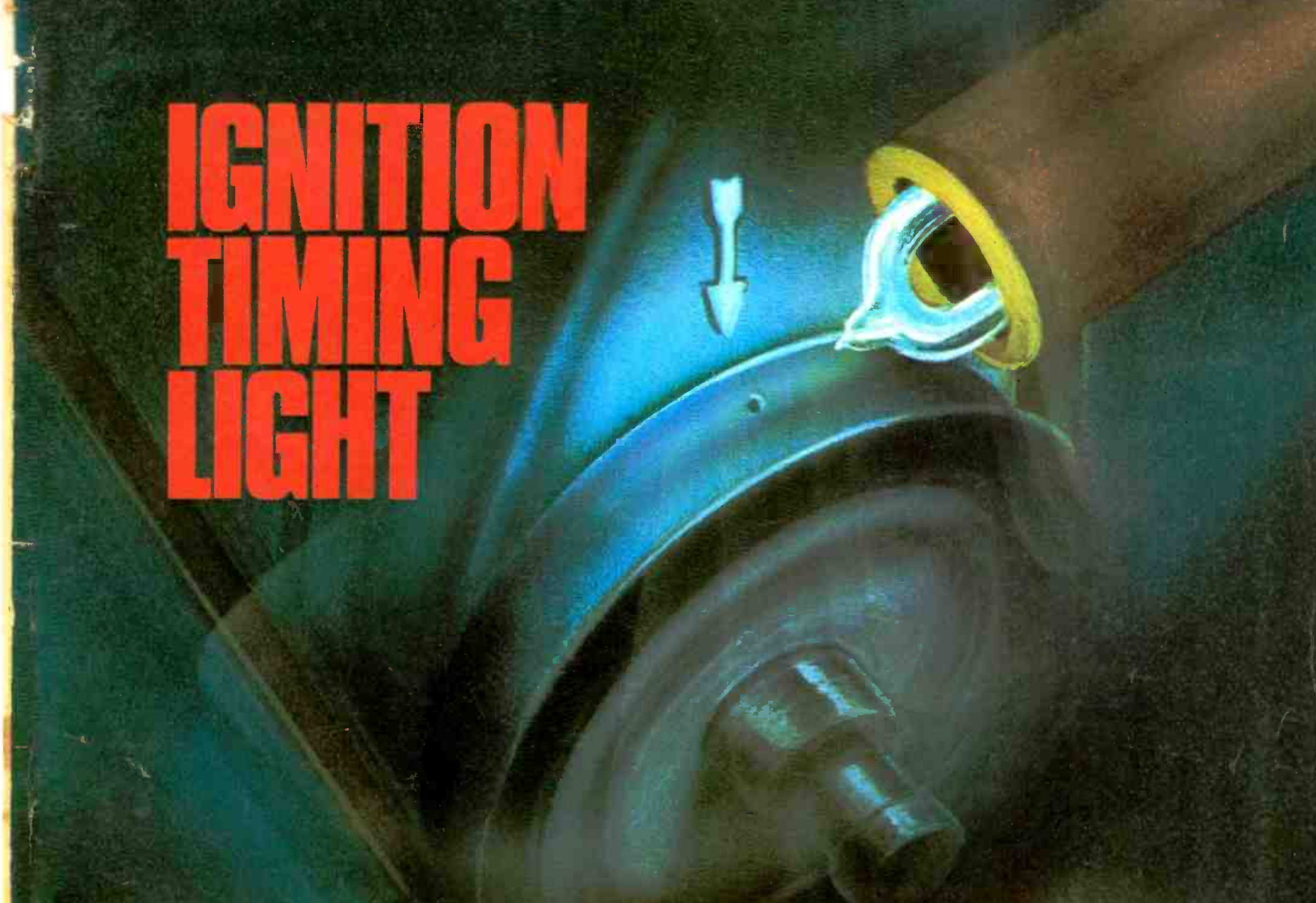
PRACTICAL

ELECTRONICS

JANUARY 1974

20p

IGNITION TIMING LIGHT



PE

RONDO LOUDSPEAKER ENCLOSURE

in this issue...

PRACTICAL ELECTRONICS

VOLUME 10 No. 1 JANUARY 1974

CONSTRUCTIONAL PROJECTS

GENERAL FEATURES

NEWS AND COMMENT

Our February issue will be published on Friday, January 11, 1974

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- ROBUST DIODE PROTECTED PRECISION MOVEMENT.
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- ACCURACY—RESISTANCE, D.C. VOLTAGE AND CURRENT 2·5%. A.C. VOLTAGE AND CURRENT 3·5%.
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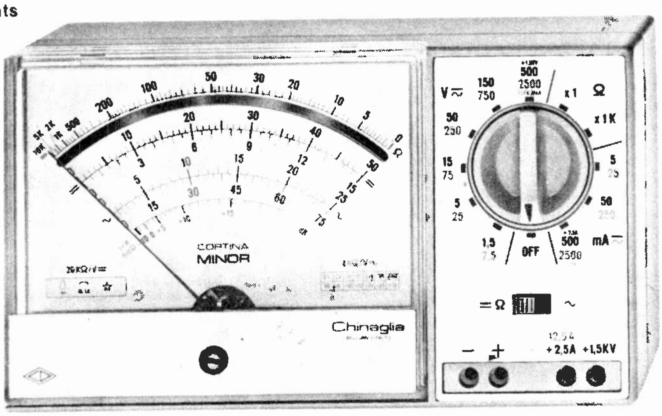

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H39	6	Integrated circuits 4 gates BMC 962, 2 flip flops BMC 945	55p
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B84	100	Silicon Diodes DO-7 glass equiv. to OA200, OA202	55p
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H16	15	Experimenters' Pak of Integrated Circuits. Data supplied	55p
H20	20	BY126/7 Type Silicon Rectifiers 1 amp. plastic. Mixed volts	55p
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Audio PNP, similar to ZTX500, 2N3702/3, BCY70, etc.
ALL AT 500 for £3·30, 1,000 for £5·50, 10,000 for £44. P. & P. 11p per 1,000.
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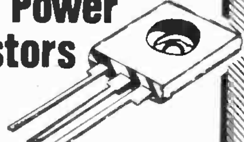

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90 watt	26½p	24½p	22p
Range 2	VCE Min. 40	HFE Min. 40	
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40 watt	33p	31p	29p
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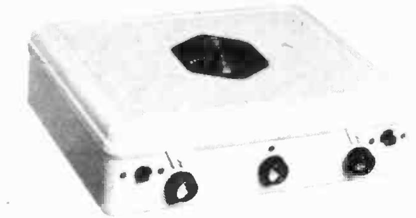

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- Transistor Tester NPN—PNP
- 4 Transistor Push Pull Amplifier
- 5 Transistor Push Pull Amplifier
- 7 Transistor Loudspeaker Radio MW/LW.
- 5 Transistor Short Wave Radio
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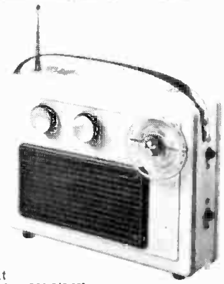
Components include:
● 24 Resistors ● 21 Capacitors ● 10 Transistors ● 3½" Loudspeaker ● Mica Baseboard ● 3 12-way Connectors ● 2 Volume Controls ● 2 Slider Switches ● 1 Tuning Condenser ● 3 Knobs ● Ready Wound MW/LW/SW Coils ● Ferrite Rod ● 6½ yards of wire ● 1 yard of sleeving, etc. ● Parts price list and plans 50p (free with parts)

NEW ROAMER NINE

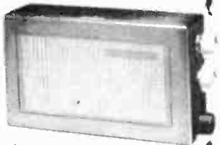


WITH V.H.F. INCLUDING AIRCRAFT

Nine Transistors, 9 Tunable wavebands as Roamer Ten. Built in ferrite rod aerial for MW/LW. Retractable chrome plated telescopic aerial for VHF and SW. Push Pull output using 600 mW transistors. 9 Transistors and 3 diodes, tuning condenser with VHF section, separate coil for aircraft, moving coil loudspeaker, volume ON/OFF and wavechange. Attractive all white case with red grille and carrying strap. Size 9¼in × 7in × 2¾in approx. Parts price list and plans 30p (FREE with parts).

TOTAL BUILDING COSTS £6·95 (+10% VAT 69p) **P.P. & INS. 44p (OVERSEAS P. & P. £1·85)**

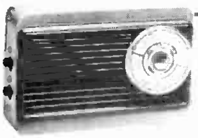
POCKET FIVE



3 Tunable wavebands. MW/LW and Trawler Band. 7 stages, 5 transistors and 2 diodes, supersensitive ferrite rod aerial, moving coil loudspeaker, attractive Black and Gold Case. Size 5½in × 1¼in × 3½in approx. Plans and parts price list 15p (FREE with parts).

Total Building Costs £2·28 (+10% VAT 22p) **P.P. & Ins. 26p (Overseas P. P. £1·25)**

TRANSONA FIVE



Wavebands, transistors and speaker as Pocket Five. Larger Case with Red Speaker Grille and Tuning Dial. Plans and parts price list 15p (FREE with parts).

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EV5 5 Transistors and 2 diodes. MW/LW. Powered by 4½ volt Battery. Ferrite rod aerial, tuning condenser, volume control, and loudspeaker. Attractive case with red speaker grille. Size 9in × 5¼in × 2¾in approx. Parts price list and plans 15p (FREE with parts).

TOTAL BUILDING COSTS £2·73 (+10% VAT 27p) **P.P. & INS. 30p (OVERSEAS P. & P. £1·25)**

EV6 Case and looks as above. 6 Transistors and 3 diodes. Powered by 9 volt Battery. Ferrite rod aerial, 3" loudspeaker, etc., MW/LW coverage. Push Pull Output. Parts price list and plans 15p (FREE with parts.)

