT125	0·27½
NKT126	0·27½
NKT128	0·27½
NKT135	0·27½
NKT137	0·32½
NKT210	0·30
NKT211	0·30
NKT212	0·30
NKT213	0·30
NKT214	0·22½

Type	£
NKT215	0·22½
NKT216	0·37½
NKT217	0·42½
NKT219	0·30
NKT223	0·27½
NKT224	0·25
NKT225	0·22½
NKT229	0·30
NKT237	0·35
NKT238	0·25
NKT240	0·27½
NKT241	0·27½
NKT242	0·20
NKT243	0·62½
NKT244	0·17½
NKT245	0·20
NKT261	0·20
NKT262	0·30
NKT264	0·20
NKT271	0·20
NKT272	0·20
NKT274	0·20
NKT275	0·20
NKT281	0·27½
NKT401	0·87½
NKT402	0·90
NKT403	0·75
NKT404	0·62½
NKT405	0·75
NKT406	0·62½
NKT451	0·62½
NKT452	0·62½
NKT453	0·47½
NKT603F	0·32½
NKT613F	0·32½
NKT674F	0·30
NKT677F	0·30
NKT713	0·25
NKT717	0·42½
NKT734	0·27½
NKT736	0·35
NKT773	0·25
NKT781	0·30
NKT10339	0·32½
NKT10419	0·30
NKT10439	0·37½
NKT10519	0·32½
NKT20329	0·47½
NKT20339	0·37½
NKT80111	0·77½
NKT80112	0·97½
NKT80113	1·12½
NKT80211	0·92½
NKT80212	0·92½
NKT80213	0·92½
NKT80214	0·92½
NKT80215	0·92½
NKT80216	0·92½
OC20	0·75
OC22	0·50
OC23	0·60
OC24	0·60
OC25	0·50
OC26	0·27½
OC28	0·62½
OC29	0·62½
OC35	0·50
OC36	0·62½
OC41	0·22½
OC42	0·25
OC44	0·20
OC45	0·12½
OC46	0·15
OC70	0·15
OC71	0·12½
OC72	0·12½
OC74	0·32½
OC75	0·22½
OC76	0·22½
OC77	0·30
OC81	0·20
OC81D	0·22½
OC83	0·25
OC84	0·25
OC139	0·32½
OC140	0·32½
OC170	0·30
OC171	0·30
OC200	0·40
OC201	0·60
OC202	0·75
OC203	0·42½
OC204	0·42½
OC205	0·90
OC207	0·75
OCP71	0·42½
ORP12	0·62½
ORP61	0·50½
P346A	0·22½
TIS34	0·62½
TIS43	0·40
TIS44	0·10
TIS45	0·10
TIS46	0·11
TIS47	0·11
TIP29A	0·50
TIP30A	0·60
TIP31A	0·62½
TIP32A	0·75
TIP33A	1·02½
TIP34A	2·05

PANEL METERS
38 Series—FACE SIZE 42 × 42 mm. All prices for 1-9 pieces. All meters D.C. £

		£			£
50	Microamp	2·00	5	Milliamp	1·37½
100	,,	1·87½	10	,,	1·37½
200	,,	1·75	50	,,	1·37½
500	,,	1·50	100	,,	1·37½
50-0-50	,,	1·87½	500	,,	1·37½
100-0-100	,,	1·75	1	Amp	1·37½
500-0-500	,,	1·37½	5	,,	1·37½
1	Milliamp	1·37½	10	Volts	1·37½
			20	,,	1·37½
			50	,,	1·37½
			300	,,	1·37½
			500	,,	1·37½

MULLARD C280 M/FOIL CAPACITORS
0·01, 0·022, 0·033, 0·047, 0·068, 0·1 **4p** each. 0·15, 0·22, 0·33 **5p** each. 0·47 **9p.** 0·68 **11p.** 1μF **14p.** 1·5μF **21p** 2·2μF **25p**

PRESETS Carbon Miniature and Sub miniature. Vertical and Horizontal. 0·1 watt, 0·2 watt, all at **0·06** each. 0·3 watt **0·075.**

CARBON POTENTIOMETERS £
Log. and Lin. Less switch .. .. 0·16
Log. and Lin. With switch .. .. 0·25
Wire-wound Pots (3 watts) .. .. .. 0·37½
Twin-Ganged Stereo Pots. (Log. and Lin.) Less Switch 0·40

HEAT SINKS £
4·8" × 4" × 1" Finned for Two TO-3 Trans. .. 0·47½
4·8" × 2" × 1" Finned for One TO-3 Trans. .. 0·32½
For SO-1 0·025 — For TO-5 0·05 Finned
For TO-18 0·05 Finned — For TO-1 0·05 Finned

ZENER DIODES £
400 mW (from 3·3v to 33v) .. .. 0·15
1 Watt (from 2·7v to 200v) .. .. 0·37½
10 Watt (from 3·9v to 100v) .. .. .. 0·30
20 Watt BZY93 Series (from 7·5v to 75v) .. 0·52½

Antex 15W. Soldering Iron .. .. 1·70
D.G. 30 W. Soldering Irons .. .. 1·10

POSTAGE AND PACKING CHARGES
U.K. .. .. 0·12½
EUROPE .. .. 0·25 (minimum)
OVERSEAS (AIR) .. LETTER 0·65; PARCEL £1·90

SILICON RECTIFIERS

PIV	50	100	200	400	600	800	1000	1200	1400
	£	£	£	£	£	£	£	£	£
1A	0·10	0·12½	0·15	0·16	0·17½	0·19	0·20	—	—
3A	0·15	0·17	0.20	0·22½	—	0·30	—	—	—
6A	—	—	0·25	0·30	0·32½	0·35	0·50	—	—
10A	—	0·52½	0·57½	0·65	0·77½	0·87½	0·97½	1·25	1·60
17A	—	0·57½	0·62½	0·77½	0·90	0·97½	1·20	1·57½	1·87½
35A	—	1·37½	1·60	1·97½	2·37½	2·70	3·10	3·50	4·50

1 amp and 3 amp are plastic encapsulation.

DIODES AND RECTIFIERS

IN914	0·07½	AAZ17	0·12½	BAY31	0·07½	OA10	0·22½
IN916	0·07½	BA100	0·15	BAY38	0·25	OA9	0·10
IN4007	0·22½	BA102	0·22½	BY100	0·17½	OA47	0·07½
IS44	0·10	BA110	0·32½	BY103	0·22½	OA70	0·07½
IS113	0·15	BA115	0·07½	BY124	0·15	OA73	0·10
IS120	0·15	BA141	0·32½	BY126	0·15	OA79	0·09
IS121	0·17½	BA142	0·32½	BY127	0·17½	OA81	0·07½
IS130	0·12½	BA144	0·12½	BY164	0·57½	OA85	0·07½
IS131	0·12½	BA145	0·20	BYX10	0·22½	OA90	0·07½
IS132	0·15	BA154	0·12½	BYZ10	0·35	OA91	0·07½
IS940	0·07½	BA156	0·22½	BYZ11	0·32½	OA95	0·07½
AA119	0·10	BAX13	0·12½	BYZ12	0·30	OA200	0·10
AA129	0·10	BAX16	0·12½	BYZ13	0·25	OA202	0·10
AAZ13	0·10	BAY18	0·17½	OA5	0·17½	TIV307	0·50
AAZ15	0·12½						

MAINS TRANSFORMERS £
1 amp Charger. Sec. 0-3·5-9-18v *Post and packing 0·22½* 1·12
2 amp Charger. Sec. 0-3·5-9-18v *Post and packing 0·22½* 1·44
1 amp (Douglas) MT103 Sec. tappings from 6v to 50v .. 1·92
2 amp (Douglas) MT104 Sec. tappings from 6v to 50v .. 2·54
Post and packing £0·28.
6 amp (Douglas) MT107 Sec. tappings from 6v to 50v .. 6·25
Post and packing 0·37½.
Various other Transformers ranging from ½A to 5A in stock.

TRIACS

SC35D ..	1·00	SC51D ..	1·95	**DIACS**	
SC36D ..	1·00	40430 ..	0·97½	MPT20 ..	0·40
SC40D ..	1·25	40486 ..	0·95	MPT28 ..	0·37½
SC41D ..	1·20	40528 ..	0·72½	MPT32 ..	0·37½
SC45D ..	1·50	40430 ..	1·30	MPT36 ..	0·37½
SC46D ..	1·42½	40432 ..	1·37½	ST2 ..	0·21
SC50D ..	2·00	40512 ..	1·45	40583 ..	0·27½

Economy Range Triacs
TC4/10 (Pressfit) 4 amp 100 PIV .. .. 0·65
TC4/20 (Pressfit) 4 amp 200 PIV .. .. 0·75
TC4/40 (Pressfit) 4 amp 400 PIV .. .. 0·87½

INTEGRATED CIRCUITS
SEE OUR ADVERTISEMENT ON OPPOSITE PAGE.
SHOWING NEW I.C.s AT NEW LOW PRICES.

THYRISTORS

PIV	50	100	200	300	400
1A	0·25	0·27½	0·37½	0·40	0·47½
4A	—	0·47½	0·55	0·57½	0·77½
5A	—	0·55	0·65	—	0·75
7A	—	0·55	0·65	—	0·97½

TIC47 0·6 amp. 200 PIV **0·55.** TIC44 0 6 amp 50 PIV **0·47**
Also 12 amp 100 PIV 0·75; 2N3525 at £1·12½.

VEROBOARD

	·15 Matrix	·1 Matrix
2½" × 3¾"	0·17	023
2½" × 5"	0·25	0·25
3¾" × 3¾"	0·25	0·25
3¾" × 5"	0·30	0·29
2½" × 17"	0·58	—
3¾" × 17"	0·80	1·02
5" × 17"	—	1·31
3¾" × 17" (Plain)	—	0·59
5" × 17" (Plain)	0·83	—
2½" × 17" (Plain)	0·57	—

Vero Pins (Bag of 36) **£0·20.**
Vero Cutter **£0·45.** Pin Insertion Tools (·1 and ·15 matrix) at **£0·55**

RESISTORS ¼ W. & ½ W. E24 Series.
Carbon Film ⅛ W., 1 W., 2 W. E12. Series.
¼ watt 5% .. .. 0·01½ — 1 watt 10% .. .. 0·02½
½ watt 5% .. .. 0·02 — ½ watt M/Oxide 2% 0·04
2 watt 10% .. .. 0·06 — ⅛ watt 5% .. .. 0·01

Wire Wound £
2½ watt 5% (up to 270 ohms only) .. .. 0·07½
5 watt 5% (up to 8·2k ohms only) .. .. 0·10
10 watt 5% (up to 25k ohms only) .. .. 0·12½

CAPACITORS. Polyester, ceramics, Polystyrene, silver mica, tantalum, trimmers etc. in stock, please enquire.

Electrolytics

MFD.	V.	£	MFD.	V.	£	MFD.	V.	£
1	18	0·06	25	50	0·06	400	16	0·14
1·6	25	0·06	32	40	0·06	500	25	0·19
2	350	0·10	32	450	0·27½	500	50	0·24
2·5	16	0·06	40	16	0·06	640	16	0·17½
4	10	0·06	50	12	0·06	1000	16	0·18
4	40	0·06	50	25	0·06	1000	25	0·25
4	350	0·11	50	50	0·10	1000	50	0·37½
5	18	0·06	64	25	0·06	2000	25	0·37½
5	50	0·06	80	16	0·06	2000	50	0·52½
6·4	6·4	0·06	80	25	0·06	2500	25	0·42½
8	40	0·06	100	6·4	0·06	2500	50	0·57½
8	450	0·15	100	12	0·06	2500	64	0·80
10	12	0·06	100	25	0·10	3000	25	0·45
10	25	0·06	100	50	0·12½	3600	100	1·70
12·5	25	0·06	125	10	0·06	4000	40	0·80
16	10	0·06	200	10	0·06	4500	64	2·25
16	15	0·06	250	25	0·14	5000	25	0·57½
16	450	0·16	250	50	0·19	5000	50	0·97½
25	6·4	0·06	320	10	0·06	5000	85	1·75
25	10	0·06						
25	25	0·06						

THERMISTORS (MULLARD)

R53 (STC) 1·27½	VA1010 0·12½	VA1039 0·15	VA1077 0·20
K151 (Siemens) 1K 0·12½	VA1015 0·19	VA1040 0·12½	VA1091 0·22½
VA1005 0·15	VA1033 0·12½	VA1053 0·12½	VA1096 0·20
	VA1034 0·12½	VA1066 0·19	VA1097 0·20
	VA1037 0·12½	VA1074 0·12½	VA3705 0·87½
	VA1038 0·12½	VA1075 0·22½	

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SEND 1/- (5 np) FOR NEW COMPREHENSIVE SEMI CONDUCTOR PRICE LIST. (24 pages)
CALLERS WELCOME
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USM-24C OSCILLOSCOPE: 3 in. oscilloscope with 2c/s to 10Mc/s vertical response, and 8c/s to 800Kc/s horizontal response. Sensitivity 50 mv. rms/inch. Triggered sweep, built-in trigger pulses and markers. Mains input 115V, 50c/s. Complete with all leads, probes and circuit diagram. **£42·50** each, carr. £2.

SIGNAL GENERATOR TS-403B/U (or URM-61A): (Hewlett Packard). A portable, self-contained, general-purpose test equipment designed for use with radio and radar receivers and for other applications requiring small amounts of RF power such as measuring standing-wave ratios, antenna and transmission line characteristics, conversion gain, etc. Both the output freq. and power are indicated on direct-reading dials. 115V, AC, 50 c/s. Freq.—1800-4000 Mc/s. CW, FM, Modulated Pulse—40-4000 pulses per sec. Pulse Width—0.5-10 microsecs. Timing—Undelayed or delayed from 3-300 microsecs from external or internal pulse. O/put—1 milliwatt max., 0 to —127 db variable. O/put Impedance—50 Ω. Price: **£120** each + £2 carr.

SIGNAL GENERATOR TYPE 902: (P.R.D.). A portable, general-purpose, broadband, microwave signal generator designed for testing and maintenance of aircraft radio and radar receivers in the SHF band. The RF output level is regulated by a variable attenuator calibrated in dbm. The frequency dial is calibrated in Mc/s. Provision is made for external modulation. Power Supply—115V, ±10% A.C., 50 c/s. Freq.—3650-7300 Mc/s. Internal Transmission—CW, Pulse, FM. External Transmission—Square Wave, Pulse. Power O/put—0.2 milliwatts. O/put Attenuator: —7 to —127 dbm. Load—50 Ω. Price: £135 each + £2 carr.

