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MAY 1976

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Plus **AUDIO**

COMPASS

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ELECTRONICS

VOLUME 12 No. 5 MAY 1976

CONSTRUCTIONAL PROJECTS

DIGITAL FREQUENCYMETER *by A. J. Buxton*
Gives digital readout of frequency measurement of up to 500MHz **376**

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Direct measurement of capacitance on your multimeter.
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AUDIO COMPASS *by M. Kenward*
An off-course alarm for use on self-steered yachts and power craft. Allows ears to replace eyes when steering a compass course at night **394**

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Generates those "Dalek"-type voice effects **406**

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INGENUITY UNLIMITED
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*FREE WITH THIS ISSUE — *PRINTED WIRING BOARD*

Our June issue will be published on Friday, May 14, 1976
(for details of contents, see page 405)

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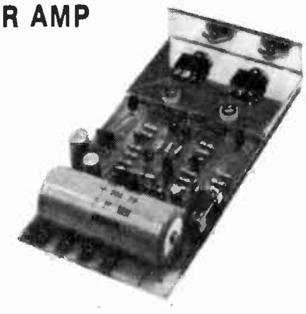

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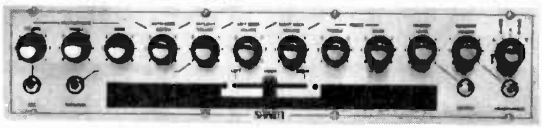

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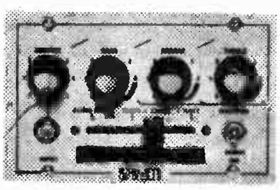

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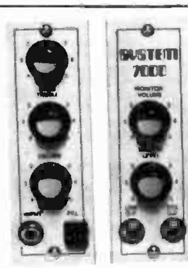

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MFC6040 Electronic attenuator	N/A

G.I.M. CONSUMER CIRCUITS

AY–5–1224 12/24 hour digital clock circuit	£4·25
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*AY–1–0212 Master tone generator	£5·55
*AY–1–5051 4 stage divider	£1·20
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SIGNETICS MEMORIES

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2602B MOS 1024 bit static RAM	£3·00

FERRANTI ICs

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ZN414 A.M. radio circuit	£1·00
Data and circuits on ZN414	5p

MULLARD CONSUMER ICs

*TAA350A	£1·96
*TAA550	60p
TAA570	£2·19
TAA630	£3·80
*TAA700	£4·03
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*TBA480	£1·75
*TBA480Q	£2·84
*TBA500	£2·42
*TBA500Q	£2·53
*TBA510	£2·42
*TBA510Q	£2·35
*TBA520	£2·99
*TBA520Q	£3·08
*TBA530	£2·53
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*TBA540	£2·88
*TBA540Q	£2·97
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*TBA560CQ	£4·23
*TBA570	£1·38
*TBA570Q	£1·47
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*TBA690Q	£2·35
*TBA700	£1·84
*TBA700Q	£1·96
*TBA720AQ	£2·23
*TBA750	£2·23
*TBA750Q	£2·23
*TBA920	£3·68
*TBA920Q	£3·77
*TBA990Q	£3·77
*TCA160B	£2·84
*TCA160C	£1·93
*TCA270	£4·09
*TCA270	£4·19
*TCA290A	£2·76
*TCA420A	£1·96

TRANSISTORS, DIODES, ETC.

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AA215	20p	BA182	20p	*BC238	10p	*BC351A	15p	BD142	56p
AC122	22p	BAV10	11p	*BC238A	11p	*BC351B	18p	BD144	£2·32
AC126	36p	BAW62	9p	*BC238B	11p	*BC352	14p	*BD157	50p
AC127	43p	BAW63	40p	*BC238C	14p	*BC352A	15p	*BD159	62p
AC128	37p	BAX13	8p	*BC239B	13p	*BC352B	18p	*BD160	£1·95
AC153	12p	BAX16	10p	*BC239C	17p	*BC352L	15p	*BD165	46p
AC175K	40p	*BB105B	63p	BC261	12p	*BC388	28p	*BD166	49p
AC176	42p	*BB105G	44p	BC261A	15p	BC445	15p	*BD167	53p
AC176/128		BC107	18p	BC268A	11p	BC446	16p	BD175	51p
	77p	BC107A	19p	*BC307	14p	BC447	15p	BD176	55p
AC176/181		BC107D	19p	*BC307A	13p	BC448	17p	BD177	59p
	48p	BC108	18p	*BC307B	14p	BC449	17p	BD178	63p
AC187/188.01		BC108A	18p	*BC308	12p	BC485	16p	BD179	68p
	99p	BC108B	18p	*BC308A	13p	BC485	16p	BD180	72p
AC188	42p	BC109	19p	*BC308B	13p	BC486	17p	BD181	£1·04
ACY19	35p	BC109B	20p	*BC309	13p	BC487	17p	BD182	£1·14
ACY20	20p	BC109C	20p	*BC309B	15p	BC488	18p	BD183	£1·24
ACY22	15p	BC113	10p	*BC317	14p	BC489	18p	BD185	62p
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AD149	85p	BC131C	15p	*BC320B	16p	BCX47	19p	BD189	84p
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AF239	60p	BC178	18p	BC348B	14p	*BD133	54p	BD234	57p
BA102	25p	BC179	20p	BC349A	14p	*BD135	34p	BD235	78p
BA114	12p	BC208A	10p	BC349B	14p	BD136	35p	BD236	62p
BA154	10p	BC214K	10p	BC349L	14p	*BD137	37p	BD237	84p
BA155	12p	*BC237	13p	*BC350	16p	*BD138	39p	BD238	96p
BA156	9p	*BC237A	12p	*BC350A	16p	*BD139	42p	BD311	£1·06

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V.A.T. 8% except where marked thus * these items 25%

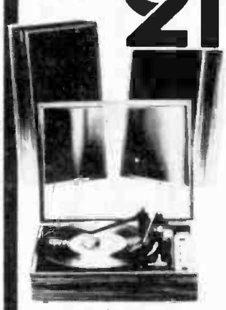
RTVC

ELIZABETHAN STEREO TUNER AMPLIFIER

This compact Tuner Amplifier gives you full medium wave and V.H.F. coverage and FM stereo. With inputs for your turntable and tape recorder. It has rotary tuning. Volume. Balance. Bass and Treble controls and push button selection switches for Phono/tape FM Stereo, FM mono,. Medium wave and A.F.C. has built-in stereo beacon and switched headphone socket.
Technical Specifications 15 transistors, 11 diodes, integrated circuit. Power output 8 watts. Size of tuner amplifier: 4" x 10" x 15½" approx. Finished in selected rosewood veneer with brushed aluminium front panel and matching controls. Output into 15 ohms speakers only.

£29.00 + p&p £1.50

* STEREO 21



COMPLETE ONLY
£23.20 + p&p £4.00

INCORPORATING A GARRARD DECK

Garrard 3 speed Deck automatic, manual facilities together with stereo cartridge and cueing device.

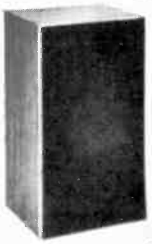
Stereo 21, easy to assemble audio system kit. No soldering required. The unit is finished in Sim Teak . and the acrylic top presents an unusually interesting variation on the modern deck plinth.
Includes – **3 speed deck**, automatic manual facilities together with stereo cartridge and cueing device.
Two speakers with cabinets.
Amplifier module. Ready built with control panel, speaker leads and full, easy to follow assembly instructions.
Specifications – For the technically minded.
Input sensitivity. 600mV. Aux. input sensitivity 120mV. Power output 2.7 watts per channel. Output impedance 8-15 ohms. Stereo headphone socket with automatic speaker cutout. Provision for auxiliary inputs – radio, tape, etc., and outputs for taping discs.
Overall Dimensions. Speakers approx 12" x 9" x 5". Complete deck and cover in closed position approx. 15½" x 12" x 6".
Extras if required. Optional Diamond Styli **£1.60.**
Specially selected pair of stereo headphones with individual level controls and padded earpieces to give optimum performance **£5.80.**

BSR DECKS WITH PLINTHS AT FANTASTIC REDUCTIONS

MP 60 Type *(illustrated)* *Less Cartridge*	£16·00 p&p £2·00
C141 *(not illustrated)* *Auto. with Cue Fitted Stereo Cartridge*	£12·00 p&p £1·50

All plinths finished in matching Teak veneer.

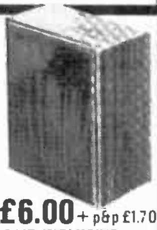
EASY TO BUILD SPEAKER KITS



These superb simulated teak-finished speaker kits have been specially designed by RT-VC for the cost-conscious hi-fi enthusiast who wants top quality speakers but doesn't want to spend the earth. Built to EMI's exacting specification, these new RT-VC speaker kits (350 type kit) incorporate 13" x 8" woofer, 3¼" tweeter and matching crossover.
Easily put together with just a few basic tools.
Specification (each speaker): Impedance 8 ohms. Power handling 15 watts RMS (30 watts peak). Response 20-20,000 Hz. Size 20" x 11" x 9½" approx. Comparable built units (EMI LE3) sold elsewhere for over £45 pair.

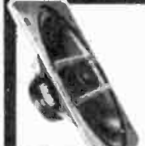
£22.00 pair complete + £5.20 p&p
Complete with crossover Components and circuit diagram.

THE 'COMPACT' EASY BUILD SPEAKER KIT



A compact bookshelf speaker system giving a high electro accoustic efficiency for the low powered amplifier.
The professional finish can be obtained with the minimum of tools, the infinite baffle type enclosures come ready mitred and professionally finished, and fix together with masking tape till glue dries.
The cabinet measures 12" x 9" x 5" deep approx finished in simulated teak, incorporating a quality 7" x 4" elliptical speaker, power handling 4 watts, flux density 30,000 maxwells, impedance 8-15 ohms nominal, voice coil dia ¾" magnet size 2⅞" approx.

£6.00 + p&p £1.70
PAIR INCLUSIVE



EMI 350 KIT

£7.25 + £1.20 p & p.
Complete with crossover Components and circuit diagram

System consists of a 13" × 8" approx. woofer with a 3" tweeter, crossover components and circuit diagram. Frequency response: 20 Hz to 20 KHz. Power handling 15 watts RMS into 8 ohms. (Peak 30 watts.)

VISCOUNT IV STEREO AMP

NOW AVAILABLE IN KIT FORM! 30 x 30 WATTS RMS

£27.50 + p&p £1.50

COMPLETE 20x20 SYSTEMS

SYSTEM 1A £69.00

The new 20 + 20 watt Stereo Amplifier incorporating the latest silicon transistor solid state circuitry, the RT-VC VISCOUNT IV gives you a powerful 20 watts RMS per channel into 8 ohms. Superb teak-finished cabinet, with anodised fascia to harmonise with any decor. Polished trim and knobs.
The VISCOUNT IV has a comprehensive range of controls – volume, bass, treble, balance mono/stereo, mode selector, and scratch filter.
Front panel socket for stereo headphones. And a host of sockets at the rear – for left and right speakers, tape recorder, auxiliary, tuner, disc and microphone.
SPECIFICATION: 20 watts RMS per channel 40 watts peak. Suitable 8-15 ohms speakers. Total distortion at 10 watts better than 0.2%. Six switched inputs: 1. Magnetic P.U. – 3 millivolts at 47 K ohms (R.I.A.A.); 2. Crystal/ceramic P.U. – 50 millivolts at 50 K ohms (R.I.A.A.); 3, 4, 6. Tape Tuner/Aux. – 140 millivolts at 50 K ohms (flat frequency response); 5. Microphone – 3 millivolts at 50 K ohms (flat frequency response).
CONTROLS: Push button ON/OFF, stereo/mono, scratch filter. 6 position rotary selector. Individual rotary controls for treble, bass, balance and volume. Headphone socket, tape out socket. Aux. mains output. **Frequency response:** 25 Hz to 25 kHz at full rated output. **Signal to noise ratio:** better than -50 dB on all inputs. **Tone control range:** Bass ±15 dB at 50 Hz; Treble ±12 dB at 10 KHz. **Power requirements:** 250V A.C. mains at 60 watts.
Approx size: 15¼" x 3" x 10". **MP60 type deck** with magnetic cartridge, de luxe plinth and cover. **Two Duo Type 11a matched speakers** – Enclosure size approx. 19½" x 10¾" x 7¾" in simulated teak. Drive unit 13" x 8" with 3" tweeter. 15 watts handling. 30 watts peak.

Complete System with these speakers £69.00 + £6.50 p&p.

SYSTEM 2 £85.00

Viscount IV amplifier (As System 1a)
MP60 type deck (As System 1a)
Two Duo Type III matched speakers – Enclosure size approx. 27" × 13" × 11½". Finished in teak simulate. Drive units 13" × 8" bass driver, and two 3" (approx.) tweeters. 20 watts RMS. 8 ohms frequency range – 20 Hz to 18,000 Hz.
Complete System with these speakers £85.00 + £7.60 p & p.

PRICES: SYSTEM 1a

Viscount IV R103 amplifier	£27.50 + £1.90 p & p.
2 Duo Type IIa speakers	£30.00 + £6.50 p & p.
MP60 type deck with Mag. cartridge de luxe plinth and cover	£22.00 + £3.30 p & p.
Total if purchased separately:	£79.50

Available complete for only: £69.00 + £6.50 p & p.

PRICES: SYSTEM 2

Viscount IV R103 amplifier	£27.50 + £1.90 p & p
2 Duo Type III speakers	£46.00 + £7.50 p & p.
MP60 type deck with Mag. cartridge de luxe plinth and cover	£22.00 + £3.30 p & p.
Total if purchased separately:	£95.50

Available complete for only £85.00 + £7.60 p & p.

Scotland and the Orkneys P & P Surcharge System 1a £1.75 System 2 £3.50

Note: 30 x 30 kit available only as a separate item.

PUSH BUTTON CAR RADIO KIT– THE TOURIST TT*

NO SOLDERING REQUIRED

NOW BUILD YOUR OWN PUSH BUTTON CAR RADIO **£9.50** +£1.05 p & p.
Easy to assemble construction kit comprising fully completed and tested printed circuit board on which no soldering is required. All connections are simple push fit type making for easy assembly.
Fine tuning push button mechanism is fully built and tested to mate with printed circuit board.
TECHNICAL SPECIFICATION: (1) **Output** 4 watts RMS output. For 12 volt operation on negative or positive earth. (2) **Integrated circuit** output stage, pre-built three stage IF Module. **Controls** volume manual tuning and five push buttons for station selection, illuminated tuning scale covering full, medium and long wave bands. Size chassis 7" wide 2" high and 4¾" deep approx.

Speaker including baffle and fixing strip £2.00 +45p p & p. Car Aerial Recommended – fully retractable £1.60+40p p & p.
The Tourist I Kit For the experienced constructor. If you can solder on a printed circuit board you can build this model. Same technical specification as Tourist TT. **Price £8.20**+£1.05 p & p.

SPECIAL OFFER

The Tourist I Kit, same specification as Tourist TT complete with speakers, fixing kit and fully retractable aerial **£10.50** + p & p £1·50

STEREO CASSETTE TAPE DECK KIT*

Kit comprises of ready built cassette tape transport mechanism. Featuring pause control, solenoid assisted auto-stop, 3 digit tape counter, belt-driven balanced fly wheel, DC motor with electronic speed control, ready built and mounted record/replay PC board, and two VU meters, power supply, PC board, mains transformer. Input and output sockets and two level controls. Specification power source 240 AC 50Hz. Output more than 0.5v imput mike –65dB 10KΩ. DIN –47dB 100KΩ. Track system 2 channel stereo record play-back. Tape speed 4.8CM/SEC. Frequency response 50-12.00Hz signal to noise ratio –42dB. Recording system AC Bias. Erasing system AC erase. Bias frequency 57KHz. Size of mechanism 8" x 5" x 3½" approx. unit easy to mount into your cabinet 3" required to clear base of mechanism approx.

NEW!

* This is an advanced kit not suitable for those without electrical knowledge and those unable to solder.

£32.50 + p&p £1.50 or send SAE for complete details.

*DISCO AMPLIFIER

Reliant Mk IV Mono Amplifier, ideal for the small disco or house parties. Output 20 watts RMS into 8 ohms (suitable for 15 ohms).
Inputs *4 electrically mixed inputs. *3 individual mixing controls. *Separate bass and treble controls common to all 4 inputs. *Mixer employing F.E.T. (Field Effect Transistors). *Solid State circuitry. *Attractive styling.
INPUT SENSITIVITIES – Input – 1). Crystal mic. guitar or moving coil mic. 2 and 10mV. (Selector switch for desired sensitivity.) – Inputs – 2), 3), 4). Medium output equipment – ceramic cartridge, tuner, tape recorder, organs, etc. – all 250mV sensitivity. AC Mains, 240V operation. Size approx: 12½"×6"×3½" **£20.00** +£1.35 p & p.

8 TRACK HOME CARTRIDGE PLAYER

Elegant self selector push button player for use with your stereo system. Compatible with Viscount IV system, Unisound module and the Stereo 21. Technical specification Mains input; 240V, Output sensitivity 125mV.

Yours for only **£14.00** +£1.70 p & p.

SPECIAL OFFER

As above but complete with build yourself Unisound Amplifier Kit (see opposite panel) + 2 'Compact' easy to build speaker kits (see opposite page) **£25.00** + p & p £2·00

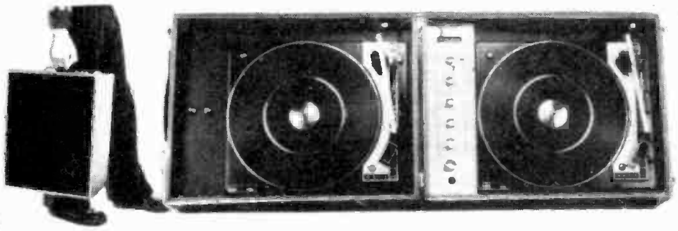
BUILD YOUR OWN STEREO AMPLIFIER*

For the man who wants to design his own stereo – here's your chance to start, with Unisound – pre-amp, power amplifier and control panel. No soldering – just simply screw together. 4 watts per channel into 8 ohms. Inputs: 120mV (for ceramic cartridge). The heart of Unisound is high efficiency I.C. monolithic power chips which ensure very low distortion over the audio spectrum. 240V. AC only.

Also available with 2 speakers (7"x4") £10 + £1.75 p & p. **£8.95** £1.05 p & p.
Also available with the 'Compact' (see opposite page) easy build speaker kit £13.50 + £2 p & p

PORTABLE DISCO CONSOLE*

INCORPORATES: Pre-Amp with full mixing facilities, including switched input for mic with volume control, switched input for auxiliary with volume control, bass and treble controls, volume control and blend control for turntables. Two B.S.R. MP60 type single play professional series decks, fitted with crystal cartridges.



TECHNICAL SPECIFICATION:
Pre-amp – Output – 200mV. Auxiliary inputs – 200mV and 750mV into 1 meg. Mic input – 6mV into 100K. 240 volt operation. **Turntables capacity** – 7", 10" or 12" records. **Rumble, wow and flutter** Rumble Better than –35dB. Wow Better than 0.2%. Flutter Better than 0.06% (Gaumont kalee meter).
Finish – Satin black mainplate with black turntable mat inlaid with brushed aluminium trim. Tonearm and controls in black and brushed aluminium.

Console size –
Unit Closed – 17¾"×13¾"×8¾" (app.)
Unit Open – 35¼"×13¾"×4¾" (app.)
This disco console is ideally matched for the Reliant IV and Disco 50 or any other quality amplifier.
The unit is finished in black PVC with contrasting simulated teak edging, diamond spun control knobs with matching control panel.

Yours for only £49.00 +£6.50 p & p.

All prices include VAT at current rates

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It's here!

READY-MADE INSTRUMENTS AVAILABLE

The Minisonic Mk. 2 has arrived—available *NOW* for the first time in kit form, the Minisonic 2 probably represents the best value for money in electronic music today.

Kits are available for complete instruments or individual sections, or for the conversion of Mk. 1 Minisonics to Mk. 2 specification. (Conversion details apply to Eaton Audio P.C.B.s, but may be adapted to suit others.)

In order to ensure that the appearance of the complete instrument enhances its performance, a complete cabinet kit is available, incorporating a *fully finished* black enamelled, silk-screened front panel, with matching back and base, and solid Afromosia end-cheeks. This kit also includes all switches, knobs, sockets, screws and panel indicators, keyboard and contact assemblies.

Cabinet Kit, including end cheeks, panels, switches, knobs, sockets, LED indicators, keyboard, set of GB (double pole) contacts
Kit MS/2–1 £192·64

Keyboard Controller—incorporating long duration "Hold" circuit
Kit MS/2–3 £8·67

Voltage Controlled Oscillator (including temperature stabilization)
Kit MS/2–4 £16·96
Note. 2 off MS/2–4 are required.

Synchronisation Components (required for one VCO only)
Sync. Kit 34p

Envelope Shaper/VCA
Kit MS2/5 £6·88
Note. 2 off MS/2–5 are required.

H.F. Oscillator/Detector
Kit MS2/6 £1·94

Hold Isolator (including relay)
Kit MS2/7 £3·24

Voltage Controlled Filter
Kit MS2/8 £7·54

Ring Modulator
Kit MS2/9 £3·75

Noise Generator
Kit MS2/10 £2·00

Output Amplifiers (including panning, mixer and headphone amplifiers—2 channels)
Kit MS2/11 £6·93

Control Envelope Inverter
Kit MS2/12 91p

Stabilised Power Supply (includes reference supply and the transformer)
Kit MS2/13 £9·00

Send large S.A.E. for further details of contents of kits.

Conversion Kits

Ancillary Functions Kit—for conversion of kbd. control, H.F. osc., detector, envelope shapers, V.C. filter, ring modulator, inverter, power supply, reference rails, output stages.
Kit MS2/14C £11·67

Oscillator Conversion Kit (for one V.C.O. only)
Kit MS/2–15C £11·04

SEPARATE ITEMS

P.C. Boards—Main Board (all modules except power supply, hold isolator, reference supply).
Board EA014 £3·80

Power Supply Board
Board EA015 £1·80
MD 8001 Dual Transistor £1·20
LM318N high speed op. amp. £2·14
2N5459 Field Effect Transistor 48p
Multiturn Preset Pots—1k, 10k or 20k (Cermet) 96p

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SEMICONDUCTOR CIRCUIT ELEMENTS by T. D. Towers. Price £5·90.

THE RADIO AMATEUR'S HANDBOOK 1976 by A.R.R.L. Price £4·85.

SERVICING WITH THE OSCILLOSCOPE by G. J. King. Price £4·80.

FOUNDATIONS OF WIRELESS AND ELECTRONICS by M. G. Scroggie. Price £4·25.

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BRIDGE ELECTRONICS COMPONENTS

	£		£		£
AC126	0·13	BD138	0·28	2N2218A	0·18
AC127	0·13	BD139	0·29	2N2219	0·17½
AC128	0·11	BD140	0·32	2N2219A	0·18
AC151	0·18	BDY56	1·00	2N2221	0·17½
AC152	0·25	BF115	0·20	2N2221A	0·18
AC153	0·27	BF200	0·25	2N2222	0·17½
AC176	0·14	BF194	0·09	2N2646	0·30
AC187K	0·27	BF195	0·09	2N2904	0·18
AC188K	0·27	BF198	0·12	2N2905	0·18
AD161	0·35	BF199	0·12	2N2906	0·18
AD162	0·35	BF257	0·24	2N2907	0·18
BA102	0·10	BF258	0·24	2N2926G	0·09
BAX13	0·03	BF259	0·24	2N3053	0·20
BAX16	0·04	BFX29	0·22	2N3054	0·40
BC107	0·09	BFX30	0·22	2N3055	0·45
BC108	0·09	BFX84	0·20	2N3393	0·12
BC109	0·09	BFX85	0·27	2N3441	0·56
BC147	0·09	BFY50	0·19	2N3442	0·96
BC148	0·09	BFY51	0·19	2N3638	0·10
BC149	0·09	BFY52	0·19	2N3638A	0·10
BC167	0·10	BY126	0·11	2N3702	0·10
BC168	0·10	BY127	0·11	2N3704	0·10
BC169	0·10	OA47	0·06	2N3706	0·10
BC182	0·09	OA90	0·04	2N3708	0·10
BC183	0·09	OA91	0·04	2N3771	1·25
BC184	0·09	OA200	0·05	2N3772	1·35
BC212	0·09½	OA202	0·06	2N3773	2·00
BC213	0·09½	IN914	0·04	2N3904	0·11
BC214	0·9½	IN4004	0·05	2N3906	0·12
BC237	0·06	IN4007	0·06	2N5294	0·35
BC238	0·06	IN4148	0·03	2N5296	0·35
BC239	0·06	IS920	0·05	2N3794	0·20
BC307	0·09	2N697	0·15	2N3819	0·30
BC308	0·09	2N698	0·14	2N4036	0·55
BC309	0·09	2N706	0·10	2N4037	0·40
BC327	0·12	2N708	0·10	2N4921	0·80
BC328	0·12	2N916	0·23	2N5060	0·25
BCY70	0·13	2N1305	0·25	2N4289	0·25
BCY71	0·13	2N1307	0·25	2N5447	0·12
BCY72	0·12	2N1308	0·25	2N5449	0·12
BD135	0·25	2N1613	0·15	2N5457	0·30
BD136	0·26	2N1711	0·15	2N5458	0·27
BD137	0·27	2N2218	0·17½	2N6027	0·40

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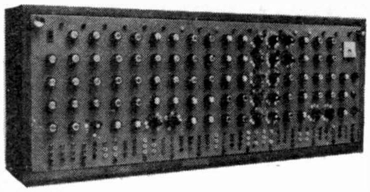


SYNTHESISERS AND KEYBOARDS

P.E. SYNTHESISER

(P.E. Feb. 1973 to Feb. 1974)

The well acclaimed and highly versatile large-scale mains-operated Sound Synthesiser complete with keyboard circuits. All function circuits may be used independently, or interconnected. The greater the number of circuits, the greater the versatility. Other circuits in our lists may be used with the Synthesiser to good advantage.

THE MAIN SYNTHESISER

Stabilised Power Supply	£12·05
Two Linear Voltage Controlled Oscillators and one Inverter—all 3 circuits:	£16·38
PCB (2 are required)—each	£1·48
Two Ramp Generators and Two Input Amplifiers—all 4 circuits	£5·62
PCB (holds all 4 circuits)	£1·38
Sample-Hold and Noise Generator—	£6·64
PCB (holds both circuits)	£1·70
Tone Control, £2·43; PCB, 80p	
Reverberation Amplifier	£6·36
Sprine Line unit for Reverb Amp	£4·95
Ring Modulator	£3·75
Peak Level Meter Circuit	£1·50
100µA Panel Meter	£3·75
PCB for Rev., R-Mod. & Meter Ccts.,	£1·94
Envelope Shaper, £5·35; PCB, £1·46	
Voltage Controlled Amp. and Diff. Amp.	£6·86
PCB (holds both circuits)	£1·32

THE SYNTHESISER KEYBOARD CIRCUITS

Can be used without the Main Synthesiser to make an independent musical instrument)

2 Log. Voltage Controlled Oscillators	£14·55
PCB for both log VCO's	£2·60
Divider, 2 Hold Circuits, 2 Modulation Amplifiers, Mixer and 2 Envelope Shapers	£19·64
PCB (Holds the first 6 circuits)	£1·80
PCB for both Envelope Shapers	£1·55
Keyboard Stabilised Power Supply	£7·30
Printed Circuit Board	94p

P.E. JOANNA

(P.E. May to Aug. 1975)

The new electronic piano that has switchable alternative voicing of Piano Honky-Tonk and Harpsichord. All PCB's are "as published".

Power Supply	£7·96
Tone Generator and Top C Envelope Shaper	£9·25
PCB for above	£1·30
Envelope Shapers	
12 sets (full requirement)	£32·16
Set of 12 PCB's (full requirement)	£15·00
Voicing and Pre-Amplifier Circuits	£8·37
PCB for above circuits	£1·84
Power Amplifier	£14·50
PCB for power amp	95p

KEYBOARDS

Kimber-Allen Keyboards as required for many published circuits, including the P.E. Joanna, P.E. Minisonic and P.E. Synthesiser. The manufacturers claim that these are the finest moulded plastic keyboards made.

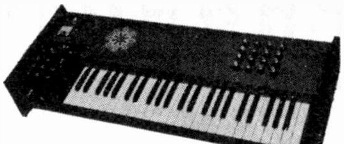
3 Octave Keyboard (37 notes C to C)	£20·50
4 Octave Keyboard (49 notes C to C)	£23·50
5 Octave Keyboard (61 notes C to C)	£27·00

Contact Assemblies for use with above keyboards: Single-pole change-over (SP) as for P.E. Joanna and P.E. Minisonic. Two-pole normally-open make-break (2P) as for P.E. Synthesiser. Special contact assembly (4PS) having 4 poles, 3 of which are normally-open make-break contacts and the fourth is a change-over contact—this special assembly enables the **same keyboard** to be used with the P.E. Synthesiser, P.E. Minisonic, and P.E. Synthesiser simultaneously thus avoiding the cost of more than one keyboard.

Contact	Each	3 Octave Set	4 Octave Set	5 Octave Set
SP	20p	£7·40	£9·80	£12·20
2P	24p	£8·88	£11·76	£14·64
4PS	48p	£17·76	£23·52	£29·28

Printed Circuit Boards for use with the above contacts and thus eliminating most of the inter-wiring required, are available—details in our lists.

PHONOSONICS



P.E. MINISONIC

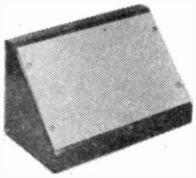
(P.E. Nov. 1974 to March 1975)

A portable, battery or mains operated, miniature sound synthesiser, with keyboard circuits. Although having slightly fewer facilities than the large P.E. Synthesiser, the functions offered by this design give it great scope and versatility.

Two Voltage Controlled Oscillators	£5·22
Voltage Controlled Filter and Voltage Reference Circuit	£3·41
Two Envelope Shapers and Two Voltage Controlled Amplifiers	£7·25
Keyboard Controller and Hold Circuits	£2·66
Keyboard Divider Resistors (select type to suit keyboard used, all are 2% tolerance). 2 Octave, £1; 3 Oct., £1·48; 4 Oct., £1·96; 5 Oct., £2·44.	
H.F. Oscillator and Detector	£1·66
Ring Mod., Noise Gen. & Env. Inverter	£5·27
Two Power Amplifiers and Two Mixers	£3·55
Battery Eliminator	£5·88
Temperature Stabiliser	£1·47
PCB to hold 2 VCOs, VCF and V-Ref	£2·02
PCB to hold 2 ESs, 2 VCAs, 2 Mixers, Ring Mod, Keyboard Control and Hold	£2·20
PCB to hold 2 Power Amps, Noise Gen, Envelope-Inverter, HF Osc. and Detector	£1·45
PCB for Battery Elim. & Temp. Stab.	£1·35

FOR ADDRESS, INFORMATION REGARDING POST AND PACKING, VAT, LISTS, AND EXPORT TERMS SEE OUR OTHER ADVERTISEMENT ON OPPOSITE PAGE

Photos: 2 of our units containing some of the P.E. projects built from our kits and PCBs. (The cases were built by ourselves and are not for sale.)



New sloping cases from OLSON

Type	Panel Dim	Depth	Height	Price
1	150mm × 100mm	95mm	95mm	£1·55
2	200mm × 100mm	95mm	95mm	£1·75
3	250mm × 100mm	95mm	95mm	£1·95

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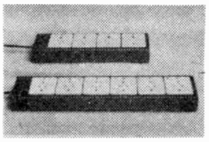
New range of cases at 45° sloping panels. Attractively designed, of robust construction, and finished in two tone colour, supplied complete with four rubber feet. Available from stock in three different widths.

MATERIALS
Cases made from 20g steel. Front panels made from 20g aluminium.

COLOURS
Cases sprayed in light brown hammer finish.
Front panels sprayed in light grey semi gloss enamel.



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SUPPLIERS OF QUALITY PRINTED CIRCUIT BOARDS, KITS AND COMPONENTS TO A WORLD-WIDE MARKET

SOUND-TO-LIGHT (P.E. Apr./Aug. 71)

The ever-popular AURORA—4 or 8 channels each responding to a different sound frequency and controlling its own light. Can be used with most audio systems and lamp intensities. A MUST for any Disco, and a fascinating visual display for the home.