TOTAL BUILDING COSTS £3·60 (+10% VAT 36p) **P.P. & INS. 30p (OVERSEAS P. & P. £1·25)**

EV7 Case and looks as above. 7 transistors and 3 diodes. Six wavebands. MW/LW. Trawler Band, SW1, SW2, SW3, powered by 9 volt Battery Push Pull Output. Telescopic Aerial for Short Waves. 3" Loudspeaker. Parts price list and easy build plans 20p. Free with parts.

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ROAMER EIGHT Mk. I

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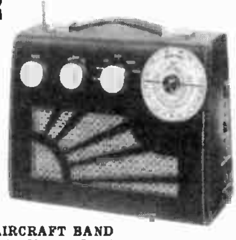
TOTAL BUILDING COSTS £6·98 (+10% VAT 69p) **P.P. & INS. 47p (OVERSEAS P. & P. £1·85)**

ROAMER TEN



WITH VHF INCLUDING AIRCRAFT

10 TRANSISTORS. 9 TUNABLE WAVEBANDS, MW1, MW2, LW, SW1, SW2, SW3, TRAWLER BAND, VHF AND LOCAL STATIONS, ALSO AIRCRAFT BAND

Latest 4" 2 watt Ferrite Magnet Loudspeaker. Built-in ferrite rod aerial for MW/LW. Retractable, chrome plated 7 section telescopic aerial, can be angled and rotated for peak short wave and VHF listening. Push-pull output using 600mW transistors. Car Aerial and tape record sockets. 10 transistors plus 3 diodes. Ganged tuning condenser with VHF section. Separate coil for Aircraft Band. Volume/on/off, wave change and tone controls. Attractive case in black with silver blocking. Size 9in × 7in × 4in.
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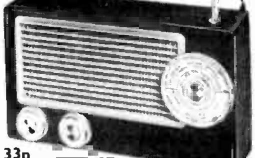
TRANS EIGHT 8 TRANSISTORS AND 3 DIODES



6 TUNABLE WAVEBANDS, MW, LW, SW1, SW2, SW3 AND TRAWLER BAND. Sensitive ferrite rod aerial for MW. and LW. Telescopic aerial for short waves. 3in speaker. 8 improved type transistors plus 3 diodes. Attractive case in black with red grille, dial and black knobs with polished metal inserts. Size 9in × 5½in × 2½in approx. Push-pull output. Battery economiser switch for extended battery life. Ample power to drive a larger speaker. Parts price list and plans 25p (FREE with parts).

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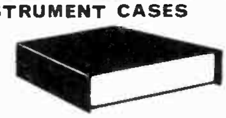

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BA5	4"	×	2½"	×	2"	41p
BA6	3"	×	2"	×	1"	34p
BA7	7"	×	5"	×	2½"	66p
BA8	8"	×	6"	×	3"	84p
BA9	6"	×	4"	×	2"	54p

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De Luxe Groov-Kleen
Model 42 £1·84
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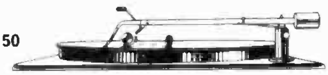

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Ref. 32A. Stylus Balance £1·36
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Ref. 34. Cassette Case £1·27
Ref. 56. Hi-Fi Stereo Hints & Tips 32p

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CCN 240. 15 watt £2·15
Model G. 18 watt £2·15
SK2. Soldering Kit £2·86
STANDS: ST1 £1·21. ST2 77p
SOLDER: 18SWG Multicore 7oz 82p
22SWG 7oz 82p. 18SWG 22ft 28p
22SWG Tube 22p

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Bits No.

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102	For model CN240 ⅛"	
1100	For model CCN240 3/32"	
1101	For model CCN240 ⅛"	
1102	For model CCN240 ¼"	
1020	For model G240 3/32"	
1021	For model G240 ⅛"	
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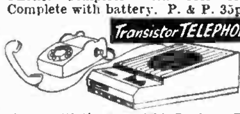

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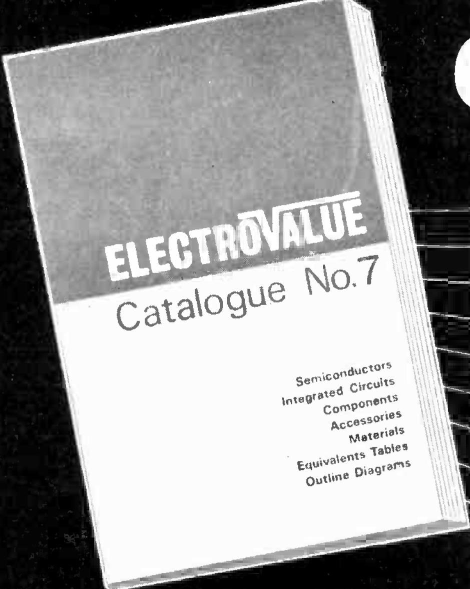

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Available complete for only £49·00 + £3·50 p. & p.

STILL ONLY £49 COMPLETE

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Viscount R 102 amplifier	£24·20 + £1 p & p
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Garrard SP25 Mk III with MAG. cartridge plinth & cover	£18·00 + £1·75 p & p
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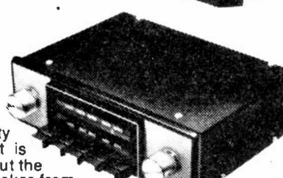

The Tourist PB is suitable for 12 volt working on both negative and positive earth vehicles it covers the full medium and long wave bands. It is permeability tuned and sturdily constructed. Output is a full 2·5 watts into an 8 ohms speaker. But the Tourist PB will operate into any loudspeaker from 8 to 15 ohms.
Apart from the output stage, which is an integrated circuit, the only other electronic components that need soldering are some capacitors, resistors, etc. The kit includes a pre-built RF tuner unit; and fully modulised IF stages which are pre-aligned before despatch. As well as electronic components this kit also contains 2 diamond-spun aluminium knobs, elegant matching front panel, dial, washers, screws and wire.
The Tourist PB can be mounted in any standard size dash panel and it has an illuminated tuning scale. Chassis size is: 7in wide, 2in high and 4⅛in deep.
* Circuit diagram and comprehensive instructions 55p free with parts.
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CAR RADIO KIT £6·60 p. & p. 55p

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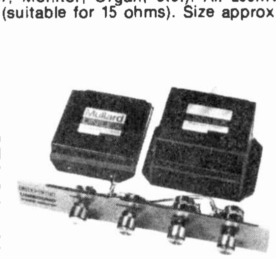

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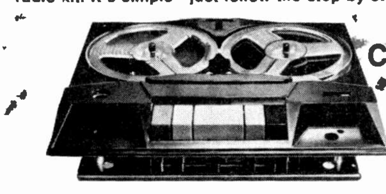

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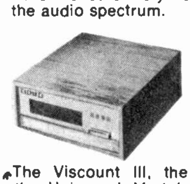

With this elegant stereo 8 track add on unit, audio enthusiasts now have the opportunity to extend their systems to include the playing of 8 track cartridges. Simply select your channel, by push button, four digital lamps indicate channel selected. Mains operated.
The Viscount III, the fabulous Stereo 21 and the Unisound Modules will all accept this unit, simply connect up. **£10·60** p. & p. 90p.

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PE

FUEL AND POWER

OUR almost total dependence upon the fossil fuels, coal and oil, has been brought home to everyone these last few weeks. Nothing concentrates the mind on such basic facts of life as a threatened fuel and power shortage.

But need it be so? Remember nuclear power, and how it was to solve all our energy problems in a few decades? Well, its present contribution to the national grid is very small. This is a great disappointment after the tremendous pioneering work performed by British scientists and engineers in the post 1946 years. The high hopes of generating electricity cheaply by nuclear fission have not been fulfilled, though the failure stems mainly from political decisions, rather than from any technical shortcomings.

The relationship between nucleonics and electronics is close and real. Present day electronic circuitry owes quite a lot to development work carried out expressly to meet the special instrumentation requirements of the first nuclear power stations.

When looking for future alternative sources of power, the possibility of harnessing solar energy on a large scale seems more conjectural. However, like nuclear power, any practical scheme for using radiation from the sun must involve electronic devices and techniques, so again there is a special relationship between these technologies.

Perhaps, arising out of our winter of discontent will come a renewal of interest in these exotic sources of energy. They evoke concepts different in the extreme, from the microscopic dimension of the nucleus, to the macrocosmic distance from earth to the sun. Here are the two most probable sources of energy that will ultimately succeed the fossil fuels we are recklessly consuming without thought for the hundreds of millions of years it has taken for the oil, gas and coal to be formed beneath the earth's crust. Yet, alas, the probability is that once the present fuel crisis is over complacency will take over again and the prodigious research effort required will not be made.

Aside from such thoughts on power generation necessitating a major national programme, the present difficult position will undoubtedly encourage further development work in certain areas by individuals and companies. One example is electroluminescent materials, since lighting panels with negligible power consumption obviously have a great future. And what of the long-awaited electric car? Work in this area will receive a new impetus, for sure.

And now, more to the point so far as our readers are concerned, there are the various ways in which electronics can help *immediately* to alleviate some of today's power and fuel problems—at home and on the road. PRACTICAL ELECTRONICS will be publishing some useful designs to help out. As a start there is this month an Ignition Timing Light. This simple device will help towards improved engine running, with attendant saving in fuel consumption. Those readers concerned with maintaining essential services in the home should note the announcement relating to next month's issue of this magazine.