TEST SET TS-147C: Combined signal generator, frequency meter and power meter for 8500-9600 Mc/s. CW or FM signals of known freq. and power or measurement of same. *Signal Generator:* O/put —7 to —85 dbm. Transmission—FM, PM, CW. Sweep Rate—0-6 Mc/s per microsec. Deviation—0-40 Mc/s per sec. Phase Range—3-50 microsec. Pulse Repetition Rate—to 4000 pulses per sec. RF Trigger for Sawtooth Sweep—5-500 watts peak. 0.2-6 microsec. duration, 0.5 microsec pulse rise time. Video Trigger for Sawtooth Sweep—Positive polarity, 10-50V peak. 0.5-20 microsec duration at 10% max. amplitude, less than 0.5 microsec rise time between 90% and 10% max. amplitude points. *Frequency Meter:* Freq. 8470-9360 Mc/s. Accuracy—+2.5 Mc/s per sec. absolute, + 1.0 Mc/s per sec. for freq. increments of less than 60 Mc/s relative, ±1.0 Mc/s per sec. at 9310 Mc/s per sec. calibration point. Accuracy measured at 25° C and 60 humidity. *Power Meter:* Input: + 7 to + 30 dbm. Output — 7 to — 85 dbm. Price: **£75** each + £1 carr.

SIGNAL GENERATOR TS-497B/URR: (Boonton). Freq. 2-400 Mc/s in 6 bands. Internal Mod. 400 or 1000 c/s per sec. External Mod. 50 to 10,000 c/s per sec. External PM. Percent Mod. 0-30 for sine wave. Am or Pulse Carrier. O/put Voltage 0.1-100,000 microvolts cont. variable. Impedance 50 Ω. Price: £85 each + £1·50 carr.

FREQUENCY METER TS-74 (same TS-174): Heterodyne crystal controlled. Freq. 20-280 Mc/s. Accuracy .05%. Sensitivity 20 mV. Internal Mod. at 1000 c/s. Power Supply—batteries 6V and 135V. Complete with calibration book. (Manufactured for M.O.D. by Telemax. "As new" in cartons.) **£75** each. Fully stabilised Power Supply available at extra cost **£7·50** each. Carr £1·50.

CT.54 VALVE VOLTMETER: Portable battery operated. In strong metal case with full operating instructions. 2.4V-480V. A.C. or D.C. in 6 Ranges, 1Ω to 10MegΩ in 5 Ranges. Indicated on 4in. scale meter. Complete with probe, excellent condition. **£12·50**, carr. 75p.

CT.381 FREQUENCY SWEEP SIGNAL GENERATOR: 85Kc/s-30Mc/s and response curve indicator with 6in. CRT tube and separate power supply. Fully stabilised. Price and further details on request.

AVO WIDE RANGE SIGNAL GENERATOR: Freq. 50Kc/s-80Mc/s in 6 bands. Mains input 100-130V; 200-260V, 50-60c/s. Second-hand, excellent cond. **£14** each, or: New cond. complete with all leads and transit case **£20** each. Carriage £1.

DESK TYPE TELEPHONES: Black, without dial, new cond. **£2** each, 50p post. USA Type 500 series, with dial, black, new **£4** each, 50p post. USA Type, with dial, second-hand cond. **£1·25** each, 50p post.

CANADIAN HEADSET ASSEMBLY: Moving coil headphones 100Ω with chamois leather earmuffs. Small hand microphone complete with switch and moving coil insert. New Condition. **£1·75** each, post 25p.

HEADSET ASSEMBLY TYPE No. 10: Moving coil headphones and microphone. (Similar to above) new cond. **£1·75**, post 25p; or second-hand cond. £1·25, post 25p.

HEADSET ASSEMBLY: with lightweight boom microphone. Good second-hand condition. **£2·50**, post 75p.

DLR HEADPHONES: 2 × balanced armature earpieces. Low resistance. £1·25 a pair, 25p post.

MOVING COIL INSERT: Ideal for small speakers or microphones. Box of 3 **£1**, post 23p.

HAND MICROPHONE: (recent design) with protective rubber mouthpiece. £2, post 23p.

MICROLINE IMPEDANCE METER MODEL 201: 5300-8100Mc/s. **£75** each, £1 carr.

MICROLINE DIRECTIONAL COUPLER MODEL 209: 5260-8100Mc/s. 24DB. **£12·50** each, post 35p.

POWER UNITS AVAILABLE FOR FOLLOWING SETS: 52 set—mains input, 150V @ 60mA and 12V @ 3 amps, new cond. **£3·50.** Receiver type 88 (1475)—mains input, 250V @ 80mA and 6·3V @ 4 amps, new cond. **£3·50.** No. 19 set **£2·50.** C12 set **£4·00.** 88 set **£2·50.** Carriage all types £1 extra.

STABILISED BENCH POWER SUPPLY: fully smooth, dual output, positive or negative, 2-6V; 6-9V; 9-12V and 12-16V all at 2 amps d.c. from mains input. £25 + £2 carr.

DIGITAL VOLTMETER & RATIOMETER Model BIE. 2116, **£65**, carr. £2.

DIGITAL VOLTMETER Model BIE. 2114, **£55**, carr. £2. (Mnftrs. Blackburn Instruments).

MARKA SWEEP GENERATOR MODEL VIDEO (Kay Electric, USA) £65, carr. £2.

ROTARY CONVERTERS: Type 8a, 24 v D.C., 115 v A.C. @ 1.8 amps, 400 c/s 3 phase, **£6·50** each, post 50p. 24 v D.C. input, 175 v D.C. @ 40mA. output, **£1·25** each, post 20p.

CONDENSERS: 40 mfd, 440 v A.C. wkg. **£5** each, 50p post. 30 mfd 600 v wkg. d.c., **£3·50** each, post 50p. 15 mfd 330 v a.c., wkg., 75p each, post 25p. 10 mfd 1000 v. 63p each, post 13p. 10 mfd 600 v. 43p each, 25p post. 8 mfd 2500 v. **£5** each, carr. 63p. 8 mfd 600 v. **43p** each, post 15p, 8 mfd. 1% 300 v. D.C. **£1·25,** post 25p, 4 mfd. 3000 v. wkg. **£3** each, post 37p. 4 mfd 2000 v. **£2** each, post 25p. 4 mfd 600 v., 2 for **£1.** 0·25 mfd, 2Kv, **20p** each, post 10p. 0·01 mfd MICA 2·5Kv. **£1** for 5, post 10p. Capacitor 0·125 mfd, 27,000 v. wkg. **£3·75** each, 50p post.

TCS MODULATION TRANSFORMERS, 20 watts, pr. 6,000 C.T., sec. 6,000 ohms. Price **£1·25**, post 25p.

SOLENOID UNIT: 230 v. A.C. input, 2 pole, 15 amp contacts, **£2·50** each. post 30p.

CONTROL PANEL: 230 v. A.C., 24 v. D.C. @ 2 amps, **£2·50** each, carr. 75p.

OHMITE VARIABLE RESISTOR: 5 ohms, 5½ amps; or 40 ohms at 2·6 amps. Price (either type) **£2** each, 25p post each.

TX DRIVER UNIT: Freq. 100-156 Mc/s. Valves 3 × 3C24's; complete with filament transformer 230 v. A.C. Mounted in 19in. panel, **£4·50** each, carr. 75p.

POWER SUPPLY UNIT PN-12A: 230V a.c. input 50-60 c/s. 513V and 1025V @ 420 mA output. With 2 smoothing chokes 9H, 2 Capacitors, 10Mfd 1500V and 10Mfd 600V. Filament Transformer 230V a.c. input. 4 Rectifying Valves type 5Z3. 2 × 5V windings @ 3 Amps each, and 5V @ 6 Amp and 4V @ 0.25 Amp. Mounted on steel base 19"Wx11"Hx14"D. (All connections at the rear.) Excellent condition **£6·50** each, carr. £1.

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LT TRANSFORMER: PRI 230V. Output 3 × 6·3 at 3 amps each winding, 3½" × 4" × 5". Fully shrouded **£1·50** post 50p.

VARIABLE VOLTAGE REGULATOR TRANSFORMER: Input 230V A.C.; Output 57·5V-230V in 16 equal steps @ 21 Amps. **£22·50** each, carr. £1·50.

TRANSFORMER: 230V A.C. input. 17·75V @ 35 Amps output. **£9·50** each, carr. £1.

TRANSFORMER: 'C' Core. 230V A.C. input. 1000-0-1000V or 750-0-750V @ 250mA. **£6·50** each, carr. 75p.

MODULATOR UNIT: 50 watt, part of BC-640, complete with 2 × 811 valves, microphone and modulator transformers etc. **£7·50** each, 75p carr.

CATHODE RAY TUBE UNIT: With 3in. tube, Type 3EG1 (CV1526) colour green, medium persistence complete with nu-metal screen, **£3·50** each, post 37p.

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DECADE RESISTOR SWITCH: 0.1 ohm per step. 10 positions. 3 Gang, each 0·9 ohms. Tolerance ± 1% **£3** each, 25p post. 90 ohms per step. 10 positions, total value 900 ohms. 3 Gang. Tolerance ± 1% **£3·50** each, post 25p.

CRYSTAL TEST SET TYPE 193: Used for checking crystals in freq. range 3000-10,000Kc/s. Mains 230V, 50c/s. Measures crystal current under oscillatory conditions and the equivalent parallel resistance. Crystal freq. can be tested in conjunction with a freq. meter. **£12·50** each, £1 carr.

LEDEX SWITCHING UNIT: 2 ledex switches, 6 Bank and 3 Bank respectively, 6 Pos.; 1 Manual switch, 16 Bank 2 Pos. **£4** each, 50p post.

VARIAC TRANSFORMERS: Input 115V, output 0-135V at 2½Amps. **£3** each 50p post. Input 115V, output 135V at 5 Amps. **£5** each, 50p post.

GEARED MOTOR: 24c. D.C., current 150mA, output 1 rpm, **£1·50** each, 25p post. **ASSEMBLY UNIT** with Letcherbar Tuning Mechanism and potentiometer, 3 rpm, **£2** each 25p post. **SYNCHROS:** and other special purpose motors available. List 3p.

DALMOTORS: 24-28V d.c. at 45 Amps, 750 watts (approx. 1hp) 12,000rpm. **£5** each, 50p post.

GEARED MOTOR; 28V d.c. 150 rpm (suitable for opening garage doors). **£4** each, 50p post.

SMALL GEARED MOTOR: 24V d.c., output 200 rpm. Meas'm'ts 1½in. dia. × 3½in. long. **£2** each, 23p post.

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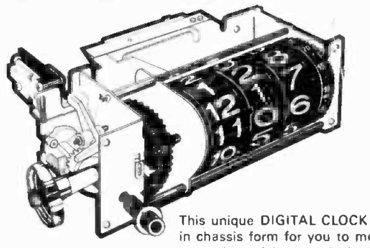
NUMBER ONE IN INSTRUMENT HIRE

Laskys

EXCLUSIVE DIGITAL CLOCK MECHANISM



- Made especially for Lasky's by famous maker
- Mains operation
- 12 hour alarm
- Auto "SLEEP" switch
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- Silent operation synchronous motor
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- Built in alarm buzzer

This unique DIGITAL CLOCK is now available EXCLUSIVELY FROM LASKY'S in chassis form for you to mount in any housing that you choose. All settings are achieved by two dual-concentric controls at the front including: ON-OFF-AUTO and AUTO ALARM, "sleep" switch, 10 minute division "click" set alarm (up to 12 hour delay), time adjustment. Ultra simple mechanism and high quality manufacture guarantee reliable operation and long life.

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The clock measures $4\frac{3}{4}$W x $1\frac{3}{4}$H x $3\frac{1}{4}$D (overall from front of drum to back of switch). SPEC: 210/240V AC. 50Hz operation; switch rating 250V, 3A. Complete with instructions. HUNDREDS OF APPLICATIONS.

COMPLETE WITH SET OF CONTROL KNOBS

LASKY'S PRICE £6.95 P & P 18p.

SPECIAL QUOTATIONS FOR QUANTITIES

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High precision, low-mass, counterbalanced pick-up arm, heavy balanced turntable, viscous cueing device, slide in cartridge, 4 pole motor.

LASKYS PRICE £11.95 POST 35p

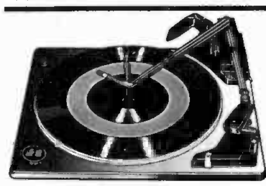
With plinth and cover £15.75 POST 40p.

BSR McDonald units and packages

A. Chassis only. **B.** Complete with Lasky's plinth and cover. **C.** Complete with Lasky's plinth, cover and AD76K cart. **D.** comp. wired on BSR plinth with cover. **E.** As D plus AD76K cartridge.

Model	A	B	C	D	E
610	£15.50	£18.75	£22.50	£24.50	£28.50
510	£13.45	£16.95	£20.75	£22.00	£26.00
310	£10.95	£13.45	£17.25	£21.00	£23.50
MP60	£11.95	£15.75	£19.50	£21.50	£25.50

GARRARD SL55B



Four speed autochanger that accepts up to 8 LP's. Has all the refinements that Garrard SL turntables are famous for. With lifting device that allows 'spot-on' track selection on all discs and perfect cueing facilities for singles. Wired for mono and stereo. Size 14in (W) x $11\frac{3}{8}$in (D) $4\frac{3}{8}$in above and 3in below unit plate.

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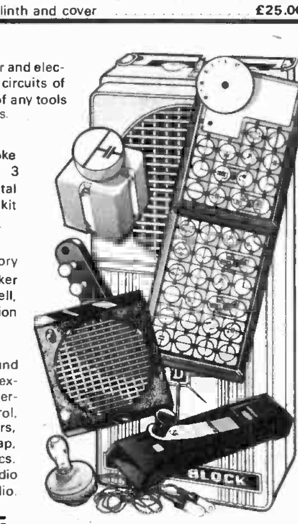

DENSHI KIT SR-1A

Kit comprises: Base board: tuner block, 4 resistors; choke coil; transformer; 28A transistor for RF. 2 diodes; 3 capacitors; battery block; morse key; antenna lead; crystal earphones; various bridge and connecting pieces. This kit permits the building of 16 basic circuits.

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Kit comprises of: 2 base boards. 50 component and accessory parts inc. 3 transistors and 2 diodes, vol. control, $2\frac{1}{4}$in speaker in extension baffle housing, cadmium sulphide photo cell, crystal mic., earpiece, test probes, morse key, extension leads etc. Build at least 100 projects Comp. with batt.

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± 10	J. A. Thompson	LAZ Mod 3C	Resistive	25·00
± 100	J. A. Thompson	LAZ Mod 3C	Resistive	25·00
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	English Electric	TCFBA1100/3B		5·00
± 12·5	Graseby			18·50
± 12	Graseby	GW 6A		18·50
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± 1	SIC de Far	J4211	Resistive	10·00
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— 5 + 30	Turner	IT-1-4F	Inductive	12·00
	Sperry	24955-0		10·00
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K.G.M.
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ROTRON
Fan. 105–125V 50–60Hz 14 Watts 4½ × 4½" × 1½" .... **£5·50**

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GRIOM (Amber filter)	4– 10	£1·35	20p
	11– 25	£1·30	Each
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Side Reading (14 m/m Fig. Ht.) 0-9 display

				Less Bases
XN3A/F	6 m/m lead	(Red filter)	4– 10	£1·10
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XN11/F	38 m/m lead	(Red ..)	26–100	£0·95

Post Free.