4 channel component set (excl. thyristors)	£13·05
8 channel component set (excl. thyristors)	£22·56
Power supply component set	£4·96
PCB for 4 frequency channels	£3·32
PCB for power supply and 8 lamp drivers	£1·56
1 Amp 400V thyristors (1 per chan. requ.) each	75p
Panel meter (1μA) (optional)	£3·75

VOICE OPERATED FADER (P.E. Dec· 73)

For automatically reducing music volume during "talk-over" particularly useful for Disco work or for home-movie shows.

Component set incl. PCB	£3·05

TAPE-NOISE LIMITER

Very effective circuit for reducing the hiss found in most tape recordings.

Component set (incl. PCB)	£2·60
Regulated power supply (incl. PCB)	£3·98

P.E. MINIMIX 6

DETAILS IN LIST

GUITAR EFFECTS PEDAL (P.E. July 75)

Will modify an audio signal not only from a guitar but from any audio source, producing 8 different switchable effects that can be further modified by manual controls. Possibly the most interesting of all the low-priced sound effects units in our range.

Component set with special foot operated switches	£6·25
Alternative component set with panel mounting switches	£4·60
Printed Circuit Board	£1·30

HI-FI TAPE-LINK (P.E. Mar./Apr. 73)

Designed for use with reasonable quality tape-decks, this high performance pre-amp includes record, playback and metering circuits. While stocks last.

Stereo component set (excl. panel meter)	£24·25
Mono component set (excl. panel meter)	£14·70
Power supply component set	£5·93
Stereo main PCB	£2·80
Stereo sub-assembly PCB	98p

VOLTAGE CONTROLLED FILTER (P.E. Oct. 74)

An independently designed VCF that can be used with the P.E. Synthesiser.

Component set	£3·41
Printed circuit board	£1·25

ENVELOPE SHAPER AND V.C.A.

The ADSR Envelope Shaper published in P.E. April 1976 and having its own voltage controlled amplifier and full manual control of its Attack, Release and Sustain functions.

Component set incl. PCB	£5·43

AUTO WAH-WAH

Component Set and P.C.B. £2·99.

RHYTHM GENERATOR

(P.E. Mar./Apr. 74)

Programmable for 64,000 rhythm patterns from 8 effects circuits (high and low bongos, bass and snare drums, long and short brushes, blocks and soft cymbal), and with variable time signatures and rhythm rates. Really fascinating and useful.

Tempo, Timing and Logic circuits	£12·59
PCB for above circuits (double-sided)	£2·94
Component set for all 8 effects circuits	£10·49
Set of 4 PCB's to hold all 8 effects	£4·74
Simple mixer (no PCB available)	£2·76
Alternative mixer with external volume controls and adjustable gain (independently designed), including PCB	£9·93
Power Supply, including PCB	£6·42

SOUND BENDER (P.E. May 74)

A multi-purpose sound controller, the functions of which include, envelope shaper, tremolo, voice operated fadar, automatic fader and frequency-doubler.

Component set for above functions (excl. SWs)	£6·58
Printed circuit board	£1·58

Optional extra—additional Audio Modulator, the use of which, in conjunction with the above component set, can produce "jungle-drum" rhythms.

Component set (incl. PCB)	£2·55

PHASING UNIT (P.E. Sept. 73)

A simple but effective manually controlled unit for introducing the "phasing" sound into live or recorded music.

Component set (incl. PCB)	£2·50

PHASING CONTROL UNIT (P.E. Oct. 74)

For use with the above Phasing Unit to automatically control the rate of phasing.

Component set (incl. PCB)	£3·75

ENVELOPE SHAPER

The ADSR Envelope Shaper published in P.E. October 1975 and having manual control of its Attack, Release and Sustain functions.

Component set incl. PCB	£4·16

WIND AND RAIN UNIT

A manually controlled unit for producing the above-named sounds.

Component set incl. PCB	£2·83

POWER SUPPLIES

Sophisticated low-noise highly-stabilised power supply kits complete with PCB's and detailed information are now available. Details in list.

Other PCBs (all "as published") While stocks last

Bench Power Supply (P.E. Sept. 1974)	70p
CCTV:	
Master Logic, Video Amp., Sync Mixer and Cathode Switch PCB (P.E. Oct. 1974)	£2·20
PCB for remaining Circuits (P.E. Oct. 1974)	£2·20
Digital Power Supply (P.E. Aug. 1972)	50p
Electronic Piano:	
Pre-amp PCB (P.E. Oct. 1972)	85p
Power Supply PCB (P.E. Oct. 1972)	60p
Power Slaves: Power Supply PCB (P.E. Aug. 1974)	55p
Rondo:	
Pre-Amp PCB (P.E. Oct. 1973)	60p
Tone, Balance and Volume Control PCB (P.E. Oct.)	£1·40

BIOLOGICAL AMPLIFIER (P.E. Jan./Feb. 73)

Multi-function circuits that, with the use of other external equipment, can serve as lie detector, alphaphone, cardiophone, etc.

Pre-Amplifier Module

Component set and PCB	£3·71

Basic Output Circuits

Combined component set with PCBs, for alphaphone cardiophone, frequency meter and visual feed-back lamp driver circuits	£5·39

Audio Amplifier Module

Type PC7	£5·50

SINE AND SQUARE WAVE GENERATOR (P.E. July 75)

Suitable for audio, digital, or general purpose. Controllable through 4 decade ranges 10Hz to 100kHz. Switched attenuation through 10 ranges from 10V to 1mV peak-to-peak.

Component set	£8·88
PCB for above components	£1·60
Power Supply	£5·70
PCB for Power Supply	96p

P.E. TUNING FORK

(P.E. NOVEMBER, 1975)

Main component set incl. PCB	£13·50
Power supply set incl. PCB	£6·57

REVERBERATION UNIT (P.W. Nov./Dec. 72)

A high quality unit having microphone and line input pre-amps, and providing full control over reverberation level.

Component set (excl. spring unit)	£7·55
Printed circuit board	£1·76
9 inch spring unit	£4·95
Panel meter (50μA) (optional)	£3·75

SEMI-CONDUCTOR TESTER (P.E. Oct. 73)

Essential test equipment for the enterprising home constructor. While stocks last.

Set of resistors, capacitors, semiconductors, potentiometers, makaswitches and PCB	£8·44
Panel meter (500μA)	£3·75

PHOTOPRINT PROCESS CONTROL (P.E. Jan./Feb. 72)

For colour and B & W, an indispensible dark-room unit for finding exposure, controlling enlarger timing, and stabilising mains voltage.

Component set (excl. meter)	£10·72
Printed Circuit Board	£1·74
Panel meter (1mA)	£3·75

P.E. SYNCHRONOME AND PEAK LEVEL INDICATOR

DETAILS IN LIST

PHOTOCOPIES

of P.E. texts for most of our kits are available. Prices in our lists.

Transistors

AC128	20p	BFY51	22p	2N3055	48p
AC176	20p	BFY52	24p	2N3702	12p
BC107	13p	BSY95A	22p	2N3703	12p
BC108	13p	MJE2955	110p	2N3704	12p
BC109	13p	OC28	60p	2N3819	35p
BC147	12p	OC71	14p	2N3823E	39p
BC148	12p	OC72	14p	2N4060	12p
BC149	12p	OC84	25p	2N4871	36p
BC157	13p	ORP12	66p	2N5245	51p
BC158	13p	ZTX107	12p	2N5777	45p
BC159	13p	ZTX108	7½p		
BC182L	12p	ZTX501	13p		
BC184	12p	ZTX503	15p		
BC187	25p	ZTX531	23p		
BC204	14p	2N706	13p		
BC209C	14p	2N914	22p		
BC212L	15p	2N1304	22p		
BC213	15p	2N2905	27p		
BC478	29p	2N2907	22p		
BCY71	22p	2N3053	18p		
BFY50	22p	2N3054	66p		

Diodes

1N914	4p
1N4001	6p
1N4002	7p
1N4004	8p
1N4006	9p
1N4007	10p
OA91	7p
OA200	8p
OA202	8p
Z5J	75p
ZS171	16p

Integrated Circuits

709 TO5	40p
709 8-pin DIL	40p
723 TO5	95p
741 8-pin DIL	32p
748 TO5	63p
748 8-pin DIL	63p
μA7805 TO220	165p
μA7815 TO220	165p
AY-1-0212	550p
AY-1-6721/6	188p
CA3046	71p
MFC4000B	73p
SG3402N	202p
EP27/3015F	135p
STK025	595p

Zeners

3·3V 400mW	15p
3·9V 400mW	15p
4·7 1W	25p
5·1V 400mW	15p
5·1V 1W	25p
5·6V 400mW	15p
5·6V 1 3W	20p
6·2V 400mW	15p
6·8V 400mW	15p
9·1V 400mW	15p
10V 400mW	15p
11V 1W	25p
12V 400mW	15p
12V 1W	25p
15V 400mW	15p
15V 1W	25p
18V 400mW	15p
18V 1W	25p
20V 400mW	15p
20V 1W	25p
27V 400mW	15p

Electrolytic Capacitors (μF/V)

0·47/63	8p	100/40	7p	2200/40	71p
1·0/63	6p	100/63	13p	2800/100	390p
1·5/63	6p	150/16	6p	3300/63	133p
2·2/63	6p	150/63	13p	4700/16	60p
4·7/63	6p	220/10	6p	4700/25	75p
6·8/40	6p	220/16	7p	4700/40	93p
10/25	6p	220/25	15p		
10/63	6p	220/40	17p		
15/40	6p	220/63	21p		
22/10	6p	330/10	6p		
22/25	6p	470/6·3	7p		
33/6·3	6p	470/10	15p		
33/16	6p	470/25	18p		
33/40	6p	470/40	20p		
33/50	6p	680/6·3	10p		
47/10	6p	680/25	20p		
47/25	6p	1000/10	14p		
47/40	6p	1000/16	25p		
47/63	7p	1000/25	30p		
100/4	6p	1000/40	54p		
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Polyester (μF)

0·01	3½p
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0·022	3½p
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0·068	4p
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0·15	5½p
0·22	6p
0·33	8p
0·47	10p
0·68	12p
1·0	15p
2·2	26p

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0·47/35	13p
1·0/35	13p
1·5/35	13p
2·2/35	13p
4·7/35	16p
10/16	16p
10/25	18p
15/6·3	16p
22/16	18p
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47/16V	30p
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Prices are correct at time of press. E. & O.E. deliveries subject to availability.

LIST

Send S.A.E. with all U.K. requests for free list giving fuller details of PCBs, kits, and other components.
Overseas enquiries for list:
Europe—send 20p.
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U.K. orders: under £15 add 22p. over £15 add 40.
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Add 25% (or current rate if different) to full total of goods, post and handling. Overseas—VAT does not currently apply.

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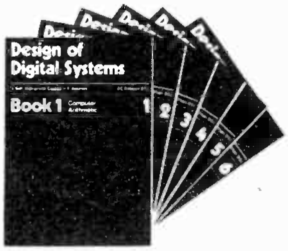

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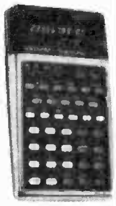

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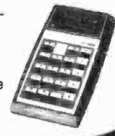

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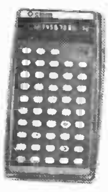

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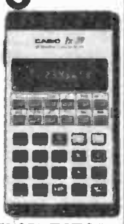

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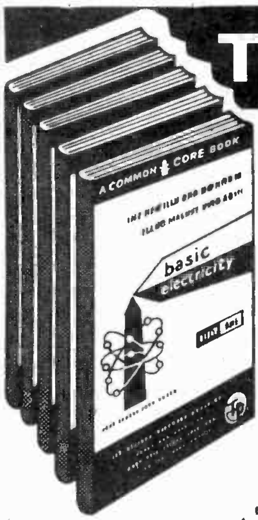

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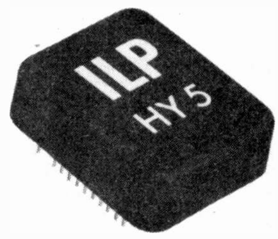

The HY5 is a mono hybrid amplifier ideally suited for all applications. All common input functions (mag Cartridge, tuner, etc.) are catered for internally, the desired function is achieved either by a multi-way switch or direct connection to the appropiate pins. The internal volume and tone circuits merely require connecting to external potentiometers (not included). The HY5 is compatible with all I.L.P. power amplifiers and power supplies. To ease construction and mounting a P.C. connector is supplied with each pre-amplifier.

FEATURES: complete pre-amplifier in single pack; multi-function equalisation; low noise; low distortion; high overload; two simply combined for stereo.
APPLICATIONS: hi-fi; mixers; disco; guitar and organ; public address.
SPECIFICATION: Inputs—magnetic pick-up 3mV; ceramic pick-up 30mV; tuner 100mV; microphone 10mV; auxiliary 3–100mV; input impedance 47kΩ at 1kHz. Outputs—tape 100mV; main output 500mV R.M.S. Active Tone Controls—treble ±12dB at 10kHz; bass ±12dB at 100Hz. Distortion—0·1% at 1kHz; signal/noise ratio 68dB. Overload—38dB on magnetic pick-up. Supply Voltage—±16–50V.

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HY30
15W into 8Ω

The HY30 is an exciting New kit from I.L.P. It features a virtually indestructible I.C. with short circuit and thermal protection. The kit consists of: I.C., heatsink, P.C. board, 4 resistors, 6 capacitors, mounting kit, together with easy to follow construction and operating instructions. This amplifier is ideally suited to the beginner in audio who wishes to use the most up to date technology available.

FEATURES: complete kit; low distortion; short, open and thermal protection; easy to build.
APPLICATIONS: updating audio equipment; guitar practice amplifier; test amplifier; audio oscillator.
SPECIFICATION: Output Power—15W R.M.S. into 8Ω. Distortion—0·1% at 15W. Input Sensitivity—500mV. Frequency Response—10Hz–16kHz −3dB.

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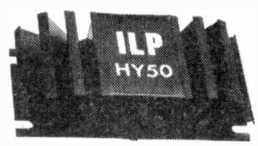

The HY50 leads I.L.P.'s total integration approach to power amplifier design. The amplifier features an integral heatsink together with the simplicity of no external components. During the past three years the amplifier has been refined to the extent that it must be one of the most reliable and robust High Fidelity modules in the World.

FEATURES: low distortion; integral heatsink; only five connections; 7 amp output transistors; no external components.
APPLICATIONS: medium power hi-fi systems; low power disco; guitar amplifier.
SPECIFICATION: Input Sensitivity—500mV. Output Power—25W R.M.S. into 8Ω. Load Impedance—4–16Ω. Distortion—0·04% at 25W at 1kHz. Signal/Noise Ratio—75dB. Frequency Response—10Hz–45kHz −3dB. Supply Voltage—±25V. Size—105 × 50 × 25mm.

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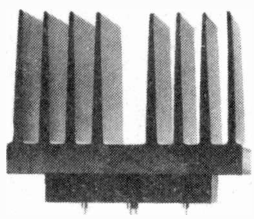
60W into 8Ω



The HY120 is the baby of I.L.P.'s new high power range, designed to meet the most exacting requirements including load line and thermal protection this amplifier sets a new standard in modular design.

FEATURES: very low distortion; integral heatsink; load line protection; thermal protection; five connections; no external components.
APPLICATIONS: hi-fi; high quality disco; public address; monitor amplifier; guitar and organ.
SPECIFICATION: Input Sensitivity—500mV. Output Power—60W R.M.S. into 8Ω. Load Impedance—4–16Ω. Distortion—0·04% at 60W at 1kHz. Signal/Noise Ratio—90dB. Frequency Response—10Hz–45kHz −3dB. Supply Voltage—±35V. Size—114 × 50 × 85mm.

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HY200
120W into 8Ω

The HY200 (now improved to give an output of 120 watts) has been designed to stand the most rugged conditions such as disco or group while still retaining true hi-fi performance.

FEATURES: thermal shutdown; very low distortion; load line protection; integral heatsink. no external components.
APPLICATIONS: hi-fi; disco; monitor; power slave; industrial; public address.
SPECIFICATION: Input Sensitivity—500mV. Output Power—120W R.M.S. into 8Ω. Load Impedance—4–16Ω. Distortion—0·05% at 100W at 1kHz. Signal/Noise Ratio—96dB. Frequency Response—10Hz–45kHz −3dB. Supply Voltage—±45V. Size—114 × 100 × 85mm

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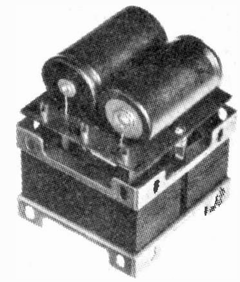
HY400
240W into 4Ω



The HY400 is I.L.P.'s "Big Daddy" of the range producing 240W into 4Ω! It has been designed for high power disco or public address applications. If the amplifier is to be used at continuous high power levels a cooling fan is recommended. The amplifier includes all the qualities of the rest of the family to lead the market as a true high power hi-fidelity power module.

FEATURES: thermal shutdown; very low distortion; load line protection; no external components.
APPLICATIONS: public address; disco; power slave; industrial.
SPECIFICATION: Output Power—240W R.M.S. into 4Ω. Load Impedance—4–16Ω. Distortion—0·1% at 240W at 1kHz. Signal/Noise Ratio—94dB. Frequency Response—10Hz–45kHz −3dB. Supply Voltage—±45V. Input Sensitivity—500mV. Size—114 × 100 × 85mm.

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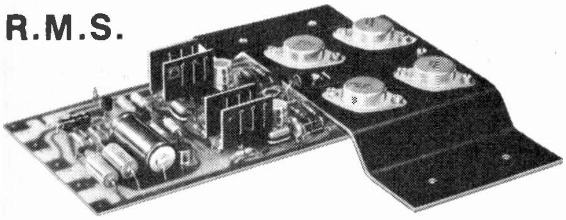

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SPECIFICATION:

Output Power: 125 watt RMS Continuous
Operating voltage: 50–80
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Frequency response: 25Hz–20kHz *Measured at 100 watts*
Sensitivity for 100 watts output at 1kHz: 450mV
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Total harmonic distortion
50 watts into 4 ohms: 0·1%
50 watts into 8 ohms: 0·06%
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Damping factor, 8 ohms: 65
Semiconductor complement: 13 transistors 5 diodes
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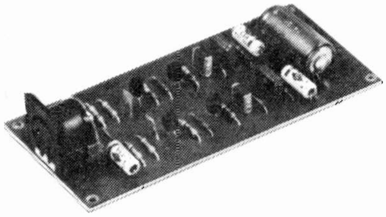

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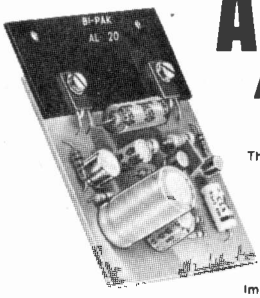

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Frequency response ± 3dB Po = 2 watts 50Hz–25kHz Sensitivity for Rated O/P—Vs = 25V. RL = 80 ohm f = 1kHz 75mV. RMS. Size: 75 × 63 × 25mm.

AL10 3W R.M.S. **£2.30** AL2 5W R.M.S. **£2.65** AL30 10W R.M.S. **£2.95**

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PA12 £6.50

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UNDER-SOLD?

Many of the great achievements and commercial successes of electronics are due to the amazing cheapness of semiconductor devices, no less than to their technical versatility. But the first of these attributes could well prove an embarrassment or liability when considering its effect upon the popular image of electronics, and this is especially important now when the whole question of salaries and status of technical employees in the industry has come to the fore, as discussed by Nexus in this month's Industry Notebook.

Cheapness of components has helped reduce certain consumer type products to the expendable grade. Cheap transistor radios provided the first examples of modern electronic products which are sometimes deemed not worth repairing but are discarded when trouble appears. With the arrival of the digital watch, this custom could be carried to its ultimate absurdity. For if prices continue to fall as confidently predicted, it could eventually become more economical and certainly more convenient to throw away the cheaper type digital watch when the batteries expire and buy another.

There is a further interesting aspect well illustrated by this product, since the digital watch is also invading the fine jewellery market. These up-market models owe everything to their external appearance—to the case—since the electronic assembly might be identical to that used in a cheaper version. Cheap, common, and expendable plastics versus expensive, exclusive, and indestructible fine metals. Micro-electronics has made it all possible, but the case designers and makers seem likely to skim off the cream.

The digital watch thus offers an illuminating but disturbing example of highly advanced technology selling for a song, and the packaging alone determining whether the final product be a cheap and expendable item or a lasting and valuable possession. Moreover, in more general terms, as the ordinary constructor knows only too well, it is not unusual for the major cost of an electronic project to be taken up by non-active components and also items such as the hardware used in the assembly of the components and to encase the completed project. We all welcome and enjoy low cost active devices, but to the technically-appreciative, values must seem somehow to have become reversed.

Almost too late it seems semiconductor makers sense that they have been blinded by their own technological success and have been unwise in waging price wars on one another in order to acquire a bigger portion of the cake. The short term gains have been considerable, but what of the future? Has then electronics sold itself short? Any cheapening of the technology, any equating of its products with, say, easy-come easy-go plastics commodities must in the long term be detrimental to the status and financial well-being of those employed in electronics. Perhaps the semiconductor industry should recall that charity begins at home, and that cut-price technology is not really in everyone's best interests, and that it often leaves the biggest plums for outsiders to gather.

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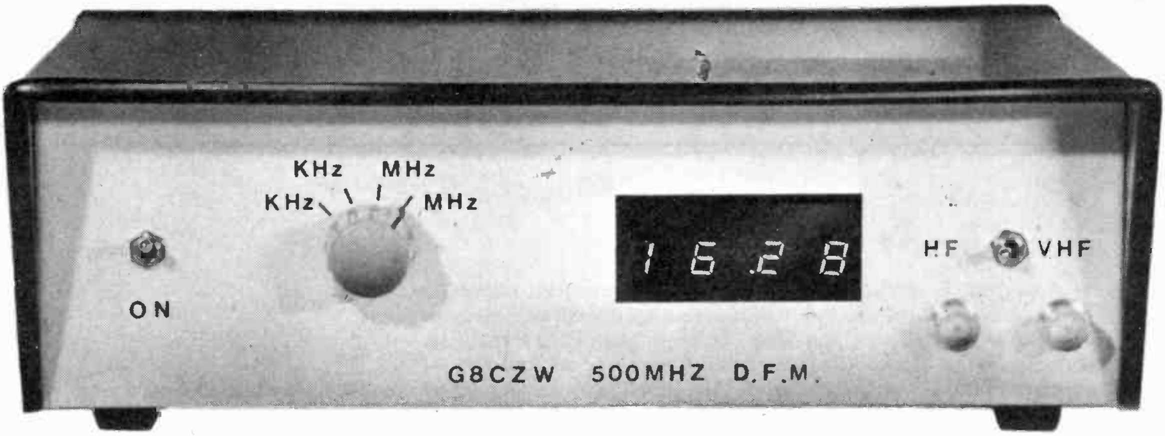


DIGITAL FREQUENCY METER

By A. J. BUXTON

THIS article describes the design, construction and testing of a digital frequency meter (D.F.M.). This particular instrument has been designed as a radio society construction project and with this in mind it was necessary to use straightforward, logical design.

Ease of fault-finding has been one of the main considerations and to this end a design has been produced which can be tested and maintained using simple test gear.

The entire logic is contained on a single printed circuit board, and the four-digit display (in this case seven-segment light emitting diodes) is on another board. The power supply and the range switching are the only items that need free wiring.

The basic unit to be described has a 50 ohm input impedance and can measure up to at least 50MHz. Modifications will be described to extend the frequency range to 500MHz and to give a high input impedance.

A major innovation in this instrument is the use of a large scale integrated (l.s.i.) circuit to replace the majority of the logic. The Ferranti ZN1040E counts, stores, decodes and drives up to four seven-segment displays.

THE ZN1040E

The ZN1040E is a large scale integrated circuit fabricated using the "collector diffusion isolation" (c.d.i.) process. Fig. 1 shows the internal functions contained within this device together with the pin connections.

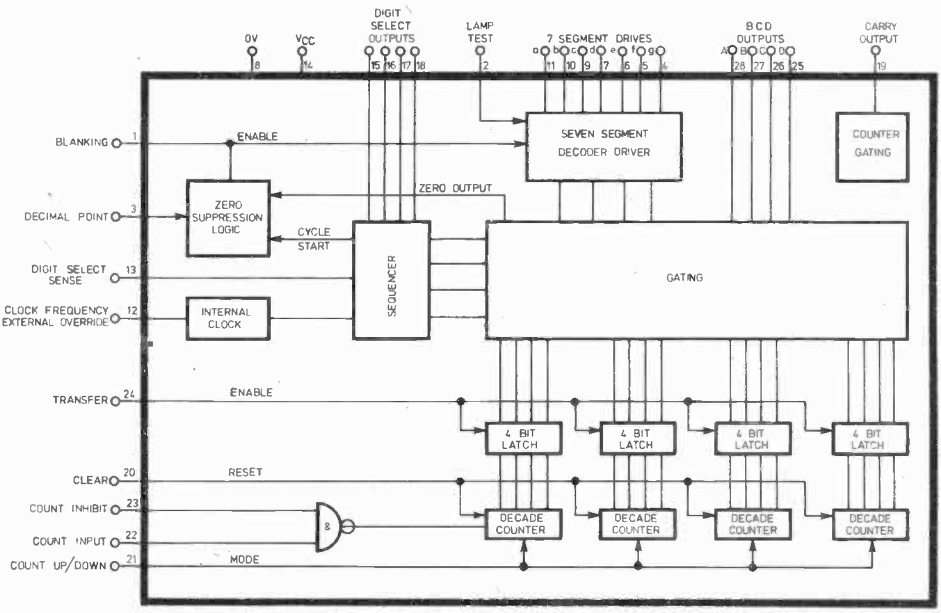


Fig. 1. The internal functions and pin connections of the Ferranti ZN1040E integrated circuit

SPECIFICATION . . .

Frequency Ranges	10·00 to 99·99kHz 100·0 to 999·9kHz 1·000 to 9·999MHz 10·00 to 99·99MHz
Input Resistance	50 ohm
Sensitivity	40mV
Input Voltage d.c. bias (max)	400V
Frequency Resolution	10Hz on Range 1
Timebase Frequency	5MHz
Timebase Ageing Rate	± 10p.p.m. per year
Timebase Temperature Stability	± 10p.p.m. (10°C to 55°C)

The device is contained in a 28-lead plastic encapsulated package. By directly driving from the multiplexed, seven-segment outputs or by decoding the binary coded decimal (b.c.d.) outputs, any contemporary display can be used.

The seven-segment drivers can sink a current of 80mA, which results in an average current of 20mA per segment when multiplexed.

When free-running, the internal multiplex clock oscillator gives a frequency of about 500kHz. This frequency can be lowered by the addition of a capacitor to pin 12. In this instrument a 0·01μF capacitor is used to give a frequency of 3kHz.

A direct drive at TTL logic levels will override the multiplexing to the driven frequency.

The ZN1040E requires a single 5V supply and consumes an internal current of 90mA. It is fully compatible with TTL devices.

CIRCUIT DESCRIPTION

A circuit diagram of the complete unit minus the power supply is shown in Fig. 2. This circuit shows the basic unit with a 50 ohm input impedance. All the circuitry is contained on two printed circuit boards: one for the logic and input circuits and one for the display. The two boards are shown as dotted lines in Fig. 2.

The circuit is more easily understood if considered in sections.

THE OSCILLATOR

The oscillator is the single most important function within a digital frequency meter as the accuracy depends almost entirely on the crystal oscillator.

Variations in temperature, crystal age and supply voltage all affect crystal frequency. Adding all the effects together, one can be faced with an error of 30Hz in 1MHz or 0·003 per cent.

Initial crystal frequency inaccuracy can be trimmed out using a capacitor (VC1). This can also be used to trim out the effects of ageing. There is admittedly room for improvement of the oscillator used in this design but it is simple and in line with the basic design concept.

A 5MHz crystal (X1) is used, this frequency being useful as temperature and mechanical stability are optimised at this frequency.

COMPONENTS . . .

MAIN UNIT

Resistors

R1–R5	270Ω (5 off)	R25	2·2kΩ
R6–R15	100Ω (10 off)	R26	470Ω
R16	2·2kΩ	R27	1kΩ
R17	100Ω	R28	3·3kΩ
R18	150Ω	R29	2·2kΩ
R19, R20	5·6kΩ (2 off)	R30	470Ω
R21	15kΩ	R31	10kΩ
R22	10kΩ	R32	1kΩ
R23	1kΩ	R33–R36	470Ω (4 off)
R24	100Ω		

All ±5% ¾ or ⅛W

Capacitors

C1	6,800pF
C2–C4	0·05μF 6V disc (3 off)
C5	10pF mica
C6	0·01μF disc
C7	0·05μF disc
C8	50μF 10V elect
C9	0·05μF disc
C10	30pF mica
C11	0·05μF disc
C12	0·1μF 6V disc
C13	100μF 10V elect
C14	30pF mica
C15	10pF mica
C16, C17	330pF mica (2 off)
C18	0·05μF disc
C19	470pF disc
C20	0·05μF disc
C21	1,000pF 6V disc
C22–C28	0·05μF disc (7 off)
C29	2,200μF 25V elect
C30	330μF 16V elect
C31	0·1μF 6V disc
C32	100μF 6V elect
VC1	3–60pF trimmer

Transistors and Diodes

TR1–TR4	ZTX4403 (4 off)
TR5, TR6	ZTX300 (2 off)
TR7	ZTX312
TR8, TR9	ZTX500 (2 off)
TR10–TR12	ZTX312 (3 off)
D1	4·7V 400mW Zener
D2–D4	ZS170 (3 off)

Integrated Circuits

IC1	NE592	IC6	ZN7400
IC2	ZN74196	IC7	ZN7403
IC3	ZN1040E	IC8–IC14	ZN7490 (7 off)
IC4	ZN7474	IC15	78M05
IC5	ZN74123		

Display

LED1–LED4 DL707 (4 off)

Switches

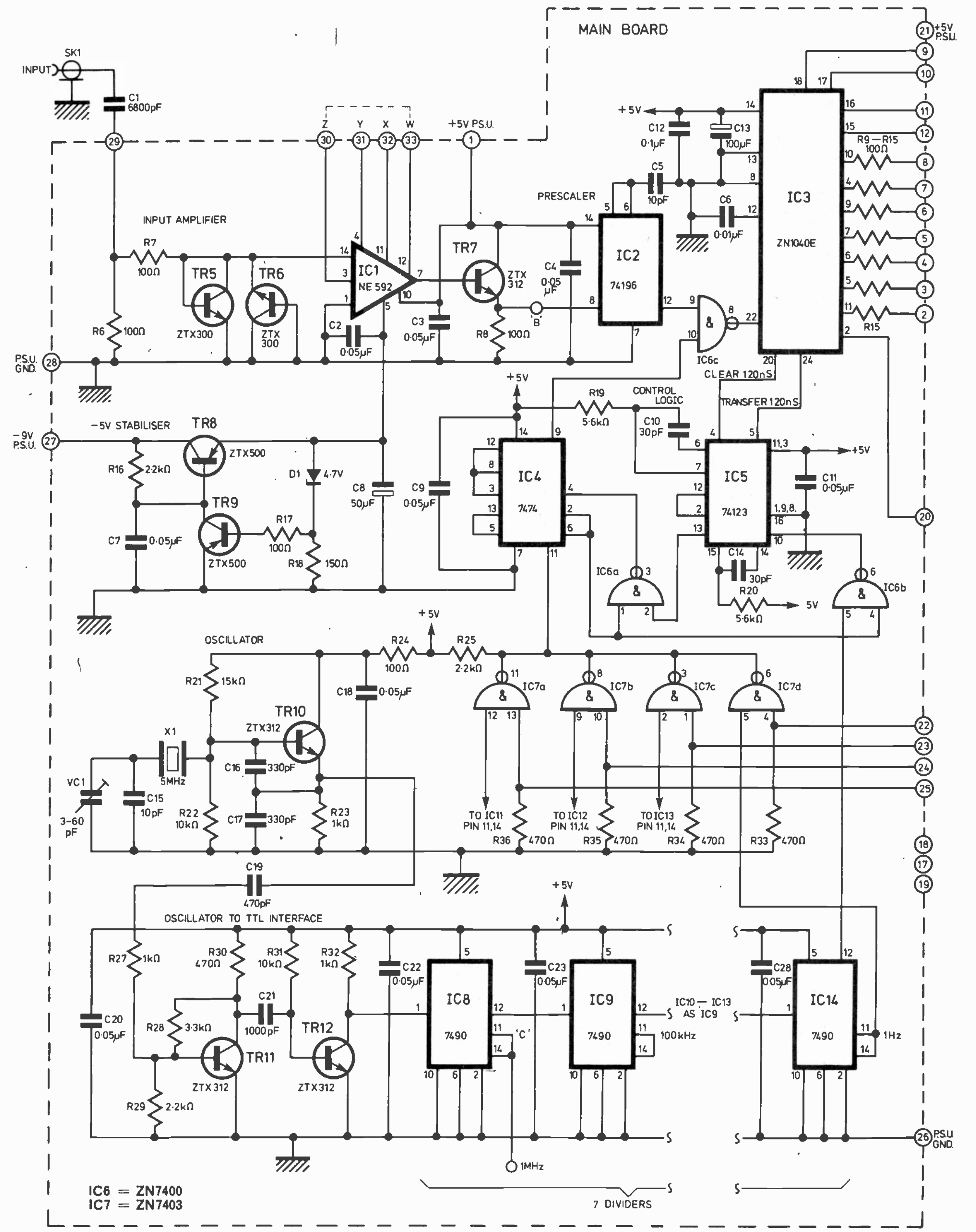
S1	2 pole 4 way rotary
S2	Single pole on/off toggle
S3	D.p.d.t. mains toggle

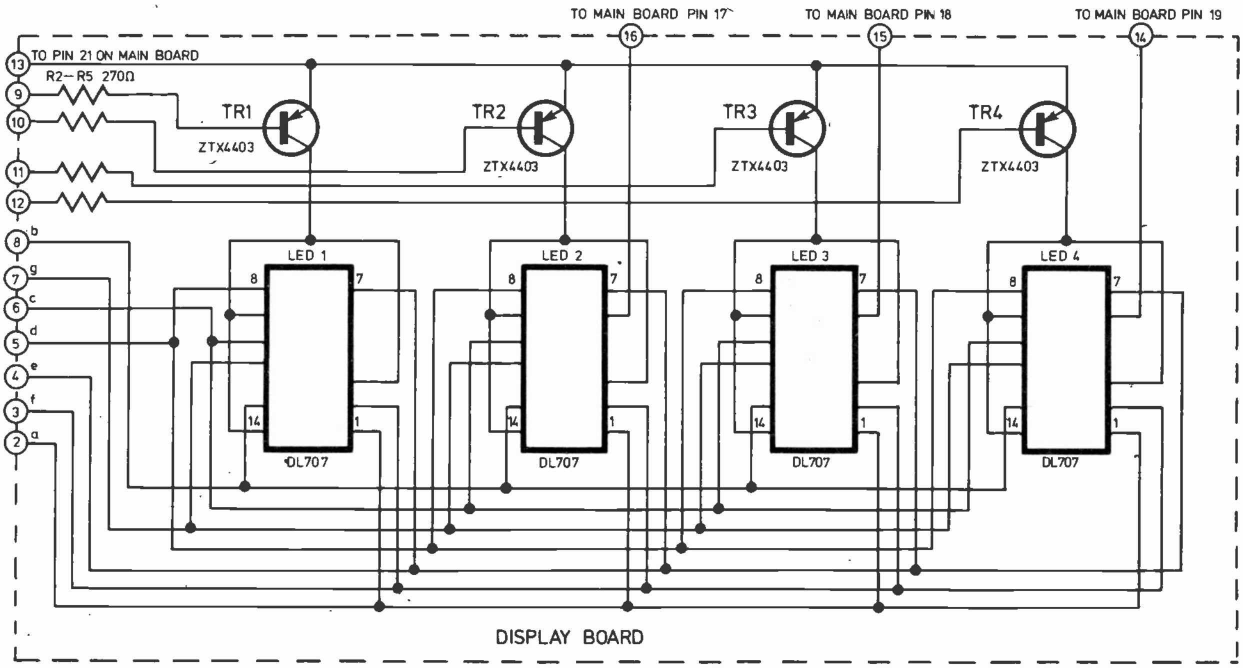
Miscellaneous

T1	Mains primary, 8–0–8V 500mA secondary (Douglas MT207CT)
X1	5MHz crystal
SK1	BNC socket
FS1	2A 20mm fuse and holder

9-way tag strip

Filter for display, p.c.b.s, sockets for i.c.s if required, case, nuts and bolts, standoffs, etc.