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DIGITAL EXPOSURE TIMER

By S. A. MONEY

ACCURATE EXPOSURE TIMES AND NO SETTING UP REQUIRED

Many amateur photographers today make use of 35mm or Instamatic 126 cameras. Because of the small size of the negatives produced by these cameras the amateur who wants to make his own prints will need to use an enlarger in order to get prints of a reasonable size.

If a number of prints are to be produced in this way then a very useful addition to the normal dark-room equipment is some form of automatic timer unit to control the length of the exposure in the enlarger.

This device is normally used to switch on the enlarger lamp for some pre-determined period of time to give an accurately reproduceable exposure with the minimum of effort on the part of the operator.

DIGITAL TIMING

In the timer to be described, timing is carried out by the use of digital techniques with the frequency of the supply mains acting as a basic clock. No calibration is required and the timing will remain accurate to within about one fiftieth of a second.

A switch provides a series of fixed exposure times which should cover most of the requirements for both black and white and colour printing.

EXPOSURE REQUIREMENTS

One of the standard methods for finding the optimum exposure time for printing from a particular negative is to produce a test strip print in which a series of steps of exposure are made across the strip. Usually the exposure for one step is twice that of the previous step.

A typical series of steps might be 2, 4, 8, 16 and 32 seconds. The resultant print usually shows a series of strips where the density of the image increases by roughly the same amount at each step. This is due to the logarithmic sensitivity characteristic of the average photographic emulsion.

For black and white work a satisfactory print will generally be obtained by selecting one of the steps of exposure on the test strip. Colour printing tends to be rather more critical and may require the use of intermediate values of exposure between two of the adjacent steps on the test strip. Provision has been made for this requirement in the design of the digital timer.

SELECTOR SWITCH

A selector switch on the timer enables the operator to select the basic exposure times of 2, 4, 8, 16, 32 and 64 seconds. A second switch has been provided by means of which the basic times may be increased by 50 per cent to give the intermediate exposures of 3, 6, 12, 24, 48 and 96 seconds.

Finer adjustment of exposure between these 12 fixed exposure times can usually be catered for by using the aperture control on the enlarger lens. If desired it is possible, by giving multiple exposures, to achieve any exposure time equal to a whole number of seconds.

The circuit diagram of the digital timer unit is given in Fig. 1. It will be seen that the unit comprises a frequency divider using integrated logic circuits, a control logic circuit, a triac switch for the enlarger lamp and a low voltage power supply for the logic elements.

FREQUENCY DIVIDER SECTION

Frequency variations in the 50Hz mains supply are normally held to less than plus and minus one per cent by the Electricity Generating Board. By deriving the basic clock for the timer from the supply frequency the resultant timing accuracy will be more than adequate for all normal photographic requirements.

A small voltage at mains frequency is extracted from the low voltage power supply in the unit and applied via C2 and R1 to the base of transistor

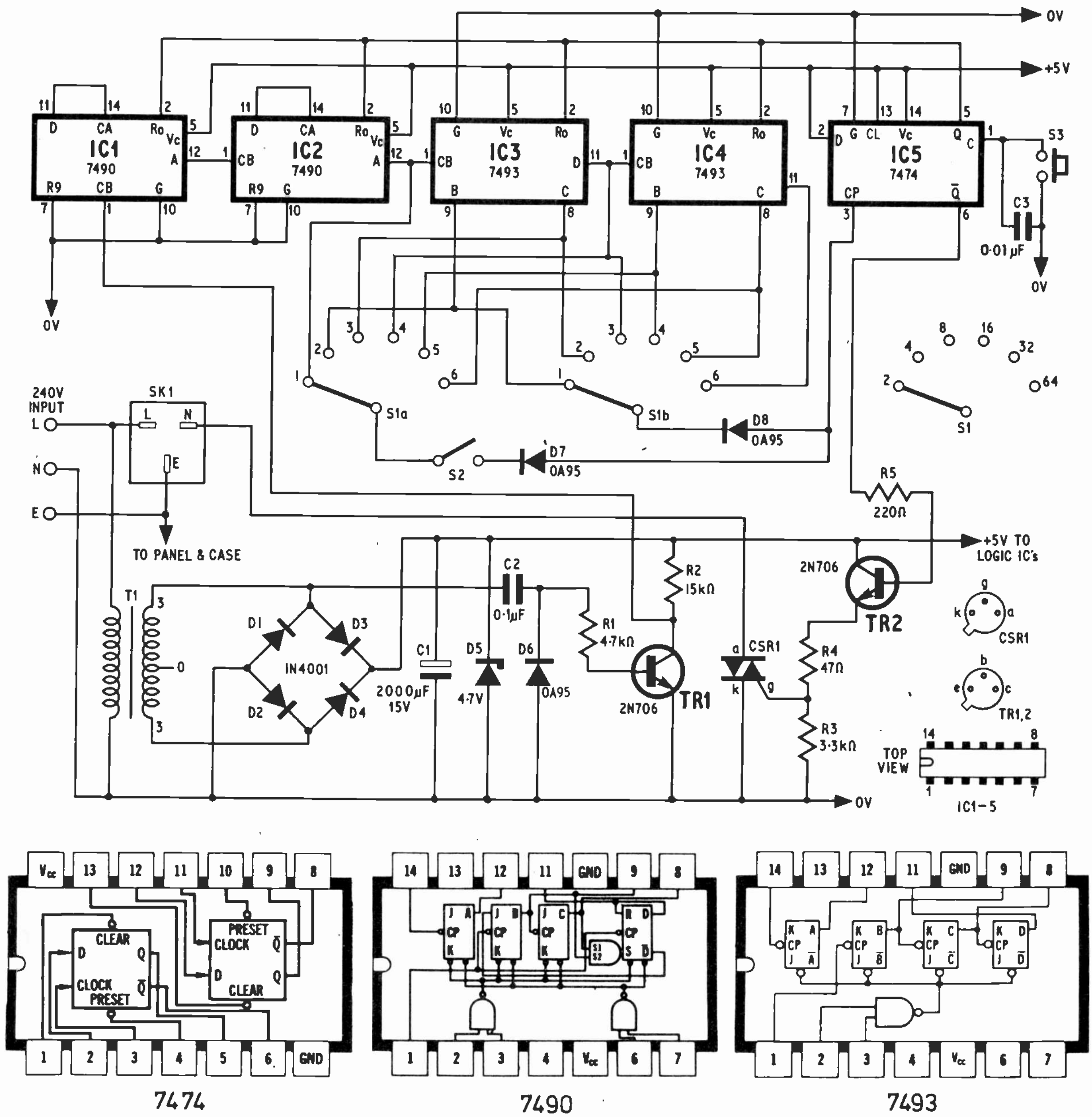


Fig. 1. Complete circuit diagram of the Digital Exposure Timer. S1 sets the exposure time, S2 is closed to increase the exposure time by 1·5 times and S3 is the expose switch

TR1. This transistor acts as a pulse shaper and produces at its collector a 50Hz square wave of about four volts amplitude. Diode D6 is used to provide d.c. restoration to maintain optimum bias for TR1.

The collector output from TR1 provides a clock drive signal for IC1 which is a 7490 decade counter. The 7490 consists of four flip-flops arranged to give a divide-by-five counter and a divide-by-two counter. By connecting the two sections in cascade a division by ten is obtained.

A second 7490 counter module (IC2) has its clock driven by the output of IC1 and provides a further divide-by-ten count. The resultant output signal from the final stage of IC2 is a square wave having a frequency of one cycle every two seconds.

The two second clock output from IC2 is now divided down further in frequency by IC3 and IC4.

In the 7493, which is similar to the 7490, the four flip-flops are arranged as four separate divide-by-two counter stages. Only three of the four stages in each 7493 module are used and these are connected in cascade to form a six stage binary counter chain.

The output frequency from the final stage of this counter chain will be one cycle every 128 seconds. It is this counter chain which controls the basic exposure times.

CONTROL LOGIC

One half of a 7474 dual D-type flip-flop module (IC5) is used to provide the control logic for the unit. This particular type of flip-flop was chosen for the purpose because it is edge triggered by the positive going edge of the clock pulse input.

Between exposures this flip-flop is in a dormant state with its Q output set at the logic 1 level (+4 volts). This Q output is joined to the reset (R0) inputs of the four counter modules (IC1 to 4).

When the reset line is held at the logic 1 level the counters are held in their reset state with all outputs at logic 0 (0 volts). On the 7490 counters only the (R0) input is connected to the reset line, the (R9) inputs being joined to the zero volt supply rail.

TIMING CYCLE

To start a new exposure cycle the push-button switch S3 is made momentarily. This action sets the "clear" input of flip-flop IC5 at logic 0 which, in turn, causes its Q output to change to logic 0.

After S3 is released IC5 will remain in this "clear" state. It is arranged that when Q is at logic 0 the enlarger lamp is turned on to make the exposure. At the same time the reset line to the counters will also go to logic 0 and allow them to start counting the 50Hz input clock pulses.

Switch S1 is used to select the basic exposure time periods. One bank of this switch (S1b) is used to select one of the six outputs of the 7493 counters (IC3 and IC4) and route it via diode D8 to the clock input of flip-flop IC5.

When this selected signal goes from logic 0 to logic 1 level it will clock the flip-flop IC5. This flip-flop is connected so that when clocked it will return to its initial condition with Q at logic 1 thus turning off the enlarger lamp and terminating the exposure.

Let us assume that the switch S1 is set so that the output from stage B of IC3 is selected via S1b. At the start of the exposure period the output from B will be at logic 0. In the 7493 type counter the output will change on the falling edge of the clock input when it goes from logic 1 to 0.

The clock for stage B is obtained from the output of IC2. The total frequency division in IC1 and IC2 is 100 so the output frequency from IC2 will be one cycle every two seconds.