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XN9	38 m/m leads	(Clear filter)	Displays Fig. "½"
XN10/C	6 m/m leads	(Clear filter)	Displays "+, — and"
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Type M0-27 Miniature. Temperature 50°C 6V 0·79A/12V 0·39A. Plug in type overall dimensions 2¼" × ⅞" .... **£2·50**

ELECTRONIC BROKERS LTD

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BROKERS

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PHOTOMULTIPLIER TUBES

20th CENTURY ELECTRONICS
Type 6097C. Operating voltage 1130V 0·003 μA for 10 A/L. Sensitivity 41μ A/L .... £8·50
E.M.I.
Type 6097B .... £8·50
E.M.I.
Type 6097A .... £8·50

POTENTIOMETERS

TEN TURN 3600° ROTATION

Res. Ohms	Linearity—Per cent	Manufacturers	Model	Price
100/100/100		Beckman	A	£8·00
100	0·5	Beckman	A.S.	£3·00
200	0·5	Beckman	A	£3·00
500	0·1	Beckman	S	£3·50
500		Colvern	2501	£2·25
500		Foxes	PX4	£2·00
500		Colvern	2610	£2·50
500		Colvern	26/1000/11	£3·00
500	1·0	Relcon	HEL107-10	£2·25
1K		Relcon	HEL0710	£2·25
2K	0·5	Beckman	SA1101	£3·00
2K	0·25	Beckman	7216	£3·00
2K		Reliance	GPM15	£2·00
2K		General Controls	GPA15/4	£2·00
5K		Relcon	07-10	£2·50
5K		Colvern	CLR2503	£3·00
10K	0·5	Beckman	A	£3·00
10K	0·1	Beckman X	A	£3·50
10K	0·1	Colvern	CLR26/1001	£3·50
15K		Colvern	CLR2402	£3·00
18K		Beckman	A	£3·00
25K	0·5	Helipot	SAJ337	£3·00
29K	0·05	Beckman	SA1244	£4·50
30K		Colvern	2402	£1·50
30K		Beckman	SA95C	£3·00
30K	0·1	Beckman	A.88	£3·50
30K	0·5	Beckman	SA1692	£3·00
30K	0·25	Beckman	SA1679	£3·25
30K	1·0	Colvern	2402/1	£1·50
50K		Reliance	07·10	£2·25
50K			07·5	£2·25
50K		Colvern	2503	£2·25
50K	X	Foxes	PX4	£2·25
50K	0·5	Beckman	A	£3·00
50K	0·1	Beckman	A	£3·50
100K/100K		Ford	A	£5·00
100K	0·1	Beckman	A	£3·50
100K	0·5	Beckman	A	£3·00
100K		Colvern	2501	£2·25
100K		Colvern	2610	£2·50
298K	0·1	Beckman	8A3902	£3·50
300K	0·1	Beckman	A	£3·50
THREE TURN 780° ROTATION				
100/100	0·5	Beckman	C	£3·00
100/100		Beckman	Type C	£3·00
300		Beckman	9303	£2·25
1K		Fox	PX2/H3	£2·25
10K	0·5	Beckman	C.88	£2·25
20K/20K	0·1	Beckman	C.8	£3·00
10K/10K	0·1	Beckman	C	£3·00
50K	0·5	Beckman	C.8	£1·75
FIFTEEN TURN 5400° ROTATION				
25K/25K		Beckman B	10 watts	£6·50
46K/46K		Beckman B	10 watts	£6·50
TWENTY TURN 7200° ROTATION				
1 Meg		General Controls	PXM130	£4·00
50K		Reliance		£2·00
156 TURN 56/60° ROTATION				
460		Kelvin Hughes	KTP0701	£9·50
FIVE TURN 1800° ROTATION				
200		Relcon	HEL07-05 F/11	£2·25
500		Colvern	CLR2505	£2·00
U1·5K		Colvern	CLR2605	£2·00
FIVE-AND-A-HALF TURN				
500		Colvern	2405	£2·00

SERVO COMPONENTS

We hold large stocks of servo components—please ask for lists.

INSTRUMENT SLIP RINGS

Type ETC 27222 C45 45 way Slip Ring Assembly .... £25·00
Type ETC27231C34 34 way Slip Ring Assembly .... £20·00

SOLENOIDS

EICHNER
Type 40.024–25C2 Voltage 42V Coil Resistance 45 ohm. Throw approx. 0·25 in. As used on Eichner tape punches. Overall Dimensions 3" × 1" × 1" .... £0·95
E.K.S.
Type E13 Voltage 24V 70 ohm Throw approx. 0·25". Overall dimensions 1½" × ¾" × ¾" .... £0·90

MAGNETIC CORE STORES

EX-COMPUTER
42 × 52 ferrite core stores. Capacity 2K bits. Complete with 84–OA10 load diodes. For building computers or storing information in binary form .... £2·75

SWITCHES

INERTIA

INERTIA SWITCH LTD.
Type L4110–A/15 Operates on 15g load .... £5·00

ROTARY DRIVEN

LEDEX (NSF LTD.)
Rotary Solenoid Switches
5 pole 5 way .... £1·00
6 pole 11 way .... £1·30
1 pole 1 way H/Duty .... £1·45
12 pole 11 way H/Duty reversible .... £3·50
4 pole 11 way .... £1·25
1 pole 4 way .... £1·25
H/Duty rotary solenoid only .... £0·75

DIFFERENTIAL PRESSURE

SMITHS
Type 1141PG/AA/1/25 Hydraulic Pressure Switch.
Range setting 10–30 p.s.i. max. overload 120 p.s.i. .... £2·50
Range setting 214 p.s.i. max. overload 400 p.s.i. .... £3·00
T.A. CONTROLS
Type FKY A/37 Pressure Switch Fixed setting 40 p.s.i. .... £2·50

SAMPLING SWITCHES

VACTRIC
6V DC 25 way .... £45·00
6·3V DC 100 way .... £29·50
24V DC 100 way .... £29·50
24V DC 4 pole 24 way £19·50
26V 400Hz 6 pole 24 way £25·00
115V 400Hz 4 pole 48 way £29·50
115V 400Hz 7 pole 48 way £29·50

SYNCHROVERTER SWITCHES

ELLIOTT
Type G1280/4431 .... £3·00
Type C1410 .... £3·00
Type 95908 6·3V 400Hz .... £3·00
Type C1417–6 .... £3·00
Type C51481 .... £3·00
Type C51484 .... £3·00
Type G1280/4568UF .... £3·00
Type K1280 .... £3·00

TIME SWITCH

SANGAMO WESTON
Type 816–2–29 250V 50Hz .... £4·00

TORQUE SWITCH

SMITHS
Type 'B' .... £2·50

ACCELERATION SWITCH

GRASEBY INSTRUMENTS
±12g .... £5·00

MINIATURE THUMBWHEEL SWITCHES

STC
Type 65C–8W21–630 AAC Digital Switch 0–9. 1 pole 10 way. Make before break—rear illumination of digit .... £0·60
Type 65C–8W21–630 BAC Digital Switch 0–4–0–4. 2 pole 5 way. Make before break—rear illumination of digit. .... £0·65
Type 65C–8W21–630 BAA. 2 pole 5 way. Make before break—no illumination .... £0·60
Type 65C–8W21–630 CAC—rear illumination of digit. Binary 10 way £0·80

TAPE HEADS (Data)

EX-IBM COMPUTER
Type E32–E36 7 track ½ inch .... £12·50
GRESHAM
Type PE7 7 track 1 inch. Slightly damaged .... £4·00
Type PO7 as PE7 .... £4·00
Type RO8 8 track 1 inch. Slightly damaged .... £4·00
Type RO7 7 track 1 inch. Slightly damaged .... £4·00
All slightly damaged:
Type PO4 4 track ½ inch. £4·00
Type RE3 3 track ½ inch. £4·00
Type PE3 3 track ½ inch. £4·00
Type 84L 9 track ½ inch. £4·00
Type 84LR 4 track ¼ inch £4·00
Type 812LR 12 track 1 inch £4·00
NEW 7 track 1 inch tape heads £12·00

TRANSDUCERS

PRESSURE

Range p.s.i.	Manufacturer	Type No.	Type	Price £	Notes
0–30 ins. Hg	JLT*	8B4	Inductive	25·00	Vacuum
±900mB	SIFM	H33	Resistive	19·50	Supply 27 ±3V

TRANSDUCERS—continued

Range p.s.i.	Manufacturer	Type No.	Type	Price £	Notes
±2·5	SEL	SE150/A	Inductive	25·00	C/W Mod
±3	HWS		Resistive	22·50	
±5	SEL	SE150/A	Inductive	25·00	C/W Mod
0–15	JLT*		Inductive	25·00	
8–24	MUNRO	AB10/A/379/12	Resistive	15·00	
0–25	SOLARTRON	NT4-316A	Inductive	25·00	
0–25	IV PRESSURE CONTROLS	187	Resistive	15·00	Air/Hydr
0–30	HWS		Resistive	22·50	
0–50	SEL	SE50AB	Inductive	25·00	C/W Mod
0–50	JLT*		Inductive	25·00	
0–100 Abs	SOLARTRON	NT3.316	Inductive	25·00	
0–100	SOLARTRON	NT4.317	Inductive	25·00	
0–150 Abs	SOLARTRON	NT4.316A	Inductive	25·00	
0–150 Abs	SOLARTRON	NT4.317	Inductive	25·00	
0–150	JLT*		Inductive	25·00	
0–200	SEL	SE50A	Inductive	25·00	C/W Mod
0–250	JLT*		Inductive	25·00	
0–350	SEL	SE150A	Inductive	25·00	C/W Mon
0–400	JLT*		Inductive	25·00	
0–400	ULTRA	TP1A45/Z08	Inductive	25·00	6V 400Hz
250–500	JLT*		Inductive	25·00	
0–700	JLT*		Inductive	25·00	
0–700	BARNET	2640	Inductive	22·50	
0–750	SEL	SE250/A	Inductive	25·00	C/W Mod
0–750	SEL	SE250/B	Inductive	25·00	C/W Mod
0–1000	SEL	SE250/A	Inductive	25·00	C/W Mod
0–1000	SEL	SE250/B	Inductive	25·00	C/W Mod
0–1000	JLT*	PP4	Resistive	25·00	OP/24V
600–1200	JLT*		Inductive	25·00	
0–1200	JLT*		Inductive	25·00	
±1200	MHH		Inductive	15·00	
0–1500	SEL	SE250	Inductive	25·00	C/W Mod
0–2000	JLT*	548	Resistive	25·00	12V 2K
0–2000	KDG	TD-216	Resistive	25·00	
0–2500	JLT*		Inductive	25·00	
0–3000	SEL	SE165	Inductive	25·00	C/W Mod
0–4000	SEL		Inductive	25·00	C/W Mod
0–4000	JLT*	548/4K	Resistive	25·00	

* JLT = J. Langham Thompson.

S E LABS OSCILLATOR/AMPLIFIER DEMODULATOR
Type SE62/12 complete with 0–4000 p.s.i. transducer .... £65·00
S E LABS TRANSDUCER MODULATOR
Type SE441/2 O/P 5V into 50k .... £25·00

DISPLACEMENT

Type 1T 2–31–35 BONDED RESISTANCE DISPLACEMENT TRANSDUCER. Range ±⅛ inch .... £15·00

STRAIN GAUGES

PHILLIPS STRAIN GAUGE
Type PR 9816 .... £15·00

TRANSFORMERS

TYPE 40288
PRI 0–200–220–240V. SEC 20–0–20V, 45–0–45V, 0–12V .... £1·50
75 WATT AUTOTRANSFORMER
Tapped 0–110–200–220–240V 50Hz .... £1·95
100 WATT AUTOTRANSFORMER
Tapped 0–110–200–230–240V 50Hz .... £2·15

UNISELECTORS

MINIATURE TYPES

A.E.I.
3 bank 12 way ...... 1400 ohm .... £3·25
A.E.I.
3 bank 12 way ...... 15 ohm 12V plug in .... £5·25
A.E.I.
3 bank 12 way ...... 35 ohm 12V plug in .... £5·25
A.E.I.
3 bank 12 way ...... 50 ohm 12V plug in .... £5·25
A.E.I.
3 bank 12 way ...... 250 ohm 12V plug in .... £5·25

VALVES

PRESSURE CONTROLS LTD.—SOLENOID VALVES
Working Pressure 600 p.s.i. max. Operating Voltage 24/28V 0·9A DC .... £10·00
DOWTY MOOG SERVO VALVE
Full details on request .... £45·00

VIBRATORS

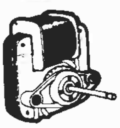
Type V5123 12 volts .... £1·25
PLESSEY
Type 12148D 12 volts .... £1·25
PLESSEY
Type 614 6 volts .... £1·25
PLESSEY
Type 61HD4 6 volts H/Duty .... £1·50
PLESSEY
Type 68R6 6 volts .... £1·25
WEARITE
Type QXA6 6 volts split reed synchronous .... £2·50
Type QXA24 24 volts split reed synchronous .... £2·50
Type QD24 24 volts split reed synchronous .... £2·50
Type QFA6 6 volts split reed synchronous .... £2·50

49-53 PANCRAS RD., LONDON, N.W.1. TEL.: 91-837 7781. TELEX 267307

DRILL CONTROLLER

New 1kW model.

Electronically changes speed from approximately 10 revs. to maximum. Full power at all speeds by finger-tip control. Kit includes all parts, case, everything and full instructions **£1·50**, plus 13p post and insurance. Made up model also available **£2·25** plus 13p p. & p.



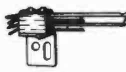
MAINS MOTOR

Precision made—as used in record decks and tape recorders—ideal also for extractor fans, blower, heater, etc. New and perfect. Snip at **50p**. Postage 20p for first one then 5p for each one ordered.

MAINS TRANSISTOR POWER PACK

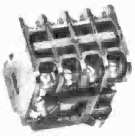
Designed to operate transistor sets and amplifiers. Adjustable output 6v., 9v., 12 volts for up to 500mA (class B working). Takes the place of any of the following batteries: PP1, PP3, PP4, PP6, PP7, PP9, and others. Kit comprises: mains transformer rectifier, smoothing and load resistor, condensers and instructions. Real snip at only **83p**, plus 18p postage.

DOUBLE LEAF CONTACT



Very slight pressure closes both contacts. **6p** each. **60p** doz. Plastic push-rod suitable for operating, **5p** each, **45p** doz.

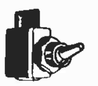
MAINS OPERATED CONTACTOR



220/240v. 50 cycle solenoid with laminated core so very silent in operation. Closes 4 circuits each rated at 10 amps. Extremely well made by a German Electrical Company. Overall size 2¼ × 2 × 2 in. **£1** each.

AUTO—ELECTRIC CAR AERIAL

with dashboard control switch—fully extendable to 40in. or fully retractable. Suitable for 12v positive or negative earth. Supplied complete with fitting instructions and ready wired dashboard switch. **£5·75** plus 25p post and ins.