MAIN BOARD
SK1
INPUT
C1 6800pF
INPUT AMPLIFIER
R7 100Ω
TR5
TR6
ZTX300
ZTX 300
R6 100Ω
IC1 NE 592
C2 0·05μF
C3 0·05μF
TR7
ZTX 312
R8 100Ω
+5V P.S.U.
Z Y X W
PRESCALER
IC2 74196
C4 0·05μF
'B'
+5V
C12 0·1μF
C13 100μF
C5 10pF
C6 0·01μF
IC3 ZN1040E
R9—R15 100Ω
R15
IC6c
CLEAR 120nS
TRANSFER 120nS
P.S.U. GND.
−9V P.S.U.
−5V STABILISER
TR8
ZTX500
R16 2·2kΩ
D1 4·7V
TR9
C7 0·05μF
R17 100Ω
R18 150Ω
C8 50μF
C9 0·05μF
R19 5·6kΩ
CONTROL LOGIC
C10 30pF
IC4 7474
IC5 74123
C11 0·05μF
C14 30pF
R20 5·6kΩ
5V
IC6a
IC6b
OSCILLATOR
R21 15kΩ
TR10 ZTX312
X1 5MHz
VC1 3-60 pF
C15 10pF
C16 330pF
C17 330pF
R22 10kΩ
R23 1kΩ
R24 100Ω
R25 2·2kΩ
C18 0·05μF
IC7a IC7b IC7c IC7d
TO IC11 PIN 11,14
TO IC12 PIN 11,14
TO IC13 PIN 11,14
R36 470Ω
R35 470Ω
R34 470Ω
R33 470Ω
C19 470pF
OSCILLATOR TO TTL INTERFACE
R27 1kΩ
R30 470Ω
R31 10kΩ
R32 1kΩ
C20 0·05μF
R28 3·3kΩ
C21 1000pF
TR11
TR12
ZTX 312
ZTX312
R29 2·2kΩ
C22 0·05μF
C23 0·05μF
C28 0·05μF
IC8 7490
IC9 7490
IC14 7490
'C'
IC10 — IC13 AS IC9
100kHz
1Hz
1MHz
P.S.U GND.
7 DIVIDERS
IC6 = ZN7400
IC7 = ZN7403



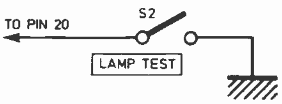
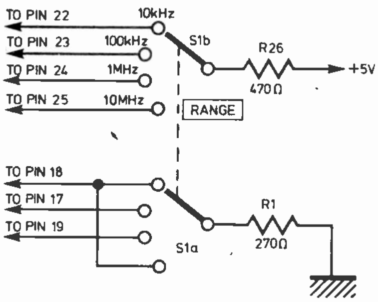


Fig. 2. Circuit diagram of the Digital Frequency Meter (50 ohm version). The dotted lines indicate the boundaries of the two printed circuit boards. The circles with numbers inside refer to the pads on the circuit boards to which wires are connected



Transistor TR10 and associated components form the basic oscillator whose output is fed to the amplifier TR11 and then to TR12 which interfaces the signal to TTL logic levels. As mentioned earlier, the frequency of this clock oscillator is set by trimming the 3 to 60pF capacitor VC1.

THE CLOCK DIVIDER CHAIN

The clock oscillator frequency is divided down to generate logic control pulses. These pulses determine the time for which the main signal gate (IC6c) is open. They also control the transfer of information to the displays and the clearing of the counters in the ZN1040E.

This four-range, four-digit counter has four orders of magnitude of full scale display, so four lengths of timing pulse are needed to cover them.

Full scale ranges are 99·99MHz (in practice limited to 50MHz by the limitations of the ZN1040E), 9·999MHz, 999·9kHz and 99·99kHz.

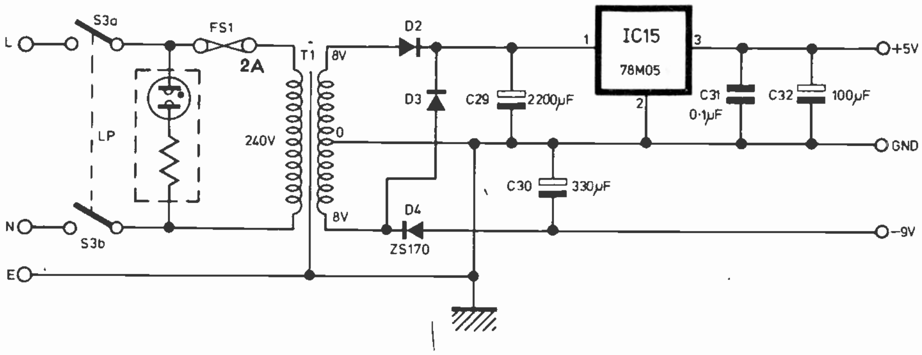


Fig. 6. Circuit diagram of the power supply which produces the 5V and −9V lines to the main board

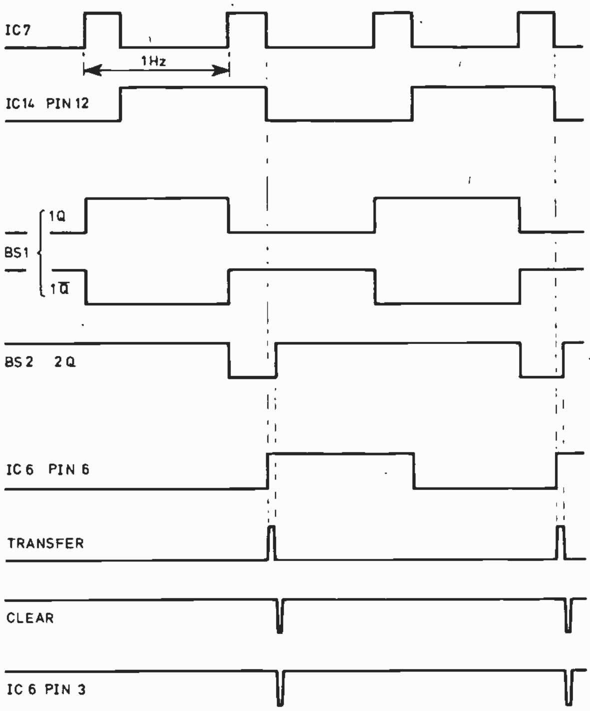


Fig. 3. The timing of the control pulses at various points in the circuit

If the counter is to display, say, 6·800MHz, then 6,800 pulses must pass to the counters. A decade divider connected to the input (IC2) divides the input frequency by ten, giving a frequency of 680·0kHz at the signal gate input (IC6c pin 9). This means that to let 6,800 pulses through, gate IC6c must be open for 1/100th of a second (10ms). The figure "6·800" will then be displayed, the range switch S1 inserting the decimal point to compensate for the prescaler.

The four ranges thus require the following gate times:

Frequency Range	Time gate open (secs)
10·00 to 99·99kHz	1
100·0 to 999·9kHz	0·1 (100ms)
1·000 to 9·999MHz	0·01 (10ms)
10·00 to 99·99MHz	0·001 (1ms)

To obtain these length pulses the 5MHz clock is divided by six and a half decade counters (IC8 to IC14). The remaining divide-by-two is used to start the transfer, clear and reset logic.

Control pulse selection is effected by selecting one of the open collector NAND gates in IC7 using switch S1b. Each of the four gates is connected to a different point in the divider chain. The non-selected gate inputs are held low by the resistors R33 to R36. The outputs of the four NAND gates are WIRED-OR connected via resistor R25.

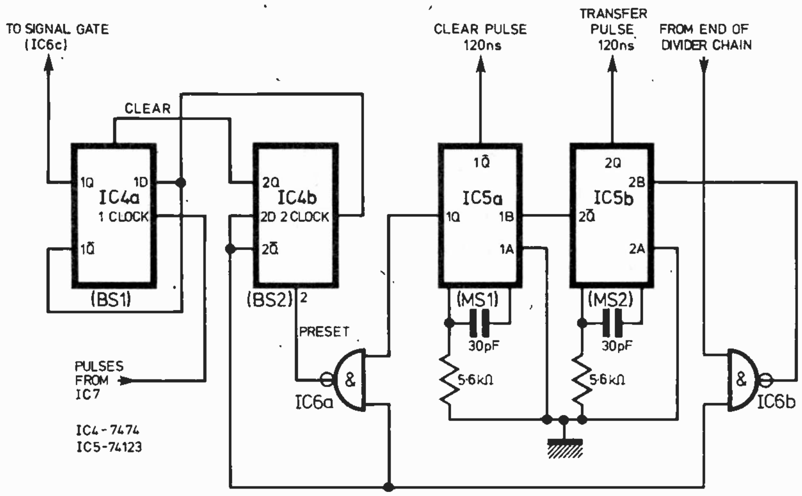
THE CONTROL LOGIC

The control logic determines when a transfer or clear pulse is required and when the signal gate can be opened, thus ensuring a correct sequence of events. The timing diagram (Fig. 3) shows the sequence when the fastest range is selected and the circuit of Fig. 4 shows the control logic in more detail.

The output from the end of the divider chain (IC4, pin 12) is a one second high, one second low series of pulses.

Consider the state when the two bistables of IC4 have been set by a pulse from IC7, so that $2\overline{Q}$ is high and output 1Q is high. The next negative edge from the divider chain will produce a positive edge at the output of IC6b. This will trigger monostable MS2, producing a 120ns positive "transfer" pulse at

Fig. 4. The control pulse generation circuitry in more detail. The logic shown here produces the clear and transfer pulses required by the ZN1040E and the signal gate control pulses



its 2Q output. This pulse transfers the information from the counters to the latches and hence to the display in the ZN1040E.

When the 2Q output of MS2 returns to low, its $\overline{2Q}$ output goes high, triggering monostable MS1 which also produces a 120ns "low" pulse. This pulse is used to clear the counters to 0000. Meanwhile the 1Q output is high for 120ns, taking the output of IC6a low which sets BS2's 2Q output high, clearing BS1 whose 1Q output goes low, thus closing the signal gate IC6c. The logic is now set for the timing period.

TIMING SEQUENCE

The 7474 is a positive edge triggered bistable. On receiving the first positive edge from IC7 after being set, BS1 is triggered. 1Q goes high thus opening gate IC6c. $\overline{1Q}$ goes low which has no effect on 2 CLOCK input as a positive edge is required.

The pulse from IC7 goes low, this having no effect on 1 CLOCK. However, when it goes high again (after the required timing period of one second) 1Q will go low thus closing the signal gate. At the same time $\overline{1Q}$ goes high which triggers BS2, setting 2Q low and clearing BS1. $\overline{2Q}$ remains high in readiness for the next negative edge which starts the whole sequence.

The action of the bistable BS1 divides the pulses from IC7 by two. A 100Hz frequency, with 2·5ms high and 7·5ms low pulses, causes the gate to be open for 10ms.

COUNTING AND DISPLAY

After the counters of the ZN1040E are cleared, the signal gate will be opened for a fixed period. The frequency of the pulses entering the count input (pin 22) will be a tenth of the frequency to be displayed. The ZN1040E has a minimum count rate of 5MHz so the measured frequency can be as high as 50MHz or greater.

The pulses at the count input are counted on the four cascaded decade counters (Fig. 1). When the signal gate is closed the control logic generates a pulse to transfer the counter information to the latches. The clear pulse then sets the counter to zero. Should there be more than 9,999 pulses, the most significant digits will be lost, only the four least significant digits of the number of pulses being retained.

This feature is most useful when measuring a frequency with more than four significant digits. If, say, 29·215MHz is to be measured, the instrument can be deliberately over-ranged to read 9·215MHz, the "2" being remembered from the measurement on the next range.

An internal clock generates the multiplexing signals which control the gating that scans the latches, and addresses the digit select output.

When any particular digit is addressed, the latch information relevant to that digit is presented at the seven-segment decoder/driver output. As each display is addressed with a one-in-four time slot, the average power supplied to each segment is 0·25 the peak power.

Resistors R9 to R15 are used to limit the output current to about 25mA peak. 6mA per segment average is adequate for most applications.

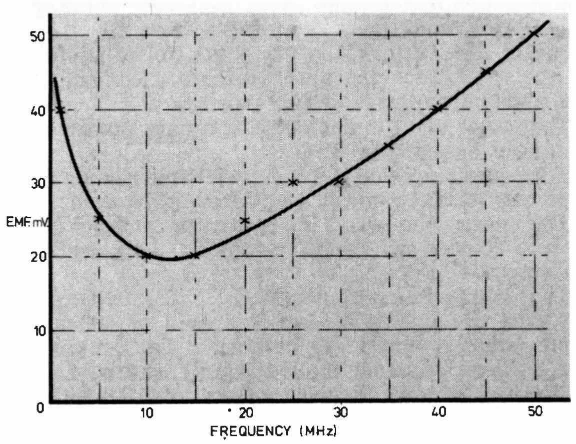


Fig. 5. Frequency plotted against sensitivity for the NE592 integrated circuit amplifier

The frequency of the internal clock can be lowered by the addition of a capacitor or overriden by driving pin 12 with an external TTL clock. A capacitor of 0·01μF has been used in this design to give a multiplex frequency of 2·8kHz.

The displays used in this meter are four DL707 (LED1 to 4). Being common anode l.e.d. displays, they are suitable for driving directly from the ZN1040E, i.e. without interface circuitry. The anode pull-up transistors TR1 to TR4 are used because of the high currents that are required if an "8" is to be displayed (all segments used). A current of 200mA peak can flow in this case. Resistors R2 to R5 limit the current flowing into the bases of these transistors.

Decimal point selection is carried out using the same switch as is used for the gate period selection (S1).

PRESCALER CIRCUIT

In order to measure frequencies higher than the 5MHz limit imposed by the ZN1040E, it is necessary to pre-divide the input frequency. IC2 is a 74196 decade divider capable of operating at 50MHz. It is wired as a divide-by-two then a divide-by-five. The 10pF capacitor C5 connected to the divide-by-two output (pins 5 and 6) acts as a load to prevent instability under no-signal conditions.

Though the frequency capability of the ZN1040E is 5MHz and of the 74196 50MHz, these are minimum figures; a typical pair of i.c.s will operate above this range.

INPUT AMPLIFIER

The input impedance of the instrument as shown in Fig. 2 is 50 ohm. If a high input impedance is required, then the buffer board to be described next month will be required.

A capacitor at the input (C1) protects the input from d.c. bias potential up to 400V. Two transistors (TR5, TR6) connected as diodes are used to limit the input voltage to IC1. Transistors are used as a cheap alternative to high speed switching diodes. If diodes are used here they must have a reverse recovery time of less than 6ns if the full capabilities of the instrument are to be realised. Resistor R7 limits the current in these two transistors.

The power input to the instrument must not exceed the power handling of R6.

The input amplifier IC1 is a wideband video amplifier type NE592 connected in the inverting mode.

The emitter follower TR7 is used to interface IC1 to IC2. Under no signal conditions, 2·1V will be measured at "B".

The i.c. has four outputs (W, X, Y, Z) used to set the gain. By linking X and Y a gain of 400 at a bandwidth of 40MHz is obtained. The graph of Fig. 5 shows frequency plotted against sensitivity.

Shorting W and Z gives a gain of 100 with a 90MHz bandwidth. A 10kΩ variable resistor between X and Y allows a variable gain of unity to 400.

The −5V line required by the NE592 is supplied by the simple stabiliser (TR8 and TR9) fed with −9V.

THE POWER SUPPLY

The power requirements of the instrument are 5V at 500mA, and −5V at 30mA. The power supply and stabiliser for the +5V line is shown in Fig. 6. The −9V line is fed to the stabiliser on the main printed circuit board which produces the −5V for IC1.

The current drain is 350mA with no-signal input and 500mA with all eights displayed.

Next month: Constructional details, high impedance buffer and v.h.f. prescaler

NEWS BRIEFS

Summer School for Teachers

THE Department of Electrical Engineering Science at Essex University will be holding its annual Electronics Summer School for teachers during the week July 12–16 and, this year, three courses *Linear Circuit Design*, *Digital Circuit Design* and *Small Computer Systems* will be run simultaneously.

The Linear Circuit Design course is concerned with the use of transistors and operational amplifiers in analogue applications and the basic circuits of a hi-fi amplifier are investigated in detail.

The Digital Circuit Design course concentrates on the use of the transistor as a switch and develops a design using integrated logic circuits; a digital patchboard is used to introduce the concepts of combinational and sequential logic design.

Small Computer Systems is a new course which should be of interest to mathematics teachers as well as those interested in electronics; the aims of the course are to introduce a typical small computer, the PDP-8, to investigate how it is used and to discuss its function in schools.

Further information on the Summer School can be obtained from Mr R. J. Mack at the Department of Electrical Engineering Science, University of Essex, Wivenhoe Park, Colchester CO4 3SQ.

BOOK REVIEWS

INTRODUCTION TO QUANTUM ELECTRONICS

By P. A. Lindsay
Published by Pitman
202 pages, 240mm × 160mm. Price £6.00

QUANTUM Electronics is no longer confined to the scientific laboratory. An important and growing technology has emerged based on the practical utilisation of electromagnetic radiation interaction with matter on the atomic scale through the medium of devices such as lasers. The applications of lasers are likely to increase in the future and already they play an important part in industry and in the medical field.

Thus the subject covered by this book could be a very rewarding one for the engineering student to pursue. The term "Introduction" might be misleading. This is an advanced level textbook and it explores the subject in a rigorous analytical manner with extensive use of maths. The author is Professor of Physical Electronics at King's College, University of London.

D.D.R.

MULLARD DATA BOOK 1976

176 pages, 134 × 96mm. Price 50p.

THIS is a handy pocket reference containing abridged data on the Mullard range of components for use in consumer applications, including valves, semiconductor devices, TV tubes, capacitors and resistors. Equivalents and comparables are also listed.

For easy reference different coloured pages are used for each of the main sections; blue for semiconductors, yellow for picture tubes and receiving valves and green for capacitors and resistors.

The book is obtainable from specialist components stockists or direct from Technical Press Ltd., Freeland, Oxford, OX7 2AP.

POINTS ARISING

HOW INVENTIVE ARE YOU COMPETITION

Full results will appear next month. Unfortunately it was not possible to include them in this issue, as originally hoped.

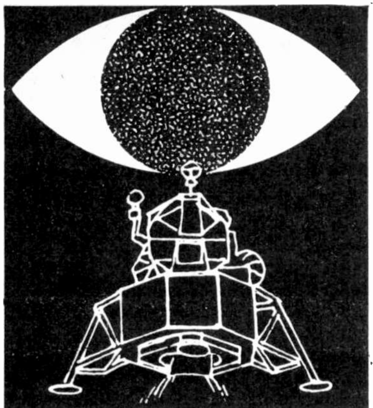
DIGI-PROBE *(April 1976)*

In Fig. 7 (p. 292) the resistor on the left-hand edge of the top board should be annotated R16. Also the lead from the junction of R15, R16 and R17 should go to IC2 pin 12 and not as shown to pin "e" on the DL704 display. The lead from pin "e" of the display should be connected to the other side of R16.

OPTO-COUPLED R.P.M. METER *(February 1976)*

Some constructors have had difficulty in obtaining the MS4A photo-cell specified. This can be obtained from: Davian Electronics, PO Box 38, Oldham, Lancs, OL2 6XJ.

This is an error on the p.c.b. master (page 146). The track in the top left-hand portion of Fig. 2 which connects the collector of TR1 to the positive supply line (shorting out R2) should be removed.



SPACEWATCH

BY FRANK W. HYDE

SOVIET VENUS PROBES

The Soviet satellites *Venera 9* and *Venera 10*, continuing their orbiting studies of Venus, have measured the temperature of the clouds near their upper boundary. This was at a level of −35 degrees centigrade. Records of the glow on the night side of the planet indicate that the spectrum differs from that of the Earth glow.

The electron density on the day side is much higher than the night side and about 90 per cent less than that of the Earth. Another feature is that the ionosphere of Venus appears to be closer to the planet and much thinner than that of the Earth.

The pictures that have been sent back so far have encouraged the Soviet investigators to examine the radio method of exploring through the cloud layer. Although some five years ago Yuri Spiridinov had devised a system of measuring relief using data sent back by *Mariner 5*, this was not pursued because the general consensus of opinion was that the surface of the planet would be mainly smooth.

The technique involves the critical refraction layer of the Venusian atmosphere about 30 kilometres or so above the surface. The angle of refraction of the radio beam is so great that it must also be reflected by the surface. Using the split beam technique, similar holography in the visible spectrum, one half of the beam passes below the critical level and the other half above the critical level.

A signal sent from Earth will be received by a space probe on the dark side, and will be the sum of the direct and reflected wave. Thus, a picture can be built up from the recordings and the result is, when computerised, a picture of the surface in the radio frequency spectrum. More than one line scan is needed of course, but since Venus moves very slowly on its axis, 243 terrestrial days, and the probe needs to be in radio shadow, a line by line scan is easily obtained.

Although the original data received from *Mariner 5* was insufficient to produce a full picture, nevertheless the contour was shown at two frequencies. The indicated variation of height ranged from 0·3 to 2·7 metres. This agreed very well with the pictures that were received from the probes landed on the surface. This technique could be applied in a number of other cases and may prove a very useful tool of the future.

OUTER BOUNDARY

Spacecraft *Pioneer 10* crossed the orbit of Saturn on February 10 and headed out to the boundary of the solar system. On that date it was some 1,000 million miles from the Earth. Its velocity was about 26,000mph.

The equipment has continued to function normally and data continues to be sent back. It is considered that with the sensitivity of the Deep Space Network, *Mariner 10* will be in communication until it reaches the orbit of Uranus and maybe further. The orbit of Uranus is about 2,000 million miles from the Earth.

POWERSAT

The American Congress now has the results of Boeing's power generation satellite proposals. This will require some 30 spacecraft, each of which will have a system of converting solar energy to microwaves which are beamed to Earth. The system has been described in detail in an earlier Spacewatch.

The Earth stations will be situated on the equator in desert areas such as Nevada in America. Provision will have to be made for heavy lifting transporters to raise some of the structures. These transporters will be about 90ft high with a cluster of 21 engines around a 100ft diameter base. The cost, if the pilot experiments are successful, would be something of the order of 60,000 million dollars over a period of 30 years.

SET BACKS

A number of casualties have resulted from the new American finance cuts in the space budget. Some of the cuts mean that decades may pass before missions can be set up again.

It is the Space Science area that has suffered most. A Jupiter orbiter probe for launch in 1981 has been deferred. The Moon orbiter and the fly-by for Comet Encke have also been abandoned. Although, here there is a possibility that *Helios* could be diverted so that the opportunity is not lost.

A tragic loss to astronomy is the withholding of further finance for the 94in orbiting telescope. It will not be possible to advance this project for at least 18 months.

The Venus *Pioneer* programme which will release probes for different depths of penetration into the Venusian atmosphere will still go ahead.

The mission which was planned for a journey via Jupiter, Saturn, Uranus has been postponed and this is the one which means decades in terms of delay because the astronomical positions will not be suitable. This was the "sling-shot" mission where the precise position of the trajectories would have enabled the gravitational effects to help the vehicle on its way.

FUTURE PLANS

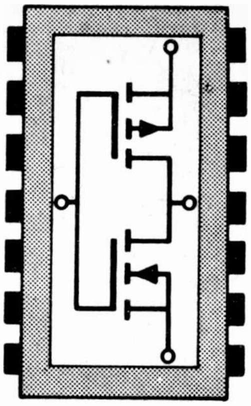
However, some good news is available and the studies planned for the next 11-year period of solar activity will go ahead. The mission will cost 85 million dollars using a 3,000lb satellite which will be known as the Solar Maximum Mission. This will be the first modular design to carry instrumentation retrievable by Shuttle.

At the time of going to press, four launchings have taken place this year. They are: *Helios B*, the second of the German Solar probes; Communications Technology Satellite, a joint effort of NASA and Canada; *Intelstat IV-A-B*, owned by International Telecommunications Organisation and *Marisat*, launched for Comsat General Corporation. *Marisat-B* will follow in May and *Marisat-C* later in the year.

The RCA *Satcom*, second of the domestic communications satellites, was due for launch in March. A NATO satellite *3-A* will be in geostationary orbit in April for North Atlantic Treaty Organisation Relay. LAGEOS, which is Laser Geodynamic Satellite for predicting ocean surface conditions and circulating patterns. It will also be concerned with earthquake hazards and is due for launch in April. *Comstar 1-A* and *Comstar 1-B* will be launched in May and August.

Finally, the *Tiros* Operational Satellite for the National Oceanic and Atmospheric Administration will be placed in orbit in September.

Using CMOS digital I.Cs



By D.B. JOHNSON-DAVIES & A.M. MARSHALL B.A.

PART 5

THIS part concerns electronic switches and oscillators with practical circuit examples.

MONOSTABLES

The monostable is basically a single-shot oscillator. It produces an output pulse of constant width independent of the duration of the input pulse, thus curtailing long pulses and extending short ones. The simple differentiating circuit of Fig. 5.1 performs the first function, as shown by the waveforms in (a). The period of the output pulse depends on the transfer voltage V_T of the inverter as the time constant RC charges from V_{SS} to V_{DD}, and will vary between devices from about 0·4RC seconds with V_T = 30 per cent of V_{DD} to 1·2RC seconds with V_T = 70 per cent of V_{DD}. If, however, the input pulse is shorter than this period, as in the waveforms (b), the capacitor does not charge fully to V_T and the output pulse will be constrained to the length of the input pulse. In other words this circuit will only act as a pulse shortener.

This differentiating circuit can be used as a simple delay unit, and Fig. 5.4 shows a frequency doubler using two such circuits, one triggering on each edge of the clock pulse.

For the circuit of Fig. 5.1 to function as a monostable, it must be made to latch on until the full output pulse has been delivered. This is achieved in Fig. 5.2 by using a NOR gate to hold the input to the differentiating circuit "high" until the capacitor has charged to V_T. This excellent monostable does however suffer from the variation in period between devices, mentioned above.

The circuit of Fig. 5.3 can be used if a more predictable period is needed. Two gates fabricated on the same chip will have closely matched transfer voltages, and by using two identical RC time constants, the between device variations are effectively cancelled out.

SCHMITT TRIGGERS

At the interface between analogue and digital circuits comes the Schmitt trigger, which gives a snappy "yes" or "no" for an undecided analogue input signal. The perfect Schmitt has a characteristic as represented in Fig. 5.5. The Schmitt, if presented with a slowly rising input voltage, will switch sharply off at V_{UT} (the upper threshold voltage) and will not switch back on again until the voltage has fallen below V_{LT} (the lower threshold voltage). This difference $V_{UT}-V_{LT}$, is called the hysteresis, and it prevents the circuit from going into oscillation when the input is held at one of the thresholds.

One way of obtaining hysteresis is to make the transfer point unstable by applying positive feedback, as in Fig. 5.6. The feedback is equal to R1/R2, and this should be less than the combined gain of the inverters for switching to occur. The average threshold voltage V_T can be varied, if required, by connecting a resistor R3 to V_{DD} for V_T of greater than $V_{DD}/2$, and to V_{SS} for V_T less than $V_{DD}/2$.

Another type of Schmitt trigger, unique to CMOS, makes use of the variation of the transfer characteristic of multi-input gates described earlier. Fig. 5.7 shows a circuit with a hysteresis of about 30 per cent of V_{DD}. This can be reduced to 15 per cent of V_{DD} if required by taking one of the three inputs of gate A to V_{DD}. The other two gates are arranged as a familiar R-S latch.

TRANSFER CURVE

If one of the inputs of a two-input gate is held at somewhere between the two logic levels (i.e. between 3 and 7 volts with a 10 volt supply) the transfer curve for the other input is altered as shown in Fig. 5.8. The Schmitt triggers of Fig. 5.9 make use of this property of CMOS gates. The circuit in (a) using NAND gates triggers at above $V_{DD}/2$, whereas using NOR gates as in (b) gives trigger levels below $V_{DD}/2$. In both circuits the hysteresis can be varied from 0 to 40 per cent of V_{DD} by altering V_x.

SCHMITT PACKAGES

As an alternative to constructing Schmitt triggers from discrete gates, the CMOS family contains a few ready-made Schmitt packages. The 4093 contains four 2-input NAND gates each with Schmitt circuits on both inputs. The 40106 is a hex-inverter with Schmitt inputs, and the package outline is the same as the 4069. In both these devices V_T is approximately $V_{DD}/2$, and the hysteresis is 2V with a 10V supply.