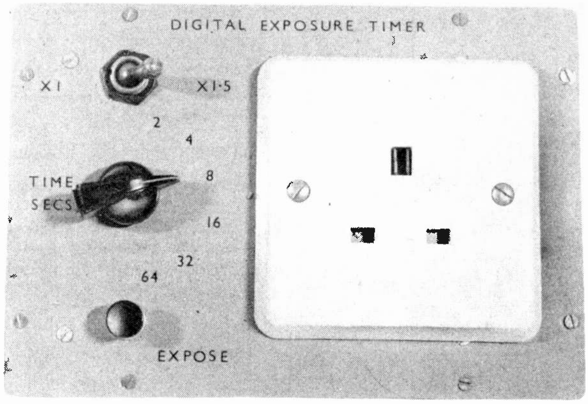
Since the counters start off from zero the output of IC2 will go to logic 1 after one second of counting and will return to logic 0 after two seconds. Stage B of IC3 will therefore be clocked to logic 1 two seconds after the start of the exposure cycle. When stage B goes to logic 1 it clocks IC5 and ends the exposure.

Thus with switch S1 in this position the exposure period will be two seconds. In the same way the exposure times produced by the other positions of S1 will be 4, 8, 16, 32 and 64 seconds as the selected output position is moved along the counter chain.

INTERMEDIATE EXPOSURES

To obtain intermediate exposure times the switch S2 and a second bank of switch S1 are brought into play. The switch bank S1a is also used to select one of the outputs from the counter chain but it is wired so that it selects its output from the stage before the one selected by S1b.

When switch S2 is closed the output from S1a is routed to the clock input of IC5 via diode D7. The two diodes D7 and D8 form an AND gate so that the outputs from S1a and S1b must both be at the logic 1 level before the flip-flop IC5 will be clocked.



Photograph of the completed Digital Exposure Timer

Once again let us assume that switch S1 is set at its two second position but in this case S2 is closed. At one second after the start of the exposure cycle the output of IC2 will go to logic 1 and therefore S1a output will go to logic 1. The output of S1b will still be at logic 0 so no clock pulse will be applied to IC5 and the exposure goes on.

After two seconds the S1a output will go to logic 0 and S1b will go to logic 1 so that there will still be no clock pulse applied to IC5. After three seconds output S1a will go to logic 1 again but this time S1b will still be at logic 1 so a clock pulse is applied to IC5 and the exposure ends.

Closing switch S2 will thus increase the normal two second exposure period to three seconds. In the same way the other positions of S1 will give exposure periods of 6, 12, 24, 48 and 96 seconds when S2 is closed.

It was found that the flip-flop IC5 tended to be triggered by mains transients picked up on the push-button switch input. This problem was overcome by connecting the capacitor C3 across the "clear" input of IC5.

LAMP CONTROL SWITCH

Instead of using a relay contact to switch the supply to the enlarger lamp, this unit makes use of a triac as a solid-state switch. The triac acts in a similar fashion to a thyristor but conducts on both half cycles of the supply.

The triac CSR1 is connected in series with the enlarger lamp and the mains supply. When the gate to cathode voltage of the triac is held below 0·5 volt the triac does not conduct and the enlarger lamp will be off.

If the gate to cathode voltage is increased so that about 15 to 20mA gate current flows the triac will conduct between anode and cathode on both half cycles of the supply. Since the voltage drop across a conducting triac is of the order 1 volt, virtually the whole of the mains supply will now be applied to the lamp and it will operate at normal brilliance. When the gate voltage is again reduced below 0·5 volt the triac ceases to conduct and the lamp will be turned off.

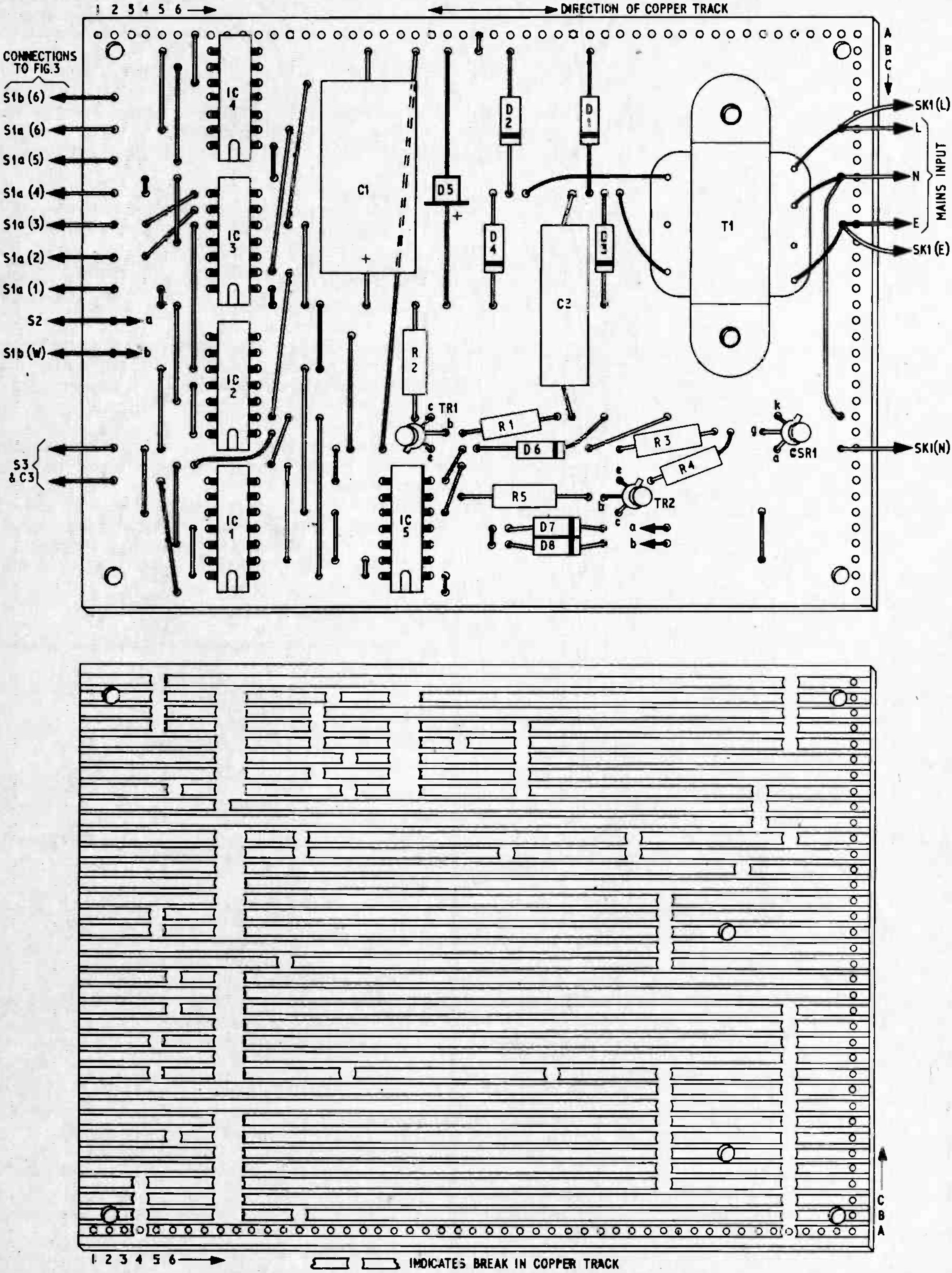


Fig. 2. Layout of the components on the Veroboard with breaks in the copper strips

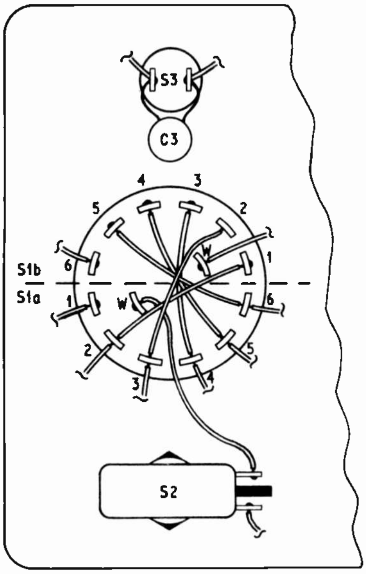


Fig. 3. Interwiring of the Digital Exposure Timer switches. Refer to Fig. 2 for connections to Veroboard

TRIAC TRIGGERING

A gate control signal for the triac is obtained from the inverted ($\bar{Q}$) output of the flip-flop IC5. Before an exposure cycle the Q output will be at logic 1 and therefore the $\bar{Q}$ output will be at zero.

The gate-cathode voltage on the triac will be low and the triac is not conducting.

When an exposure cycle occurs the $\bar{Q}$ output will rise to the logic 1 level thus increasing the gate voltage to make the triac conduct and turn on the lamp. The output from IC5 itself is not capable of delivering the current required to operate the triac gate directly. An emitter follower buffer stage TR2 is therefore included to drive the triac gate.

Triac CSR1 is a TO5-can type rated at 400 volts and 2 amps. This device should be capable of handling all of the normal mains voltage enlarger lamps up to about 200 watts without the need for a heat sink.

LOW VOLTAGE LAMPS

If the enlarger is fitted with a low voltage lamp it is not advisable to use this triac to switch the supply to the lamp directly. Low voltage lamps require much higher currents and would demand the use of a larger triac. The voltage drop produced by the triac will no longer be an insignificant part of the lamp supply and will result in the lamp being under-run with a corresponding loss in light output.