TOGGLE SWITCH

3 amp 250v. with fixing ring. **7½p** each **75p** doz.

MICRO SWITCH

5 amp. changeover contacts, **9p** each, **£1·00** doz. 15 amp. on/off **10p** each or **£1·05** doz. 15 amp. changeover **15p**, 10 for **£1·35**.

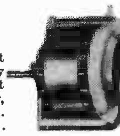
MINIATURE WAFER SWITCHES

2 pole, 2 way—4 pole, 2 way—2 pole, 3 way—4 pole, 3 way—2 pole, 4 way—3 pole, 4 way—2 pole, 6 way 1 pole, 12 way. All at **18p** each, **£1·80** dozen, your assortment.

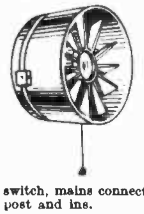
WATERPROOF HEATING ELEMENT

26 yards length 70W. Self-regulating temperature control. **50p** post free.

PAPST MOTORS



Est. 1/20th h.p. Made for 110-120 volt working, but two of these work ideally together off our standard 240 volt mains. A really beautiful motor, extremely quiet running and reversible. **£1·50** each. Postage one 23p, two 33p.

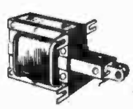


EXTRACTOR FAN

Cleans the air at the rate of 10,000 cubic ft. per hour. At the pull of a cord it extracts grease, grime and cooking smells before they dirty decorations. Suitable for kitchens, bathrooms, factories, changing rooms, etc., it's so quiet it can hardly be heard. Compact, 5¼" casing with 5½" fan blades. Suitable wherever it is necessary to move air fast. Kit comprises motor, fan blades, sheet steel casing, pull switch, mains connector, and fixing brackets. **£2** plus 36p post and ins.

HEARING AID AMPLIFIERS

(Ex behind ear deaf aids) 3 transistors on tiny P.C. board with volume control—whole thing only about half as big as Oxo cube. **£1·75** or with sub-miniature microphone and L.S. attached **£3·50**.



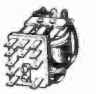
MAINS OPERATED SOLENOIDS

Model 772—small but powerful 1" pull—approx. size 1¼ × 1¼ × 1¼" **60p**.

Model 400/1 ½" pull. Size 2¼ × 2 × 1½" **75p**.

Model TT10 1½" pull. Size 3 × 2½ × 2½" **£1·80** plus 20p post and ins.

MAINS RELAY BARGAIN

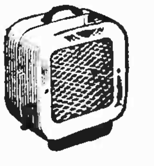


Special this month are some single, double and treble pole changeover relays. Contacts rated at 15 amps. Operating coil wound for 240V. A.C. Good British Make. Unused. Size approx. 1½ × 1 ins. Open construction.

Single pole	25p each	10 for £2·25
Treble pole	35p each	10 for £3·15

CAR ELECTRIC PLUG

Fits in place of cigarette lighter. Useful method for making a quick connection into the car electrical system. **38p** each or 10 for **£3·42**.



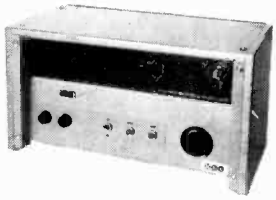
2¾kW FAN HEATER

Three position switching to suit changes in the weather. Switch up for full heater (2¾kW), switch down for half heat (1⅜kW), switch central blows cold for summer cooling—adjustable thermostat acts as auto-control and safety cut-out. Complete kit **£3·75**. Post and ins. 38p.

HORSTMANN "TIME & SET" SWITCH

(A 30 Amp Switch.) Just the thing if you want to come home to a warm house without it costing you a fortune. You can delay the switch on time of your electric fires, etc., up to 14 hours from setting time or you can use the switch to give a boost on period of up to 3 hours. Equally suitable to control processing. Regular price probably around £5. Special snip price **£1·50** Post and ins. **23p**.

ERGOTROL UNITS



These units made by the Mullard Group are for operating and controlling d.c. Motors and equipment from A.C. mains.

Thyristors are used and these supply a variable d.c. resulting in motor speed control and operating efficiency far superior to most other methods.

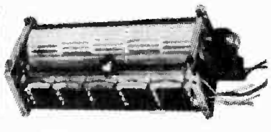
The units are contained in wall mounting cabinets with front control panel on which are fuses—push buttons for on/off and the variable thryristor firing control.

4 models are available—all are brand new in makers cases:

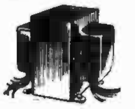
Model 2410 for up to 5 amps	£17·50
Model 2411 for up to 10 amps	£27·50
Model 2415 for up to 80 amps	£95·00

Note: 2415 is a floor mounting 3 phase unit.

OUT OF SEASON BARGAIN
TANGENTIAL HEATERS



Once again we are able to make a special bargain offer of these very popular heating units. Tangential heaters although brought out a few years ago are still the latest and best type as nothing has yet been made which could be called an improvement on them. The Tangential unit is still the only one used in good quality heaters made by Hoover, G.E.C. and all the famous names. The unit comprises quiet running AC induction motor with special bearings, the tangential impeller and a 2 section heater element which allows switching half and full heat in the case of the 2kw and one-third-two-thirds and full heat in the case of the 3kw. These heaters are also fitted with a safety cut-out to cut the heaters should the impeller stop or the air flow be impeded. They are free standing and need only the simplest of cases, even a wooden cabinet is suitable (or the plinth of the kitchen cabinet). Lots of customers missed our special summer offer of these heaters last year so order early. 200/240 2kw model **£2·50**. 200/240 3kw model **£3·50**. Control switch heaters only **25p** or two-heat, cold-blow and off **35p**. Postage and insurance 33p on heaters.



AMPLIFIER MAINS TRANSFORMER

50V 1½ amp. Upright mounting with fixing brackets and metal shrouds to contain magnetic field, 50 c/s primary, tapped 110V, 117V, 210V, 230V and 250V. 2 secondaries, one 50V 1½ amp, other 6V 1 amp for pilot light, etc. **£1·95**, postage 30p.

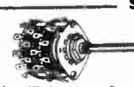
LIGHT DIMMER

For any lamp up to 200 watt. Mounted on switch plate to fit in place of standard switch. Virtually no radio interference. Price **£1·99** plus 20p post and ins.

CAPACITOR DISCHARGE CAR IGNITION

This system which has proved to be amazingly efficient and reliable was first described in the *Wireless World* about a year ago. We can supply kit of parts for an improved and even more efficient version (*Practical Wireless*, June). Price **£4·95** plus 30p post. When ordering please state whether for positive or negative systems. Also available, ready made ignition systems for 6V. vehicles. **£5·25** plus 20p.

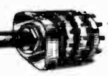
STANDARD WAFER SWITCHES



Standard size 1¼ wafer—silver-plated 5-amp contact, standard ¼" spindle 2" long—with locking washer and nut.

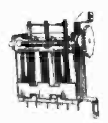
No. of Poles	2 way	3 way	4 way	5 way	6 way	8 way	9 way	10 way	12 way
1 pole	40p	40p	40p	40p	40p	40p	40p	40p	40p
2 poles	40p	40p	40p	40p	40p	40p	40p	70p	70p
3 poles	40p	40p	40p	40p	70p	70p	70p	95p	95p
4 poles	40p	40p	40p	70p	70p	70p	70p	£1·20	£1·20
5 poles	40p	40p	70p	70p	95p	95p	95p	£1·45	£1·45
6 poles	40p	70p	70p	70p	95p	95p	95p	£1·70	£1·70
7 poles	70p	70p	70p	95p	£1·20	£1·20	£1·20	£1·95	£1·95
8 poles	70p	70p	70p	95p	£1·20	£1·20	£1·20	£2·20	£2·20
9 poles	70p	70p	95p	95p	£1·45	£1·45	£1·45	£2·45	£2·45
10 poles	70p	70p	95p	£1·20	£1·45	£1·45	£1·45	£2·70	£2·70
11 poles	70p	95p	95p	£1·20	£1·70	£1·70	£1·70	£2·95	£2·95
12 poles	70p	95p	95p	£1·20	£1·70	£1·70	£1·70	£3·20	£3·20

MINIATURE INSTRUMENT SWITCHES



Precision made with diecast indexing mechanism and 1" moulded wafers. Full length ¼ in. spindle, 5 amp and silver-plated contacts. Range except for 9-way is as standard wafer switches. Prices obviously higher. For 40p, read **60p**; for 70p, read **£1**; for 95p, read **£1·40**; for £1·20, read **£1·80**; for £1·45 read **£2·20**. Note also 2-way types available up to 36 poles; 3-way, 30 poles; 4-way, 24 poles; 5-way, 19 poles; but 10- and 12-way only available up to 6 poles.

3 STAGE PERMEABILITY TUNER



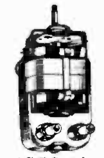
This Tuner is a precision instrument made for the famous Radiomobile Car Radio. It is a medium wave tuner (but set of long wave coils available as an extra if required) with a frequency coverage 1620 Kc/s-525 Kc/s and intended to operate with an I.F. value of 470 Kc/s. Extremely compact (size only 2½ × 2 × ¾ in. thick) with reduction gear for fine tuning. **65p**, with circuit of front end suitable for car radio or as a general purpose tuner for use with Amplifier.

ELECTRIC CLOCK WITH 20 AMP. SWITCH

Made by Smith's these units are as fitted to many top quality cookers to control the oven. The clock is mains driven and frequency controlled so it is extremely accurate. The two small dials enable switch on and off times to be accurately set—also on the left is another time or alarm—this may be set in minutes up to 1 hour. At the end of the period a bell will sound. Offered at only a fraction of the regular price—**£2·50**, less than the value of the clock alone—post and ins. 15p.

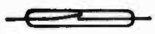
DISTRIBUTION PANELS

Just what you need for work bench or lab. 4 × 13 amp sockets in metal box to take standard 13 amp fused plugs and on/off switch with neon warning light. Supplied complete with 7 feet of heavy cable. Wired up ready to work, **£2·25** less plug; **£2·50** with fitted 13 amp plug; **£2·65** with fitted 15 amp plug, plus 23p P. & P.



MULTI-SPEED MOTOR

Replacement in many well-known food mixers. Six speeds are available 500, 850 and 1,100 r.p.m. from either or both of the nylon sockets (where the beaters of the food mixers normally go) and 8,000, 12,000 & 15,500 r.p.m. (ideal polishing speeds) from the main drive shaft. This drive shaft is ¼ in. diameter and approximately 1 in. long. A further point about this motor is that being 230/240v. AC-DC series wound its speed may be further controlled with the use of our Thyrister controller. This is a very powerful and useful motor size approx. 2 in. dia. × 5 in. long, mains 230/240v. Price **88p** plus 23p postage and insurance. 12 or more post free.



REED SWITCHES

Glass encased, switches operated by external magnet—gold welded contacts. We can now offer 3 types:

Miniature. 1" long × approximately ⅛" diameter. Will make and break up to ½A up to 300V. Price **13p** each, **£1·20** dozen.

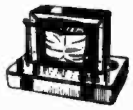
Standard. 2" long × $\frac{3}{16}$" diameter. This will break currents of up to 1A, voltage up to 250V. Price **10p** each, **90p** per dozen.

Flat. Flat type, 2" long, just over $\frac{1}{16}$" thick, flattened out, so that it can be fitted into a smaller space or a larger quantity may be packed into a square solenoid. Rating 1A 200V. Price **30p** each, **£3** per dozen.

Small ceramic magnets to operate these reed switches **9p** each, **90p** dozen.

BALANCED ARMATURE UNITS

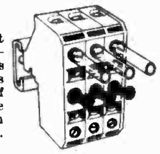
These Capsules are 1" in diameter and ¼" thick. They will operate as a microphone or loud speaker so can be used in intercom and similar circuits. **33p**. Ten for **£3**.



12 VOLT 1½ AMP POWER PACK

This comprises double-wound 230"/240V mains transformer with full wave rectifier and 2000 m/f/d/ smoothing. Price **£1·50**.

MAINS CONNECTOR

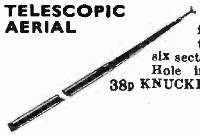


A quick way to connect equipment to the mains safely and firmly—disconnection by plugs prevents accidental switching on; has sockets which allow insertion of meter without disconnection; cable inlets firmly hold one hair wire on up to four 7/029 cables. **85p** each.

QUICK CUPPA

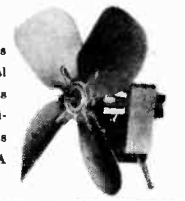
Mini Immersion Heater. 350W. 200/240V. Boils full cup in about two minutes. Use any socket or lamp holder. Have at bedside for tea, baby's food, etc. **£1·25**, post and insurance 14p. 12V car model also available. Same price. Jug model also available **£1·50** plus P. & P. 14p.

TELESCOPIC AERIAL



for portable, car radio or transmitter. Chrome plated—six sections, extends from 7¼ to 47". Hole in bottom for 6BA screw. **38p** KNUCKLED MODEL FOR F.M. **50p**.

AC FAN



Small but very powerful mains motor with 5 in. blades. Ideal for cooling equipment or as extractor. Silent but very efficient. **90p**, post 23p. Mounts from back or front with 4BA screws.

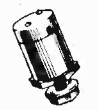
TREASURE TRACER

Complete Kit (except wooden battens) to make the metal detector as described editorially in Practical Wireless, August issue. **£2·50** plus 20p post and insurance.

LIGHT CELL

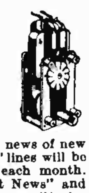
Almost zero resistant in sunlight increases to 10 K. Ohms in dark or dull light, epoxy resin sealed. Size approx. 1in. dia. by ½in. thick. Rated at 500 MW. wire ended. **43p**. Suit most circuits.

TRANSDUCER



Made by Acos, reference No. 1.D.1001. For measuring vibration, etc., to be used in conjunction with "G" Meter. Regular price £5. Our price **£4**. Brand new and unused. Acos 'G' meters available **£12** or with auto cut-out **£18**.

HIGH ACCURACY THERMOSTAT



Uses differential comparator I.C. with thermister as probe. Designer claims temperature control to within 1/7th of a degree. Complete kit with power pack **£5·50**.

MOTOR WITH GEARBOX

Very powerful 7 r.p.m., operates from standard A.C. mains. **£1·50**, plus 18p P. & P.

A New Service to Readers. A bulletin bringing news of new lines, special snips and "too few to advertise" lines will be posted to subscribers during first week of each month. The bulletin will be called "Advance Advert News" and the Subscription is **60p** per year. Subscribers will also receive our completed 1971 catalogue when this is published.