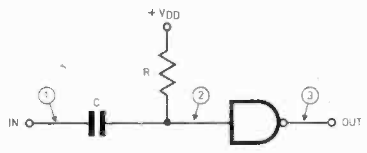
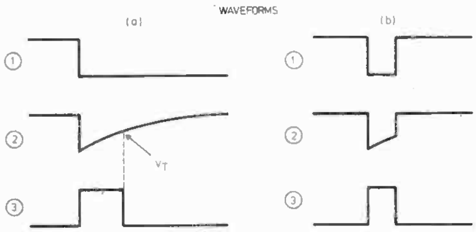


Fig. 5.1. Simple differentiating circuit. The period of the output pulse depends on the transfer voltage V_T of the inverter. For explanation of waveshapes below, see text



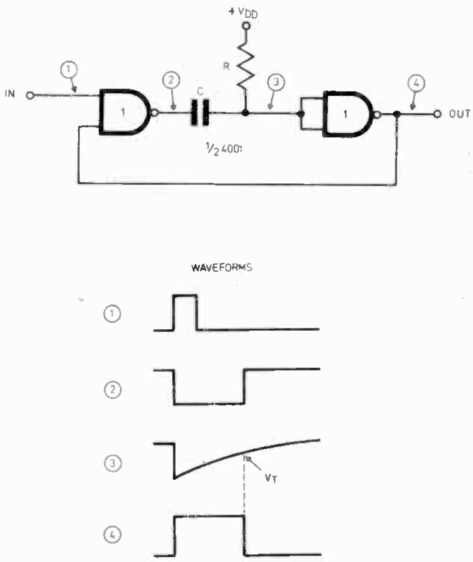
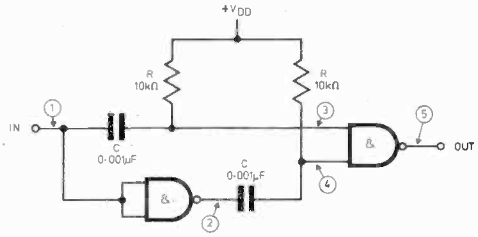


Fig. 5.2. Monostable circuit achieved by connecting a NOR gate to hold "up" the input to the differentiating circuit until the capacitor has charged to V_T



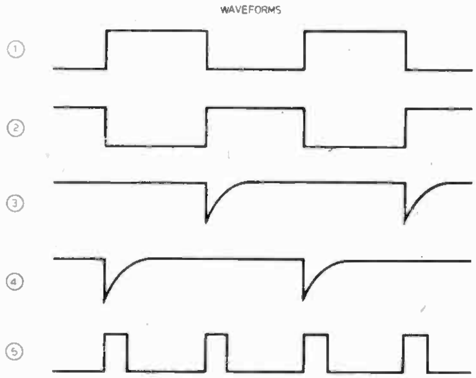


Fig. 5.4. Frequency doubler using two differentiating circuits, one triggering on each edge of the clock pulse, as can be seen from the waveshapes

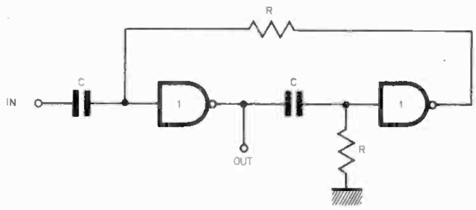


Fig. 5.3. With gates fabricated on the same chip and identical RC time constants output pulse periods can be more accurately predicted

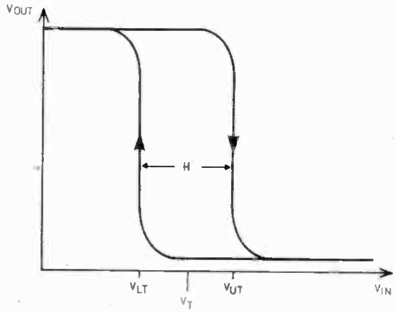


Fig. 5.5. The ideal Schmitt trigger characteristic. It can be defined either in terms of V_{LT} and V_{UT} (the lower and upper thresholds) or in terms of V_T and H (the average threshold voltage and hysteresis)

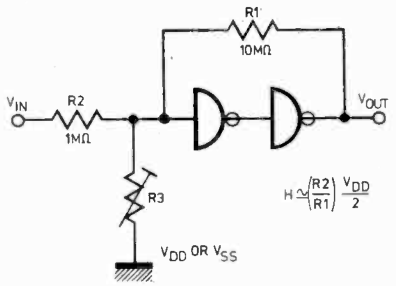


Fig. 5.6. Schmitt trigger formed from two inverters with positive feedback. R1 can be from 1 to 100 times R2. With the values shown (R3 not connected) and a supply of 10V, $V_{LT} = 5{\cdot}0V$ and $V_{UT} = 5{\cdot}8V$ approximately

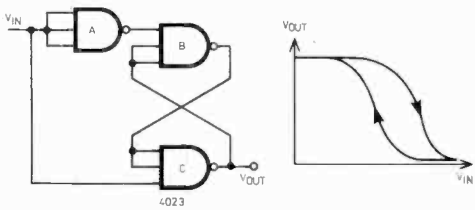


Fig. 5.7. Schmitt trigger using three-input gates

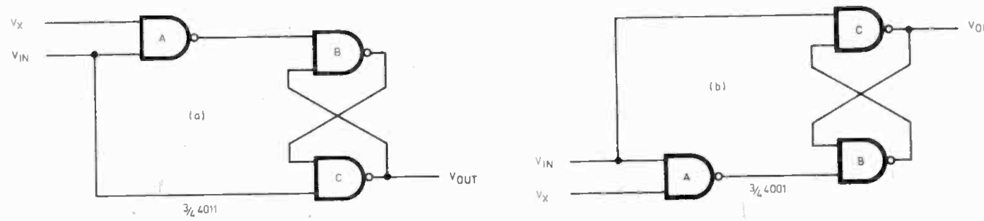


Fig. 5.9. Schmitt trigger circuits with hysteresis determined by the voltage V_X. (a) With NAND gates the circuit triggers at a voltage greater than $V_{DD}/2$. (b) Equivalent circuit with NOR gates triggers at below $V_{DD}/2$

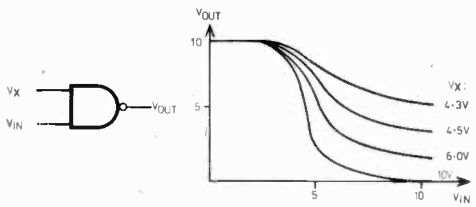


Fig. 5.8. Transfer curve variations for non-logic levels V_X at one input of a two-input NAND gate. The supply is 10V

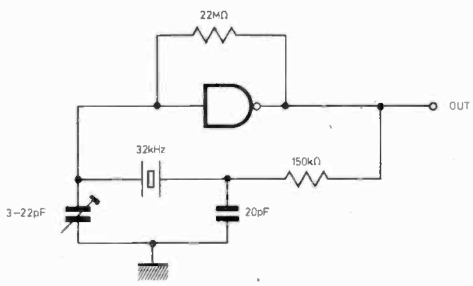


Fig. 5.10. Crystal oscillator

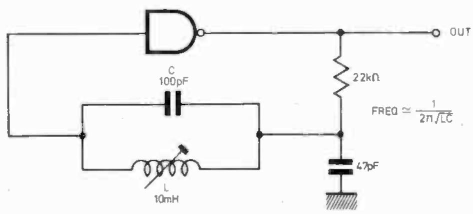


Fig. 5.11. Showing an L/C oscillator the frequency of which being stable to within about 0·001 per cent for a 2V change in the supply voltage

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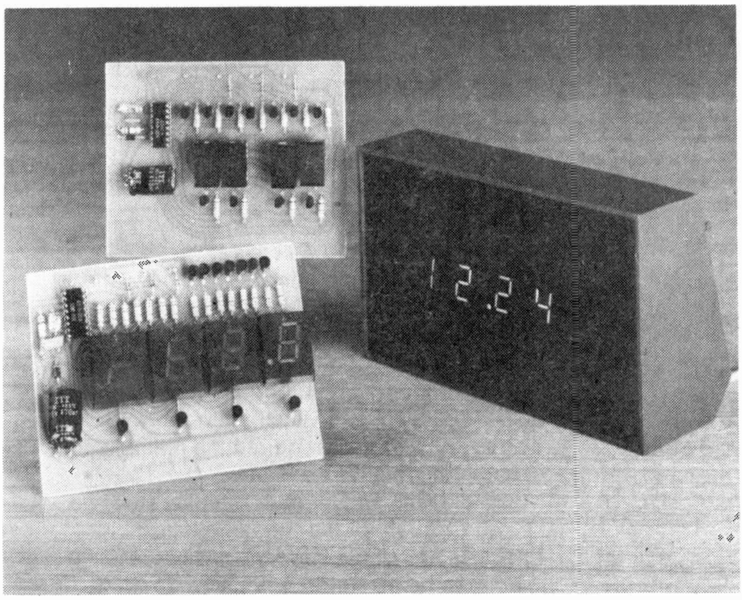

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4002/14002	0·15	4025/14025	0·15	4045/—	1·15	4068/14068	0·15	4099/—	1·50	14517/—	5·40	14552/—	8·05
4006/14006	0·95	4026/—	1·40	4046/14046	1·10	4069/14069	0·15			14518/4518	1·00	14553/—	3·50
4007/14007	0·15	4027/14027	0·45	4047/—	0·70	4070/14070	0·15			14520/4520	1·00	14554/—	1·20
4008/14008	0·75	4028/14028	0·70	4048/—	0·45	4071/14071	0·15			14521/—	2·00	14555/4555	0·70
4009/14009	N/S	4029/—	0·90	4049/14049	0·45	4072/14072	0·15	4700/—	1·50	14522/—	1·50	14556/4556	0·70
4010/14010	N/S	4030/14507	0·45	4050/14050	0·45	4073/14073	0·15	7083/—	4·25	14524/—	N/S	14557/—	3·20
4011/14011	0·15	4031/—	1·80	4051/14051	0·75	4075/14075	0·15			14526/—	1·50	14556/—	0·90
4012/14012	0·15	4032/14032	0·85	4052/14052	0·75	4076/14076	1·25			14527/4527	1·20	14559/—	2·95
4013/14013	0·45	4033/—	1·10	4053/14053	0·75	4077/14077	0·15			14528/4089	0·85	14560/—	1·55
4014/14014	0·80	4034/14034	1·55	4054/—	0·95	4078/14078	0·15	14501/—	0·15	14529/—	1·30	14561/—	0·45
4015/14015	0·80	4035/14035	0·95	4055/—	1·05	4081/14081	0·15	14502/4502	1·00	14530/—	0·65	14562/—	5·25
4016/14016	0·45	4036/—	1·80	4056/—	1·05	4082/14082	0·15	14505/—	3·30	14531/—	1·25	14566/—	1·20
4017/14017	0·80	4037/—	0·75	4057/—	20·35	4085/—	0·55	14506/—	0·35	14532/4532	1·60	14572/—	0·35
4018/—	0·80	4038/14038	0·85	4059/—	10·60	4086/—	0·55	14508/4508	2·35	14534/	6·00	14580/40180	6·00
4019/14519	0·45	4039/—	2·85	4060/—	0·90	4089/—	0·65	14510/4510	1·10	14536/—	2·85	14581/40181	3·05
4020/14020	0·90	4040/14040	0·85	4061/—	16·40	4093/14093	0·65	14511/4511	1·25	14537/—	15·25	14582/40182	1·15
4021/14021	0·80	4041/—	0·65	4062/—	N/S	4094/—	1·50	14512/—	1·05	14539/—	1·05	14583/—	0·71
4022/14022	0·75	4042/14042	0·65	4063/—	0·90	4095/—	0·85	14514/4515	2·55	14541/—	1·80	14585/—	1·45

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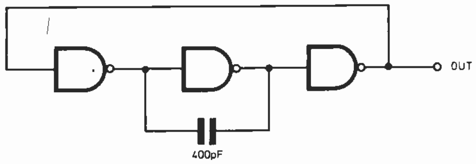


Fig. 5.12. Ring oscillator which uses only one capacitor which is charged and discharged through the inverters

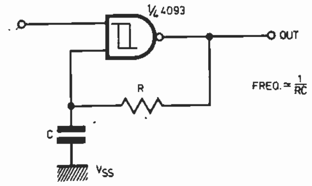


Fig. 5.13. Schmitt used as an oscillator

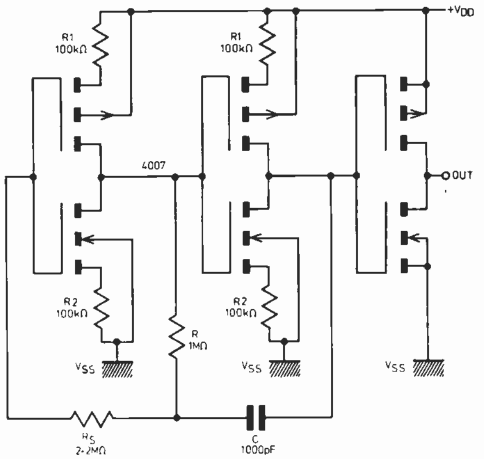


Fig. 5.14. Low-power astable with current limiting resistors R1 and R2. These can be any value up to about 470kΩ. With the values given the frequency is about 450kHz

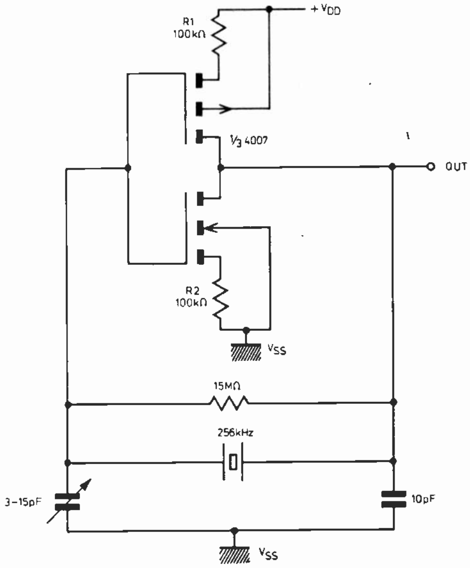


Fig. 5.15. Low-power crystal oscillator. Frequencies of up to 10MHz are possible with a supply of 15V

STABLE OSCILLATORS

For more critical applications, stable oscillators can be made by connecting a crystal or L-C network as a feedback network across an inverter. A crystal oscillator circuit is shown in Fig. 5.10, and crystals resonating at up to several megahertz can be accommodated by altering the values of the two capacitors. Fig. 5.11 shows an L-C oscillator, the frequency being stable to within about 0·001 per cent for a 2V change in the supply voltage.

The ring oscillator of Fig. 5.12 uses only one external capacitor which is charged and discharged through the MOSFETS of the inverters. It will oscillate at between 1kHz and 10MHz for values of C from 1μF to 1pF.

The Schmitt trigger will operate as an oscillator giving a range of 1Hz to 1MHz with suitable values of R and C (Fig. 5.13). Six discrete oscillators can be built with one 40106 package.

LOW POWER

Where power consumption is critical, as in battery-powered circuits, it may be worth modifying these simple oscillator circuits given in the previous part in order to conserve a few milliwatts.

The quiescent current drawn by a gate is negligible; of the order of nanoamps. The major part of the dissipation of a CMOS oscillator occurs during the transition between states, due to the charging and discharging of circuit capacitances, and therefore increases with frequency. This dissipation can be reduced at the expense of decreased output drive capability by the addition of resistors between the source and V_{SS}, and the drain and V_{DD} of the MOSFET pair, thus decreasing the current that flows during conduction. The 4007 dual complementary pair plus inverter provides access to the individual MOSFETS and so can be used in such circuits.

Fig. 5.14 shows a low-power oscillator constructed from a 4007 package, with a frequency of about 1/2·2RC. The power consumption at 10 volts falls from about 5mW with R1 and R2 shorted as in the simple oscillator circuit, to about 200μW with R1 = R2 = 100kΩ. Due to the increased output impedance the oscillator is very sensitive to loading, and so an inverter is added as an output stage.

The crystal oscillator of Fig. 5.15 requires only about 30μW with a supply of 5 volts, and the presence of R1 and R2 has the added effect of stabilising the frequency against variations in supply voltage.

continued on page 408

ADD-ON CAPACITANCE UNIT

By R.W. LAWRENCE B.Sc.

THE measurement of capacitance has always been more difficult than the measurement of resistance, voltage, etc.

The traditional method of performing the operation is with some form of impedance bridge, but this can involve a lengthy ritual of balancing and adjustment to obtain a final reliable reading.

The circuit to be described will allow instant measurement of capacitance from less than 1pF to greater than 10µF, displaying the result on an ordinary multimeter.

THEORY OF OPERATION

The add-on capacitance unit uses simple, conventional techniques and relatively few components. Referring to the block diagram (Fig. 1) it will be seen that there are three basic sections: an oscillator, a virtual earth amplifier, and a precision rectifier arrangement whose output feeds a voltmeter (a multimeter set to a range whose f.s.d. lies between 1–3V).

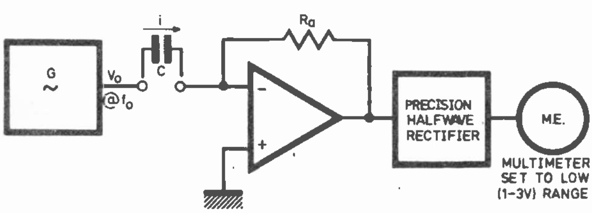


Fig. 1. Block diagram of the Add-on capacitance unit

If we assume the sinewave oscillator is set to a frequency f_0, its output voltage is V_0, and the unknown capacitance value is C, then simple theory yields the current flowing into the virtual earth as being:

$$i = \frac{V}{Z} = \frac{V_0}{1/2\pi f_0 C}$$

This current is directly proportional to the admittance (the reciprocal of impedance) of the capacitor which, in turn, is proportional to the value of the capacitance and the frequency.

VIRTUAL EARTH

Since the current cannot flow into the inverting input of the operational amplifier, an equal and opposite current from the output will flow via the feedback resistor R_a such that the two cancel out at the inverting input providing the so-called "virtual earth".

The voltage appearing at the output of the op. amp. will thus be $i \times R_a$. However, since i itself is proportional to capacitance and frequency (of the oscillator) and the output of the virtual earth amplifier is proportional to i, it follows that this output voltage will also be proportional to the feedback resistor R_a as well as the capacitance and frequency.

In practice R_a and the frequency f_0 are switched to allow a very wide range of capacitors to be measured (less than 1pF to well over 10µF) with good accuracy (dependent on the quality of the meter and components, but can be as good as 1–2 per cent).

The output from the virtual earth amplifier is then rectified with a precision rectifier and presented to the voltmeter (multimeter) for display. The precision

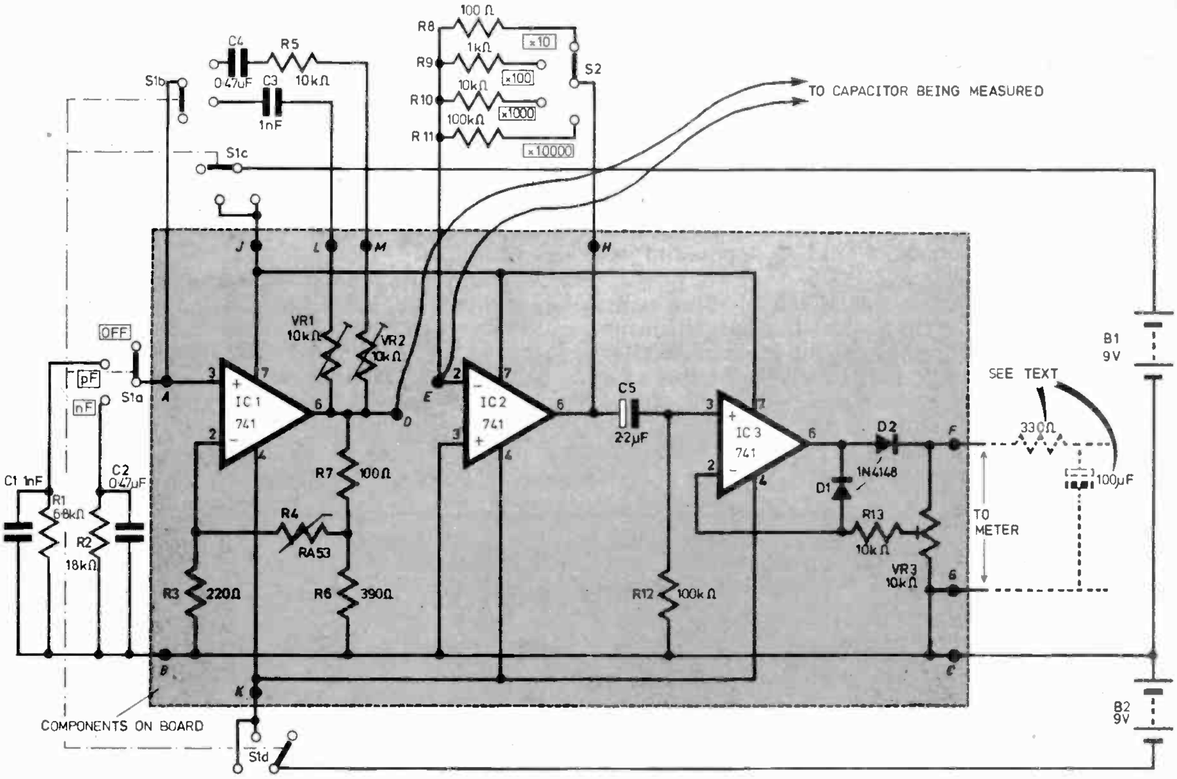


Fig. 2. Full circuit diagram

rectifier merely uses a further op. amp. to overcome diode forward voltage drops and thus obtain accurate rectification down to low output levels.

The circuit diagram is shown in Fig. 2.

INTEGRATION

The output from the unit consists of half sine-waves, and it is left to the meter to integrate these and provide a continuous reading. No problems were encountered with the larger type of meters (AVOs, etc.), but with smaller ones needle "judder" may cause annoyance. If this arises the effect can be alleviated with the simple addition of two extra components.

If a 100μF capacitor is connected across the output of the unit via a 330Ω resistor and the meter output is taken across the capacitor, the integration process is greatly improved and the judder cut down considerably. The addition of these components increases the meter reading a certain amount and therefore the gain of the rectifier stage must be reduced to maintain accurate calibration.

COMPONENTS

The only components that are required to be of any appreciable accuracy or stability are the range resistors R8 to R11. If possible these should be 1 per cent types, otherwise 5 per cent types can be used if they are "hand-picked" with an accurate ohmmeter.

The integrated circuits are all 741s. Although it was initially suspected that bandwidth/slew rate limitations would prohibit their use this was not found to be the case in practice, and high accuracy was maintained throughout all ranges. This obviously keeps the price down and maintains appeal to the economy-minded constructor.

Resistors mounted on the Veroboard have to be small if they are to be mounted horizontally. There is no reason why slightly larger resistors should not be used provided they are end-mounted.

STABILISATION

The thermistor specified is the popular R53 type. When used in Wien bridge oscillators of conventional design these have the property of stabilising the output at a little less than 1V r.m.s. This was found to be rather low for this application and hence a potential divider has been inserted between the output of the 741 and the thermistor.

This causes the thermistor to think that the output level is lower than it is and the circuit stabilises at an output level of around 2V r.m.s. as opposed to the original 700–800mV.

One of the unfortunate side effects of using some types of thermistors as amplitude stabilising elements is the time required for the output to stabilise after range switching. This is particularly so in this case where a large frequency change is performed. If it is felt that the settling time is too long (it in fact amounts to about 3 or 4 seconds) an alternative f.e.t. stabilised arrangement can be substituted (see "Modifications").

CONSTRUCTION

A certain amount of dexterity is required in the construction of the Veroboard as space is very much at a premium. If the specified components are used no great problems should be encountered, and the unit can easily be built on the free board provided.

Construction should commence by cutting the breaks on the Veroboard with either a proper Vero spot-face cutter or a drill of correct size. Components should then be soldered in with care to avoid bridging of parallel tracks. Wire links can be made from stripping ordinary single cored connecting wire or using greater than 22 s.w.g. tinned copper wire from other sources.

C1, R1, C2, R2 and R5–9 are mounted on their respective switches to lessen the number of components on the Veroboard. Obviously, if a larger piece of board is available they can be mounted adjacent to the other components.

CALIBRATION AND TESTING

Firstly, it is worthwhile mentioning that initial setting up and testing of the device is made easier by having an oscilloscope at hand.

As a precautionary measure the current supplied to the unit should be measured when the unit is first tested. This should be in the region of 5–10mA using 9V supplies. The outputs of the 741s (pin 6) should then be checked to be at approximately at earth potential (this is a good test as it is a quick method of checking all is well throughout the complete circuit). Solder bridging, missing Vero breaks and components not properly soldered in are the sort of faults usually found to be at the root of any problems encountered.

The oscillator section should begin to oscillate within a few seconds of switching on; checking and re-checking once again being necessary if no output is obtained.

Calibration should commence with the rectifier gain potentiometer VR3 being set to minimum gain (slider nearest to D2 cathode). The two operating frequencies 20Hz and 20kHz should then be set as accurately as possible with a scope. If one is not available then VR1 and VR2 should be adjusted to their mid-positions.

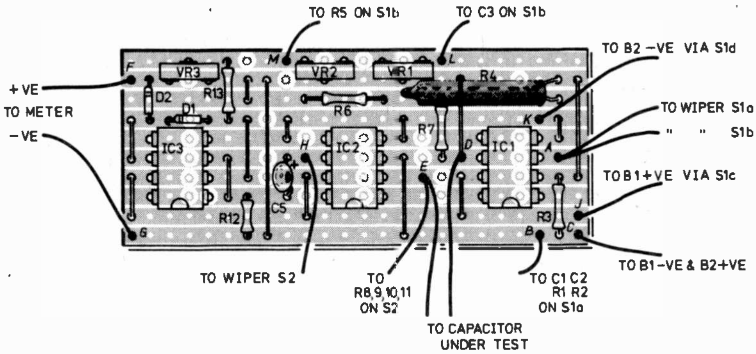


Fig. 3. Component layout and board-cutting details

COMPONENTS . . .

Resistors

R1	6·8kΩ	R9	1kΩ 1%
R2	18kΩ	R10	10kΩ 1%
R3	220Ω	R11	100kΩ 1%
R4	RA53 bead type thermistor (R.S. Components—access via Doram)		
R5	10kΩ	R12	100kΩ
R6	390Ω	R13	10kΩ
R7	100Ω	*R14	330Ω (270Ω–1kΩ, see text)
R8	100Ω 1%	*R15	100kΩ

All resistors $\frac{1}{10}$W 5% unless otherwise specified

Capacitors

C1, 3	1nF plastic or ceramic
C2, 4	0·47μF plastic or ceramic (pref. type C280)
C5	2·2μF tantalum 10V
*C6	2·2μF elect. 10V

Potentiometers

VR1–3 10kΩ min. vertical

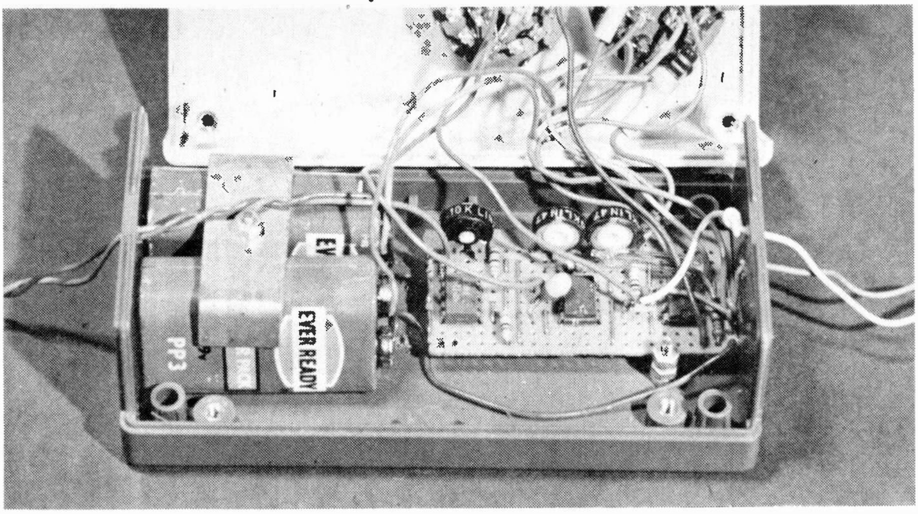
Semiconductors

D1–3	1N4148
*D4	1N4148
*TR1	2N3819
IC1–3	741

Miscellaneous

R.S. Components "midget" wafer switches, 3-pole 4-way, and 4-pole 3-way. Case: Vero plastic box 120 × 65 × 40mm code no. 65-2518. Knobs and hardware, crocodile clips, two PP3 batteries

* Components marked with an asterisk required for optional modification only—see text



Internal layout of the add-on unit. The batteries are held in place with an aluminium bracket and a 30mm CSK 6BA bolt. There is enough room either side of the free board to allow it to be held in place with the 6BA bolt/nut arrangement as shown

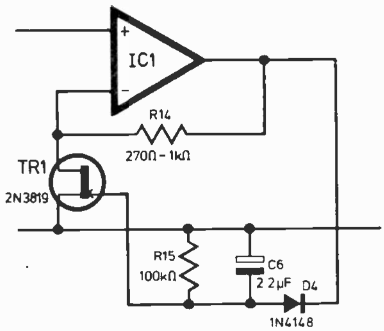


Fig. 4. Alternative f.e.t. stabilising network around oscillator section

PRECISION CAPACITORS

At some stage in the calibration procedure it is necessary to refer to either one, or (preferably), a range of accurate capacitors. These can often be found on ex-equipment circuit boards which are generally on sale at many electronics stores. An ideal range would contain such values as 10pF, 100pF, 1nF, 1µF, 10µF, all within 20 per cent tolerance. Obviously it may prove difficult for some constructors to obtain such capacitors, in which case less accurate ones will have to be resorted to. The majority of the above mentioned capacitors are in fact used for checking and it is possible to calibrate the capacitance unit successfully with only one 10,000pF, exploiting the fact that two ranges overlap (10,000pF and 10nF). It may therefore be considered worthwhile to invest in one precision 10,000pF capacitor and use standard types for spot checks throughout the other ranges.

Set the nF/pF switch to nF and check that the oscillator output is about 1·5–2V r.m.s. Set the multiplier switch to ×10. Connect the 10,000pF capacitor to the test leads and the "meter output" to an appropriately adjusted multimeter (a low voltage d.c. range with an f.s.d. between 1 and 3V). The capacitance unit is designed to give 1V output for "full-scale" reading on each range; hence, if a 1V range is available this would do best.

The rectifier gain control should now be increased with VR3, and if all is well it should be possible to adjust the output level such that the meter is reading 1V. The nF/pF switch should now be set to the pF position and the multiplier switch to 10,000 (corresponding to 10,000pF f.s.d.). The meter should read in the region of 1V and any discrepancy adjusted out with the 20kHz trimmer VR1.

If this cannot be done, and no scope was initially available to set the two operating frequencies reasonably accurately, VR1 should be adjusted to give as near 1V output as possible and VR3 then used to set it exactly. In doing this the nF range will be misaligned, and therefore, with the 10,000pF capacitor still connected, and the range and multiplier switches once again set to read 10nF, VR2 should be used to adjust the output to read 1V once more. It is a question of juggling with the three calibration potentiometers (VR1–3) as outlined above until the unit is satisfactorily calibrated, although it is worth stressing that an oscilloscope can save quite a lot of time in this process.

MODIFICATIONS

Earlier it was mentioned that the response time of the thermistor was rather long and that it could be reduced by inserting an f.e.t. stabilising arrangement in place of it. The modified section is shown in Fig. 4. The output of the oscillator is rectified and then used to bias the gate of an *n*-channel f.e.t. If the output level reduces the f.e.t. is turned on which increases the gain of the amplifier and stabilises the level. In practice the value of the feedback resistor R14 is a little critical; if it is too large the output level will not be held stable, and if too small, no output will result. A value of between 270Ω and 1kΩ was found to be suitable. ★

AUDIO COMPASS

By M. KENWARD

SOME time ago we were asked to design and construct an inexpensive unit to enable a blind man to steer a yacht on a straight course. The design, which is a direct result of that request, is fully described in this article.

In addition to being of immense help to blind sailors, the design will also assist those sailors who use wind vane steering, as it can provide an off course alarm, and also power boat enthusiasts, as it can be used to steer a straight course without the need to look away from the water ahead. It could also prove very useful on a long passage where a compass course must be sailed, particularly at night, as it allows the use of ears rather than eyes, which can become tired.