It is usual for low voltage lamps to be fed from the mains supply via a transformer. It is practicable to use the triac to switch the supply to the primary of the lamp transformer. Since the transformer can present an inductive load it will be necessary to wire a 0·1µF capacitor and a 100 ohm resistor in series across the triac to protect it from switching transients. The capacitor used should have a working voltage of at least 500 volts.

POWER SUPPLY

An internal power unit provides the 5V supply for the counters and the control logic. This employs a small transformer giving an output of 6V at about 150mA.

Four 1N4001 silicon diodes (D1 to D4) are used as a bridge rectifier with a 2,000µF capacitor C1 acting as a reservoir and providing ripple filtering. The 4·7V Zener diode D5 operates as a shunt stabiliser to produce a d.c. output voltage of approximately five volts.

A signal taken from one of the a.c. inputs to the bridge, at the junction of D1 and D3, provides the clock frequency input to the base of transistor TR1.

CONSTRUCTION

All circuit components, with the exception of the switches, are mounted on one circuit card. This is made up using 0·1in matrix Veroboard which fits in conveniently with the pin spacing on the integrated circuits. The midget transformer used is small enough to be mounted directly onto the circuit card.

A compact assembly can be produced by mounting the circuit board behind the front panel on a set of spacing pillars.

The layout of components and wiring of the circuit board is shown in Fig. 2. To make the required breaks in the copper tracks either a Vero cutter or the tip of a $\frac{3}{16}$in twist drill may be used. Care must

COMPONENTS . . .

Resistors
R1 4·7kΩ R4 47Ω
R2 15kΩ R5 220Ω
R3 3·3kΩ
All $\frac{1}{4}$W ± 10% carbon

Capacitors
C1 2,000µF 15V elect. C3 0·01µF
C2 0·1µF

Transistors
TR1, TR2 2N706 *or* similar *npn* general purpose (2 off)

Diodes
D1–D4 1N4001 (4 off)
D5 4·7V 1·5W Zener
D6–D8 OA95 or similar (3 off)

Triac
CSR1 400V 2A triac (TO5 can)

Integrated Circuits
IC1 SN7490N decade counter
IC2 SN7490N decade counter
IC3 SN7493N 4 bit binary counter
IC4 SN7493N 4 bit binary counter
IC5 SN7474N flip-flop

Switches
S1 2-pole 6-way break before make rotary
S2 s.p.s.t. toggle
S3 push-to-make release-to-break push-button

Transformer
T1 Mains primary, 3V-0-3V 200mA secondary (R.S. Components)

Miscellaneous
SK1 13A mains socket
Veroboard 0·1in matrix 5in × 3$\frac{3}{4}$in
Case, approx. 7in × 5in × 3in

be taken in this operation so that the minimum amount of material is removed from board under the copper track.

Flexible stranded wire is preferable for the wire links across the circuit card. Solid core wire tends to cut through its p.v.c. insulation when the links are soldered to the card.

For the spacing pillars 6BA brass hexagon bar was used. The pillars are made $1\frac{1}{4}$in in length and they are drilled and tapped at each end to take 6BA fixing screws. An alternative would be to use wood dowels for the pillars and to fix the card and the front panel using small wood screws.

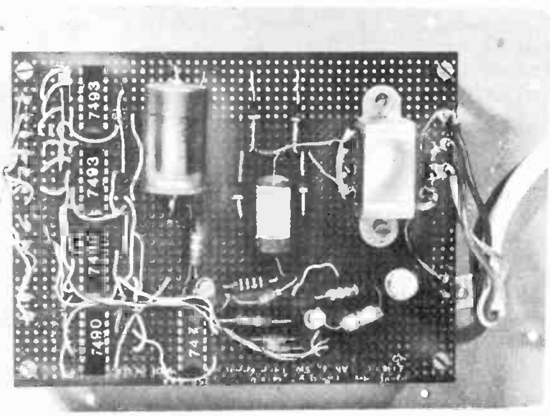
FRONT PANEL

The front panel is made from 16 s.w.g. aluminium. Component layout is shown in the photograph and interwiring between the Veroboard and the front panel is shown in Figs. 2 and 3.

For safety it is essential that the front panel should be solidly connected to the earth pin of the socket and to the earth wire of the mains lead. The mains cable itself should be anchored to the front panel by means of a cable clip.

A case for the unit can be readily made up from $\frac{3}{8}$in plywood. The four sides and bottom may be glued or screwed together to form a box which should be at least $2\frac{1}{4}$in deep on the inside.

For neatness the fixing holes in the front panel should be countersunk. Instrument head or countersunk screws should then be used for fixing the panel to the spacing pillars and to the case.



Photograph showing the layout of the components on the Veroboard

OPERATION

The enlarger mains lead is simply plugged into the socket on the unit. The timer itself may then be plugged into a suitable mains supply. When the unit is switched on at first there may be a brief flash from the enlarger lamp as the logic resets itself.

Whilst focusing and setting up the enlarger it is convenient to have the timer set to the 96 seconds time period, and to retrigger it as required. Once the enlarger has been set up the desired exposure is selected on the timer using S1 and S2. With the paper set up in the enlarger the exposure is initiated by pressing switch S3. ★

NEWS BRIEFS

THE NEW REVOLUTION

THE Royal Albert Hall, London — Victorian monument to the Industrial Revolution with friezes depicting arts and industry decorating the outside walls —was the scene of the Imperial College of Science and Technology Commemoration Day Ceremony on October 25. To the impressive setting provided by the Hall, splendid colour was added by the gowns of the college dignitaries, professors, and associates assembled for this important occasion in the academic year.

Amongst the new Honorary Fellows introduced was Robert W. Sarnoff, Chairman of RCA. In his Special Visitor's Address, Mr. Sarnoff discussed the new electronic revolution which has ". . . begun amplifying the power of the mind just as the Industrial Revolution amplified the power of muscle." He spoke of the likely impact of electronics during the next decade or so, and remarked upon the modest requirements of electronics in terms of materials and energy, and on the absence of environmental pollution or urban blight arising from expansion in this field of technology. Wider dissemination of knowledge and information for private and business use through compact communication and computing systems was one of the great contributions the whole world would enjoy as the Electronic Revolution really gets under way.

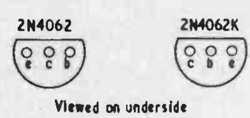
POINTS ARISING

PARTY STROBE LIGHT (December 1973)

In Fig. 1 and the components list diodes D1 and D2 should have been identified as 1N4004.

SEMICONDUCTOR TESTER (November 1973)

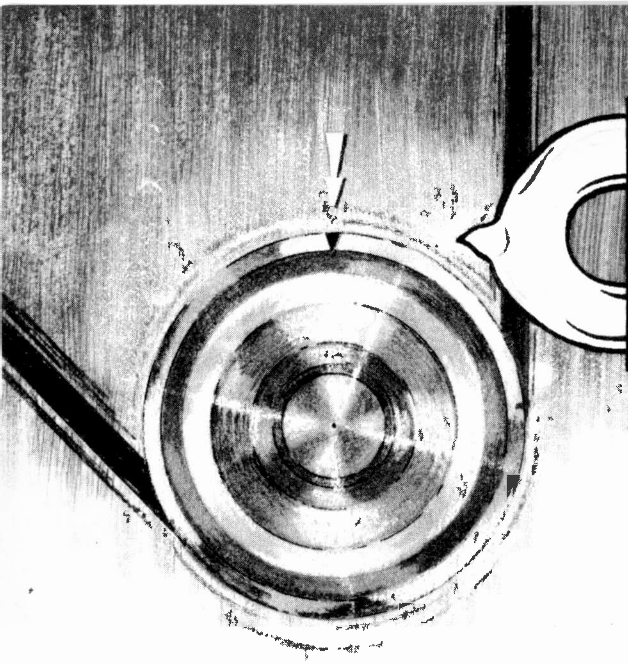
The transistors shown in the Veroboard layout (Fig. 7) are 2N4062K, an equivalent for the 2N4062 but with differing pin connections as shown :



In addition, the emitter and collector connections of TR3 are reversed and should be transposed.

VOICE OPERATED FADER (December 1973)

The printers apologise for omitting the title and the author's name.



IGNITION TIMING LIGHT

BY F.T. KLER

Can improve engine performance and contribute to a more economical use of fuel

CORRECT ignition timing is essential to the efficient and economic running of a car engine. Incorrect timing may produce poor acceleration and performance, overheating, loss of power and possibly reduced engine life.

Ignition timing is essentially stroboscopic. A powered timing light is triggered by the voltage from the spark plug to which it is connected, usually the No. 1 cylinder.

Using the light enables the operator to see how the actual timing compares with the specified timing while the engine is running. Any advancement or retardation is achieved by adjustment of the distributor.

TWO TYPES

Two types of timing light are available using either the neon or xenon tube. With a neon, this can be operated directly by the spark plug voltage to which it is connected. However, the light output compared to the xenon tube is a lot less.

The flash requirements for the xenon tube are a high d.c. voltage and a trigger pulse which will ionise the gas within the tube. A transistor inverter provides the d.c. in the unit to be described with triggering from No. 1 spark plug as in Fig. 1.

OPERATION

Upon application of 12V to the circuit, both transistors will commence to turn on, due to the bias network R1 and R2. Because of normal manufacturing spreads in gain and base/emitter voltage drop, one transistor will begin to draw more collector current through its half of the primary winding than the other.