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28 watts, r.m.s. 40Hz to 40kHz ± 3dB

Viscount III Audio Suite complete £49

PRICES SYSTEM 1

Viscount III R101 amplifier	£22.00 + 90p p&p
2 x Duo Type II speakers	£14.00 + £2 p&p
Garrard SP25 Mk. III with MAG. cartridge, plinth and cover	£23.00 + £1.50 p&p
Total	£59.00

Available complete for only £52.00 + £3.50 p&p

SYSTEM 2

Viscount R101 amplifier	£22.00 + 90p p&p
2 x Duo Type III speakers	£32.00 + £3 p&p
Garrard SP25 Mk. III with MAG. cartridge, plinth and cover	£23.00 + £1.50 p&p
Total	£77.00

Available complete for £69 + £4 p&p

SYSTEM 3

Viscount III amplifier R100	£17.00 + 90p p&p
2 x Duo Type II speakers, pair	£14.00 + £2 p&p
Garrard SP25 Mk. III with CER. diamond cartridge, plinth and cover	£21.00 + £1.50 p&p
Total	£52.00

Available complete for only £49.00 + **£3.50 p&p**

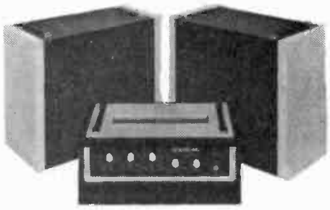
SPEAKERS Duo Type II

Size 17" x 10¾" x 6¾". Drive unit 13" x 8" with parasitic tweeter. Max. power 10 watts. 3 ohms. Simulated Teak cabinet. **£14 pair** + £2 p&p. Duo Type III Size 23½" x 11½" x 9½". Drive unit 13½" x 8¼" with H.F. speaker. Max. power 20 watts at 3 ohms. Frec. range 20Hz to 20kHz. Teak veneer cabinet. **£32 pair** + £3 p&p.

SPECIFICATION R100/101

14 watts per channel into 3 to 4 ohms. Total distortion @ 10W @ 1kHz 0.1%. P.U.1 (for ceramic cartridges) 150mV into 3 Meg. P.U.2 (for magnetic cartridges) 4mV @ 1kHz into 47K. equalised within ±1dB R.I.A.A. Radio 150mV into 220K. (Sensitivities given at full power). Tape out facilities; headphone socket, power out 250mW per channel. Tone controls and filter characteristics. Bass: +12dB to −17dB @ 60HZ. Bass filter: 6dB per octave cut. Treble control: treble +12dB to −12dB @ 15kHz. Treble filter: 12dB per octave. Signal to noise ratio: (all controls at max) RT101 – P.U.1. & radio – 65dB. P.U.2. – 58dB. **R100** same as RT101 but P.U.2. (for crystal cartridge) 450mV into 3 Meg. Cross talk better than −35dB on all inputs. Overload characteristics 26dB on all inputs. Size 1¾" x 9" x 3¾".

SOUND 50 — 50 WATT AMPLIFIER & SPEAKER SYSTEM



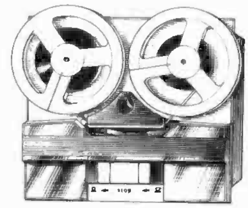
Output Power. 45 watts R.M.S. (Sine wave drive). *Frequency response:* −3 db points 30 Hz at 18 KHz. *Total distortion:* less than 2% at rated output. *Signal to noise ratio:* better than 60 db. *Speaker Impedance:* 3, 8 or 15 ohms. *Bass Control Range:* ±13 db at 60 Hz. *Treble Control Range:* ±12 db at 10 KHz. *Inputs:* 4 inputs at 5 mV into 470 K. Each pair of inputs controlled by separate volume control. 2 inputs at 200 mV into 470K. To protect the output valves, the incorporated fail safe circuit will enable the amplifier to be used at half power. *SPEAKERS:* Size 20" x 20" x 10" incorporating 12" heavy duty 25 watt high flux, quality loudspeaker with cast frame. Cabinets attractively finished in two tone colour scheme—Black and grey.

COMPLETE SYSTEM £50 Plus £6 P. & P.
Sound 50 amp and 2 speakers

or available separately
Amplifier: £28.50 plus £1.50 P. & P.
Speaker: £12.50 each plus £2.25 P. & P.

CONTINENTAL 4-TRACK, 3-SPEED TAPE DECK

with high impedance heads



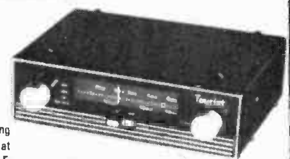
R.C.74 tape deck. Three speeds—7½, 3¾ and 1⅞ ips. 4-track record/playback head. Plus 4-track erase head. Positive pressure pad system. Takes any tape spool up to and including 7". The R.C.74 is driven by a powerful 200/250V 50-cycle A.C. motor. A heavy, accurately balanced, flywheel brings wow and flutter levels down to approx. 0.3% total at 3¾ and 7½ ips. Fast rewind in both directions.

Controls couldn't be simpler! Just five push buttons that interlock to cut out accidental tape damage. Efficient servo-action type braking. Easy drop-in tape loading.

The R.C.74 comes with an attractive moulded deck cover, which has positions for tone and volume controls. The unit is built into a rigid die-cast frame, and overall size of the whole unit is 12⅞ x 11⅜ x 6 inches. Every single deck fully tested before dispatch. Spools not supplied.

Price complete **£15.00.** Plus 75p p. & p.

TOURIST MARK 3 ALL TRANSISTOR CAR RADIO



Beautifully designed to blend with the interiors of all cars. Permeability tuning and long wave loading coils ensures excellent tracking, sensitivity and selectivity on both wave bands. R.F. sensitivity at 1 MHz is better than 8 micro volts. Power output into 3 ohm speaker is 3 watts. Pre-aligned I.F. module and tuner together with comprehensive instructions guarantees success first time. 12 volts negative or positive earth. Size 7" x 2" x 4½" deep.

Circuit diagram 13p Free with parts. Speaker, baffle and fixing kit £1.25 extra plus 20p P. & P. Speaker postage free when ordered with parts.

SET OF PARTS **£6.30**
Plus 50p P. & P.

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Primary 200-250 Volts Secondary 240 Volts Centre Tapped (120V) and Earth Shielded

ALSO AVAILABLE WITH 115/120V SECONDARY WINDINGS

Ref. No.	VA (Watts)	Weight lb	oz	Size cm.	£	P & P Np
61	100	5	12	10·2 × 8·9 × 8·3	2·28	52
62	250	12	4	9·5 × 12·7 × 11·4	5·05	67
63	500	27	0	17·1 × 11·4 × 15·9	9·74	*
92	1000	40	0	17·8 × 17·1 × 21·6	17·94	*
128	2000	63	0	24·1 × 21·6 × 15·2	29·66	*
129	3000	84	0	21·6 × 21·6 × 20·3	46·38	*
190	6000	178	0	31·1 × 35·6 × 17·1	76·11	*

AUTO SERIES (NOT ISOLATED)

Ref. No.	VA (Watts)	Weight lb	oz	Size cm.	Auto Taps	£	P & P Np
113	20		11	7·3 × 4·3 × 4·4	0-115-210-240	0·74	20
64	75	1	14	7·0 × 6·4 × 6·0	0-115-210-240	1·44	30
4	150	3	0	8·9 × 6·4 × 7·6	0-115-200-220-240	1·74	36
66	300	6	0	10·2 × 10·2 × 9·5	,, ,,	3·38	52
67	500	12	8	14·0 × 10·2 × 11·4	,, ,,	5·03	67
84	1000	16	0	11·4 × 14·0 × 14·0	,, ,,	9·12	82
93	1500	28	9	13·5 × 14·9 × 16·5	,, ,,	13·22	*
95	2000	40	0	17·8 × 16·5 × 21·6	,, ,,	17·26	*
73	3000	45	8	17·4 × 18·1 × 21·3	,, ,,	23·47	*

TOTALLY ENCLOSED 115V AUTO TRANSFORMER

115V 500 Watt totally enclosed auto transformer, complete with mains lead and two 115V outlet sockets, £6·85. P & P 67np

LOW VOLTAGE SERIES (ISOLATED)
PRIMARY 200-250 VOLTS 12 AND/OR 24 VOLT RANGE

Ref. No.	Amps. 12V	Amps. 24V	Weight lb	oz	Size cm.	Secondary Windings	£	P & P Np
111	0·5	0·25		12	7·6 × 5·7 × 4·4	0-12V at 0·25A × 2	0·74	22
213	1·0	0·5	1	0	8·3 × 5·1 × 5·1	0-12V at 0·5A × 2	0·88	22
71	2	1	1	0	7·0 × 6·4 × 5·7	0-12V at 1A × 2	1·16	22
18	4	2	2	4	8·3 × 7·0 × 7·0	0-12V at 2A × 2	1·62	36
70	6	3	3	12	10·2 × 7·6 × 8·6	0-12V at 3A × 2	1·95	42
72	10	5	6	3	7·9 × 10·8 × 10·2	0-12V at 5A × 2	2·56	52
17	16	8	7	8	12·1 × 9·5 × 10·2	0-12V at 8A × 2	3·95	52
115	20	10	11	13	12·1 × 11·4 × 10·2	0-12V at 10A × 2	5·03	67
187	30	15	16	12	13·3 × 12·1 × 12·1	0-12V at 15A × 2	9·28	82
226	60	30	34	0	17·0 × 14·5 × 12·5	0-12V at 30A × 2	17·05	*

30 VOLT RANGE

Ref. No.	Amps.	Weight lb	oz.	Size cm.	Secondary Taps	£	P & P Np
112	0·5	1	4	8·3 × 3·7 × 4·9	0-12-15-20-24-30V	0·88	22
79	1·0	2	0	7·0 × 6·4 × 6·0	,, ,,	1·18	36
3	2·0	3	2	8·9 × 7·0 × 7·6	,, ,,	1·75	36
20	3·0	4	6	10·2 × 8·9 × 8·6	,, ,,	2·16	42
21	4·0	6	0	10·2 × 10·0 × 8·6	,, ,,	2·56	52
51	5·0	6	8	12·1 × 10·0 × 8·6	,, ,,	3·18	52
117	6·0	7	8	12·1 × 10·0 × 10·2	,, ,,	3·79	52
89	10·0	12	2	14·0 × 10·2 × 11·4	,, ,,	6·21	67

50 VOLT RANGE

Ref. No.	Amps.	Weight lb	oz	Size cm.	Secondary Taps	£	P & P Np
102	0·5	1	11	7·0 × 7·0 × 5·7	0-19-25-33-40-50V	1·16	30
103	1·0	2	10	8·3 × 7·3 × 7·0	,, ,,	1·69	36
104	2·0	5	0	10·2 × 8·9 × 8·6	,, ,,	2·34	42
105	3·0	6	0	10·2 × 10·2 × 8·3	,, ,,	3·18	52
106	4·0	9	4	12·1 × 11·4 × 10·2	,, ,,	4·20	52
107	6·0	12	4	12·1 × 11·1 × 13·3	,, ,,	6·21	67
118	8·0	18	9	13·3 × 13·3 × 12·1	,, ,,	8·10	97
119	10·0	19	12	16·5 × 11·4 × 15·9	,, ,,	10·15	97

60 VOLT RANGE

Ref. No.	Amps.	Weight lb	oz	Size cm.	Secondary Taps	£	P & P Np
124	0·5	2	4	8·3 × 9·5 × 6·7	0-24-30-40-48-60V	1·18	36
126	1·0	3	0	8·9 × 7·6 × 7·6	,, ,,	1·64	36
127	2·0	5	6	10·2 × 8·9 × 8·6	,, ,,	2·56	42
125	3·0	8	8	11·9 × 9·5 × 10·0	,, ,,	3·90	52
123	4·0	10	6	11·4 × 9·5 × 11·4	,, ,,	5·03	67
120	6·0	16	12	13·3 × 12·1 × 12·1	,, ,,	7·28	82
122	10·0	23	2	16·5 × 12·7 × 16·5	,, ,,	12·05	*

*Carriage via B.R.S.

LEAD ACID BATTERY CHARGER TYPES
PRIMARY 200-250 VOLT FOR CHARGING 6 OR 12 VOLT BATTERIES

Ref. No.	Amps.	Weight lb	oz	Size cm.		£	P & P Np
45	1·5	1	9	7·0 × 6·0 × 6·0	Please note, these units do not include rectifiers	1·17	30
5	4·0	3	11	10·2 × 7·0 × 8·3		1·77	42
86	6·0	5	12	10·2 × 8·9 × 8·3		2·67	52
146	8·0	6	4	8·9 × 10·2 × 10·2		3·04	52
50	12·5	11	14	13·3 × 10·8 × 12·1		4·52	67

All ratings are continuous. Standard construction: open with solder tags and wax impregnation. Enclosed styles to order.

MAINS KEYNECTOR

For fast mains input to one or more electrical appliances up to 13 amps without wiring a plug. Ideal for production testing, servicing and display, etc. *Send for descriptive leaflet.* £2·75. P & P 25np

★ Custom production winding service

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WW—109 FOR FURTHER DETAILS

DABAR
AUDIO MIXER MODULES

A range of audio Pre-amplifier Modules is now available enabling the construction of custom-built audio mixers for studio. P.A. and discotheque installations at reasonable cost and with many facilities usually available only on expensive systems. The Modules, constructed on glass fibre printed-circuit boards, are complete with anodised aluminium black facia plates and four control knobs identified: L.F., H.F., Echo Send and P.F.L. The modules are designed for use with external faders or volume controls and fulfil most requirements in the audio field. Up to ten input modules may be mixed into the combined Mixer/Line Amplifier Type MX/LNTA which is available on a matching facia plate with V.U. meter. The line amp will deliver +20dBM. All mixing may be effected with 10k log faders.

The modules are fixed with four screws and dimensions are 7½in x 2¾in.

Input modules available:

UM1 200-600 ohm MIC
UM2 50k ohm MIC
UM3 Mag P/U 1.5mV R.I.A.A.
UM4 Mag P/U 5mV R.I.A.A.
UM5 Crystal P/U 500mV
UM6 High Level Tape/Tuner 500mV

Mixer/Line amp MX/LNTA: 10 inputs plus expander input; 600 ohm line out with preset for V.U. adjustment.

Power Unit for above Modules: Type PU11/30, 30V, 500mA. 100W slave amplifier—100W into 4 ohm load 13¾in x 10½in x 7½in.

Prices: UM1-6, **£9** each. MX/LNTA, **£12.** PU11/30, **£8.** 100W Slave Amp **£60.**

Manual showing mixing arrangements, connection data, etc., **25p.** S.A.E. all inquiries. Trade inquiries welcome.

DABAR ELECTRONIC PRODUCTS

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NELSON-JONES

Approved parts for this outstanding design (W.W. April 1971).

Featuring 0·75 μV sensitivity. Mosfet front end. Ceramic I.F. strip. Triple gang tuning. ½V r.m.s. output level, suitable for phase locked decoder, as below. Designer's own P.C.B.

All parts including P.C.B. S.A.E. please lists.

PHASE LOCKED STEREO DECODER
PORTUS AND HAYWOOD

Approved kit for this superb decoder (W.W. Sept. 1970).