The audible output from the unit is provided through a crystal earpiece and can be a high frequency, no output or a low frequency. The no output indicates that the yacht is on course and the high or low frequency that the yacht has gone off course in one direction or the other. The width of the no output (or dead) band can be varied from about 5 degrees (2·5 degrees off course on either side) up to about 50 degrees (25 degrees off course either side) this is to suit the conditions and the response of the boat/helmsman and is adjusted by the helmsman with a sensitivity control.

In use the boat is put on course, the compass is revolved until the unit gives no output at maximum sensitivity and the helmsman then steers to keep no output, adjusting the volume and sensitivity to suit himself. When used as an on off course alarm a relay switches on a loud alarm to indicate that the boat has gone off course by more than the amount previously set.

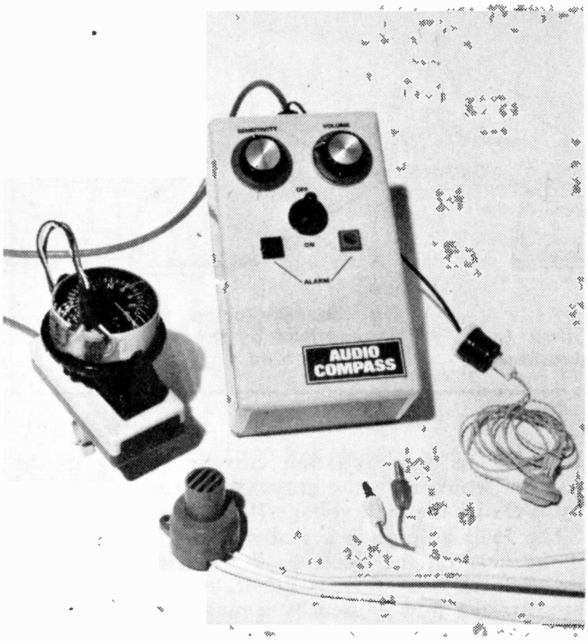
CIRCUIT OPERATION

Two Hall effect probes are mounted on a suitable compass to detect the position of the magnet inside that compass. The Hall effect probes (H1 and H2) are fed with a constant voltage by TR1 (Fig. 1), the voltage being derived from the forward voltage drop of D1 and D2 in series (about 1·4V). The output from each probe is fed to an input of the 741 op. amp. IC1, one to the inverting input and one to the non-inverting input. Provided both inputs are at the same level the output at pin 6 will be zero (comparator arrangement) this can be corrected by adjustment of the offset control VR1.

If the pole of the compass magnet is between the two probes the output from them will be similar. If the pole moves towards one probe the output from that probe will increase (see section on Hall effect later) and from the other decrease—this will cause the output of IC1 at pin 6 to rise or fall at a rate dependent on the setting of the sensitivity control VR2 (this provides a variable degree of negative feedback to IC1).

The output from pin 6 is fed directly to the bases of TR2 and TR3 which act simply as switches to prevent the relays from loading the output of IC1. If the output goes high, TR2 is turned on, thus connecting the two relays across the 0V and +9V lines. Relay RLA will be turned on, thus connecting the supply to the unijunction oscillator formed by TR4 and its associated components and producing an audible output in the crystal earpiece connected to SK1. Relay RLB will not turn on due to the presence of D3.

If however the output at pin 6 goes low TR3 will be turned on thus operating RLA and RLB, this



The complete Audio Compass also showing the audible warning device used as the off course alarm

not only connects the oscillator but also shorts out R5, thus greatly increasing the frequency of the oscillator and hence of the output at SK1. The audible note thus indicates towards which probe the compass magnetic pole has moved.

The sockets SK2 and SK3 across RLA1 may be used to trigger an audible alarm, powered by the yacht's or other supply, to give an audible off course alarm. This facility can be set to trigger from about 2·5 degrees off, to about 25 degrees off by means of VR2 but does not indicate which way off course the yacht has gone (more about this later), and when in operation **prevents the use of the normal audible output.** The facility is added for those who use some form of wind vane self steering. It will provide an audible alarm if the yacht has been steered off its original course by the preset amount. The alarm recommended is the RS type audible warning device 12V or 24V, as required.

COMPONENT NOTES

One or two further points concerning the circuit operation should be made clear before we proceed, these concern the components used and their siting in the unit. It was found necessary to provide a stabilised supply for the two probes as their output varies considerably with the current flowing through them. The simple supply formed by TR1, R1, D1

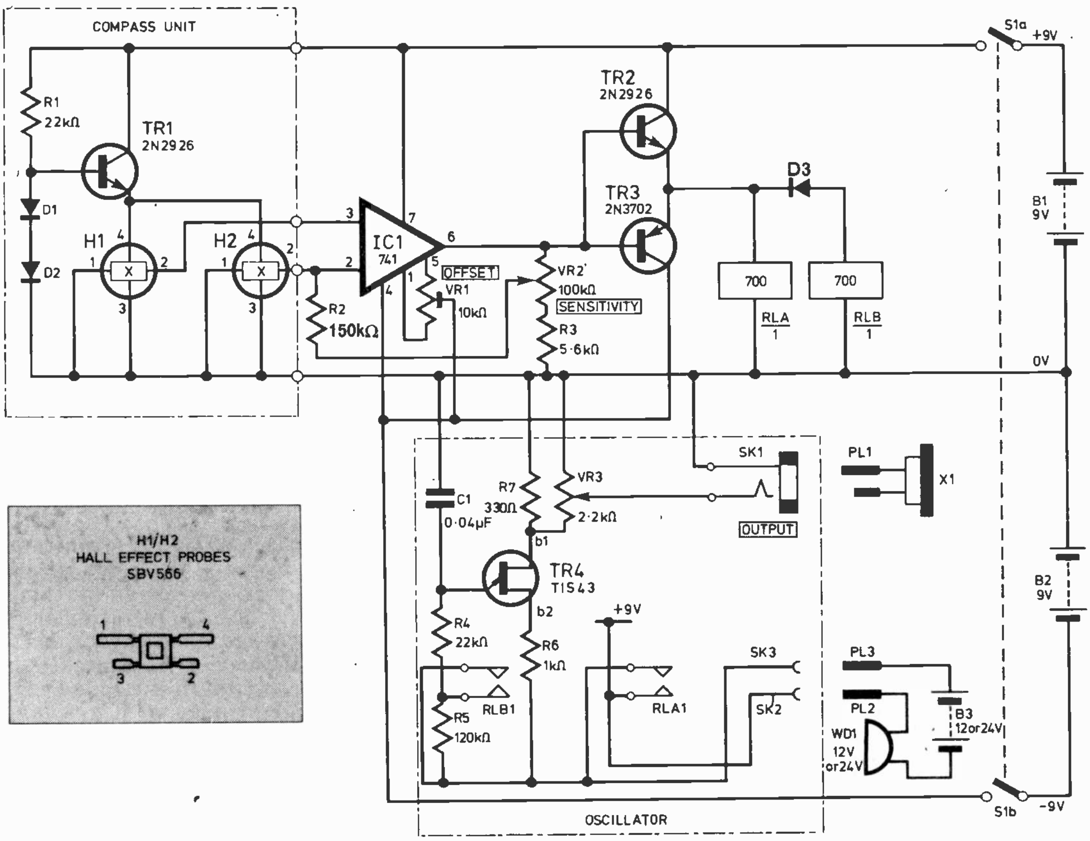


Fig. 1. The complete circuit diagram of the Audio Compass

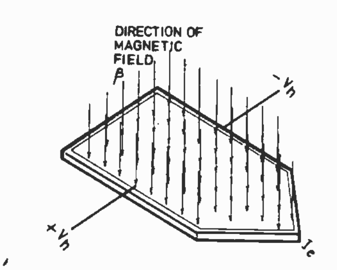


Fig. 2. Generation of Hall voltage

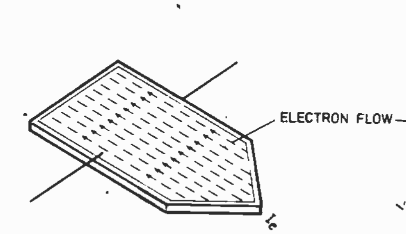


Fig. 3a. Electron flow in a conductor or semiconductor

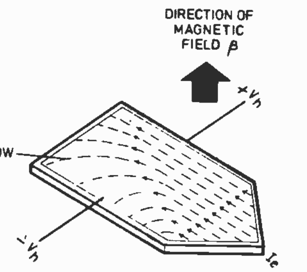


Fig. 3b. Distorted electron flow caused by the magnetic field indicated

and D2 was found to be perfectly adequate, provided internal cells are used and the unit is not connected to the boats supply. The components forming this stabiliser are sited as near the two probes as possible in order to negate any lead resistance which may prove troublesome.

The values of resistors R2 and R3 set the limits to the sensitivity of the unit and those shown were found to be most suitable. Reduction of R3 will decrease the minimum dead band, but if this is taken too far the unit will be difficult to set up and it would become impossible to keep within the dead band when in use.

Similarly, reduction of R2 will increase the dead band, but if this is taken too far, the limits of the sensing probes will be reached and either no output will result or only one note may sound. Experimentation with these values, either up or down, will not harm the unit and some constructors may find it helpful to do this. It is not recommended that preset resistors are permanently employed as their value could easily be altered with a knock.

It should be fairly obvious from the circuit description above that relay RLB must operate at the same instant or preferably before RLA. If this is not the case the output will always start at a low frequency and then go high if the voltage at TR2/TR3 emitters goes low.

To prevent this, the working voltage of both relays must be checked and that which operates at the lowest voltage used for RLB; the operating voltage will probably be around 3V. For this same reason a germanium diode **must** be used for D3 since the voltage drop across this will only be about 0·2V, instead of 0·7V for a silicon diode.

The two diodes used in the stabiliser circuit must be silicon diodes and are used to provide a "Zener" voltage of about 1·4V.

HALL EFFECT

The Hall Effect was discovered by E. H. Hall about 90 years ago and the principle involved accounts for the deflection of cathode ray beams in magnetically deflected tubes, so it has been employed for some considerable time, although many readers may not be aware of it.

Basically the effect causes a voltage (the Hall voltage) to be set up in a conductor or semiconductor in the presence of a magnetic field when an excitation current flows through the conductor or semiconductor. The effect is illustrated by Fig. 2. The current I_e is the excitation current flowing in the material which is in the presence of a magnetic field β this causes the Hall voltage V_h to be set up.

The Hall voltage is actually caused by the effect of the field on the electrons flowing in the conductor. The electron flow is illustrated in Fig. 3a and the distorted flow caused by a magnetic field in Fig. 3b.

The electrons tend to build up along the edge of the conductor and, since they are negatively charged give rise to the Hall voltage as indicated. The maximum Hall voltage is limited because the abundance of negatively charged electrons tends to repel further electronis (like charges repel), hence a state of equilibrium is reached when the magnetic force equals the repulsion of further electrons. This state is reached in much less than a microsecond and the Hall voltage will therefore quickly follow any variations in magnetic field. If the excitation current is varied, a greater number of electrons are introduced and hence V_h increases.

It is thus easy to see why V_h is directly proportional to both I_e and β.

PRACTICAL CONSIDERATION

In the application described the Hall voltage is minute since the field around the compass magnet is also very small. In addition to this an offset voltage is set up in the device which causes a continuous voltage of about 1·5V per ampere (excitation current) to appear in addition to the Hall voltage. This offset voltage can be greatly reduced by the design and material of the probe—of the order of 2mV or less per ampere—but such probes are expensive (about £30 each—as opposed to about £1 each for those used).

The effect of the offset voltage is taken care of in the circuit of Fig. 1 by using the 741 a comparator so that it only senses the *difference* in the input voltage and not its level. Since two similar probes are used the offset voltage on each will be similar and any slight variations can be cancelled by the offset control VR1 (a multiturn preset) which varies the bias on the two input circuits of IC1.

We have shown that variations in the excitation current will provide variations in the Hall voltage. To provide stability both probes are fed by the stabiliser. Although this does not hold the current through each probe constant it has been found to be perfectly adequate since the probes are similar and therefore have a similar resistance/temperature characteristic. They are also mounted relatively close to each other.

The current through each probe has been set to about 15mA to provide enough sensitivity, consistent with reasonable battery life when using a PP9 battery. This current could, if required, be increased—by increasing the Zener voltage set by D1–D2—up to a maximum of 75mA for each device. If this maximum is approached, steps must be taken to ensure that no one probe is exceeding that current.

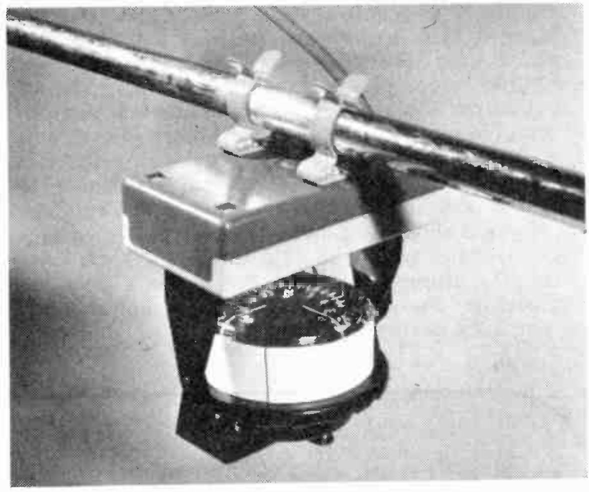
HOUSING

The construction of the unit has been kept as simple and straightforward as possible. It was decided that to be of use to the blind yachtsman it would not only need to be portable but also easily able to be fixed and used on any yacht, as few blind people own their own boats.

It is necessary to mount the compass where it can be adjusted to set the course and where it is free from knocks. To this end the compass unit has been equipped with two Terry clips so that it can be fitted to the stern pulpit of most yachts.

Similarly, the control unit which measures about 190 × 110 × 65mm is fitted with rubber suction pads so that it can be attached to any smooth flat surface near the helmsman. The two units are linked by a single four-way lead. This lead must be long enough to cover most situations (about 2 metres).

The control unit carries the batteries and has an output for the earpiece as well as sockets for an audible alarm. Both boxes carrying circuitry should be fairly splash proof and all metal work must be able to stand up to salt water type environment.



One way of mounting the compass unit on the rail. It could also be inverted so that the compass is more easily accessable

COMPONENTS . . .

Resistors

R1 22kΩ	R4 22kΩ
R2 150kΩ	R5 120kΩ
R3 5·6kΩ	R6 1kΩ

All ±10% ¼W carbon

Capacitor

C1 0·039μF

Potentiometers

VR1 10kΩ multiturn preset
VR2 100kΩ lin. carbon
VR3 2·2kΩ log carbon

Semiconductors

H1, H2 SBV 566 Hall effect probes (2 off—Electrovalue)
D1, 2 any small silicon diodes (2 off)
D3 any small germanium diode
TR1, 2 2N2926
TR3 2N3702
TR4 TIS43
IC1 741 op amp

Miscellaneous

RLA1, 2 6–9V d.c. 700 coil reed relay (348-970 Doram 2 off)
SK1 Line jack socket and plug (PL1) to suit X1
SK2, 3 Plastic encapsulated banana sockets and plugs (PL2, 3) to suit (2 off each)
S1 D.p.d.t. switch with thread to match dolly cover—see miscellaneous
B1 PP9 9V battery and clips
B2 PP3 9V battery and clips
X1 Crystal earpiece with plug and lead at least 1 metre long.
WD1 Audible warning device 12V or 24V as required (Doram). Only required for off course alarm function.
Cases 188 × 110 × 60mm and 100 × 50 × 25mm Vero or Bocon (West Hyde Developments) plastic boxes with interlocking lid; cable gland ENCGQ (West Hyde Developments); plastic dolly cover for S1 (WS234 Home Radio Components); knobs pointer (2 off—see text); Veroboard 0·1in matrix approx. 100 × 100mm; connecting wire; 4B.A. fixings; 4 way cable at least 2 metres (see text); three suction pads, two terry clips for 25mm diameter tube (stern pulpit).

Compass

Sestrel Junior dingy compass with gimballed mount (see text).

The control box of the Audio Compass, this is fitted with three suction pads for mounting purposes

Obviously if the unit is to be used only on one craft or if it is to be used only as an off course alarm, it could be permanently fixed and in the latter case could be completely housed below deck. The off course alarm only application allows certain sections of the circuitry to be omitted, more about this later, however, since the cost of these sections is relatively low we would advise the constructor to build the complete unit so that the audio compass can be used should the need arise. This also means that the owner would be able to offer a blind crew a useful position and, from the author's own experience, this could prove to be valuable and interesting for both parties.

CONSTRUCTION

Construction of the two units is shown in Figs. 4 and 5. There are no special precautions other than saying it is probably safer to use a holder for IC1. This is useful when changing i.c.s as we have found that there are a number of duff ones about. It is also necessary to take the usual precautions when soldering D3, since this is a germanium device and thus easily damaged by excess heat.

The output socket for the crystal earpiece is mounted on a 300mm length of twin-cable which passes out of the case through the cable gland. This adds extra length to the lead and allows the box to remain sealed (it is difficult to get a sealed jack

CONTROL UNIT

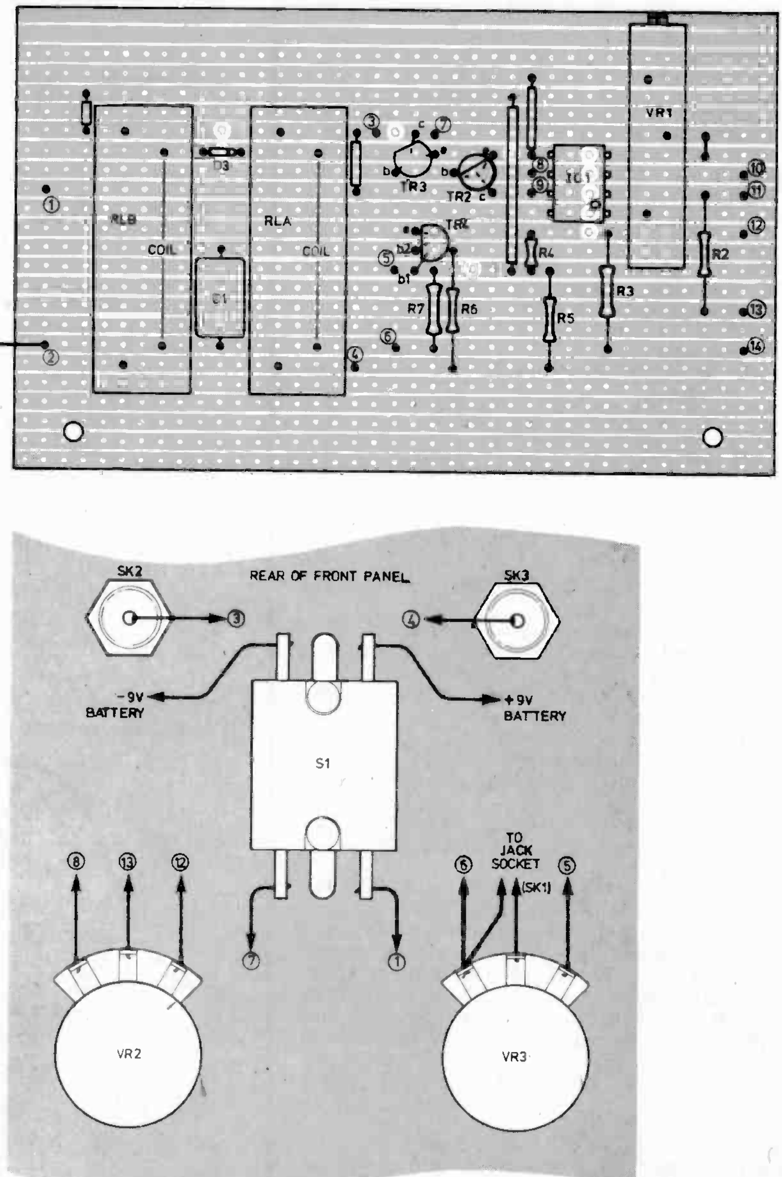


Fig. 4. Construction and wiring of the control unit. Veroboard layout is shown above with connecting points indicated by numbers which tie up with the lower diagram and Figs. 5 and 6

socket). The socket can be a "line" type or can be mounted in any suitable small container and may be easily changed if it becomes badly corroded.

The fitting and wiring of the two probes is shown in Fig. 6. These probes are very small and **must be handled and soldered with great care in order not to damage the leads.** They do not seem to be particularly heat sensitive but excess heat should be avoided. The probes are eventually covered with Araldite to protect them and fitted—square marked side inwards—against the plastic ring which is fitted over the compass, in line vertically with the magnet.

Construction of the compass unit is shown in Fig. 6. The materials used should be plastic or brass as indicated, because these are non magnetic and corrosion resistant. The revolving ring is made of Contiboard white iron-on edging which is used glue side inwards with the ends overlapped and "ironed" together to form a ring.

INITIAL TESTING

Before testing the unit the supply current on the positive line should be checked to ensure the probes are not consuming too much current. Supply current should be about 30 to 50mA (depending on the output of IC1) and definitely not more than 60mA. If all is in order the unit can be tested for correct operation.

COMPASS UNIT

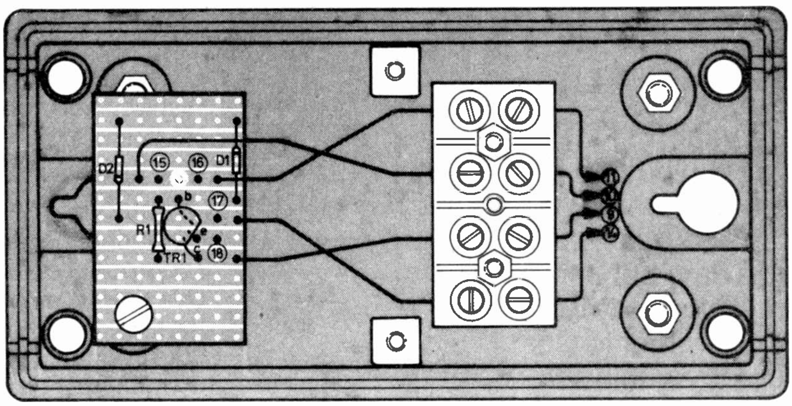


Fig. 5. Layout and wiring of the compass unit. The lead outlets can be sealed with silicon compound

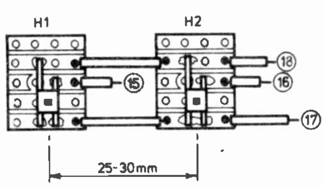
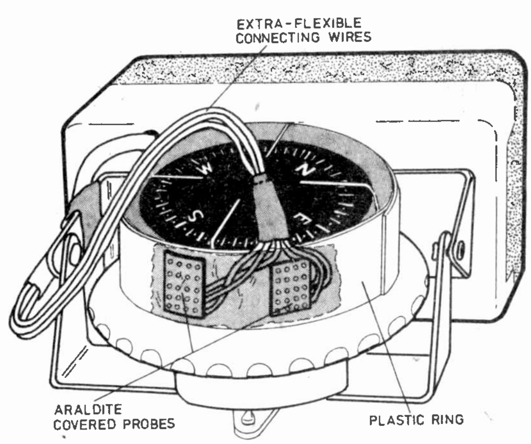
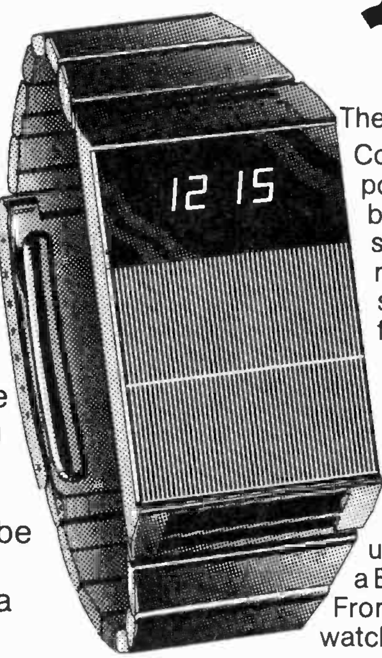


Fig. 6. Fitting and wiring of the two Hall effect probes. Basic arrangement of the compass unit is also shown, the wires to the probes should be extra-flexible to allow the compass to swing freely



The Black Watch kit £14.95!



★ Practical–easily built by anyone in an evening's straightforward assembly.

★ Complete–right down to strap and batteries.

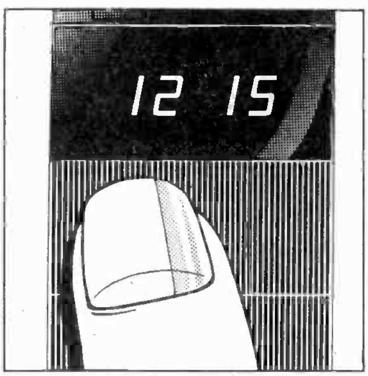
★ Guaranteed. A correctly-assembled watch is guaranteed for a year. It works as soon as you put the batteries in. On a built watch we guarantee an accuracy within a second a day–but building it yourself you may be able to adjust the trimmer to achieve an accuracy within a second a week.

The Black Watch by Sinclair is unique. Controlled by a quartz crystal, and powered by two hearing aid batteries, it uses bright red LEDs to show hours and minutes, and minutes and seconds. And it's styled in the cool prestige Sinclair fashion: no knobs, no buttons, no flash.

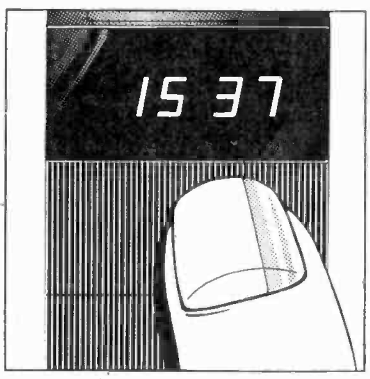
The Black Watch kit is unique, too. It's rational – Sinclair have reduced the separate components to just four–and it's simple: anybody who can use a soldering iron can assemble a Black Watch without difficulty. From opening the kit to wearing the watch is a couple of hours' work.

Touch and tell

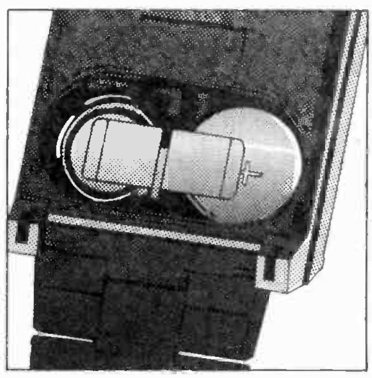
Press here for hours and minutes...



here for minutes and seconds.



Batteries easily replaced at home.

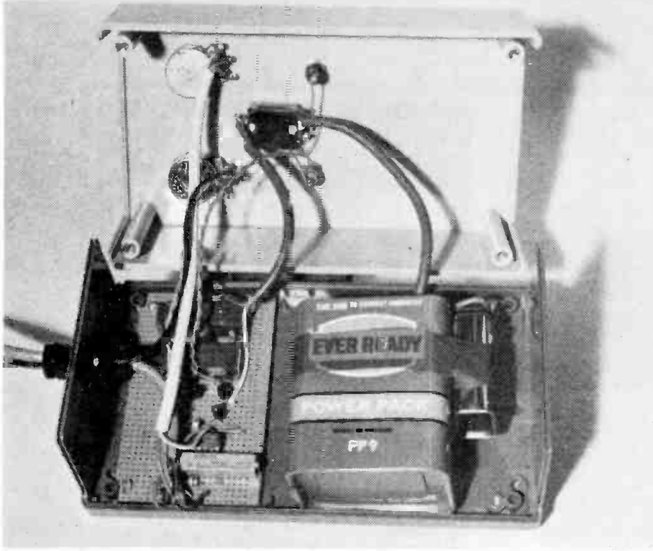


The specialist features of the Black Watch

Smooth, chunky, matt-black case, with black strap. (Black stainless-steel bracelet available as extra–see order form.)

Large, bright, red display–easily read at night. Touch-and-see case–no unprofessional buttons.

Runs on two hearing-aid batteries (supplied). Easily re-set using special button–no expensive jeweller's service.



Internal view of the control box showing general layout. Foam rubber can be used to hold the batteries in place

To do this switch on and, with the sensitivity control turned fully up and the probes away from the compass, adjust the offset control VR1 until no output results or until the output frequency is just on the point of changing. Next introduce a metal screwdriver between the two probes and move it between the probes. The magnetism usually contained in the screwdriver should be enough to cause the two output signals to be produced, depending on which probe is approached.

If the unit does not function correctly the output of the i.c. can be checked, it should vary from +7 to −7 volts with variation of magnetic field at the probes. Once this is established a similar voltage should appear at the emitters of TR2 and TR3 and this should cause RLA and RLB to operate. Check this by measuring the resistance across RLA1 and RLB1. If all is well but no output results the fault must be in the unijunction oscillator, check the wiring and test for faulty components.

Voltages on IC1 pins 2 and 3—the Hall voltage plus offset—should be about 0·3V and it may be possible to see slight variation of this on a high impedance voltmeter (20,000Ω/V plus) if one pole of a magnet is brought close to the relevant probe.

Construction of the compass unit. Use of a connecting block allows the two units to be separated

ALARM ONLY

Should it be decided to construct only an off course alarm the unijunction oscillator, relay RLB and D3 may be omitted. The contacts of RLA1 then go only to SK2 and SK3 and are wired to the alarm and external supply as shown in Fig. 1.

The omission of these parts will save very little current and make little difference to the duration of the battery supply. With the above omissions the alarm will sound whichever way off course the craft has gone and thus no indication of direction is provided. If direction indication is deemed necessary for the alarm function, two different alarms should be employed e.g. that specified and a bell. The second alarm being wired to RLB1—which, together with D3 must be retained—in the same way as indicated for WD1 and RLA1. In addition to this a second germanium diode must be inserted in series with RLA, in the opposite polarity to D3. Thus when the output voltage of TR2/3 goes positive RLA will operate and when negative RLB will operate.

If as suggested earlier, the complete unit is constructed although only to be used as an alarm, the output earpiece can be left disconnected while in use—this will not affect operation of the unit or do any harm.

FINAL ASSEMBLY

The compass is gimballed in one direction only to take care of the heel of the craft, the floating card and magnet can move to overcome any pitching. The probes must be covered in Araldite and fixed to the ring on the compass housing in line with the magnet. A course setting line can be drawn between the probes.

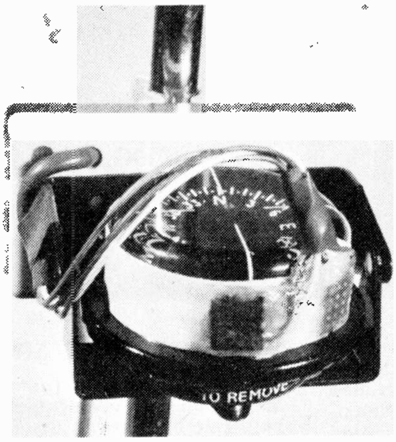
It has been found that Araldite will not produce a good bond on the plastic ring and this is all to the good as it means that the probes and their Araldite covering may be prised off if necessary.

The possibility of using compasses other than that specified can be investigated simply by affixing the probes in the most suitable position (as near to, and on the same plane as the magnet) with insulation tape and trying the unit. The compass should be of good enough quality to function correctly without violent swings when in use.

Once in place the probes and their wiring can be protected by a couple of layers of plastic insulation tape. It must be noted that the ring should not be continually rotated on one direction as this will eventually break the leads. If this is thought to be a problem a stop should be fitted to the rotating section to prevent it going past 360 degrees.

When complete the unit can be set up by arranging the compass so that the north pole lines up with the line between the probes. Preset VR1 should then be adjusted with VR2 at maximum sensitivity, until no output results or the frequency just changes. The unit is then ready for use.

The complete unit is intended to be reasonably water resistant and to this end a cable gland is used where the wires enter the main case. Also a flexible plastic dolly cover is used to protect S1 from the influx of water.



Another method of mounting the compass unit. It should be remembered that the gimbal takes care of yacht heel

The simplest method of sealing the two potentiometers is to employ knobs with a fairly large diameter and flat underside. Two cut-down babies' teats are then glued to the case so that when the knobs are fitted they push down on the rubber ring forming a reasonable seal. The teats can be easily and cheaply replaced when worn.

The cable entries to the compass unit can be sealed with silicon bath sealing compound and this could also be used around the joint on the smaller case once final testing is complete. The larger case must be easily taken apart to facilitate battery charging.