This difference in primary currents produces a small net flux in the transformer core, and the appearance of this flux in turn induces a potential difference across each of the other windings. The feedback windings between the bias network and the transistor bases are connected in such a way as to reinforce the original imbalance, that is, the base of whichever transistor has the higher collector current is driven slightly positive, turning it on harder, while the other transistor is turned off by the fall in potential on its base. This is a positive

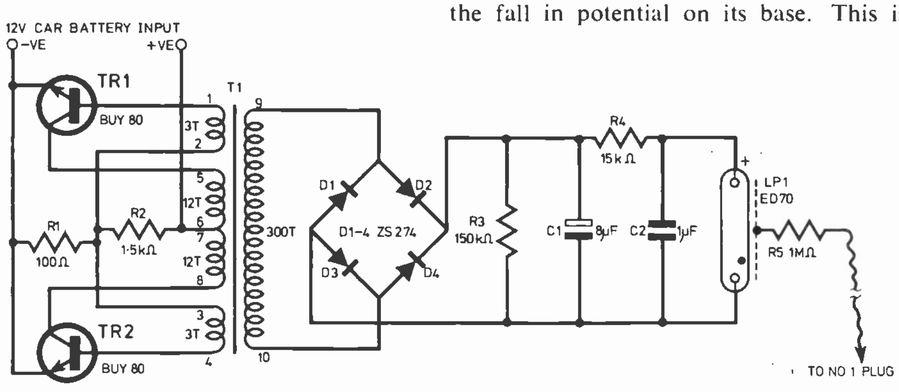
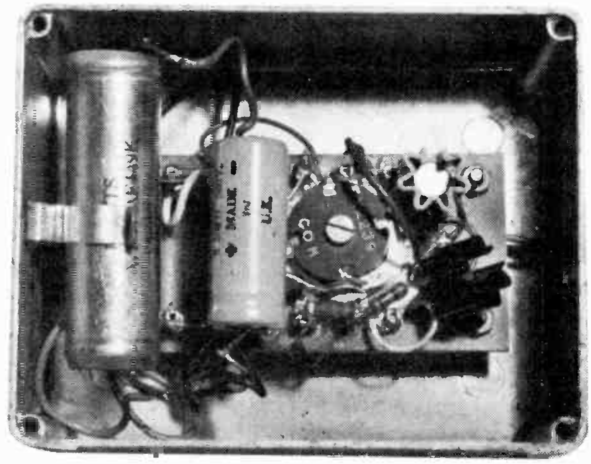


Fig. 1. Circuit diagram of Ignition Timing Light

feedback condition, as the original imbalance is now being reinforced by the differential drive to the transistors.

As the current in the primary winding increases, it causes an increase in magnetic flux in the core, which, however, has an upper limit set by the material used. When this limit is reached, the flux no longer increases and the core is said to be saturated. Since it is the rate at which the flux is changing which produces the e.m.f. in a winding, and the flux has now stopped increasing, it follows that the voltages on the feedback windings must fall to zero. Under these circumstances, the transistor which had been held off by the reduced bias applied to it now has a chance to conduct once more. The collector current through this transistor and its associated primary winding acts to produce a flux in opposition to the original direction. Thus there will now be an overall reduction in the magnetic flux in the core, and this reduction brings the transformer out of saturation and at the same time gives rise to e.m.f.s across the feedback windings of opposite polarity to the original e.m.f.s.

This time, the transistor which took the core up to saturation is turned off, while the other is turned on. Again, positive feedback holds one transistor off and the other transistor on until the core saturates with the flux in the other direction. When saturation takes place, the positive feedback disappears, and the transistors change state. Thus the process is continuous, and each flux reversal induces a high voltage across the output winding.



The encased electronic assembly

D.C. OUTPUT

The secondary winding is connected to a conventional bridge rectifier and reservoir capacitor C1. This feeds the discharge capacitor via a charging resistor R4 which eliminates any possibility of a continuous arc in the xenon tube. R3 is connected across the reservoir capacitor to discharge it after use. The voltage across this is about 350V.

COMPONENTS . . .

Resistors
- R1 100Ω ½ watt 10%
- R2 1·5kΩ ½ watt 10%
- R3 150kΩ 1 watt 10%
- R4 15kΩ 1 watt 10%
- R5 1MΩ ½ watt 10%

Capacitors
- C1 8μF elect, 500V
- C2 1μF 600V

Transistors
- TR1–TR2 BUY 80 Ferranti (2 off)

Transformer
- T1 FX2239 pot cores (2 off) (Mullard) complete with bobbin, clips and tagboard (see text) (Gurneys Radio, 91 The Broadway, Southall, Middlesex)

Diodes
- D1–D4 ZS274 (Ferranti) (4 off)

Miscellaneous
- Eddystone box $4\frac{11}{16}$in × $3\frac{11}{16}$in × $2\frac{1}{16}$in, crocodile clips (3 off), transistor heat sinks (2 off), 30 and 40 s.w.g. wire as required (see text) LP1—ED70 xenon tube

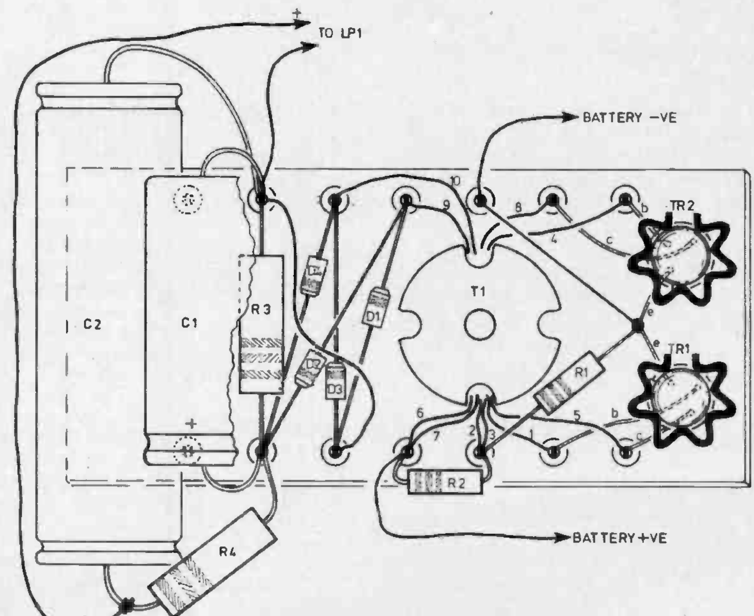
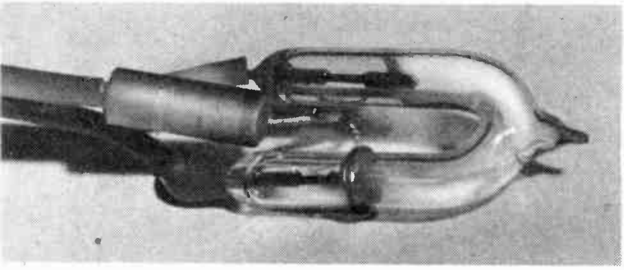


Fig. 2. Component and wiring details



CONSTRUCTION

The majority of components are mounted on a 14 pin tag board as in Fig. 2. The most difficult item for construction is the transformer. To make this, first wind on the bobbin 24 turns of 30 s.w.g. enamelled wire. Centre tap this winding and identify the lead-out with coloured sleeves.

On top of this primary winding, wind 300 turns of 40 s.w.g. enamelled wire keeping the ends bare.

Insulate these windings with p.v.c. tape, now wind on three turns of 30 s.w.g., then take off a centre and wind another three turns ensuring that the ends are colour coded to facilitate tag connections. The cores can now be assembled around the bobbin using the clips to fix it on the tag board.

After fixing the components according to Fig. 2, the board is attached to the base of a $4\frac{11}{16}$in × $3\frac{11}{16}$in × $2\frac{1}{16}$in Eddystone box using nuts, bolts and insulating spaces.

The handle housing the ED70 tube and R5 must be made of some insulating material such as p.v.c. or Tufnol capable of withstanding the spark plug e.h.t. In the prototype a turned Tufnol bar of $\frac{3}{4}$in inside diameter and $1\frac{1}{2}$in outside was used. The overall length was $5\frac{1}{2}$in. The tube can be fixed using Araldite or silicon rubber compound within the barrel.

Home Radio supply $\frac{3}{4}$in p.v.c. tube which can be used for this. They also supply push-on end caps.

SET UP

The timing light requires the two input leads to be connected across the car's 12 volt battery. The other lead is then connected to No. 1 cylinder h.t. lead at the sparking plug. Then engine may now be started, but the revs should be kept at tickover (i.e. 500–600 r.p.m.).

By flashing the light on the crank pulley markings and the crank case markings, the state of the timing will be seen. Adjustment of the timing is achieved by the distributor micrometer vacuum screw, which can advance or retard the ignition to the manufacturers' figures. ★

The probe assembly with the xenon tube and R5 removed

NEWS BRIEFS

AUTOMATIC RADIO DIRECTION FINDER

Radio direction is an important aid to sailors since it allows radio beacons to be used as accurate reference points so that position can be accurately determind.

A new automatic direction finder from EMI is intended for use mainly in fishing and larger commercial pleasure craft. Beacon selection is simple: individual crystals are inserted, each crystal covering a specified beacon group; a five-position switch on the front panel is used to spot select the group required.

The bearings obtained are displayed on a back-lit circular dial and can be either relative to the ship's heading or direct magnetic bearing according to the compass course set on the outer scale.

The rotating ferrite rods of the directional aerial are contained in a small weatherproof dome and are controlled by a servo from the main unit.

COMMUNICATIONS FOR NORTH SEA PLATFORMS

A five million pound project to provide a communications system for the North Sea gas and oil rigs has been announced by the Post Office. Scheduled to come into service in early 1975, the heart of the system will be two new radio stations equipped with 40ft dish aerials able to provide reliable communications to platforms more than 200 miles from the coast.