Featuring 40dB separation up to 10kHz. NO COILS. Negligible spurious tones (birdies). Simple setting up. Suitable for wide variety of tuners including the NELSON-JONES TUNER as above

Complete decoder kit £8·97, p.p. & ins. 15p

Stabilised PSU kit £3·55 p.p. 18p

LIGHT EMITTING DIODES (Red)

Solid state visible light source, typical life of many years continuous operation. May be used as indicator, light modulator, etc. Maximum current 20mA.

Only 50p each inc. connection data

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TRANSISTORS

A SELECTION FROM OUR LIST

AAY30	10p
AAY42	15p
AAZ13	10p
AAZ15	10p
AAZ17	10p
AC107	35p
AC126	20p
AC127	25p
AC127Z	50p
AC128	20p
AC176	20p
AC187	25p
AC188	25p
ACY17	30p
ACY18	25p
ACY19	25p
ACY20	20p
ACY21	20p
ACY22	10p
ACY39	55p
ACY40	20p
ACY41	15p
ACY44	25p
AD140	50p
AD149	50p
AD161	35p
AD162	35p
AF114	25p
AF115	25p
AF116	25p
AF117	25p
AF118	60p
AF124	25p
AF125	20p
AF126	20p
AF127	20p
AF139	30p
AF180	50p
AF181	45p
AF185	50p
AF186	40p
AF239	40p
ASY26	25p
ASY27	30p
ASY28	25p
ASY29	30p
ASZ21	55p
BA100	15p
BA102	30p
BA110	25p
BA115	7
BAX13	5p
BAX16	7p
BAY31	7p
BAY38	15p
BC107	10p
BC108	10p
BC109	10p
BC109C	12p
BC113	10p
BC114	20p
BC115	20p
BC116	20p
BC116A	25p
BC117	20p
BC118	20p
BC119	30p
BC134	20p
BC135	15p
BC136	20p
BC137	20p
BC138	20p
BC147	15p
BC148	12p
BC149	15p
BC153	20p
BC154	20p
BC167	15p
BC169	12p
BC169C	15p
BC177	20p
BC178	20p
BC179	20p
BC182L	10p
BC183L	10p
BC184L	12p
BC212L	12p
BC213L	12p
BC214L	15p
BCY30	30p
BCY31	40p
BCY32	60p
BCY33	30p
BCY34	35p
BCY38	45p
BCY39	£1·00
BCY40	50p
BCY70	15p
BCY71	20p
BCY72	15p
BD115	75p
BD123	85p
BD124	80p
BD131	75p
BD132	80p
BDY11	£1·50
BDY17	£1·50
BDY38	65p
BDY60	£1·00

BF115	25p
BF154	20p
BF158	15p
BF159	35p
BF180	35p
BF194	15p
BF195	15p
BF196	15p
BF197	15p
BFX13	25p
BFX29	25p
BFX30	25p
BFX84	25p
BFX85	30p
BFX86	25p
BFX87	25p
BFX88	20p
BFY18	25p
BFY50	20p
BFY51	20p
BFY52	20p
BFY53	15p
BFY90	65p
BSX20	15p
BSX21	20p
BSY27	15p
BSY95A	12p
BSY95	12p
BU105	£2·25
BY100	15p
BY126	12p
BY127	15p
BY182	90p
BYZ10	35p
BYZ11	30p
BYZ12	30p
BYZ13	25p
BZY78	£1·00
GET102	35p
GET103	25p
GET111	45p
GET113	25p
GET114	20p
GET115	50p
GET116	55p
GET880	45p
GET882	30p
GEX66	£1·50
GM378A	55p
MAT101	25p
MAT121	25p
MC724P	60p
MJ420	80p
MJ421	80p
MJ2801	£1·10
MJ2901	£1·50
MJE340	50p
MJE370	20p
MJE371	80p
MJE520	75p
MJE521	70p
MJE2955	£1·10
MJE3055	75p
MPSA06	25p
MPSA56	20p
MPSA70	15p
MPSU06	50p
MPSU56	55p
NKT214	20p
NKT216	35p
NKT403	75p
NKT404	55p
OA5	25p
OA10	25p
OA47	10p
OA70	10p
OA79	10p
OA81	8p
OA90	8p
OA91	7p
OA95	7p
OA200	7p
OA202	10p
OC16	50p
OC20	85p
OC22	50p
OC23	60p
OC24	60p
OC25	40p
OC26	25p
OC28	60p
OC29	60p
OC35	50p
OC36	60p
OC42	40p
OC43	50p
OC44	15p
OC45	12p
OC70	12p
OC71	12p
OC72	20p
OC75	25p
OC76	25p
OC77	40p
OC81	20p
OC81D	20p
OC81Z	40p
OC83	25p

OC84	25p
OC139	25p
OC140	40p
OC141	60p
OC170	25p
OC171	30p
OC200	40p
OC201	75p
OC202	80p
OC206	95p
OCP71	97p
ORP12	50p
ORP60	40p
RAS310AF	35p
RAS508AF	45p
RAS508CF	50p
SD21AC	25p
ST140	15p
ST141	20p
TIP29A	50p
TIP30A	60p
TIP31A	60p
TIP32A	70p
TIP33A	£1·00
TIP34A	£1·50
TIP29B	55p
TIP29C	60p
TIP30B	65p
TIP30C	70p
TIP31B	65p
TIP31C	70p
TIP32B	75p
TIP32C	80p
TIP33B	£1·10
TIP33C	£1·20
TIP34B	£2·15
TIP34C	£2·25
TIP35A	£2·50
TIP35B	£2·70
TIP35C	£2·85
TIP36A	£3·00
TIP36B	£3·25
TIP36C	£3·50
TI843	40p
TI850	12p
TI851	10p
TI852	18p
TI860	18p
TI861	20p
TI862	25p
V405A	25p
VR525	35p
WO1	30p
WO6	45p
ZTX107	15p
ZTX108	12p
ZTX109	15p
ZTX300	12p
ZTX301	15p
ZTX302	20p
ZTX303	20p
ZTX304	25p
ZTX500	15p
ZTX501	15p
ZTX502	20p
ZTX503	17p
ZTX504	40p
ZTX531	25p
IN914	7p
IN916	10p
IN4001	6p
IN4002	7p
IN4003	8p
IN4004	8p
IN4005	10p
IN4006	12p
IN4007	15p
IN4148	7p
1S44	7p
1S921	7p
1S922	8p
2G301	25p
2G302	30p
2G303	35p
2N404	20p
2N696	15p
2N697	15p
2N698	30p
2N706	10p
2N706A	12p
2N708	15p
2N930	20p

2N987	40p
2N1131	25p
2N1132	25p
2N1302	18p
2N1303	18p
2N1304	22p
2N1305	22p
2N1306	25p
2N1307	25p
2N1308	25p
2N1309	25p
2N1613	20p
2N2147	75p
2N2160	60p
2N2217	25p
2N2218	20p
2N2218A	25p
2N2219	20p
2N2219A	25p
2N2220	25p
2N2221	20p
2N2221A	25p
2N2222	20p
2N2222A	25p
2N2369	15p
2N2369A	15p
2N2646	4[illegible]
2N2904	20p
2N2904A	25p
2N2905	25p
2N2905A	25p
2N2906	20p
2N2906A	25p
2N2907	23p
2N2907A	25p
2N2925	15p
2N2926	10p
2N3011	20p
2N3053	20p
2N3054	50p
2N3055	75p
2N3525	£1·0[illegible]
2N3614	55p
2N3702	10p
2N3703	10p
2N3704	12p
2N3705	10p
2N3707	12p
2N3708	10p
2N3714	£2·0[illegible]
2N3715	£2·20
2N3716	£2·85
2N3771	£2·0[illegible]
2N3772	£2·05
2N3773	£2·35
2N3791	£2·7[illegible]
2N3819	35p
2N3820	55p
2N3823	50p
2N3824	95p
2N3903	20p
2N3906	25p
2N4058	12p
2N4061	12p
2N4062	12p
2N4289	12p
2N4290	12p
2N4871	40p
2N5457	30p
2N5458	35p
2N5459	40p
2S001	60p
2S002	75p
2S301	50p
2S302	50p
2S303	60p
2S304	75p
2S323	65p
2S324	75p
2S701	45p
2S703	65p
40250	50p
40360	40p
40361	40p
40362	50p
40430	£1·0[illegible]
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Part No.	Description	Prices 1-24	25+	100+	250+	500+
7400	Quadruple 2-input NAND gates	20p	18p	15p	13p	10p
7401	Quadruple 2-input open collector NAND gates	20p	18p	15p	13p	10p
7402	Quadruple 2-input NOR gates	20p	18p	15p	13p	10p
7403	Quadruple 2-input open collector NAND gates	20p	18p	15p	13p	10p
7404	Hextuple inverters	20p	18p	15p	13p	10p
7405	Hextuple inverters with open collector outputs	20p	18p	15p	13p	10p
7410	Triple 3-input NAND gates	20p	18p	15p	13p	10p
7413	Dual 4-input Schmitt triggers	30p	25p	22p	20p	18p
7420	Dual 4-input NAND gates	20p	18p	15p	13p	10p
7430	Single 8-input NAND gates	20p	18p	15p	13p	10p
7440	Dual 4-input NAND buffer gates	20p	18p	15p	13p	10p
7441	BCD-Decimal decoder/Nixie driver	75p	70p	60p	55p	50p
7442	BCD-Decimal decoder (4-line to 10-line) TTL outputs	75p	70p	60p	55p	50p
7443	Excess 3-Decimal decoder TTL outputs	£1·00	90p	80p	70p	60p
7447	BCD-Decimal seven segment decoder/indicator driver	£1·35	£1·20	£1·10	£1·00	90p
7448	BCD-Decimal seven segment decoder/driver TTL outputs	£1·25	£1·10	£1·00	90p	80p
7450	Expandable dual 2-input AND-OR-INVERT gates	20p	18p	15p	13p	10p
7451	Dual 2-wide 2-input AND-OR-INVERT gates	20p	18p	15p	13p	10p
7453	Quadruple 2-input expandable AND-OR-INVERT gates	20p	18p	15p	13p	10p
7454	4-wide 2-input AND-OR-INVERT gates	20p	18p	15p	13p	10p
7460	Dual 4-input expanders	20p	18p	15p	13p	10p
7470	Single J-K flip-flop (gated inputs)	30p	25p	22p	20p	18p
7472	Single J-K flip-flop (gated inputs)	30p	25p	22p	20p	18p
7473	Dual J-K flip-flop	40p	37p	33p	30p	27p
7474	Dual D flip-flop	40p	37p	33p	30p	27p
7475	Quadruple bistable latch	45p	40p	35p	32p	30p
7476	Dual J-K flip-flops with Preset and Clear	45p	40p	35p	32p	30p

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IC12	£2·50	709C(TO5)	55p	SL403D	£2·25	923(TO5)	40p
PA246	£2·45	709C(D.I.L.)	65p				
TAD100	£1·50	723C(TO5)	£1·25	TOSHIBA		TOSHIBA	
TAD110	£1·50	741C(TO5)	85p	20 watt amp.	£4·47	Pre amp	£1·50

TRIACS

All stud mounting with accessories

Type	P.I. volts	Current	1-12
SC35A	100	3A	80p
SC35B	200	3A	85p
SC35D	400	3A	90p
SC40A	100	6A	90p
SC40B	200	6A	£1·00
SC40D	400	6A	£1·05
SC45A	100	10A	£1·05
SC45B	200	10A	£1·15
SC45D	400	10A	£1·25
SC50A	100	15A	£1·35
SC50B	200	15A	£1·45
SC50D	400	15A	£1·75
SC40E	500	6A	£1·25
SC45E	500	10A	£1·45
SC50E	500	15A	£1·95

SILICON RECTIFIERS

1 amp miniature plastic wire ended

Type	P.I.V.	1-49	50+	100+	500+	1000+
IN4001	50	6p	5p	4½p	4p	3½p
IN4002	100	7p	6p	5p	4½p	4p
IN4003	200	8p	7p	6p	5p	4½p
IN4004	400	8p	7p	6p	5p	4½p
IN4005	600	10p	9p	8p	7p	6p
IN4006	800	12p	10p	9p	8p	7p
IN4007	1000	15p	12p	10p	9p	8p

1·5 amp Miniature plastic

Type	1-12	P.I.V.
PL4001	8p	50
PL4002	9p	100
PL4003	10p	200
PL4004	10p	400
PL4005	12p	600
PL4006	15p	800
PL4007	16p	1000

3 amp plastic

Type	1-12
PL7001	15p
PL7002	15p
PL7003	16p
PL7004	20p
PL7005	21p
PL7006	23p
PL7007	25p

ZENER DIODES

400 M/W 5% Miniature BZY 88 Ranges
All voltages 3·3 Volt-33 Volt.
12p each

25+ 10p
100+ 8p
500+ 7p
1000+ 6p
Any one type.

1½ Watt 5% Wire Ends Metal Case
6·8 Volt all voltages to 100 Volts
25p each

25+ 22p
100+ 20p
500+ 17p
1000+ 15p
Any one type

3 Watt Plastic Wire Ends 5%
All voltages 5·1 100 Volts. 30p each

25+ 27p
100+ 25p
500+ 22p
1000+ 20p
Any one type.