IN USE

Due to the design of the unit similar output notes and dead band are produced with respect to both the north and south poles of the compass. This is not a problem once the boat is on course but should none the less be noted.

The off course signal will continue to sound, should a correction not be made, until the craft has passed through 180 degrees. Because of this action it is always best to set the probes to sense one pole, say north, as this then provides a standard output with variation in course, e.g. if going off course in an easterly direction a high note would sound if in a westerly direction a low note. Should the other pole be sensed, these notes would reverse.

Due to the fact that the compass specified cannot be corrected and that its environment will change, it should not be used as an accurate course indicator. It is better to put the craft on the correct heading and set the audible compass (at maximum sensitivity) to suit. It is possible to make up a normal deviation chart for the compass, if it is mounted in a fixed position, to enable accurate setting should this be required.

The prototype compass has been successfully tested in various yachts and it has been found that in most sea conditions the movement of the craft gives rise to bleeps from the unit before a continuous note sounds, these bleeps gradually increasing in length as the craft goes off course until a continuous note sounds. This provides a good indication of the rate of change of heading, of how far off course one has gone, and therefore of the amount of correction required. This also provides good indication when coming back on course, since the reverse then happens with the bleeps getting shorter until silence prevails.

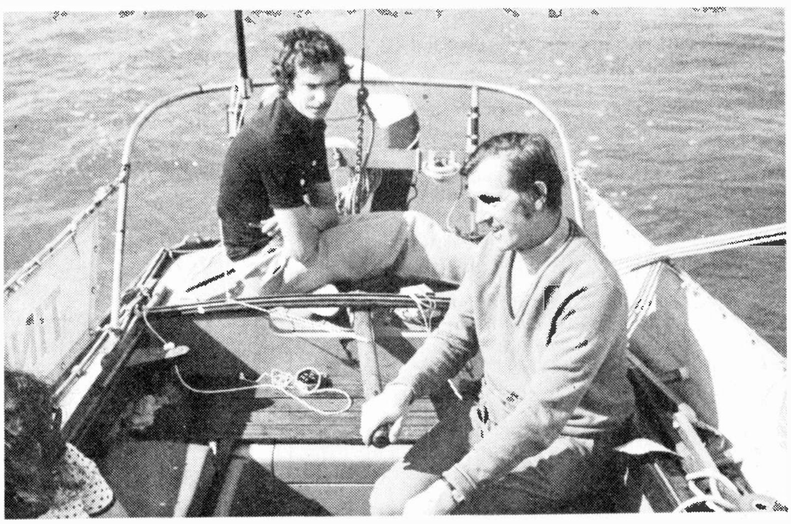
A similar output will result when an off course alarm is employed—if the first few bleeps do not arouse the crew the continuous note soon would.

COST

The complete unit can be constructed for approximately £20, about half of this being the cost of the compass specified. The audible alarm, if required, will add approximately £1·50 to the overall cost. Please note that the above prices are only estimates and do not include V.A.T.

ACKNOWLEDGEMENT

The author wishes to thank Des Sleightholme, editor of *Yachting Monthly*, who put forward the original idea, for his assistance in testing the unit and Jeff Bull who acted as a "guinea pig" and provided valuable criticism from the blind helmsman's point of view. ★



A happy man. The Audio Compass allows Jeff Bull, who is totally blind, to take full control of the helm without any directional assistance from other crew members

SEMICONDUCTOR UPDATE... By R.W. COLES

A8400 S1-1020G
FX205 S1-1030G
S1-1010G, S1-1050G,

V-F-V BREAKTHROUGH

There has been available for a number of years, an extremely useful and versatile class of circuit modules known as V to F's or F to V's, to those professional engineers fortunate enough to be able to justify their expense. Yes, you guessed it, the reason why V to F's and F to V's have not been seen in these pages before is because they have been much too expensive for amateur use. I am very pleased to report that this situation has now changed with the introduction by Teknis Electronics of a monolithic V-F-V which knocks spots off the expensive hand-made modules on the grounds of cost, size and performance!

The abbreviation V to F stands for "voltage-to-frequency" and F to V stands for "frequency to voltage" and the new device from Teknis, the **A8400,** will do both, unlike some of its more expensive predecessors which were often just single-function devices.

The usefulness of a device which can convert a d.c. input voltage into a directly related output frequency of between 0 and 100kHz, and vice versa, is really quite mind boggling. Fancy turning your frequency counter into a digital voltmeter with 0·05 per cent linearity and 5 digit resolution? Just hook up an A8400 as a V to F and feed the output into your counter and you've done it—just like that . . .

Or, do you want to record slowly changing d.c. signals on a tape recorder with simple replay? Use an A8400 connected as a V to F to turn those d.c. signals into audio tones, then replay them later through an A8400 connected as an F to V—it's that easy. The possible applications go on and on, and are limited only by your imagination, the availability of a cheap monolithic device brings to amateurs the advantages enjoyed by instrumentation engineers for years.

The A8400 does cost rather more than a 741, in fact about £12 in small quantities, but this is about a third of the cost of its nearest rival, and a bargain in my book!

PSEUDO-SINE

Consumer Microcircuits Ltd. are a British firm who make a very useful range of m.o.s. integrated circuits intended for use in audio-tone signalling and control system applications. Their range already includes tone transceivers, frequency sensitive switches and tone triggered timers, and has recently been extended with a fascinating little device known as the **FX205 sinewave oscillator.** As expected the FX205 is as unique as the other circuits in the Consumer Microcircuits range, and could well be useful for use in a wide range of amateur projects, from radio control systems to intercoms.

The FX205 generates a stable audio tone of between 25Hz and 5kHz using only a single external resistor and capacitor, the output signal being of a "pseudo-sinewave" shape generated entirely by the digital circuitry of the chip. Internal circuitry includes an astable oscillator, a monostable, a digital to analogue converter and a four bit binary counter.

In operation the astable is timed by the external RC network and the resulting output is divided down by the counter, the outputs of which drive the D to A converter which is weighted so as to produce the "pseudo-sine" output signal which is sufficiently pure for use as a signalling tone. The internal monostable can be used, if desired, to produce "tone bursts" up to ten seconds in length under the control of an external trigger signal, which could be just a push switch closure.

A "tone enable" input is also provided for use when gated operation is required, and the option is available of using an external synchronising signal instead of the internal oscillator. Where multiple-tone signals are required, the outputs of several FX205s can be "WIRE-OR'd" together.

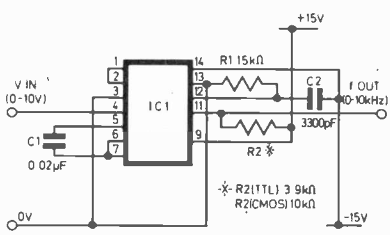


Fig. 1. A8400 as a V to F converter

PAINLESS POWER

Monolithic audio power amplifiers are limited in power dissipation due to chip size constraints, so if you want to make those woofers throb with a bit more than the paltry 10 watts afforded by even the sturdiest monolithic devices, you'll have to either use a discrete design or go in for a pre-packaged hybrid.

A new series of hybrid amplifiers with output powers of 10, 20, 30 and 50 watts is now available from Rastra Electronics Ltd., and you may find that one of these is more cost-effective than a conventional discrete design, especially if you are suffering from the dreaded "wiring-up-itis" (wiring-up-itis, has of course been known to make expensive woofers disappear up their own infinite baffles, to make 2N3055's glow like beam tetrodes, and make grown men cry!)

The new hybrids from Rastra the **S1-1010G, S1-1020G, S1-1030G** and **S1-1050G** are made in Japan by Sanken and are complete power amplifiers suitable for Hi-Fi, musical instruments and public address applications. The output stage is a quasi-complementary class B type using passivated power transistors with good "second-breakdown" resistance, and built-in current limiting on the S1-1030G and S1-1050G. The performance specification seems quite good, for the S1-1050G for example, full power bandwidth is from 20Hz to 20kHz while delivering 20V r.m.s. to an 8 ohm load with a 66 volt supply. Full power t.h.d. is 0·5 per cent maximum, and the signal to noise ratio is typically 90dB.

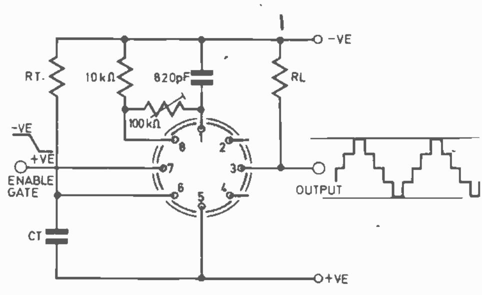
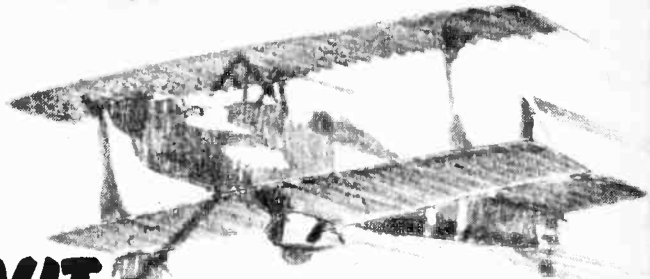


Fig. 2. FX205 as a tone-burst generator. The burst length is determined by R_T and C_T

NEXT MONTH!

OUT AND ABOUT with PE



NEW SERIES

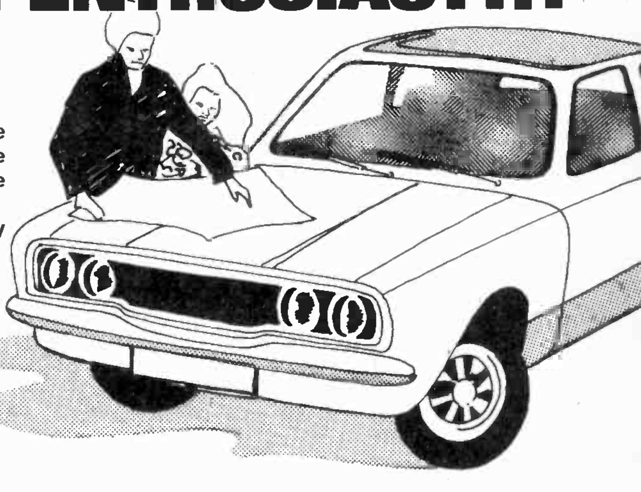
for RADIO CONTROL ENTHUSIASTS...

PROPORTIONAL CONTROL

Incorporating a 9-channel control unit for use with all types of models, this system features 7 channels with full proportional control and 2 channels which provide basic "on-off" control. The system operates on a time-division multiplex principle, and compares very favourably with the more expensive commercial units on the market at the moment.

PLUS

for the MOTORING ENTHUSIAST...



DIGITAL MILOMETER

Designed for use on car rallies or for applications where accurate map reading and navigation from a car are essential, or merely as an accurate elapsed distance indicator.
The use of 7-segment displays allows easy reading Day or Night

AUDIO MILLIVOLTMETER

With a frequency response extending from below 20Hz to above 200kHz and a sensitivity which allows a f.s.d. of 1mV to be obtained, the Audio Millivoltmeter will no doubt find a ready home on many an audiophile's test bench

PRACTICAL
ELECTRONICS

Our June issue will be published on Friday, May 14, 1976

PLEASE NOTE:
It is in *your* interest to place a firm order with your newsagent—in advance. Back numbers are not available, so make sure of your copy now!

Simple COMPUTER VOICE

By E.A. PARR B.Sc.

ORIGINALLY intended to generate a computer sounding voice for an amateur dramatic society, this device can be used to make "Dalek" type voices, and as such can provide hours of entertainment for children.

The circuit is simple, easy to set up, uses little current, can be battery operated, and is suitable for fitting into a child's space suit or Dalek outfit, as well as its original application.

The output level is 500mV, hence it is compatible with both the AUX input on most amplifiers (for stage use) and the many available i.c. power amplifiers for battery operation in a child's toy.

CIRCUIT DESCRIPTION

The usual way of producing a mechanical voice is by synthesiser techniques such as ring modulation. An oscillator giving a sine wave output is used to amplitude modulate the audio signal.

A circuit similar to this was tried, but whilst it worked and gave good results, it was somewhat tricky to set up, and there were doubts about its long term stability.

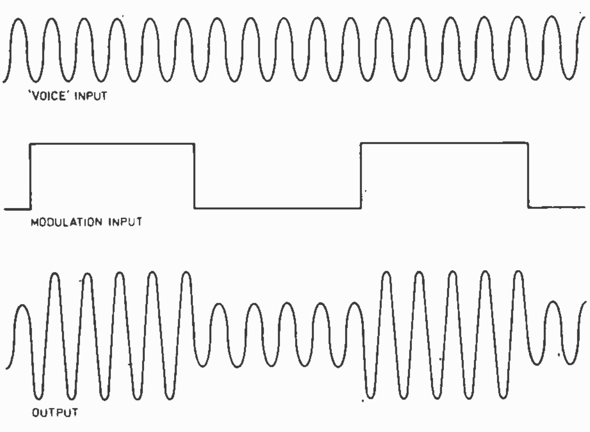


Fig. 1. Voice input before and after modulation

The final circuit behaves in a similar way to a conventional amplitude modulator, but the modulating waveform is a square wave (Fig. 1).

The circuit diagram of the final circuit is shown in Fig. 2. IC1 is a 741 operational amplifier arranged as an inverting amplifier. The circuit is designed for a single power supply, hence R3, R4 provide a mid rail voltage at their junction. The gain of the amplifier is determined by the ratio R5/R2. The microphone used has an output of 15mV so the gain is set to 30 to give the required 500mV output.

COMPONENTS . . .

Resistors
R1 10kΩ (100kΩ for high output microphone)
R2 1kΩ (39kΩ for high output microphone)
R3 1kΩ
R4 1kΩ
R5 39kΩ
R6 1kΩ
R7 100kΩ
R8 22kΩ
All resistors 10% ¼W carbon

Potentiometers
VR1 50kΩ lin.
VR2 50kΩ lin.
VR3 500kΩ lin.
All horiz. min. presets

Capacitors
C1 0·1μF plastic or ceramic
C2 25μF 16V elect.
C3 1μF 16V elect.
C4 0·1μF plastic or ceramic

Integrated circuits, diodes
IC1 741
IC2 555
D1 Any general purpose silicon diode (1N914, 1N4148, etc.)

Miscellaneous
Relay RLA R.S. Components (access through Doram) type: D.I.L. reed relay, Form A (for 6–12V supplies)
Veroboard 2½in × 3in (65mm × 80mm), case and hardware to suit

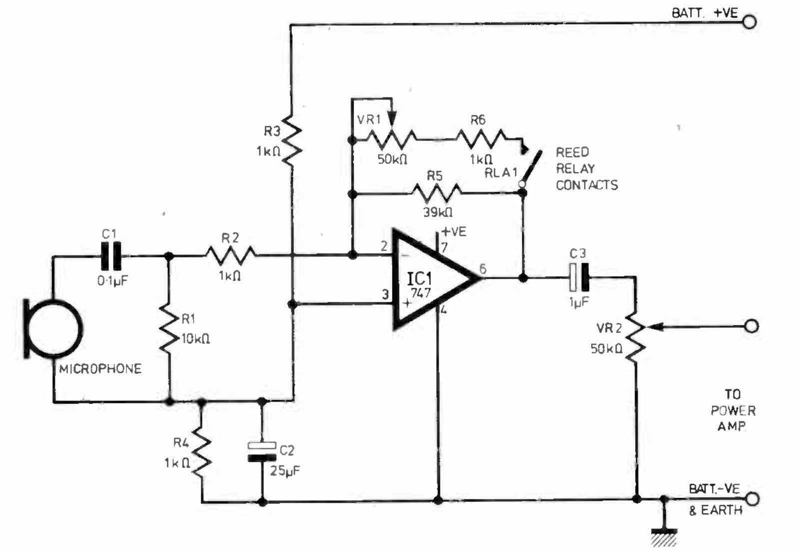


Fig. 2. Circuit diagram of the modulator

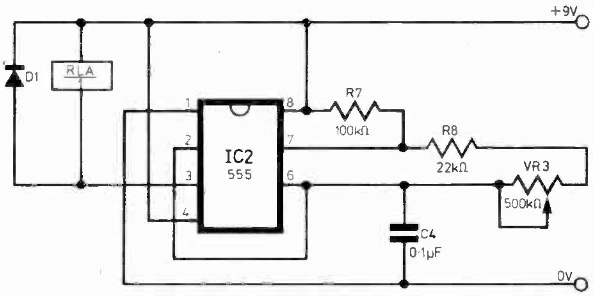


Fig. 3. Details of the modulation oscillator

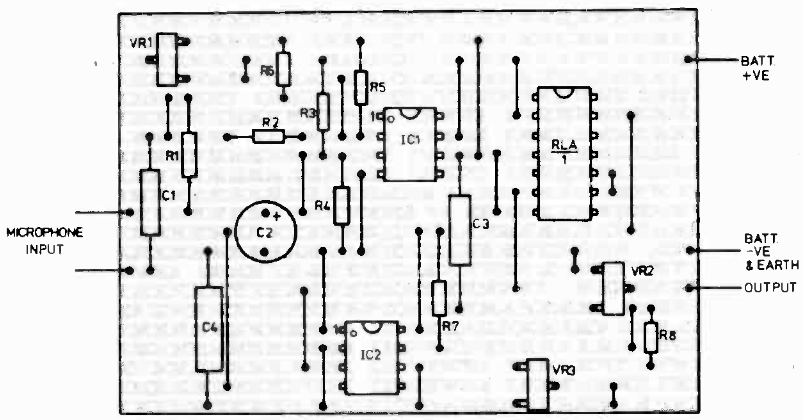


Fig. 4. Component layout and Vero cutting details

When relay RLA1 contact closes, the gain is reduced and is given by the ratio (VR1 + R6 in parallel with R5)/R2.

RV1 therefore controls the "depth" of the modulation and thus the amount of distortion.

MICROPHONE

The moving coil microphone used was somewhat bassy, so capacitor C1 was included to give a certain amount of bass cut. As the gain of the amplifier is determined by negative feedback, it is very easy to add shaping should such features as bandpass filtering be required.

If a ceramic or other high output microphone is used, resistors R1 and R2 should be increased in value to reduce the gain of the amplifier.

CONSTRUCTIONAL DETAILS

The circuit is constructed on 0·1in Veroboard, and layout and track cutting diagrams are given in Figs. 3 and 4. These are straightforward and should present no problems.

Trim pots are used on the circuit although there is no reason why the pots should not be mounted remotely.

To sum up: VR1 controls the depth of the distortion, VR2 the volume, VR3 the rate of distortion. In theory VR1 should affect the volume, but in practice at the levels of distortion necessary, the effect is not unduly noticeable.

MODULATION OSCILLATOR

The relay is "buzzed" by an oscillator (shown in Fig. 3) constructed from the ubiquitous 555 timer. The frequency of oscillation is controlled by R7, R8, C4 and VR3.

VR3 controls the "rate" of the modulation. The relay can be driven up to 250Hz but it was found that the best results were given in the range 20–60Hz.

Diode D1 clips any inductive spikes generated as the relay coil de-energises. This is included in the reed relay used in the prototype.

It might be thought that the life of the relay would be very short being maltreated in this manner, but as the relay used (and most reeds) have a mechanical life in excess of 10 million operations the author did not feel this posed any problem.

Contact life is not so easy to assess as it is determined by two conflicting factors. A large switched current causes contact burn, conversely a small arc helps to clean oxidation off the contacts. The current being switched in this circuit is infinitesimal, so the contact life will be determined by the dirt on the contacts. It is impossible to say when failure will occur, but the prototype has been working for several months without showing any signs of iminent death.

The supply can be anywhere in the range 6 to 15 volts (with suitable choice of reed relay). The prototype was built for 9 volts operation.

With a 9 volt supply, the current consumption is about 12mA. ★

CMOS DIGITAL I.C.s

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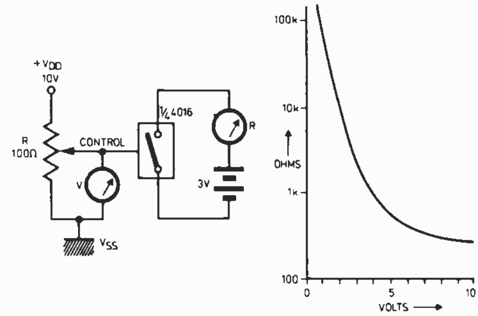


Fig. 5.16. The bilateral switch as a voltage-controlled variable resistor. The curve shows the variation in resistance with control voltage. The measuring arrangement is also shown.

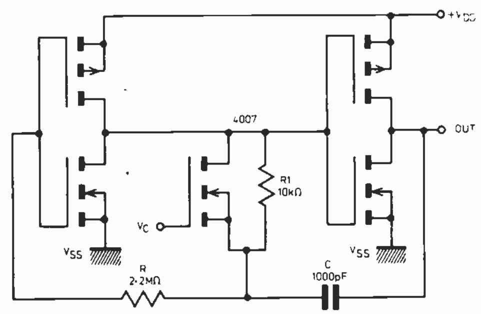


Fig. 5.17. Voltage-controlled oscillator. The voltage V_C determines the frequency, and with a 10V supply a range of between 10 and 15kHz is obtained with the values shown

VOLTAGE CONTROLLED CIRCUITS

The bilateral switch has so far been considered as an almost perfect switch; its resistance changes from about 300 ohms with the control pin at V_{DD} to several megohms with the control grounded. However, it can also operate as a voltage-controlled variable resistor (VVR) if non logic-level voltages are applied to the control input (Fig. 5.16).

The resistance depends somewhat on the voltage levels at the terminals of the bilateral switch, and this causes slight distortion of the transmitted signal. The voltage at either terminal should not go above V_{DD} or below V_{SS}. This simple VVR features extremely good isolation between the control input and the terminals, the resistance being greater than 10^{12} ohms, and can be used as the basis for voltage controlled filters, amplifiers and oscillators. A single *n*-channel device can also act as a VVR, and a similar curve is obtained although the minimum "on" resistance may be as high as 1,000 ohms. A simple VCO (voltage controlled oscillator) based on this and built from a single 4007 package (one device is not used) is shown in Fig. 5.17. The paralleled resistance of the *n*-channel MOSFET and R1 varies between approximately 1,000 ohms with the MOSFET "on", and R1 with MOSFET "off". A range of between 10 and 15kHz is obtained with the values shown for V_C of between 0 and 10 volts.

Next month : Retriggerable monostable and digital low pass filters

MARKET PLACE

Items mentioned in this feature are usually available from electronic equipment and component retailers advertising in this magazine. However, where a full address is given, enquiries and orders should then be made direct to the firm concerned. All quoted prices are those at the time of going to press.

CASES

To complement their range of Minicases, **Olson Electronics** have just introduced a new range of robust, sloping front instrument cases.

Ideal for housing many of the constructional projects published in this magazine, particularly test gear, the cases are made from 20g mild steel and the 45 degree sloping front panel from 20g aluminium. The cases are only 95mm high by 95mm deep and supplied in three width sizes: 150mm, 200mm and 250mm. The front panel is 100mm by the required width.

Supplied with four rubber feet they are sprayed in light brown hammer finish and the front panels are finished in light grey semi-gloss enamel.

Full particulars of these excellent cases can be obtained from **Olson Electronics Ltd., Factory No. 8, 5–7 Long Street, London, E2 8HJ.**

WORK HOLDER

A unit which allows the constructor a free hand when soldering components into small circuit boards is the latest product from **Special Product Distributors.**

Called the JA500 Reversible Assembly Frame, a small board is clamped in position and a foam pad, in a covering lid, holds the components to be soldered firmly in position which allows the work piece to be turned over for soldering.

The frame will handle circuit boards up to 220mm × 170mm and the overall dimensions of the assembly is 250mm × 280mm.

Further details and price of the Reversible Assembly Frame can be obtained from **Special Product Distributors Ltd., 81 Piccadilly, London, W1V 0HL.**

CERAMIC SOUNDERS

There are very many practical applications for audible warning or indicating devices, some of which include paging, systems failure, etc. where the sound output requirement, whilst being less than, say, an intruder alarm, has the composite advantages of reliability and efficiency.

ITT are marketing a range of five piezo ceramic sounders of sound outputs varying below 93dB. The tones available are continuous or pulsed.

Details are available from **ITT Components Group Europe, Materials Division, Edinburgh Way, Harlow, Essex.**

NEW TOOLS

A new range of high quality American tools for electronics are being offered by **West Hyde Developments.** These consist of 4½in curved needle pliers, 5¾in long-nosed pliers, 4¼in side-cutters and 4in face-cutters.

Made from finest alloy steels, they have p.v.c. handles and are supplied in strong p.v.c. pockets which can be easily hung up.

As well as the tools, there are two mirrors with useful features; one has a magnetic base, the other a variable angle head that can be remotely controlled.

Further details are available from **West Hyde Developments Ltd., Ryefield Crescent, Northwood, Middlesex.**

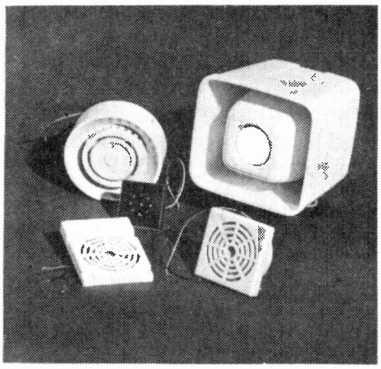
CATALOGUE

The new 100-page Electronics Catalogue from **Tandy** now lists a very large range of components from light emitting diodes and integrated circuits to calculator keyboard and printed circuit etchant kits.

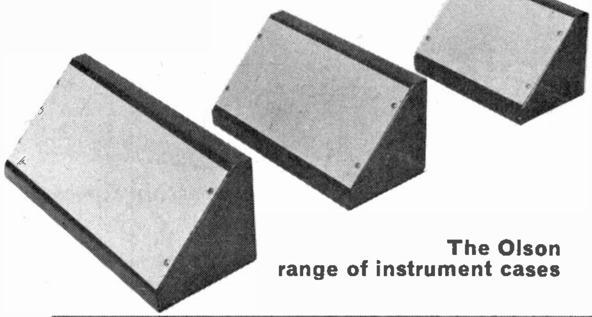
Although the semiconductors seem rather expensive they are all guaranteed to be first quality and not rejects or "fall-outs".

The catalogue is devoted mainly to their vast range of audio hi-fi equipment and includes complete systems. Test gear, car radios and aerials are also included.

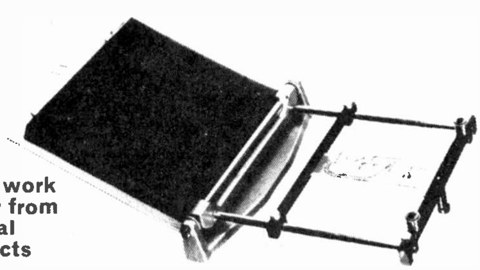
Copies of the 1975/76 Electronics Catalogue can be obtained from **Tandy Corporation (Branch UK), Bilston Road, Holyhead Road, Wednesbury, Staffs.**



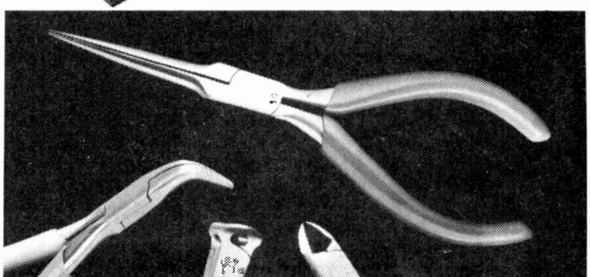
Ceramic sounders from ITT



The Olson range of instrument cases



JA500 work holder from Special Products



Quality tools from West Hyde

HELLS BELLS AND DECIBELS

By D. MAYNARD

ONE of the things which usually causes students problems is the use of the decibel. In specifications it is quite common to find it used as the unit for gain. Sometimes the decibel is used for the power gain of an amplifier and sometimes for the voltage gain. Often the unit is used erroneously, and we must be sure of the meaning presented to us.

THE DECIBEL DEFINED

First, let us look at the definition of the decibel. The "deci" means "one tenth of" and the bel is a logarithmic unit of the ratio of two powers. Normally we use the unit when measuring gains or losses. Consider Fig. 1 which shows an amplifier of input impedance Z_1 with a load impedance Z_2. I_1 and I_2 represent input and output currents, while V_1 and V_2 are input and output voltages respectively.

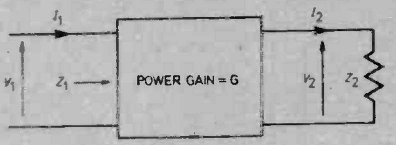


Fig. 1 Loaded power block from which equations are derived

Let us assume that V_1 is 10mV, Z_1 is 10kΩ, V_2 is 10 volts and Z_2 is 10Ω. Then by Ohm's Law:

$$I_1 = \frac{V_1}{Z_1} = 0{\cdot}1\mu A$$

and

$$I_2 = \frac{V_2}{Z_2} = 1A$$

Voltages and currents are all r.m.s. Numerically, the power gain (G) is therefore:

$$G = \frac{V_2 . I_2}{V_1 . I_1} = \frac{10 . 1}{10^{-2} . 10^{-7}} = 10^{10}$$

Note that this is a number. It means that the output power is ten thousand million times greater than the input power. The voltage and current gains are respectively:

$$\frac{V_2}{V_1} = 10^3 \text{ and } \frac{I_2}{I_1} = 10^7$$

Obviously the voltage gain multiplied by the current gain is equal to the power gain.

So far we have made no mention in our calculations of decibels. If the input power is P_1, and the output power P_2, then the gain in bels is:

$$G = \log_{10}\frac{P_2}{P_1} = 10 \text{ bels}$$

The decibel is only one tenth of a bel and therefore there are ten times more decibels than bels for a given gain.

$$G = 10 \log_{10}\frac{P_2}{P_1} = 100 \text{ decibels}$$

VOLTAGE GAIN IN DECIBELS

We sometimes find voltage gains expressed in decibels, and this is where the error and confusion arise. The definition we used said that the decibel contains a power ratio. We can rewrite our expression for gain as follows:

$$G = 10 \log \frac{V_2^2 . Z_1}{Z_2 . V_1^2} \text{ dB}$$

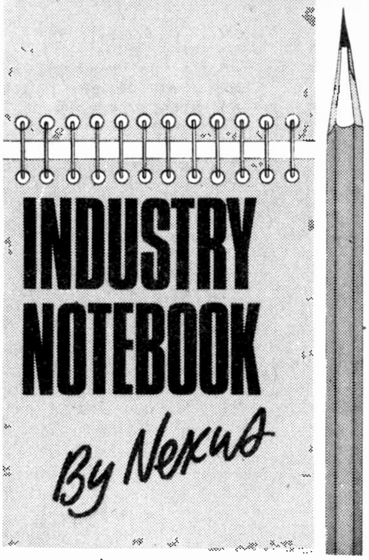
When, and only when, $Z_1 = Z_2$ we can say that:

$$G = 10 \log \left[\frac{V_2}{V_1}\right]^2 \text{ db which in turn gives us:}$$

$$G = 20 \log \frac{V_2}{V_1} \text{ dB}$$

Students find difficulty in remembering when to use 10 log and when to use 20 log. If in doubt, always use 10 log and always consider power. Having said that we are then faced with information that gives voltage gains in decibels when the input and output impedances of the device are different. Theoretically, the figures are meaningless but in practice the person specifying the gain has used 20 log V_2/V_1 regardless of the fact that it does not apply. In our example, the voltage gain would be incorrectly stated as 60dB.

Finally, may I appeal to writers of specifications to either stick to power gain figures or else to quote the maximum sensitivity of the amplifier. We would then have the figures we are really interested in. That is the input voltage (and impedance) required to produce the quoted maximum output power. ★



SALARY AND STATUS

Looking through the situations vacant columns in the professional electronics press it is clear that experienced engineers are still in demand both at home and overseas. But it is equally clear that the salaries offered to professional engineers have increased only relatively marginally during the past three years while unqualified people have enjoyed unprecedented increases in income.

Registered dock workers, for example, now enjoy a guaranteed minimum of £3,000 a year whether they work or not. Coal face workers are in sight of £5,000 a year. Shift workers on London Transport are in the £3,000 to £4,000 bracket, and complaining assembly-line workers in automobile plants are not nearly as bankrupt as their employers. There are even well-authenicated examples of unemployed people drawing up to £5,000 a year from the State, providing they have enough children and hire-purchase commitments.