Because many of the rigs are out of sight of the land the Post Office is using a new technique known as "trans-horizon radio". In this system powerful microwave signals are beamed into the troposphere and are scattered by atmospheric turbulence so that a small but usable signal reaches the receiver. Some production platforms will act as relay stations, passing on the signal to the other platforms by ordinary line-of-sight microwave link.

WEATHER SATELLITE WILL BEAM DATA TO ALL NATIONS

A spacecraft launched by NASA on November 8th is now the primary weather watcher in the worldwide system. Known as NOAA-3, the new satellite is in a 942 mile high sun-synchronous orbit and observes every portion of the earth twice a day.

A new feature of this satellite is that data will be beamed directly to nations around the world so that any nation equipped to receive the signals will be able to make use of the information.

The satellite, built by RCA under the direction of NASA's Goddard Space Flight Centre, will monitor the temperature of the atmosphere up to 20 miles above the earth. There is also a scanning radiometer which will transmit cloud cover pictures to 550 simple, inexpensive stations located in 80 countries around the world.

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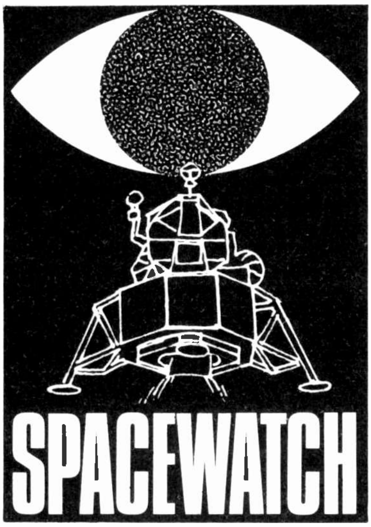


BY FRANK W. HYDE

RESEARCH ROCKETS

In October 1973 the largest UK space rocket research project involving *Skylark* and *Petrel* rockets was launched from the rocket range at Andøya in Norway. This was the first project in which the objectives were dependent on the co-ordinated firing of the *Petrel* and *Skylark*.

Financed by the Science Research Council, under the control of the Radio and Space Research Station for the University space groups, the main objectives are the study of the auroral sub-storm phenomena at various stages of development and at different altitudes.

The whole project was made possible because of the facilities made available to the United Kingdom space scientists by the Royal Norwegian Council for Scientific and Industrial Research. The range on Andøya Island off the north coast of Norway at a latitude of 69°N was particularly suitable for the project.

The auroral sub-storms occur at high latitudes and at these times energetic particles are precipitated. At the same time there is increased ionisation of the atmosphere caused by the particles and the ionisation causes increased absorption of radio waves.

The particles themselves are believed to originate from the low energy plasma within the solar wind. These particles are precipitated at high energies before they are precipitated into the atmosphere.

The five main experiments examined the well defined phases of typical sub-storms. The experiments were devised so that a comprehensive study of the physical processes could be made.

The five main experiments were carried on the *Skylark* rockets, one to each. The supporting experiments were flown on the *Petrel* vehicles. The nature of the investigations is complex and is reflected in the construction of the payloads. The procedure to launch was also complex and the timing of each rocket launch required considerable accuracy. Special design of payloads was required because of limited space available and also the need to avoid interaction between experiments on the same rocket.

The main experiments were arranged to investigate:

1. Particle acceleration which occurs at the onset of the negative phase of a sub-storm.
2. Particle storage and the onset of particle precipitation during the initial phase of a sub-storm.
3. The fine structure of the particle precipitation within the auroral area.
4. The ionospheric density of the electrons and their temperature, ionospheric electric fields and thermospheric winds.
5. Wave-particle interactions during a sub-storm, and the effcts on the propogation of v.l.f. emissions in the ionosphere.

Onboard instruments operated at different levels, those in the *Skylark* at between 200 and 300km altitude and those in the *Petrel* at about 150km. Thus the coverage of the two levels should add very much to the understanding of these mechanisms.

An additional feature used in the experiments was the tuned laser. This is being used to track sodium "dumping" from a rocket. For the first time also pulse coded modulated (PCM) telemetry was used.

The groups directing experiments were the Radio Space Research Station, and Universities from Birmingham, Sussex, Southampton, Sheffield, University College. A group from the Royal Institute of Technology, Stockholm, also collaborated with the Radio and Space Research Station.

The *Skylark* rockets are made by BAC and the *Petrel* rockets by Bristol Aerojet Ltd.

NEWS FROM JUPITER

The satellite of Jupiter, Io, that has an effect on the radio radiations from the planet has an atmosphere of its own. This is thought to be mostly methane and ammonia like its parent. There is, however, a peculiar thing about this atmosphere. It has been noted on a number of occasions that after being eclipsed by another body, Io on reappearance seems to be considerably brighter in the ultraviolet region. This brightness is seen to be enhanced for about 20 minutes after eclipse.

The phenomena was puzzling and unpredictable, but now it would seem that there is yet another possible solution. It was noted that the brightening took place when Jupiter is at perihelion, and eclipses the satellite. It has been suggested by Cruikshank and Murphy at the Hawaii University, that the heavy gas of Io's atmosphere becomes frozen when the satellite passes behind Jupiter into an extremely low temperature region. There is good evidence that the time of twenty minutes agrees with such a mechanism. It would take about twenty minutes for the solid gas to evaporate and the very bright appearance is consistent with freezing as the explanation.

As *Pioneer 10* will have been occulted by Io on December 3, data will have been acquired about the atmosphere of the satellite by using radio signals from the spacecraft to measure its properties.

Hitherto, it had been thought that Io had no atmosphere since the disappearance and the emergence of a star occulted by the satellite seemed to be instantaneous. This discovery comes at a time when the large satellite Ganymede has shown that it has a significant though not very hospitable atmosphere. The final acceptance of the fact that the atmosphere is a reality has come after a long period of observation started by Dr. G. E. Taylor of the Royal Greenwich Obervatory.

Well known for his work on the prediction of occultations Dr. Taylor predicted that an occultation of Ganymede was due. The difficulty of making an exact time of the event arises from the fact that the precise position of the star invloved is often not known.

SPECIAL OBSERVATIONS

To put this matter right special observations were made from Perth and the Cape of Good Hope in order to fix the relative position of Ganymede and the star SAO 186800. The fix was accurate to 0·3 arc/secs. This enabled the occultation observers in India, Java and Australia to monitor the event.

Australia were not able to carry out their task successfully since it turned out that they were 50km south of the actual track across the Earth. However, the other two observers were successful and their observations clearly showed that the atmosphere existed by reason of the slow disappearance of the star and its subsequent emergence equally slow. Though the fall in light value was only 5 per cent (not very surprising when it is realised that the star is only of magnitude 8) neverthe less the indication was positive.

The received data has now made it possible to decide a more accurate estimate of the diameter of Ganymede, which turns out to be 250km less than was thought. Again it is a fortunate period for this discovery since *Pioneer 10* will be able to obtain more data.

INDUSTRY NOTEBOOK

By Nexus

CRYSTAL BALL

The National Economic Development Office report "Industrial Review to 1977 — Electronics" (Neddy Books, Millbank Tower, London, SW1P 4QX, price 50p) is so full of ifs and buts and windy generalisations that its value is limited. Of course, the authors are handicapped from the start by lack of reliable statistics, thus it is hard enough to interpret the immediate past, let alone attempt an intelligent forecast of the future. The chosen base year is 1971 and the report attempts to analyse the growth of the industry, sector by sector, for national economic growth rates of 3·5 per cent and 5 per cent per annum through to 1977.

Quite realistic assumptions with all the economic indicators pointing in the right direction when the words were written. How unfortunate, then, that the assumptions were overtaken at the very moment of publication by new factors such as the world energy crisis, political turmoil in the United States, industrial strife at home. And, of course, the as yet unmeasured consequences of Britain's entry into the EEC.

Electronics is a dynamic industry operating internationally in a dynamic political and economic framework. What the industry really needs is an annual report based on really up-to-date figures with short-term forecasting of trends. In fact if the trade associations would only standardise on the presentation of industry statistics in their annual reports I would settle for these alone, bound up into one handy volume.

Let us turn from people trying to analyse the industry to people out and about actually working towards that magic 15 per cent growth, characteristic of the industry in its better years.

PRODUCTIVITY

The grafters of the industry—those who churn out the "nuts and bolts" which keep the rest going—are all too often overlooked amid the glare of publicity afforded to glamour technology and super systems.

I take, as an example, the Mullard plant at Blackburn where production is measured by the million pieces and productivity is unashamedly the goal. It is a huge plant covering 46 acres and was established in a small way in 1938. Famous for its high volume valve production it is now busy on additional products following a slow run-down in valve production as solid state devices have become more widely used. But Mullard Blackburn still produces 27 million valves a year so don't imagine the valve is already dead.

Electrolytic capacitors is one of the many other lines produced at Blackburn, brought into production in 1969 with an output for the year of 10 million. Production has now risen to an annual level in excess of 80 million, with a forecast expansion of well over 100 million per year by 1975. Much the same story applies to foil capacitor production where production is approaching 200 million a year.

A new product is glass delay lines for PAL TV receivers. By refining production processes, including automatc testing and adjustment of delay characteristics, production is approaching 2 million a year.

There has also been a big upsurge in production of electronic modules. Speed control modules for washing machines, voltage multipliers for TV sets, radio and audio modules such as tuners, pre-amps, i.f. strips, stereo decoders and a.f. power modules.

It is heartening to see such dedication to productivity which is the name of the game if prices are to be held down.

PIONEERS

It was equally heartening to spend a week at the Japan Electronics Show at Osaka and see at first hand how British products measured up to the Japanese market. BSR record players and autochangers are selling in the areas of Japan, Taiwan and South Korea at the rate of 600,000 a year, a remarkable achievement based entirely on BSR's enormous productivity which lands the product in Japan at a quality/price ratio which leaves the local competition gasping for breath.