10 Watt Stud Mounting 5%
All voltages 4·7 100 Volts. 40p each

25+ 37p
100+ 35p
Any one type

Miniature Potted Bridge Rectifiers

Silicon ¼ × ¼ × ⅛"

Type	P.I.V.	Current	1-12
1002	100	2a	55p
2002	200	2a	65p
4002	400	2a	75p
6002	600	2a	80p
1004	100	4a	65p
2004	200	4a	70p
4004	400	4a	75p
6004	600	4a	80p
1006	100	6a	70p
2006	200	6a	75p
4006	400	6a	£1·00
6006	600	6a	£1·10

Power Rectifiers Stud Mounting

6 amp. Type	P.V.I	1-12
BYZ10	800	40p
BYZ11	600	35p
BYZ12	400	30p
BYZ13	200	25p
10 amp		
SK103	100	45p
SK203	200	50p
SK403	400	55p
SK603	600	60p
SK803	800	75p

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AF117 Mullard 25p
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100 + 17p
500 + 15p
1000 + 12p

2N2646 Motorola 45p
25 + 35p
100 + 32p
500 + 28p
1000 + 25p

OC170 Mullard 25p
25 + 20p
100 + 18p
500 + 15p
1000 + 13p

BY127 Mullard 15p
25 + 12p
100 + 10p
500 + 9p
1000 + 8p

OC35 Mullard 50p
25 + 45p
100 + 40p
500 + 35p
1000 + 30p

TIP29A Texas 50p
25 + 45p
100 + 40p
500 + 35p
1000 + 30p

2N2926 Green 10p
25 + 9p
100 + 8p
500 + 6p
1000 + 5p

BC107 All Makes 10p
25 + 8p
100 + 7p
500 + 6p
1000 + 5p

40361 40p
25 + 35p
100 + 32p
500 + 28p
1000 + 25p

2S303 Texas 60p
25 + 55p
100 + 50
500 + 45p
1000 + 40p

2N3055 Fairchild 75p
25 + 65p
100 + 50p
500 + 40p
1000 + 35p

AF239 Siemens 40p
25 + 35p
100 + 30p
500 + 25p
1000 + 20

BYZ13 Mullard 25
25 + 20p
100 + 17p
500 + 15p
1000 + 12p

OA202 10p
25 + 8p
100 + 7p
500 + 6p
1000 + 5p

OC28 Mullard 60p
25 + 55p
100 + 50p
500 + 45p
1000 + 40p

SC45D Triac £1·25
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100 + £1·00
500 + 95p
1000 + 90p

2N3819 Texas 35p
25 + 30p
100 + 25p
500 + 20p
1000 + 17p

BC108 and 9 All makes 10p
25 + 8p
100 + 7p
500 + 6p
1000 + 5p

40362 50p
25 + 45p
100 + 40p
500 + 35p
1000 + 30p

AD161 AD162 35p each
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100 + 28p
500 + 25p
1000 + 22p

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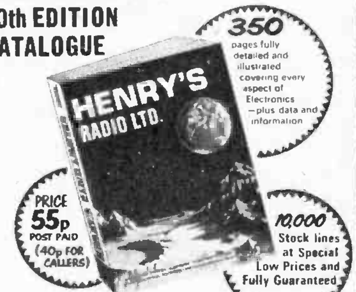

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S.T.C. sealed 2 pole c/o. 2,500 ohms. (okay 24v) **13p** ea; 12v **35p** ea.
CARPENTERS polarised Single pole c/o 20 and 65 ohm coil as new, complete with base **37p** ea.
Single pole c/o 14 ohm coil **33p** ea; Single pole c/o 45 ohm coil **33p** ea. Single pole c/o 4,000 ohm coil **33p** ea.
Varley VP4 Plastic covers 4 pole c/o 5K—**30p** ea. 15K—**33p** ea.

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COLVERN 3 watt. Brand new. 5; 10; 25; 50; 100; 250; 500 ohms; 1; 2·5; 5; 10; 25; 50k all at **13p** ea.
MORGANITE Special Brand new. 2·5; 10; 100; 250; 500K; 2·5 meg. 1 in. sealed. **17p** ea.
BERCO SQ. Brand new. 5; 10; 50; 250; 500 ohms; 1; 2·5; 5; 10; 25; 50K at **25p** ea.
STANDARD 2 meg. log pots. Current type **15p** ea.
INSTRUMENT 3 in. Colvern 5 ohm **35p** ea; 50k and 100K **50p** ea.
BOURNE TRIM POTS. 10; 20; 50; 100; 200; 250; 500 ohms; 1; 2.5; 5; 25K at **35p** ea.
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Size 1 × 2¼ ins.			Size 1¼ × 5½ ins.		
0.05mfd	2·5kV	**50p** ea.	0·01mfd	10kV	**50p** ea.
0.001mfd	5kV	**40p** ea.	0·002mfd	18kV	**65p** ea.
0·001mfd	10kV	**50p** ea.	0·05mfd	15kV	**80p** ea.
			0·01mfd	15kV	**80p** ea.
			0·0005mfd	20kV	**60p** ea.
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0·05mfd	8kV	**50p** ea.	0·1mfd	5kV	**35p** ea.

Brand new 0.25mfd 5 KV. Dubilier **50p** ea. P. & P. 15p.
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2	35V.	Electrolytic Waycom Printilyt I	
5	25V.	Electrolytic Waycom Printilyt I	
10	25V.	Electrolytic Waycom Printilyt I	
250	25V.	Electrolytic Hunts MEF 35BT	
1	160V.	Foil Waycom Tropyfol M	10p
1	250V.	Polyester	
1·5	20V.	Tantalum	
12·5	25V.	Electrolytic	
1·5	35V.	Tantalum	20p
2·2	35V.	Tantalum	
2·7	35V.	Tantalum	
3·3	100V.	Polycarbonate S.T.C. PMA 3·3K 100	
3·3	35V.	Tantalum	
3·9	35V.	Tantalum	
4·7	35V.	Tantalum	
4·7	63V.	Polycarbonate Waycom MK5	
5·6	35V.	Tantalum	
8·2	20V.	Tantalum	

Price each in quantities 1-100

SEMI-CONDUCTORS

	Description		Cost each
Diode	15921	Texas	2·5p
Zener Diode	C7V5	Mullard BZY88	7·5p
Zener Diode	C6V2	Mullard BZY88	
Zener Diode	C9V1	Mullard BZY88	
Zener Diode	C6V8	Mullard BZY88	
Zener Diode	C5V6	Mullard BZY88	
Zener Diode	C8V2	Mullard BZY88	
Transistor	2N3704/K	Texas Silec	
Transistor	2N4062/K	Texas Silec	
Transistor	2N3711/K	Texas Silec	
Transistor	2N3708/K	Texas Silec	
Transistor	2N3702/K	Texas Silec	
Transistor	2S 302		20p
Transistor	OC 28	Mullard	45p

Price each in quantities 1-100

POTENTIOMETERS

Value	Description	Cost each
1K	Pre-set ISKRA PN11B	3p
2K	Pre-set ISKRA PN11B	
2K5	Pre-set ISKRA PN11B	
50K	Pre-set ISKRA PN11B	
100K	Pre-set ISKRA PN11B	
1K	Welwyn Pre-set P345	5p
10K	Welwyn Pre-set P345	
50K	Welwyn Pre-set P345	

Prices each in quantities 1-100

THERMISTORS

Description	Cost each
VA 10665 Mullard	5p
Ziemens Halske K273 1·2K Ω at 60°C, 2·8 K Ω at 20°C (Nom.)	20p

Prices each in quantities 1-100

½ WATT RESISTORS

Value Ohms	Tol ± %	Supplier and Ref.	Cost/100
10	5	ISKRA UPM	35p
22	5	ISKRA UPM	
47	5	ISKRA UPM	
56	5	ISKRA UPM	
82	5	ISKRA UPM	
100	5	ISKRA UPM	
150	5	ISKRA UPM	
180	5	ISKRA UPM	
220	5	ISKRA UPM	
270	5	ISKRA UPM	
470	5	ISKRA UPM	
560	5	ISKRA UPM	
820	5	ISKRA UPM	
1K8	5	ISKRA UPM	
2K7	5	ISKRA UPM	
3K9	5	ISKRA UPM	35p
6K8	5	ISKRA UPM	
8K2	5	ISKRA UPM	
10K	5	ISKRA UPM	
22K	5	ISKRA UPM	
33K	5	ISKRA UPM	
1M2	5	ISKRA UPM	
1M5	5	ISKRA UPM	
2M7	5	ISKRA UPM	
3M3	5	ISKRA UPM	
3M9	5	ISKRA UPM	
4M7	5	ISKRA UPM	
68	2	ELECTROSIL TR5	100p
82	2	ELECTROSIL TR5	
91	2	ELECTROSIL TR5	
100	2	ELECTROSIL TR5	
150	2	ELECTROSIL TR5	
180	2	ELECTROSIL TR5	
220	2	ELECTROSIL TR5	
270	2	ELECTROSIL TR5	
330	2	ELECTROSIL TR5	
360	2	ELECTROSIL TR5	
390	2	ELECTROSIL TR5	
470	2	ELECTROSIL TR5	
560	2	ELECTROSIL TR5	
680	2	ELECTROSIL TR5	
820	2	ELECTROSIL TR5	
910	2	ELECTROSIL TR5	
1K	2	ELECTROSIL TR5	
1K2	2	ELECTROSIL TR5	
1K5	2	ELECTROSIL TR5	
1K8	2	ELECTROSIL TR5	
2K	2	ELECTROSIL TR5	
2K2	2	ELECTROSIL TR5	
2K4	2	ELECTROSIL TR5	
2K7	2	ELECTROSIL TR5	
3K3	2	ELECTROSIL TR5	
3K9	2	ELECTROSIL TR5	
4K5	2	ELECTROSIL TR5	
4K7	2	ELECTROSIL TR5	
5K1	2	ELECTROSIL TR5	
5K6	2	ELECTROSIL TR5	
6K2	2	ELECTROSIL TR5	
6K8	2	ELECTROSIL TR5	
8K2	2	ELECTROSIL TR5	
9K1	2	ELECTROSIL TR5	
13K	2	ELECTROSIL TR5	
15K	2	ELECTROSIL TR5	
33K	2	ELECTROSIL TR5	

Prices per 100 in quantities 100-10,000

¼ WATT RESISTORS

Value Ohms	Tol ± %	Supplier and Ref.	Cost/100
33	5	MULLARD B803104 NB	35p
47	5	ISKRA UPM	
68	5	ISKRA UPM	
100	5	ISKRA UPM	
150	5	ISKRA UPM	
220	5	ISKRA UPM	
270	5	ISKRA UPM	
330	5	ISKRA UPM	
390	5	ISKRA UPM	
470	5	ISKRA UPM	
680	5	ISKRA UPM	
820	5	ISKRA UPM	
1K	5	ISKRA UPM	
1K2	5	ISKRA UPM	
3K3	5	ISKRA UPM	
8K2	5	ISKRA UPM	
10K	5	ISKRA UPM	
18K	5	ISKRA UPM	
22K	5	ISKRA UPM	
220K	5	ISKRA UPM	
820K	5	ISKRA UPM	
1M2	5	ISKRA UPM	
2M7	5	ISKRA UPM	
4M7	5	ISKRA UPM	
5M6	5	ISKRA UPM	
3K9	10	MORGANITE	
1M5	10	ISKRA UPM	
1M8	10	ISKRA UPM	
2M2	10	ISKRA UPM	
6M8	10	ISKRA UPM	
330	2	ELECTROSIL TR4	100p
1K	2	ELECTROSIL TR4	
1K2	2	ELECTROSIL TR4	
1K8	2	ELECTROSIL TR4	
2K2	2	ELECTROSIL TR4	
2K7	2	ELECTROSIL TR4	
12K	2	ELECTROSIL TR4	
18K	2	ELECTROSIL TR4	

Prices per 100 in quantities 100-10,000

⅛ WATT RESISTORS

Value Ohms	Tol ± %	Supplier and Ref.	Cost/100
150	5	MULLARD B803104NB	35p
220	5	MULLARD B803104NB	
330	5	MULLARD B803104NB	
470	5	MULLARD B803104NB	
820	5	MULLARD B803104NB	
1K	5	MULLARD B803104NB	
1K2	5	MULLARD B803104NB	
1K5	5	MULLARD B803104NB	
1K8	5	MULLARD B803104NB	
2K2	5	MULLARD B803104NB	
2K7	5	MULLARD B803104NB	
3K3	5	MULLARD B803104NB	
3K9	5	MULLARD B803104NB	
4K7	5	MULLARD B803104NB	
5K6	5	MULLARD B803104NB	
6K2	5	MULLARD B803104NB	
6K8	5	MULLARD B803104NB	
8K2	5	MULLARD B803104NB	
10K	5	MULLARD B803104NB	
11K	5	MULLARD B803104NB	
12K	5	MULLARD B803104NB	
15K	5	MULLARD B803104NB	
18K	5	MULLARD B803104NB	
22K	5	MULLARD B803104NB	
27K	5	MULLARD B803104NB	
33K	5	MULLARD B803104NB	
39K	5	MULLARD B803104NB	
47K	5	MULLARD B803104NB	
56K	5	MULLARD B803104NB	
68K	5	MULLARD B803104NB	
82K	5	MULLARD B803104NB	
100K	5	MULLARD B803104NB	
120K	5	MULLARD B803104NB	
150K	5	MULLARD B803104NB	
180K	5	MULLARD B803104NB	
220K	5	MULLARD B803104NB	
270K	5	MULLARD B803104NB	
390K	5	MULLARD B803104NB	
470K	5	MULLARD B803104NB	
560K	5	MULLARD B803104NB	
820K	5	MULLARD B803104NB	
1M	10	MULLARD B803104NB	
1M2	10	MULLARD B803104NB	
1M5	10	MULLARD B803104NB	
3M3	10	MULLARD B803104NB	
6M8	10	MULLARD B803104NB	
10M	10	MULLARD B803104NB	
1K2	2	ELECTROSIL TR5	

Prices per 100 in quantities 100-10,000

6 WATT RESISTORS

Value Ohms	Tol ± %	Supplier and Ref.	Cost/100
22	10	WELWYN W22	750p

Prices per 100 in quantities 100-10,000

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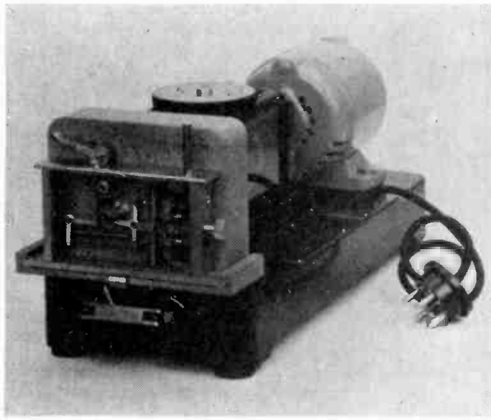
GNT Transmitter

MODEL 112



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GNT Transmitter

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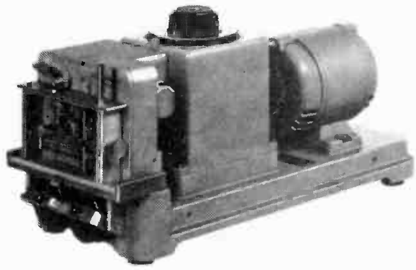

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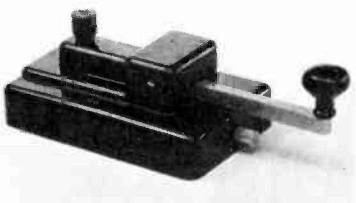

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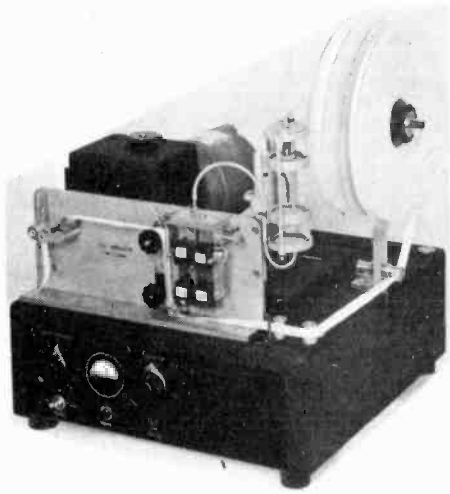

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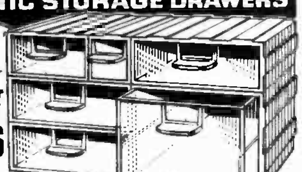

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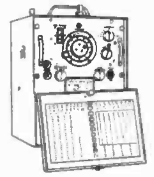

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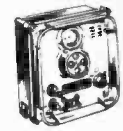

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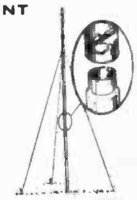

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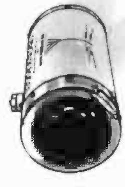

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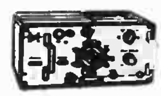

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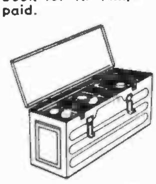

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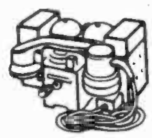

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Telephone: Codicote 242 for appointment.