Now and again one spots what looks, from the salary point of view, a winner. Up to £8,000, for example, was recently offered for a product planning manager in communications technology which, in this instance, meant satellite communications. Candidates were required to have "the maturity, standing and personality to negotiate at all levels from Director downwards and the necessary drive to lead a team in expanding the company's capability in the microwave field and particularly space".

But that was only the beginning. A candidate also needed to have had practical field experience, have developed hardware, and preferably have commercial experience in the preparation of tenders. He must have knowledge of the national and international agencies concerned with space communications and, of course, all the technical standards in force. It would also be helpful if the candidate had some knowledge of line transmission and analogue and digital modems, multiplexing and switching equipment, data programs and video circuits.

The job entails forecasting the forthcoming market and defining the hardware needed, and producing in collaboration with development engineers, a programme to ensure that hardware is available at the right time at the right price. Quite rightly, the advertisement states that "This is possibly one of the most important appointments to be made in the Company for some time."

Clearly then, this is a key job which was no doubt keenly contested and ably filled. But it seems strange that such an important position, central to the company's future prosperity and that of possibly hundreds of work people should, in gross money terms, be worth no more than two bus drivers or one and a half hewers of coal, however worthy the drivers and hewers may be. After tax, of course, the differential becomes even less attractive.

MAINSTREAM

If we now drop our sights a little and look at the mainstream of engineers we find experienced chartered engineers attracting salaries in the range £3,000 to £4,000 and technician engineers from £2,000 to a little over £3,000 for the best people.

Generally, the best payers are the Civil Service and the nationalised corporations. But, even here, salaries tend to be low. A communications technician for a gas board with at least five years' experience of u.h.f./v.h.f. mobile radio and a sound knowledge of the principles of microwave/multiplex links and digital systems can start with as little as £2,361.

At an armed services resettlement briefing for electronics tradesmen earlier this year, people soon to leave the services were surprised and dismayed to learn that their service pay and allowances were superior to the salaries they could command in "civvy street". They were mostly mature people, many with family responsibilities, to whom a salary of £2,500 and the need to find accommodation represented a major fall in standard of living and probably quality of life as well. They'd be better off to stay on.

WORK OF LOVE

From a strictly financial point of view electronic engineers, be they of chartered or technician status or even totally unqualified academically, are their own worst enemies. They tend to love their work and regard it as a vocation more than a job. If they need to have employment to live, then there is nothing they'd rather be in than electronics with its ever-changing technology and novelty, and its intellectual challenge. Provided they were receiving a reasonable reward they were contented.

Unhappily, 25 per cent per annum inflation has overtaken the professional electronics engineer, and those in the lower pay brackets are now barely above the poverty line. With inflation currently at 15 per cent and scheduled not to drop to single figures before the end of the year, the more poorly paid will soon be in distress and the better-off still steadily sinking in real terms.

POINT OF CONFLICT

The Council of Engineering Institutes has now come out firmly with the proposal that professional engineers should join a trade union. By the Government sanctioning and even encouraging the widespread introduction of the closed shop, this move was perhaps inevitable. A great number of engineers will discover that if they are not union members they will have no job. A second compelling reason for the recommendation is that union muscle, ruthlessly applied, always achieves its objective. This is an established fact of which there are many recent examples.

The professional engineers are now in a dilemma. Professionally they have one code of conduct and as union members they will have another and these will often be in conflict. In a universally closed shop, to defy union instruction can mean expulsion from the union and thus expulsion from employment for the remainder of a working life. But equally, to comply with union instruction may involve both agonies of conscience and breaches of professional codes of conduct.

How this muddle of loyalties will be resolved remains to be seen. Perhaps there is no solution except to emigrate to the United States or West Germany where industrial affairs are conducted more logically and where real merit is rewarded realistically.

A selection of readers suggested circuits. It should be emphasised that these designs have not been proven by us. They will at any rate stimulate further thought. Any idea published will be awarded payment according to its merits. Why not submit YOUR IDEA?

Please Note

Articles submitted for publication should conform to the usual practices of this journal, e.g. with regard to abbreviations and circuit symbols. Diagrams should be on separate sheets, not inserted in the text.

MULTIPLE OCTAVE ORGAN

THIS is my original circuit for a simple organ, using the NE555V, which can play through several musical octaves on a limited keyboard of eight keys in two different ways.

The circuit (Fig. 1a) uses a NE555V operated in its astable mode, frequency of oscillation being given

$$\text{as } f_1 = \frac{1}{t} = \frac{1{\cdot}44}{(R_{in}\,8 + 2R_B)C}.$$

$$\text{Thus } \frac{f_2}{f_1} = \frac{R_{A_1} + 2R_{B1}}{R_{A_2} + 2R_{B2}}$$

The musical notes are in the ratio of 9/8 : 10/9 : 16/15 : 9/8 : 10/9 : 9/8 : 16/15.

This also shows that the musical ratio depends only on the ratio of the resistors R1 to R8, R_B being kept constant; also the capacitor between pin 6 and pin 1 of IC1 kept constant.

From eqn 1, with the note C at 262Hz, S1 at 2:

R1=53kΩ (i.e. 33kΩ + 20kΩ)
R2=47kΩ
R3=42kΩ (i.e. 20kΩ + 22kΩ)
R4=39kΩ
R5=34·5kΩ (i.e. 33kΩ + 1·5 kΩ
R6=30kΩ
R7=27kΩ
R8=25·8kΩ (i.e. 24kΩ + 1·8kΩ).

S1 is a single pole, 3-way switch used for octave selection. At position 1 the notes range from C_1 to C‴, i.e. 131Hz to 262Hz. Similarly at position 2, the range is C′ to C″ (262–524Hz) and position 3 covers C″–C‴ (524Hz–1,024Hz).

As the organ notes consist of a pulse of fixed duration (determined by R_B and capacitor selected by S1) repeated at musical frequencies, it is desirable to clamp the output pulses to a fixed duration to produce a "smooth" octave selection. A suitable monostable circuit using a NE555V is shown in Fig. 1b.

One of the inherent disadvantages of a simple organ is that the pressing of two or more keys will give only a note. However, this is exploited here to *play two musical octaves* on the eight keys *without* using the octave selection switch S1. It can be shown from eqn 1 that pressing key c′ and key d′ will produce note of C″ and that this occurs systematically as shown in Fig. 1c below.

This method will enable one to play notes in the upper octave without bothering to operate S1.

The output is melodious as it consists of a pulse of short duration repeated at musical frequencies; a tweeter is recommended at the amplifier output to reproduce these short pulses more clearly. For simplicity the semitone keys are omitted but can easily be added by calculating the required resistor from eqn 1. With the semitone keys added, there will be 13 keys and the corresponding ratio of each frequency to the one before it is 1·0595. Since the musical ratio is virtually dependent on R1 to R8, they should be preferably better than ±5 per cent. Close tolerance capacitors should be used for S1 for octave selection as they maintain musical ratios of the musical octaves.

Pek Yaw Kee,
Sarawak, E. Malaysia.

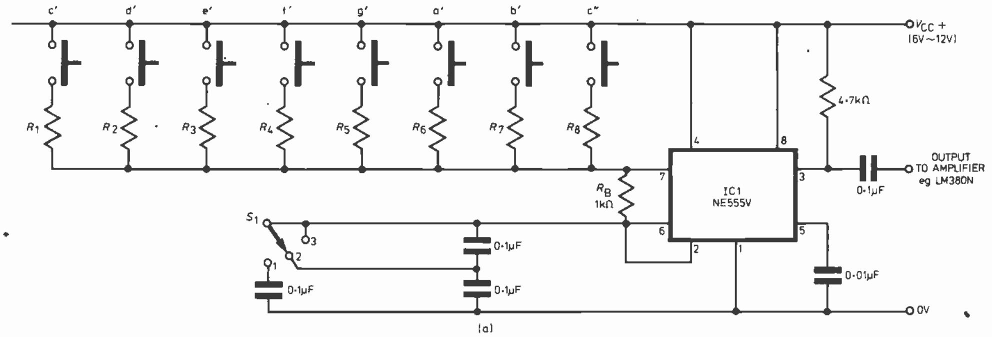


Fig. 1a

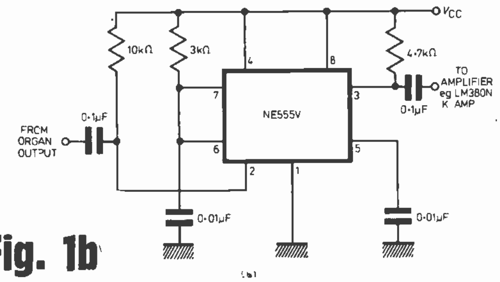


Fig. 1b

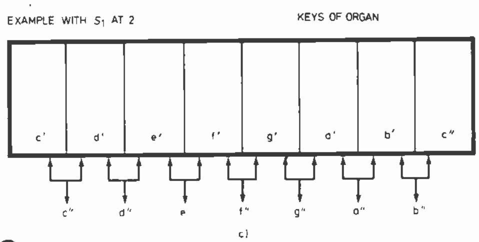


Fig. 1c

AUTOMATIC TIME SWITCH

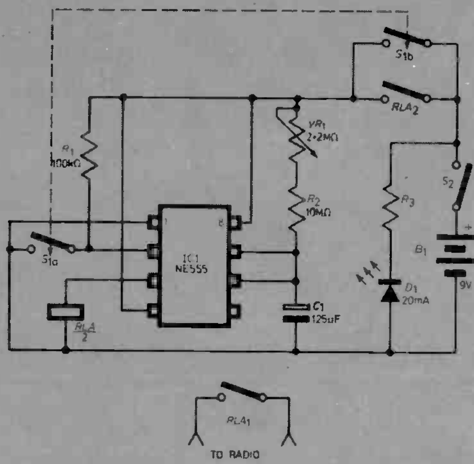


Fig. 1

THIS automatic time switch was designed to switch a radio and itself off after about half-an-hour, so that I could leave the radio on and go to sleep. The tuner has a start/reset switch which is illuminated by an l.e.d., see Fig. 1.

The circiut uses a NE555 timer as a monostable. The delay period is adjusted by VR1 which compensates for the tolerances of R2 and C1. The relay is a 6V 2-pole make type, with as high a coil resistance as possible. S1 is a 2-pole make switch and R3 is selected to suit the l.e.d. The relay contacts RLA1 interrupt the positive supply line to the radio.

P. Levey,
London, S.E.26.

FURTHER USES FOR UNIJUNCTIONS

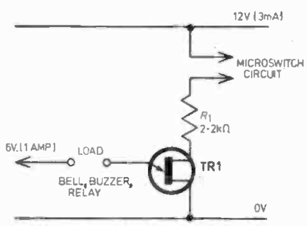


Fig. 1. Burglar Alarm

RARELY does one see the Unijunction transistor being put to any use other than as a relaxation oscillator. It can of course be put to many diverse uses.

In Fig. 1 it is used as a Burglar Alarm. Even if the microswitch circuit is remade after it is broken the bell, buzzer, etc. will stay on. Most common unijunction transistors will sink up to one amp, and so relatively heavy loads can be used without resorting to a relay. To reset the alarm, one of the load leads is broken.

In Fig. 2 the Unijunction transistor is used as a Frequency Divider. If half-wave rectified a.c. from the mains is put in the input, the first stage divides by five, as with the second, and the third divides by two. Surplus unijunctions and transistors can be used, but the capacitor charging resistors may have to be changed. Generally if each stage is disconnected from the previous one, it should run at a slightly lower frequency than its expected working frequency. The circuit can be adapted readily for other applications as it is cheaper than TTL dividers.

A. F. Rabagliati,
Oundle, Northants.

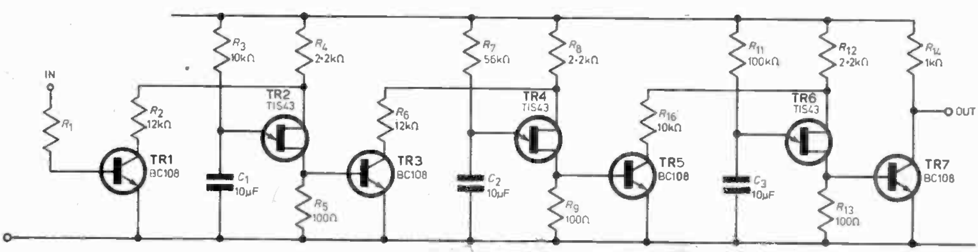


Fig. 2. Frequency Divider

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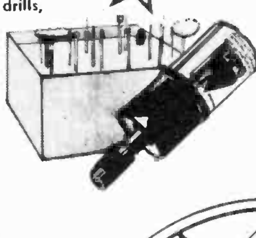

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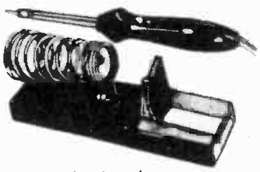

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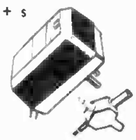

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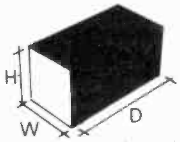

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VISUAL INDICATOR FOR DISCOTHEQUE PFL SYSTEMS

READERS who run mobile discotheques, like myself, may be interested in this simple yet effective visual cueing device to be used in place of headphones on existing equipment with PFL (Pre-fade-listen) facilities. For those readers not familiar with PFL, it is a system which allows the operator or DJ to locate the start of a second record whilst a first is playing, and so eliminate the time gap between one record and the next.

This device described, gives the operator a visual indication of the start of a record by means of an l.e.d. modulated in brightness by the music signal.

The circuit, see Fig. 1, consists of an REC70 bridge rectifier D1 and a small red l.e.d. type TIL209, D2, connected as shown. The music signal is rectified by the bridge and produces a varying d.c. voltage across the l.e.d.

The prototype was constructed inside a standard jack plug, of the type with a long plastic barrel, see Fig. 2.

The system has been tested with several makes of disc mixer, and found very successful. In most cases a gain control for the PFL is incorporated in the mixer, and when using the visual cueing light, this invariably needs to be set at maximum for highest sensitivity. In this case the d.c. peak voltage is unlikely to exceed 3V and result in any damage to the l.e.d. With this setting, it may be found that once the record is playing the l.e.d. appears continuously on, but this is no disadvantage as the cueing light has only to indicate the start of the record.

S. E. Grist,
Guildford,
Surrey.

Fig. 1

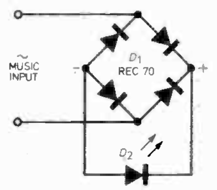
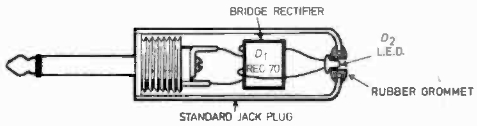


Fig. 2



"LIGHTS ON" INDICATOR

THIS is a useful aid for motorists in that it gives a warning that the car lights are still on when attempting to get out of it.

The circuit (Fig. 1) is a simple unijunction transistor oscillator which gives a continuous note for about five seconds when the door is opened, that is, when the door switch is closed. The period setting can be changed by altering the value of C2.

When power is removed from the circuit it will reset in five minutes.

As the audible warning is for negative earth vehicles, for positive earth interchange connections at A and B.

R. A. Sudron,
Shadwell.

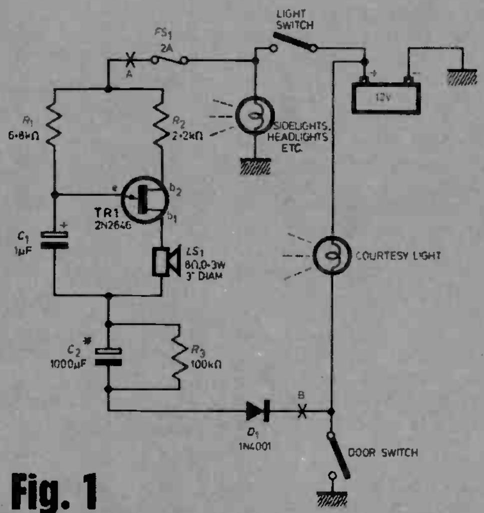


Fig. 1

COURTESY LIGHT TIMER

THE circuit in Fig. 1 is designed to extinguish a car interior light approximately 20 seconds after the car door is closed, allowing time to fasten seat belts, etc. The timer starts when the switch contacts open, and the light is extinguished automatically after the delay period has elapsed.

TR3 and Darlington pair TR4 and TR5 form a complementary bistable which is triggered on when TR5 collector is earthed by the switch S1, whose contacts carry the current for the interior lamp, LP1.

When S1 contacts open, the lamp current flows through TR5. About 1·5V is dropped across this, turning on TR1 via R3; C1 then charges through TR1 and R1. When C1 has charged to about 5V, TR2 conducts and diverts base current from TR3. The bistable then turns rapidly into the off state, discharging C1 via D1 and R2 ready for the next operation. Battery drain in the off state is about 1mA, which is taken by R3.

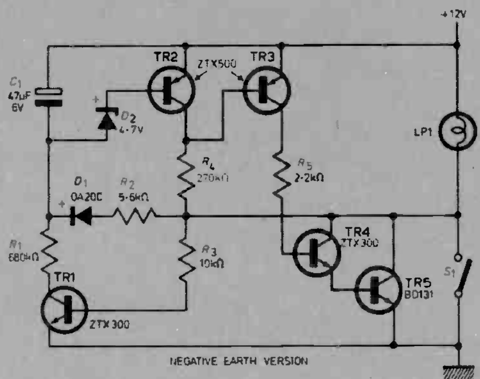


Fig. 1

For loads of up to 6W no heatsink is needed for TR5 and a very compact unit can be built, possibly in the lamp housing itself. Loads of up to 36W can be switched with a heatsink. If the load is shorted the bistable should switch off without damage.

The circuit shown is for negative earth vehicles. A positive earth version can be made using a BD132 for TR5, transposing ZTX300 and ZTX500 transistors and reversing the polarities of C1, D1 and D2.

P. Albericci,
Stockport

DUAL FADE FOR SLIDE PRESENTATION

THE following might be of interest to some of your photographically minded readers.

The latest fashion for Dual Fade Slide Presentation seemed a natural subject for solid state control, so triac circuitry came to mind. Most modern slide projectors use a low voltage halogen lamp and the low voltages necessitated a slightly different approach to circuitry.

Fig. 1 shows the basic interface circuitry which was built into a projector. This had spare pins available on its standard 6-pin DIN socket (pin 3 to earth, pin 2 is the slide change solenoid). The triac is simply wired in parallel with the existing lamp on/off switch.

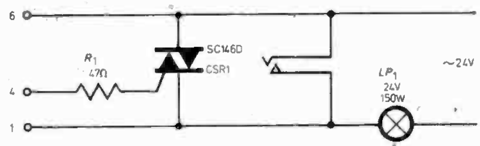


Fig. 1

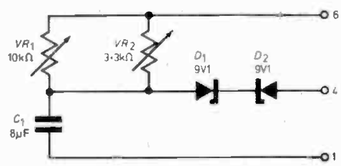


Fig. 2

Fig. 2 shows the simple manual control used to fade the projector lamp. Zeners D1, D2 take the place of the diac used in mains voltage circuits. The high value of capacitance is required to provide the relatively large gate current to the triac which is sluggish in the low voltage conditions. VR1 is a slider potentiometer for ease of use during a show, and VR2 is a preset which enables the full scale of the slider to be used.

A pair of projectors using this circuitry has been used for several successful slide-tape shows and the colour change of the lamps during dimming has not been found to be objectionable.

A simple remote control of the lamp can be provided by a switch between pins 4 and 6. A tape control system is being developed using circuitry similar to the voltage controlled dimmer in *Ingenuity Unlimited* page 320, April 75.

P. Woods,
Meanor, Derbys.

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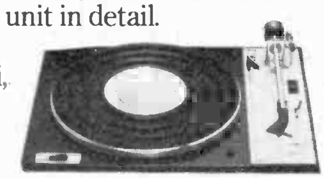

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ACY39	27p	BF196	16p
AD161	40p	BF197	17p
AD162	40p	BF244B	27p
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AF117	20p	BF337	42p
AFY19	32p	BF338	40p
AF239	44p	BF458	48p
ASY26	29p	BFW11	40p
AST27	33p	BFW43	28p
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BC107	10p	BFX48	35p
BC108	10p	BFY18	16p
BC109	10p	BFY50	16p
BC116A	17p	BFY51	16p
BC118	12p	BFY52	16p
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10µF	25V	7p	470µF	63V	20p
22µF	25V	7p	1000µF	10V	12p
47µF	25V	7p	1000µF	16V	17p
47µF	40V	8p	1000µF	25V	20p
47µF	63V	8p	1000µF	50V	36p
100µF	10V	7p	1000µF	63V	44p
100µF	25V	8p	2200µF	10V	20p
100µF	40V	9p	2200µF	16V	24p
200µF	10V	7p	2200µF	25V	30p
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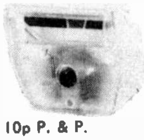

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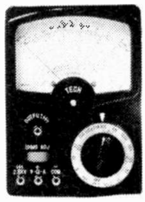

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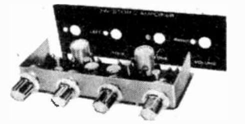

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LOW VOLTAGE INDICATOR

THIS circuit (Fig. 1) was designed for use with an electronic voltmeter to indicate when the battery voltage falls below 7·5V where the accuracy of the meter begins to deteriorate.

The circuit can be made to switch at any voltage by altering R1, R2, D1, and by swopping pins 2 and 3 there is a choice of either normally on or normally off operation. The normally off arrangement is shown as in this state the circuit only takes 1·4mA.

P. Boscott,
Banbury

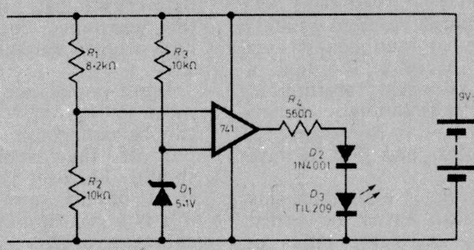


Fig. 1

CAR ALARM

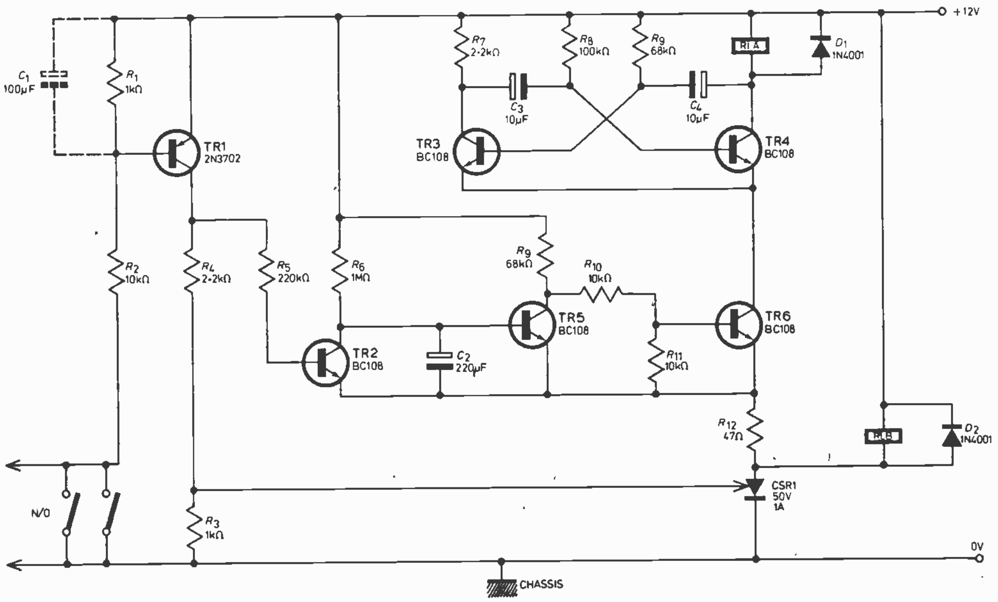


Fig. 1

THE requirements to be met for the car alarm were that it should give an audible/visual alarm for a preset interval and then reset to a "ready" state, the car meanwhile being immobilised. The quiescent power consumption must also be low.

The following circuit was devised which gives an alarm lasting about 20 seconds (bleeps horn and/or flashes headlamps) and breaks the ignition circuit, after which it resets ready to be triggered again. The methods used to trigger the alarm are door courtesy switches and/or a trembler switch. This alarm has the advantage over other types that it attracts attention and immobilises the car, but does so without being a public nuisance and without draining the battery (the alarm might be set off by an innocent party accidentally).

With power applied, in the quiescent state, the CSR1 is switched off and current is only drawn through TR2, this being about 20 microamps.

If any of the alarm switches are earthed TR1 conducts, both causing TR2 to conduct and switching on the CSR. TR2 thus shorts the timing capacitor each time a switch is made and the timing period starts from this point. The CSR supplies power to the Schmitt trigger and, as TR6 is conducting initially, to the multivibrator. RLA contacts then open and close periodically to give the alarm. These contacts can be connected to the horn or headlamps but must therefore be of suitable rating. The writer used a miniature 700 ohm relay which closed at 20 milliamps and fitted heavier 5 amp contacts salvaged from defunct microswitches so obtaining a 10 amp capacity relay at low cost.

As the timing capacitor charges up, TR5 base voltage is raised until the Schmitt switches, TR6 being cut off and TR5 conducting. TR5's current is less than the holding current of the CSR which switches off, leaving the circuit in its quiescent state again.

Relay RLB is enabled when the CSR is on, and must be a latching type, either electrically or mechanically. The latter is probably preferable as the ignition reset switch can be hidden away.

If trouble is experienced by spurious triggering of the alarm, this should be cured by connecting a capacitor across TR1 base as shown and decoupling the supply if required.

Layout is completely non-critical, as are components. BC108's were used because they were to hand, but lower gain types are suitable. Note that TR1 is *pnp*, the rest are *npn*. The CSR was a surplus item. The time delay can be altered by varying the values of R6 and C2.

D. W. Bickley,
Wolverhampton.

RECORDING LEVEL INDICATOR

ORDINARY tape recorder VU meters cannot respond quickly enough to sudden loud peaks. One can therefore record at too high a level without knowing, resulting in distortion. Peak-reading meters solve this problem to some degree, but are complex and not always totally successful.

The circuit (Fig. 1) eliminates this problem, and can easily be added to almost any transistor tape recorder. If the peak level of the input a.c. signal exceeds a certain level, the 555 timer wired as a monostable is triggered, illuminating the l.e.d. for about 0·4 sec, as a warning that the recording level is too high. VR1 sets the trigger level, low resistance corresponding to a high trigger voltage, between 0 and 2·5V.

Input impedance is over 10kΩ for most settings of VR1, and the unit can be connected direct to the output of the record amplifier. It should however be connected in front of the tape head driver, as this is a constant-current driver, not constant-voltage.

D1 may be any l.e.d. D2, C3 and R4 stabilise the trigger level against changes of V_{cc}. If V_{cc} is stabilised, these components can be omitted, connecting point X to V_{cc} and leaving pin 5 of the NE555 unconnected, VR1 should now be 100kΩ. This circuit will work for any V_{cc} from 6 to 15V, although R2 may need reducing to 680Ω at low voltages. The maximum current demand with l.e.d. on, is 20mA, and less than 5mA with it off. In use, it is best to set it to trigger at a level corresponding to +2–3dB record level.

N. R. Arnot,
Welwyn Garden City,
Herts.

TOUCH KEYBOARD

FOR those not wishing to spend £20 on keyboard mechanics for their synthesiser, I have devised an electronic alternative.

The complete circuit is shown in Fig. 1. The contacts are made by etching a keyboard on fibreglass p.c.b. The circuit marked A is duplicated for as many keys as required. A finger pressed on the contacts switches the transistor pair, producing about 5·3V across the resistor. The diodes "code" the key position into a 6-bit binary signal passing on to circuit B. (The key shown is the 13th.)

This circuit is a sampling digital-analogue convertor, which takes an input from the keyboard when a key is pressed.

The output may be taken to a buffer stage as shown, allowing the keyboard to be compressed, expanded or offset up and down the spectrum. An integrator would produce a portamento effect.

A typical key design is shown in Fig. 2. If single plate operation is required the circuit of Fig. 3 could replace the two transistor circuit of Fig. 1, but it may be found unreliable.

N. B. Sargeant,
Fleet.

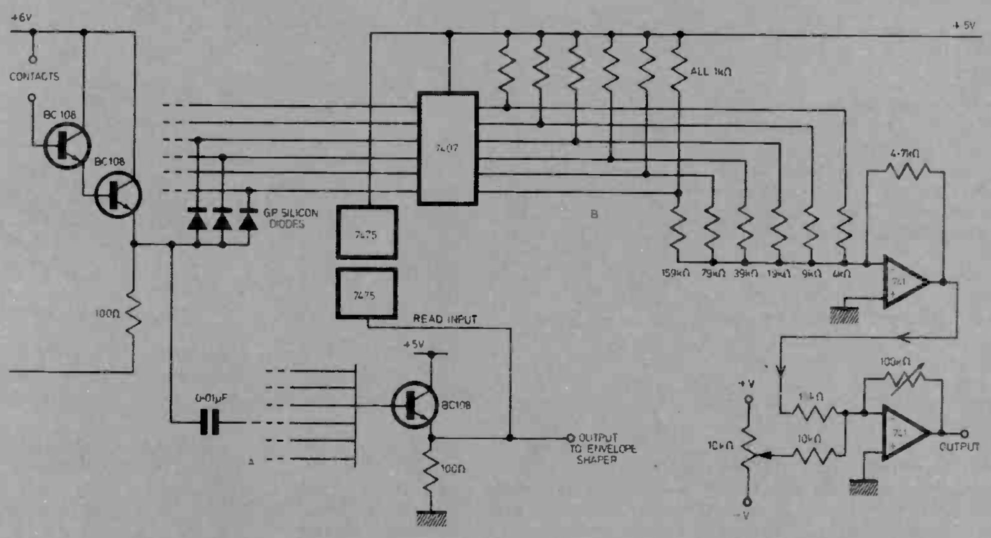


Fig. 1

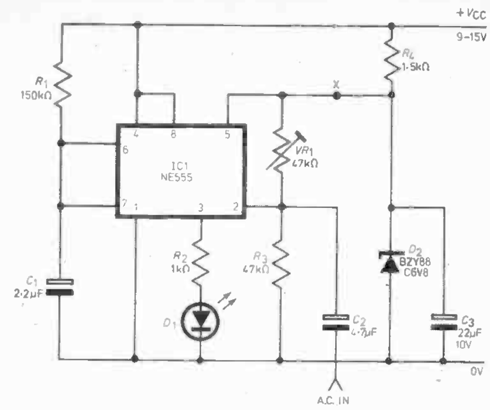


Fig. 1

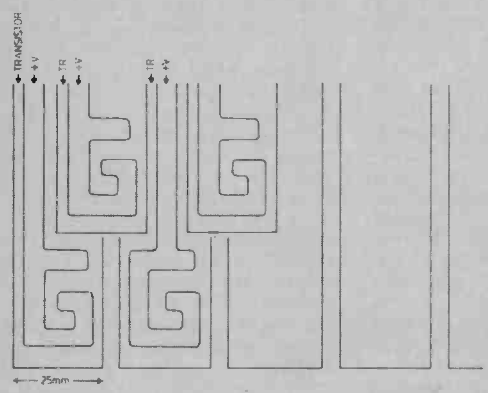


Fig. 2

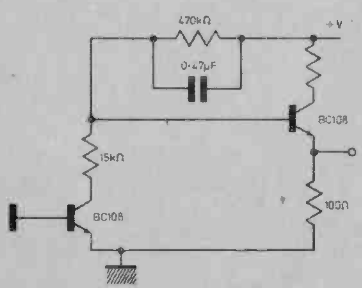


Fig. 3

PATENTS REVIEW...

PATENT INCREASE

On January 1, 1976, the price of a printed copy of a British Patent rose, by more than 100 per cent, to 75p. This is still cheap for a fact-packed specification of a hundred-or-so pages, accompanied by a dozen-or-so sheets of drawings, and is tolerable for the more average length of a dozen pages. But it makes any patent of brief content rather expensive.

For this reason, readers should remember that most of the official publications of the British Patents Office can be consulted free of charge at over two dozen libraries dotted around the United Kingdom. Fortunately, this situation is unlikely to change, because it would undermine the basic principle of patenting, whereby an inventor is awarded a monopoly in return for disclosing details of his invention to the public in a Patent Office publication.

Free access to any patent mentioned in this column should currently be available through the public, commercial or central library in the following towns:

Aberdeen; Aberystwyth; Belfast; Birmingham; Bradford; Bristol; Coventry; Edinburgh; Glasgow; Huddersfield; Hull; Leeds; Leicester; Liverpool; London (British Museum; Science Museum; Science Reference Library attached to the Patent Office); Loughborough (University of Technology); Manchester; Middlesbrough; Newcastle upon Tyne; Norwich; Nottingham; Plymouth; Portsmouth; Preston; Sheffield; Swindon; Wolverhampton.

LICENSING GUIDE

The British Library recently published another of its extremely useful "Guides to Literature". These are available free by post from the Bayswater Branch of the Science Reference Library (10 Porchester Gardens, Queensway, London W2 4DE), or on personal request from the SRL attached to the Patent Office at Southampton Buildings, Chancery Lane, London WC2.

Each guide has the same general format; a background to the subject and clear references to all the most useful literature that is available to the public in the SRL.

So far there have been no publications specifically on electronics topics (subjects covered have been artificial polymers, automotive fuels and odd protein sources), but news of any guideline on a selected area of electronics will be reported if and when it is published.

The latest guideline relates to "Patent Licensing Opportunities", and could be of considerable interest to both inventors and manufacturers working in the electronics field. Some of the source references given relate to regular publications which publicise both inventions available for licence and potential licensees seeking inventions; other references relate to the legal aspects of licensing, both here and abroad.

In the latter context, it is important to bear in mind that since we have joined the EEC the situation in Europe has become somewhat confused. Briefly, the Treaty of Rome forbids any restriction or distortion of competition within the EEC and thus would appear to ban any exclusive licence, i.e. any licence that gives any one manufacturer in a territory the right to corner a market without fear of competition from other manufacturers.

In 1962 the Common Market Commission issued its now famous, so-called "Christmas message" which appeared to condone exclusive licenses if tied to a patent. But this 1962 exemption has been steadily confused and eroded. Currently, to the publicly admitted dismay of the CBI, inventors and manufacturers must realistically regard any straightforward exclusive licence in Europe as void under the Treaty of Rome.

There is legal machinery for asking the Commission in Brussels to give its advance opinion on a draft licence, but this is a lengthy procedure, riddled with red tape. Thus anyone with an electronic invention to license and hopes of profit without problems, is best advised to steer clear of licensing any one manufacturer to the exclusion of others. Likewise firms are best advised to avoid entering into exclusive licences if humanly and commercially possible.

REMOVING DENTS

A simple but allegedly previously ignored approach to straightening out dents in car bodywork is claimed by Erwin Schill, of Switzerland, in BP 1 403 164.

According to the inventor, it is well known that to use a welding tool to soften the damaged metal leaves stresses in the sheet after removal of the dent. The proposed solution is to use a welding tool in the manner of a hammer, so that a multitude of tiny spots are heated briefly to a high temperature, rather than a whole area.

The necessary tool is shown in Fig. 1; the handle incorporates a hammer head with a central copper electrode which is surrounded by a safety sheath. The dent is flattened using short tapping movements so that the electrode briefly contacts the metal and heats spots of around 1mm square to 1,000°C for a fraction of a second at a time. The material surrounding each contact point draws in and if the spots are peppered over the surface to be treated (Fig. 2) the result is an overall flattening without undesirable stressing of the metal.

BP 1 403 164

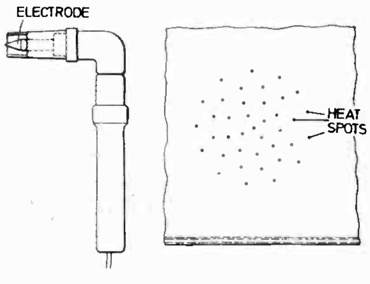
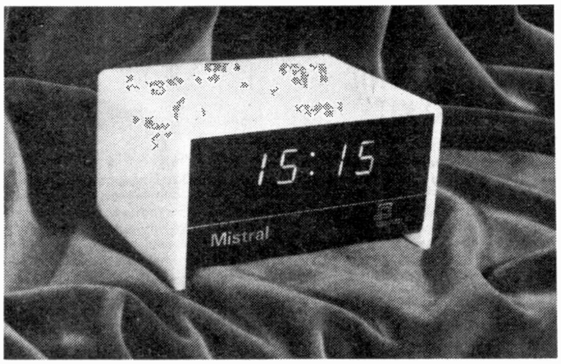


Fig. 1 **Fig. 2**

Copies of Patents can be obtained from the Patent Office Sales, St. Mary Cray, Orpington, Kent Price 75p each

THE 'MISTRAL' 1 DIGITAL CLOCK

★COMPLETE KIT★



- Pleasant green display · 12/24 Hour readout
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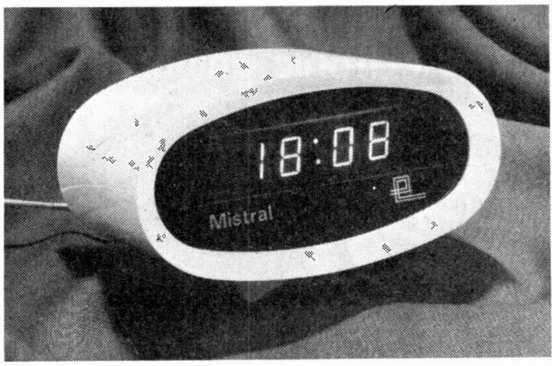

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1419 — ADVANCED

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

BASIC FUNCTION (+, −, ×, ÷) AND MEMORY
- Algebraic mode operation
- Constant operations
- Repeat operations
- Chain operations
- Change sign operation
- Display and Y register exchangeable
- One accumulating memory
- Display and memory exchangeable

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

PRICE £25·89

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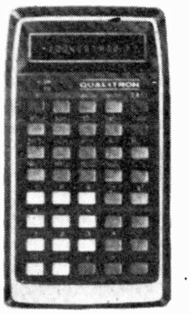
1420 — SENIOR

- 14 digit LED display
- 10 digit mantissa with sign and 2 digit exponent with sign for data entry or results ($10^{-99} \sim 10^{99}$)



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

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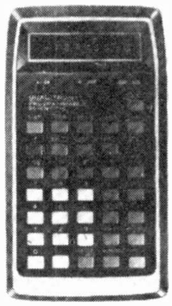
1421 — PROGRAMMABLE



BESIDES HAVING THE CAPABILITY OF A SCIENTIFIC CALCULATOR:
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- 8 digits capacity for data entry or results ($10^{-8} \sim 10^{8}$)
- Full floating point
- Automatic display blanking
- Three register operational stack
- Change sign operation
- Reverse polish notation
- Display and Y register exchangeable
- One accumulating memory (Memory store, Memory recall, M + X, M − X and M + X²)
- Trigonometric functions (sin, cos, tan)
- Inverse trigonometric functions ($\sin^{-1}$, $\cos^{-1}$, $\tan^{-1}$)
- Radians and degrees exchangeable
- π constant
- Logarithms (ln, log)
- Anti-logarithms (e^x)
- Power function (y^x)
- Reciprocal (1/x)
- Square root ($\sqrt{x}$)
- Square (X^2)

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Col. 3 Contacts
Col. (4) Price
HD = Heavy duty

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430	15–24	4 c/o	85p*
600	10–20	6M	85p*
700	12–24	2 c/o	65p*
700	16–24	4 c/o	85p*
700	16–24	4M2B	65p*
1,250	18–36	2 c/o	65p*
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Miniature relay. 675 ohm coil. 24 Volt D.C. 2 c/o. **80p** post paid.

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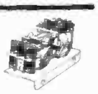

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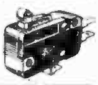

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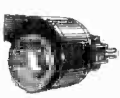

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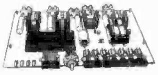

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15 R.P.M.

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20 R.P.M.

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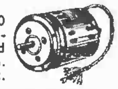
REVERSIBLE MOTOR



General Electric, 230V a.c. 1,600 r.p.m. 0·25A. Complete with anti-vibration mounting bracket and capacitor. O/A size 110mm × 95mm. Spindle $\frac{3}{16}$in. dia. 20mm long. Ex. equipment tested, **£3.** Post 50p.

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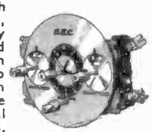

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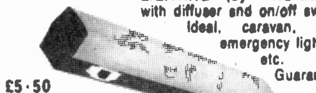

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40601	0·67
40602	0·61
40603	0·58
40604	0·56
40636	1·10
40669	1·00
40673	0·73
AC126	0·20
AC127	0·40
AC128	0·35
AC151V	0·27
AC152V	0·49
AC153	0·35
AC153K	0·40
AC154	0·25
AC176	0·41
AC176K	0·40
AC187K	0·35
AC188K	0·40
ACY18	0·24
ACY19	0·27
ACY20	0·22
ACY21	0·26
ACY28	0·20
ACY30	0·58
AD142	0·57
AD143	0·68
AD149V	0·74
AD150	1·15
AD161	0·69
AD162	0·69
AD161 }	PR
AD162 }	1·20
AF106	0·40
AF109R	0·40
AF114	0·35
AF115	0·35
AF116	0·35
AF117	0·35
AF118	0·35
AF124	0·30
AF125	0·30
AF126	0·28
AF127	0·28
AF139	0·65
AF186	0·46
AF200	0·65
AF239	0·65
AF240	0·90
AF279	0·70
AF280	0·79
AL102	1·00
AL103	1·00
BC107	0·14
BC108	0·14
BC109	0·14
BC113	0·15
BC115	0·17
BC116	0·17
BC116A	0·18
BC117	0·21
BC118	0·14
BC119	0·29
BC121	0·35
BC125	0·16
BC126	0·23
BC132	0·30
BC134	0·13
BC135	0·13
BC136	0·17
BC137	0·17
BC140	0·68
BC141	0·68
BC142	0·23
BC143	0·25
BC147	0·10
BC148	0·09
BC149	0·11
BC153	0·18
BC154	0·18
BC157	0·16
BC158	0·16
BC160	0·78
BC167B	0·15
BC168B	0·15
BC168C	0·15
BC169B	0·15
BC169C	0·15
BC170A	0·15
BC171	0·16
BC172	0·12
BC177	0·19
BC178	0·18
BC179	0·21
BC182	0·12
BY182L	0·12
BC183	0·12
BC183L	0·12
BC184	0·13
BC184L	0·13
BC186	0·25
BC187	0·27
BC207	0·12
BC208	0·11
BC212K	0·16
BC212L	0·16
BC214L	0·18
BC237	0·16
BC238	0·15
BC239	0·15
BC251	0·25
BC253	0·25
BC257	0·16
BC258	0·16
BC259	0·17
BC261	0·25
BC262	0·25
BC263	0·25
BC300	0·38
BC301	0·34
BC302	0·29
BC303	0·54
BC307	0·17
BC308A	0·15
BC309C	0·20
BC317	0·12
BC318	0·12
BC337	0·20
BC338	0·20
BCY30	0·80
BCY31	0·85
BCY32	1·15
BCY33	0·85
BCY34	0·79
BCY38	1·00
BCY39	1·50
BCY40	0·97
BCY42	0·28
BCY58	0·30
BCY59	0·32
BCY70	0·17
BCY71	0·22
BCY72	0·18
BD115	0·75
BD116	0·75
BD121	1·00
BD123	0·82
BD124	0·67
BD131	0·40
BD132	0·50
BD135	0·21
BD136	0·22
BD137	0·24
BD138	0·26
BD139	0·71
BD140	0·87
BD529	0·80
BD530	0·80
BDY20	1·05
BF115	0·29
BF117	0·55
BF121	0·35
BF123	0·35
BF125	0·35
BF152	0·20
BF153	0·25
BF154	0·20
BF159	0·27
BF160	0·23
BF163	0·32
BF166	0·40
BF167	0·25
BF173	0·27
BF177	0·29
BF178	0·35
BF179	0·43
BF180	0·35
BF181	0·36
BF182	0·35
BF183	0·55
BF184	0·30
BF185	0·30
BF194	0·12
BF195	0·12
BF196	0·13
BF197	0·15
BF198	0·18
BF200	0·40
BF225J	0·23
BF244	0·21
BF245	0·45
BF246	0·58
BF247	0·65
BF254	0·19
BF255	0·19
BF257	0·47
BF258	0·53
BF259	0·55
BFR39	0·24
BFR79	0·24
BFS21A	2·30
BFS28	1·04
BFS61	0·27
BFS98	0·25
BFX29	0·32
BFX30	0·34
BFX84	0·30
BFX85	0·25
BFX87	0·28
BFX88	0·30
BFX89	0·90
BFY50	0·30
BFY51	0·28
BFY52	0·21
BFY53	0·18
BFY90	0·75
BRY39	0·38
BSX20	0·28
BSX21	0·30
BU104	2·00
BU105	2·25
C106D	0·65
CA3018A	0·85
CA3020A	1·80
CA3028A	0·79
CA3035	1·37
CA3046	0·70
CA3048	2·11
CA3052	1·62
CA3089E	1·96
CA3090Q	4·23
LM301A	0·48
LM308	1·17
LM309K	1·88
LOO5T1	1·50
LM380	0·98
LM381	2·07
LM702C	0·75
LM709	
TO99	0·48
8DIL	0·38
14DIL	0·40
LM710	0·47
LM723C	0·66
LM741	
TO99	0·40
8DIL	0·40
14DIL	0·38
LM747	1·00
LM748	
8DIL	0·44
14DIL	0·41
LM3900	0·61
LM7805	1·88
LM7812	1·99
LM7815	1·99
LM7824	1·99
MC1303	1·50
MC1310	2·50
MC1330P	0·90
MC1351P	0·80
MC1352P	0·60
MC1466	3·50
MC1489	2·75
ME0402	0·20
ME0404	0·13
ME0412	0·18
ME4102	0·11
ME4104	0·11
MJ480	0·95
MJ481	1·20
MJ490	1·05
MJ491	1·45
MJ2955	1·00
MJE340	0·48
MJE2955	1·20
MJE3055	0·75
MJE370	0·65
MJE371	0·75
MJE520	0·60
MJE521	0·70
MP8111	0·32
MP8112	0·40
MP8113	0·47
MPF102	0·39
MPSA05	0·25
MPSA06	0·31
MPSA12	0·35
MPSA55	0·21
MPSA56	0·31
MPSU05	0·65
MPSU06	0·58
MPSU55	0·63
MPSU56	0·80
NE555V	0·70
NE556	1·30
NE560	4·48
NE561	4·48
NE565A	4·48
OC23	1·35
OC28	1·48
OC35	1·16
OC42	0·50
OC45	0·32
OC71	0·17
OC72	0·25
OC81	0·25
OC83	0·24
ORP12	0·55
R53	1·80
SL414A	1·80
SL610C	2·35
SL611C	2·35
SL612C	2·35
SL620C	3·50
SL621C	3·50
SL623	5·24
SL640C	4·00
SL641C	3·10
SN76003N	2·92
SN76013N	1·95
SN76023N	1·60
SN76033N	2·92
ST2	0·20
TAA263	1·20
TAA300	1·84
TAA350	1·96
TAA550	0·32
TAA611C	2·18
TAA621	2·03
TAA661B	1·03
TBA641B	2·25
TBA651	1·69
TBA800	0·89
TBA810	0·98
TBA820	0·80
TBA920	1·79
TIL209	0·30
TIP29A	0·49
TIP29C	0·80
TIP30A	0·58
TIP30C	0·85
TIP31A	0·62
TIP31C	1·00
TIP32A	0·74
TIP32C	1·25
TIP33A	1·01
TIP33C	1·45
TIP34A	1·51
TIP34C	2·60
TIP35A	2·90
TIP36A	3·70
TIP41A	0·79
TIP41C	1·40
TIP42A	0·90
TIP42C	1·60
TIP49C	0·70
TIP53	1·70
TIP2955	0·98
TIP3055	0·50
TIY43	0·28
ZTX300	0·13
ZTX301	0·13
ZTX302	0·20
ZTX500	0·15
ZTX501	0·13
ZTX502	0·18
ZTX530	0·23

MULLARD RADIO MODULES

RF/IF AMPLIFIER
LP1173 £6·68
LP1181 £3·94

STEREO PREAMPLIFIER
LP1183/2 £4·32
LP1184/2 £7·18

FM/IF AMPLIFIER
LP1185 £5·56

FM TUNER
LP1186 £6·88
LP1400 £7·22

P.C. MARKER PEN DALO 33PC, 87p.
ZENER DIODES 400MW 11p, 1W 17p, 2·5W 35p.
IC SOCKETS 8 DIL 10p, 14 DIL 14p, 16 DIL 13p.
RESISTORS ¼W 2p (100 per value 0·013p); ½W 3p (100 per value 0·014p).
SCORPIO CAR IGNITION KIT £12·50.
JUMBO 7 SEGMENT DISPLAYS £2.
DL 707 £1·75.
MINITRON £1·55.
LEDs Red, Yellow, Green, 16 dia. 31p, 20 dia. 33p.

SEE MARSHALLS FOR CMOS

CD4000	0·18	CD4018	0·88	CD4042	0·70
CD4001	0·18	CD4019	0·52	CD4043	0·83
CD4002	0·18	CD4020	0·98	CD4044	0·77
CD4006	0·99	CD4021	0·88	CD4045	1·30
CD4007	0·18	CD4022	0·85	CD4046	1·20
CD4008	0·82	CD4023	0·18	CD4047	0·95
CD4009	0·52	CD4024	0·72	CD4049	0·45
CD4010	0·52	CD4025	0·19	CD4050	0·45
CD4011	0·18	CD4027	0·43	CD4510	1·25
CD4012	0·18	CD4028	0·83	CD4511	1·94
CD4013	0·45	CD4029	1·06	CD4516	1·25
CD4014	0·88	CD4030	0·52	CD4518	1·87
CD4015	0·89	CD4031	1·88	CD4520	1·87
CD4016	0·45	CD4037	0·88		
CD4017	0·88	CD4041	0·70		

Veroboard

	Copper 0·1	Copper 0·15	Plain 0·1	Plain 0·15
2·5 × 3¾in	36p	26p	—	17p
2·5 × 5in	40p	39p	—	19p
3¾ × 3¾in	40p	39p	—	—
3¾ × 5in	45p	47p	—	32p
3¾ × 17in	£1·61	£1·26	£1·00	£1·92
PINS × 36	30p	30p		
× 200	£1·16	£1·16		

Trade and Retail Supplied

NEW YEAR REDUCTIONS FOR TTL

SN7400	0·16
SN7401	0·16
SN7401AN	0·29
SN7402	0·16
SN7403	0·16
SN7404	0·19
SN7405	0·19
SN7406	0·36
SN7407	0·36
SN7408	0·19
SN7409	0·18
SN7410	0·16
SN7411	0·20
SN7412	0·22
SN7413	0·28
SN7416	0·28
SN7417	0·28
SN7420	0·16
SN7423	0·23
SN7425	0·23
SN7427	0·23
SN7430	0·15
SN7432	0·22
SN7437	0·28
SN7438	0·28
SN7440	0·16
SN7441AN	0·68
SN7442	0·65
SN7445	0·78
SN7446	0·84
SN7447	0·80
SN7448	0·90
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SN7451	0·16
SN7453	0·16
SN7454	0·16
SN7460	0·16
SN7470	0·29
SN7472	0·21
SN7473	0·31
SN7474	0·31
SN7475	0·45
SN7476	0·30
SN7480	0·42
SN7481	1·00
SN7482	0·65
SN7483	0·82
SN7484	0·95
SN7485	1·00
SN7486	0·29
SN7490	0·42
SN7491	0·75
SN7492	0·45
SN7493	0·45
SN7494	0·75
SN7495	0·68
SN7496	0·68
SN74100	1·10
SN74107	0·30
SN74118	0·85
SN74119	1·75
SN74121	0·32
SN74122	0·42
SN74123	0·65
SN74141	0·75
SN74145	0·72
SN74150	1·20
SN74151	0·68
SN74153	0·68
SN74154	1·20
SN74155	0·78
SN74157	0·76
SN74160	0·88
SN74161	0·88
SN74162	0·88
SN74163	0·88
SN74164	1·60
SN74165	1·60
SN74167	3·30
SN74174	0·99
SN74175	0·70
SN74176	1·14
SN74180	1·10
SN74181	1·95
SN74190	1·86
SN74191	1·86
SN74192	1·15
SN74193	1·15
SN74196	1·60
SN74197	1·58
SN74198	1·80
SN74199	1·80

15% DISCOUNT FOR 100 MIX

Potentiometers

Linear or Log	Single	Double
Rotary Pots	25p	75p
Rotary Switched	55p	—
Sliders	45p	75p

Full range of capacitors stocked. See catalogue for details

Presets—Horizontal or Vertical
0·1W 8p 0·3W 10p

GET A GREAT DEAL FROM MARSHALLS. TV SPARES FOR BONA FIDE DEALERS, ITT, MULLARD, NATIONAL AND MOTOROLA. SEND FOR OUR NEW TWO PART CATALOGUE ON YOUR HEADED PAPER, £1 INCLUDING POST AND PACKING. REFUNDABLE WHEN YOU PLACE YOUR FIRST ORDER OVER £10.

MICRO-MIN SWITCHES

2P 2W 60p; 1P 2W 50p.

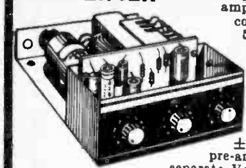
SUB MIN SWITCHES

1P 2W 55p; 2P 2W 60p; 2P 2W centre off 60p; 1P on-off 45p.

MAIL ORDER

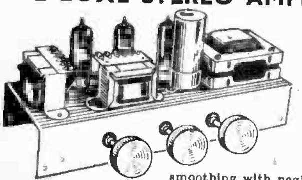
ALL PRICES EXCLUDE VAT.
POSTAGE & PACKING 25p.

SUPERSOUND 13 HI-FI MONO AMPLIFIER



A superb solid state audio amplifier. Brand new components throughout. 5 Silicon transistors plus 2 power out-put transistors in push-pull. Full wave rectification. Output approx. 13 watts r.m.s. into 8 ohms. Frequency response 12Hz. 30KHz ±3db. Fully integrated pre-amplifier stage with separate Volume, Bass boost and Treble cut controls. Suitable for 8-15 ohm speakers. Input for ceramic or crystal cartridge. Sensitivity approx. 40mV for full output. Supplied ready built and tested, with knobs, escutcheon panel, input and output plugs. Overall size 3" high × 6" wide × 7½" deep. AC 200/250V. PRICE £15·00. P. & P. 85p.

DE LUXE STEREO AMPLIFIER



A.C. mains 200-240 v. Using heavy duty fully isolated mains transformer with full wave rectification giving adequate smoothing with negligible hum. Valve line-up:–2 × ECL86 Triode Pentodes. 1 × EZ80 as rectifier. Two dual potentiometers are provided for bass and treble control, giving bass and treble boost and cut. A dual volume control is used. Balance of the left and right hand channels can be adjusted by means of a separate 'Balance' control fitted at the rear of the chassis. Input sensitivity is approximately 300m/v for full peak output of 4 watts per channel (8 watts mono), into 3 ohm speakers. Full negative feedback in a carefully calculated circuit, allows high volume levels to be used with negligible distortion. Supplied complete with knobs, chassis size 11"w × 4"d. Overall height including valves 5". Ready built and tested to a high standard. £12·50. P. & P. 95p.

ALL PURPOSE POWER SUPPLY UNIT 200/240v. A.C. input. Four switched fully smoothed D.C. outputs giving 6v. and 7½v. and 9v. and 12v. at 1 amp on load. Fitted insulated output terminals and pilot lamp indicator. Hammer finish metal case overall size 6" × 3¾" × 2½". Ready built and tested. **Price £6·35. P. & P. 85p.**

VYNAIR & REXINE SPEAKERS & CABINET FABRICS app. 54 in. wide. Our price £1·50 yd. length. P. & P. 35p per yd. (min. 1 yd.). S.A.E. for samples.

HARVERSON'S SUPER MONO AMPLIFIER

A super quality gram amplifier using a double wound fully isolated mains transformer, rectifier and ECL82 triode pentode valve as audio amplifier and power output stage. Impedance 3 ohms. Output approx. 3·5 watts. Volume and tone controls. Chassis size only 7in. wide × 3in. deep × 6in. high overall. AC mains 200/240v. Supplied absolutely Brand New completely wired and tested with good quality output transformer. P. & P. 85p. BARGAIN PRICE **£5·00**

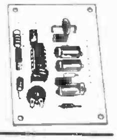
BRAND NEW MULTI-RATIO MAINS TRANSFORMERS. Giving 13 alternatives. Primary: 0–210–240v. Secondary combinations 0–5–10–15–20–25–30–35–40–60v. half wave at 1 amp. or 10–0–10, 20–0–20, 30–0–30v. at 2 amps full wave. Size 3in. long × 3½in. wide × 3in. deep. Price £2·.90 P. & P. 75p.

MAINS TRANSFORMER. For power supplies.
Pri. 200/240v. Sec. 9–0–9 at 500 mA. £1·50. P. & P. 35p.
Pri. 200/240v. Sec. 12–0–12 at 1 amp. £1·65. P. & P. 55p.
Pri. 200/240v. Sec. 10–0–10 at 2 amp. £2·35. P. & P. 70p.

GENERAL PURPOSE HIGH STABILITY TRANSISTOR PRE-AMPLIFIER

For P.U. Tape, Mike, Guitar, etc. and suitable for use with valve or transistor equipment. 9-18v. battery or from H.T line 200/300v. Frequency response 15Hz—25KHz. Gain 26dB. Solid encapsulation size 1½" × 1½" × ½". Brand new complete with instructions. Price £1·60 P. & P. 15p.

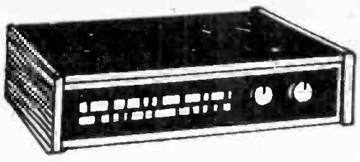
STEREO-DECODER SIZE 2" × 3" × ½"



Ready built. Pre-aligned and tested. Sens. 20-560mV for 9-16V neg. earth operation. Can be fitted to almost any FM VHF radio or tuner. Stereo beacon light can be fitted if required. Full details and instructions (inclusive of hints and tips) supplied. £6·25 plus 20p P. & P. Stereo beacon light if required 45p extra.

QUALITY RECORD PLAYER AMPLIFIER MK. II A top quality record player amplifier employing heavy duty double wound mains transformer, ECC83, EL84, and rectifier. Separate Bass, Treble and Volume controls. Complete with output transformer matched for 3 ohm speaker. Size 7in wide × 3in deep × 6in high. Ready built and tested. PRICE £6·50. P. & P. 90p. ALSO AVAILABLE mounted on board with output transformer and speaker. PRICE £7·75. P. & P. £1·00.

HARVERSONIC MAINS OPERATED SOLID STATE STEREO FM TUNER



Enjoy Fabulous Stereo Radio at this Low Introductory Price!

Designed and styled to match our 10 + 10 amplifier but will suit any other standard stereo amplifier. The design incorporates the very latest circuitry techniques with high-grain, low noise IF stages. Automatic frequency control to "lock on" station and prevent drift. IC stereo decoder for maximum stereo separation. L.E.D. for stereo beacon indicator. Nominal output of tuner 100mV. Approximate size 12¼in wide × 8in deep by 2¼in high. Supplied ready built, fully tested and fully guaranteed. AC mains 200/240V (not available in kit form).

Special Offer for 1 month only £25·00 + £1·20 P. & P.

LATEST ACOS GP91/1SC mono compatible cartridge with t/o stylus for LP/EP/78. Universal mounting bracket. £1·75. P. & P. 18p.

CERAMIC STEREO CARTRIDGE. Universal mounting brackets and turnover stylus. 70mV per channel output. ONLY £2·06. P. & P. 18p.

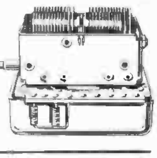
SONOTONE 9TAHC COMPATIBLE STEREO CARTRIDGE T/O stylus Diamond Stereo LP and Sapphire 78. ONLY £2·62. P. & P. 10p. Also available fitted with twin Diamond T/O stylus for Stereo LP. £3·18. P. & P. 18p.

LATEST CRYSTAL T/O STEREO/COMPATIBLE CARTRIDGE for EP/LP/Stereo 78. £1·98. P. & P. 18p.

LATEST T/O MONO COMPATIBLE CARTRIDGE for playing EP/LP/78 mono or stereo records on mono equipment. Only £1·75. P. & P. 18p.

SPECIAL OFFERS

Mullard LP1159 RF-IF Double Tuned Amplifier Module for nominal 470kHz. Size approx. 2⅜" × 1¼" × ½" 7·6V + earth. Brand new pre-aligned. Full specification and connection details supplied. £2·50 + P. & P. 12p.



Pye VHF/FM Tuner Head covering 88·108M/Hz. 10·7M/Hz IF output 7·8V + earth. Supplied pre-aligned, with (gang) full circuit diagram and connection details supplied. Beautifully made with precision-geared FM and 323 Pf + 323 Pf AM Tuning only £3·50 + P. & P. 35p.

PRECISION MADE

Push Button Switch bank. 8 Buttons giving 16 S/P C/O interlocked switches plus 1 Cancel Button Plus 3 d/p c/o. Overall size 5" × 2½" × 1". Supplied complete with chrome finished switch buttons 2 for £1·50 + 10p, P. & P.

HI-FI LOUDSPEAKER SYSTEM MkII

Beautifully made simulated teak finish enclosure now with most attractive slatted front. Size 16½" high × 10½" wide × 9" deep (approx.). Fitted with E.M.I. Ceramic Magnet 13" × 8" bass unit, H.F. tweeter unit and crossover. AVAILABLE IN NOMINAL 4 ohm, 8 ohm or 16 ohm impedance (state which).

OUR PRICE £12·50 each. Carr. £1·60

Cabinet Available Separately £7·50. Carr. £1·20.
Also available in 8 ohms with EMI 13" × 8" bass speaker with parasitic tweeter £11·00. Carr. £1·60

LOUDSPEAKER BARGAINS

5in. 3 ohm £1·45, P. & P. 35p. 7 × 4in. 3 ohm £1·69, P. & P. 48p. 10 × 6in. 3 or 15 ohm £2·50, P. & P. 75p. E.M.I. 8 × 5in. 3 ohm with high flux magnet £2·06, P. & P. 50p. E.M.I. tweeter. Approx. 3½". Available 3 or 8 or 15 ohms, £2·00 + 25p, P. & P.

"POLY PLANAR" WAFER-TYPE, WIDE RANGE ELECTRO-DYNAMIC SPEAKER

Size 11⅝" × 14⅛" × 1⁵⁄₁₆" deep. Weight 19oz. Power handling 20W r.m.s. (40W peak). Impedance 8 ohm only. Response 40Hz–20kHz. Can be mounted on ceilings, walls. Send S.A.E. for details. Only £7·68 each. P. & P. 70p.

Now also available 8"-8 ohm. 10 watts r.m.s. 20 watt peak 40 Hz-20,000 Hz. Overall depth 1". Ideal for Hi-Fi or for use in cars. £5·18 + 40p P. & P.

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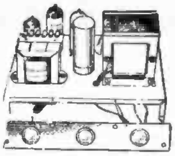

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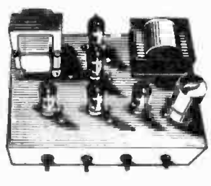

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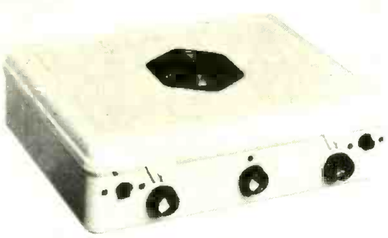

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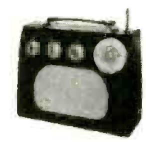

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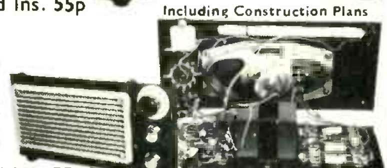

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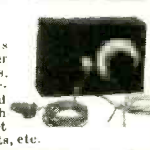

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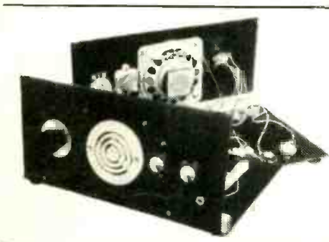

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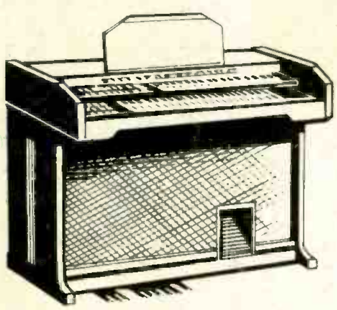

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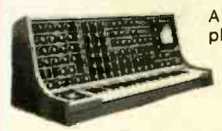

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