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LINE advertisements (run-on): 45p per line (approx. 7 words), minimum two lines.
Where an advertisement includes a box number (count as 2 words) there is an additional charge of 25p.
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BOX NUMBERS: Replies should be addressed to the Box number in the advertisement, c/o Wireless World, Dorset House, Stamford Street, London, S.E.I.
No responsibility accepted for errors.

Advertisements accepted up to THURSDAY, 12 p.m., 7th OCT., for the NOVEMBER issue, subject to space being available.

NATIONAL ENVIRONMENT RESEARCH COUNCIL

The Institute of Geological Sciences has vacancies for Technical Officers Grade III/IV as follows:

(1) A temporary post (tenable until March, 1974) exists in the Edinburgh Global Seismology Unit for a Technical Officer III to participate in field operations in the U.K. or overseas, which are aimed at the observation of earth tremors resulting from earthquakes or explosions. The post involves acceptance of responsibility, after initial training, for the operation and maintenance of a substantial body of equipment, including solid-state amplifiers, VHF or UHF radio links and multi-track magnetic tape-recorders.

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Qualifications should include *either* (A) O.N.C. in Electrical Engineering *or* (B) evidence of an equivalent standard of technical education, with 5 years apprenticeship or equivalent, and a subsequent 3 years of suitable engineering experience (preferably assembly and testing of electronic equipment) or 3 years suitable experience for T.O. IV.

Candidates should be in good physical condition. Ability to drive an advantage.

Salaries: T.O. III £1196-£1799 according to age, maximum starting salary £1579 at age 21 or over. Allowance of £200 payable at all points of scale.

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Enquiries to:

Establishment Officer
Institute of Geological Sciences
19 Grange Terrace
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Our steadily increasing business requires the appointment of another young engineer to join our Service Department in the West End of London. The successful applicant will be an enthusiastic and diligent worker with a good understanding of basic tape recorder principles and a standard of workmanship consistent with the quality of the product.

Good salary and conditions including four weeks annual holiday.

Interviews to be held in London.

Please send full details in writing to:—

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One year's electronics experience + ONC or C & G?

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You would work on the installation and maintenance of a wide range of sophisticated electronic systems and specialised equipment throughout the U.K. You would be involved with RT, Radar, Data Transmission Links, Navigation Aids, Landing Systems, Closed Circuit T.V. and Computer Installations. You could also work on the development of new systems.

To qualify for entry to our training course you must be aged 19 or over, have at least one year's experience in electronics and preferably O.N.C. or C. & G. (Telecoms). Your starting salary would be £1,143 (at 19) to £1,503 (at 25 or over), scale max. £1,741 – shift duty allowances. Good career prospects.

Send NOW for full details of how you can become a Radio Technician. Complete the coupon and return to **A. J. Edwards, C.Eng., MIEE, Room 705, The Adelphi, John Adam Street, London WC2N 6BQ,** *marking your envelope 'Recruitment'.*

I meet the requirements, please tell me more about the work of a Radio Technician.

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ADDRESS ____________________

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Not applicable to residents outside the United Kingdom.

NATS
National Air Traffic Services

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RADIO TECHNICIANS with Wales Gas

Wales Gas Communications Section is setting up its own teams to install and maintain the new Mid-Band VHF Mobile Radio System coming into operation throughout South Wales. Resulting from this, there are two new positions open, involving the commissioning and maintenance of VHF radio-telephone systems and mobiles in the Board's South, West and East regions, but based at Grangetown, Cardiff.

A current driving licence and a minimum of three years' experience of such systems, together with an appropriate City and Guilds qualification in Telecommunications (or equivalent) are essential. The salary will be in the range of £1302-£1542 per annum and there are sick pay and contributory pensions schemes in operation.

Please write for application form to
The Personnel Director, (RS).
Wales Gas Board, Snelling House, Cardiff CF1 2UF.

SENIOR SCIENTIFIC ASSISTANT

This vacancy is in the Physics Division of the Central Electricity Research Laboratories, Kelvin Avenue, Leatherhead, Surrey, where the work will be concerned with the development of novel instrumentation for use in generating stations, initially on a radio-telemetry project. A sound knowledge of the application of modern electronic techniques to mechanical and physical measurement is required.

Senior Scientific Assistants work under Research Officers, but are given opportunity for the use of personal initiative in the solutions of problems arising. Academic qualifications to H.N.C. level is desirable, but applicants with lesser formal qualifications, having relevant experience, will be considered.

Salary range £1,056—£1,881 p.a. inc.

Applications stating full relevant details and present salary to the Personnel Officer at the above address as soon as possible. Quote Ref. WW/244

UNIVERSITY OF SURREY
DEPARTMENT OF ELECTRONIC AND ELECTRICAL ENGINEERING

ELECTRONIC ENGINEERS

Vacancies exist in the Department of Electronic and Electrical Engineering for the following positions:

RESEARCH ASSISTANT

Trained Engineer, experienced in MODERN ELECTRONICS, required to carry out advanced design and development in support of research work and industrial contracts. Broad based experience in both modern analogue and logic circuitry is desirable and the ability to take projects from design concept to prototype construction.

The appointment, for three years in the first instance, will be made within the three salary ranges below, according to age and experience:

£1,491 to £1,767
£1,902 to £2,592
£2,727 to £3,417

Membership of F.S.S.U. optional.

Applicants must be academically qualified in the appropriate field and must have had at least 2/3 years' experience in a research and/or development environment.

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required to service a wide range of electronic equipment and to build specialised electronic apparatus. Applicants should have had sufficient experience in electronics to enable them to work with the minimum of supervision.

Salary scale **£1,398 to £1,707** per annum plus **£51** per annum for appropriate Qualification Allowance. Superannuation scheme, and good holidays.

Applications should be sent to the Staff Officer, University of Surrey, Guildford, Surrey, by 30th September, 1971 1408

KING ALFRED'S COLLEGE, WINCHESTER

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to be responsible for day-to-day running and servicing of new cctv unit as part of rapidly expanding Audio-Visual Resources Centre in this College of Education.

Salary within N.J.C. Technicians Grade 5 Scale—£1,653-£1,932 per annum.

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Required for an expanding company manufacturing professional recording equipment. He or she must be conversant with modern recording studio techniques.

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Essex.
Telephone:- Stansted 3437

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CLIFTON, NOTTINGHAM

Applications are invited for the post of

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Salary: N.J.C. Grade AP4/5, £1,932 to £2,457 (commencing salary in accordance with age, qualifications and experience).
Applicants must be familiar with and able to service and maintain C.C.T.V. cameras, camera control units, and all ancillary equipment and systems in addition to standard items of teaching aids equipment.
Further particulars and forms of application, to be returned by 30th September, from the Principal. 1407

SITUATIONS VACANT

A FULL-TIME technical experienced salesman required for retail sales; write giving details of age, previous experience, salary required to—The Manager, Henry's Radio, Ltd., 303 Edgware Rd., London, W.2. [67

DRAUGHTSMEN. Mechanical and Electrical required by expanding electronics company specialising in lighting control and audio visual products. This position is salaried and gives ample opportunity for advancement. Please apply Electrosonics Ltd., 47 Old Woolwich Road, Greenwich. London, S.E.10. Tel. 858 4784. [22

GRAMPIAN have a further vacancy for a Senior Development Engineer. He must have a proven record of experience and responsibility in audio electronic equipment design and preferably with some knowledge also of transducer design. Qualifications H.N.C., H.N.D. in electronic subjects.—Write in first instance to Grampian Reproduces Ltd., Ref: H.G./1, Hanworth Trading Estate, Feltham, Middlesex. [1414

IF you have had at least 5 years continuous technical experience with an audio equipment manufacturer then GRAMPIAN may be able to offer you a situation of interest appropriate to your ability. We are only interested in people who are truly conscientious and dedicated to this section of industry.—Apply to Grampian Reproduces Ltd., Ref. S.M./1, Hanworth Trading Estate, Feltham, Middx. [1420

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BUILD IT in a DEWBOX quality plastics cabinet 2 in. × 2½ in. × any length. D.E.W. Ltd. (W), Ringwood Rd., FERNDOWN, Dorset. S.A.E. for leaflet. Write now—Right now. [76

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If you are British born and resident in the United Kingdom, under 35 years of age (40 for exceptionally well qualified candidates), write NOW for full details and an application form from:—

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in our Department of Bio-Medical Engineering

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NEW CATALOGUE No. 18, containing credit vouchers value 50p, now available. Manufacturers' new and surplus electric and mechanical components, price 22½p, post free. Arthur Sallis Radio Control Ltd., 28 Gardner Street, Brighton, Sussex. [94

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Single Panel: 17" (any type) £2; 19"/21" (any type) £3; 23" (any type) **£4. Twin Panel (Bonded):** 19" (Bonded) £5; 23" (Bonded) **£6. Panorama Tubes (Metal Rim):** 19" (Panorama) £5; 23" (Panorama) £6. Add £1 Carriage.

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Please write with SAE for quotations on any spares.

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NIPPIBOARD

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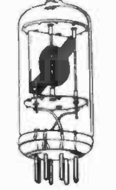

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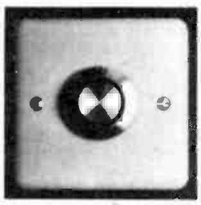

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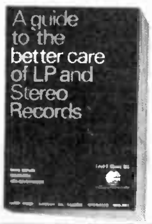

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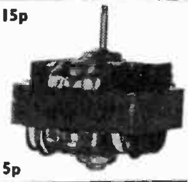

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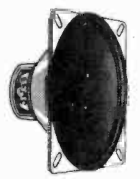

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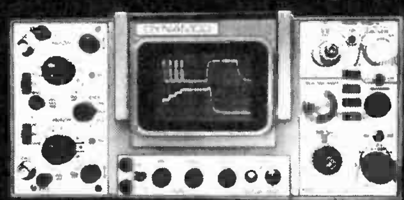

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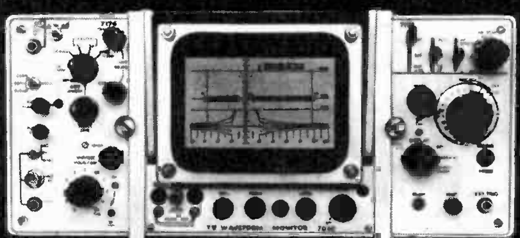

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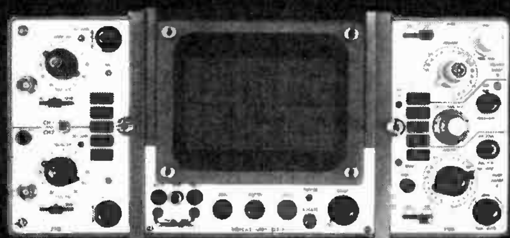

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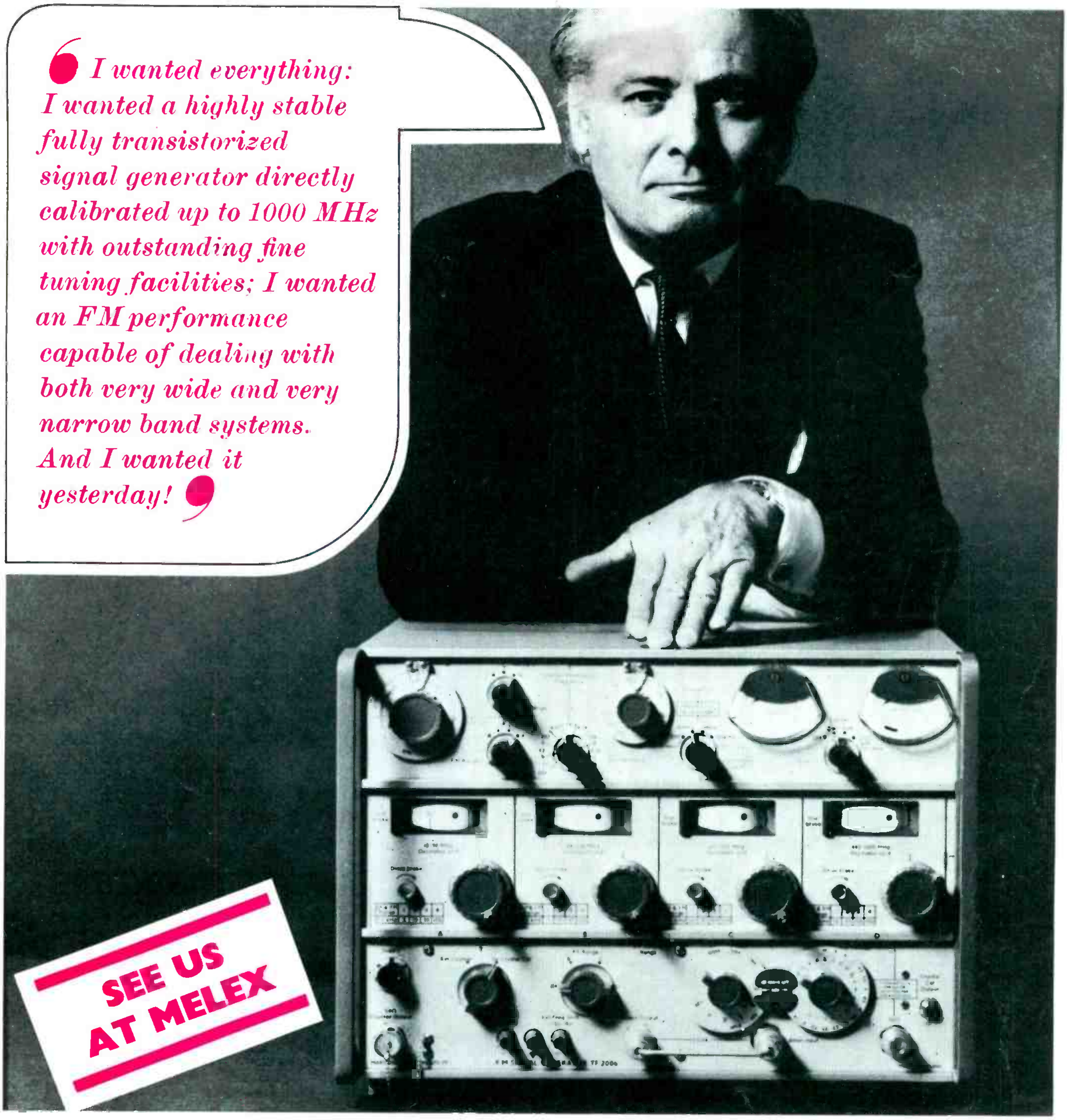

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