More interesting, however, was the group of 17 British companies which exhibited at the Show under the auspices of the British Overseas Trade Board in a group exhibit organised by the Electronic Engineering Association.

For most companies it was their first experience in penetrating the Japanese market and there was, naturally enough, some prior doubt on the value of the investment in time and money spent. They needn't have worried. The market is by no means wide open but there are plenty of business opportunities now that trade liberalisation is becoming a reality in Japan and this, coupled with a current exchange rate which gives British products a keen price-edge, augers well for a substantial trade build-up.

The Osaka show coincided in time with the opening of the British Marketing Centre in Tokyo at which regular exhibitions of British goods are to be held and which can be used by visiting executives for business meetings with agents and customers. Decca Radar was the first electronics company off the mark exhibiting at the opening show of marine equipment sponsored by the British Marine Equipment Council. But electronics will not be at the Centre in force until mid-74 when Avionics will be the theme.

Meantime, a contingent of 35 British companies will be exhibiting at the Internepcon Tokyo Show in January 1974 and a big increase in British participation is already being forecast for the 1974 Japan Electronics Show.

AWARD

Congratulations to Pye TMC whose "Sphericall" automatic telephone dialler won the "best international product" award at the big Canadian Electronics exhibition at Toronto. Sphericall has already won a Council of Industrial Design award and I can vouch personally for the interest it aroused when shown in Osaka, Japan.

Basically it is a simple attachment to an ordinary dial telephone but it has push-buttons and a 10-number store in which the user can programme his ten most used numbers. To call any of these you just press two buttons and Sphericall does the rest, including "try again". It uses an Emihus-designed MOS-LSI chip.

Sales could be enormous once the big PTT boys, including our own Post Office, grant approval for connecting it to domestic lines.

INGENUITY UNLIMITED

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.
This is YOUR page and any idea published will be awarded payment according to its merits.

RIAA PRE-AMPLIFIER

THE pre-amplifier described here employs the MFC8040 low-noise integrated circuit. The basic internal circuitry of the device is given in Fig. 1.

Fig. 2 shows the external components necessary to produce a pre-amplifier equalised in accordance with the RIAA playback characteristic.

The circuit provides a gain of 34dB at 1kHz with a typical input of 15mV. Input impedance is 75kΩ. A curve, given in Fig. 3, plots the response up to 20kHz with the 0dB reference point set at 770mV output (15mV input). An output filter is incorporated which rapidly attenuates the output above 80kHz.

From the total harmonic distortion point of view the circuit performs very well, the figures being 0·1 per cent at 60 and 1,000Hz rising to 0·2 per cent at 10kHz with an output of 300mV r.m.s.

However, one of the main features of the design is the low-noise which is typically only 1mV and is predominantly low-frequency.

J. Francoz,
Geneva.

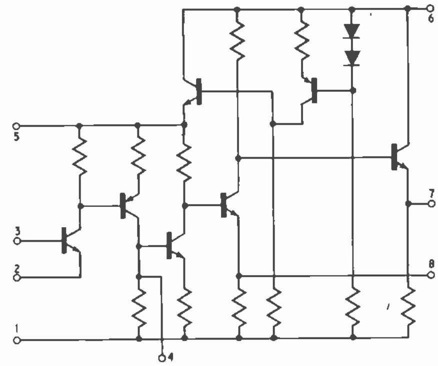


Fig. 1. Internal circuit diagram of IC1

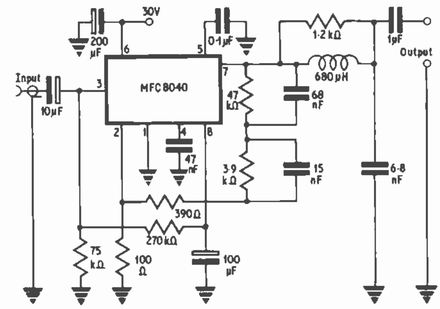


Fig. 2. Circuit diagram of the RIAA pre-amplifier

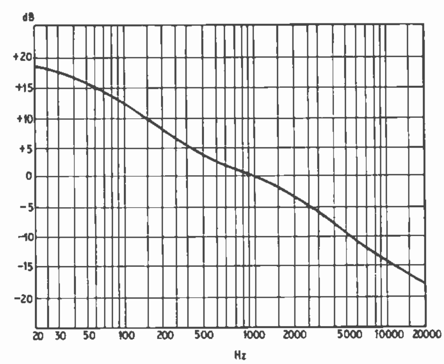


Fig. 3. Response curve of the pre-amplifier

555 CIRCUIT MARK/SPACE RATIO

IN *"Points Arising"* in the October issue a reader has pointed out that a constructor attempting to use the 555 timer chip to construct a 1 : 1 mark-space ratio monostable may run the risk of damaging TR1 because of the reduction of RA below a suggested value of 1kΩ. Presumably the word "astable" should have been used instead of "monostable" in this sentence.

It should be pointed out that the current passed by the discharge transistor of the 555 is typically limited to 25mA. Thus it appears impossible to damage the 555 device in this way.

The type of astable circuit shown in Fig. 1 can be used to provide a mark-space ratio of unity or any other reasonable value. The capacitor charging current flows through RA and D1, whilst the discharging current flows through RB and D2. The charging and discharging paths are therefore quite separate and the resistors in those paths can be selected quite independently of one another. The values of RA and RB should be equal for a 1 : 1 mark/space ratio.

J. B. Dance,
Warwickshire.

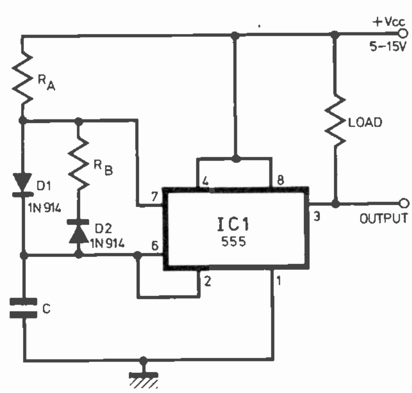
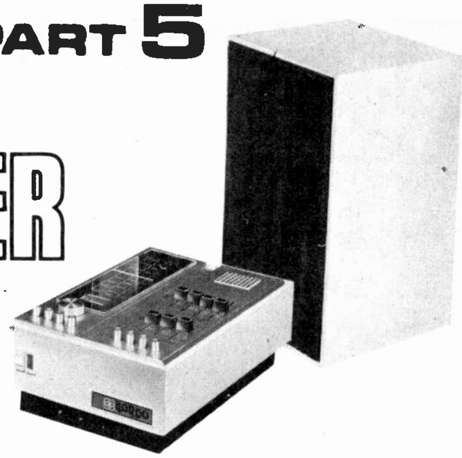


Fig. 1. The 555 Timer astable ratio circuit

PE RONDO PART 5

LOUDSPEAKER ENCLOSURE



BY R.A.COLE

THE loudspeaker enclosures for the Rondo system have been designed specifically to overcome many of the problems that beset the constructor attempting to produce loudspeakers equal in performance and finish to a shop bought product.

Each Rondo enclosure utilises the infinite baffle principle and can be considered to be in the medium size book-shelf category. It is however generally considered that although compact, the infinite baffle loudspeaker is lacking in bass response. The Rondo system is designed to overcome this deficiency.

BASICS

In order to explain the basic principles of the Rondo enclosure, it is necessary to briefly deal with speaker drive units and their loading. A loudspeaker drive unit used in "free air" (not mounted in any way) has a very poor bass response. In fact its response falls off below 2kHz (see Fig. 5.1). If it is mounted on a small baffle its response improves drastically. This improvement is caused by the reduction in interaction between the waveforms emitted from the front and back of the cone.

The larger the baffle, the lower the frequency at which this interaction takes effect. The interaction is caused by the waveforms from the back and front of the cone being out of phase and cancelling each other. The lowest frequency produced by a baffle-mounted speaker has a wavelength equal to twice the distance from the cone to the edge of the baffle.

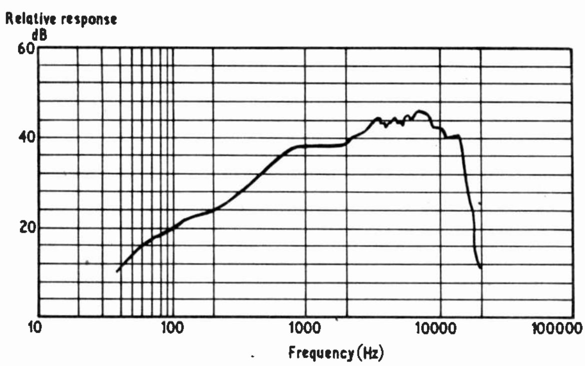


Fig. 5.1. The response characteristic of a driver unit in free air and unmounted

To produce 40Hz without interaction, a baffle of 14ft × 14ft is needed although in practice the walls and floor in proximity reduce this dimension somewhat. In order that there should be no air coupling between the front and rear of the cone, the baffle should theoretically be of infinite size. If a smaller baffle is "folded" back on itself to produce an air tight box round the speaker unit, there is also no interaction between the front and rear of the cone.

This box is called an infinite baffle enclosure.

THE SEALED BOX

It is obvious, however, that movements of the cone will produce compressions and rarefactions of the air within this sealed box and, due to the elasticity of air, the loudspeaker cone will not accurately follow the electrical signals fed to its voice coil.

Sound waves from the rear of the cone will also be reflected from the back of this cabinet. These waves will then pass forward through the thin speaker cone, producing the undesirable effect known as "honking".

Standing waves within the cabinet will also produce serious colouration to the sound emitted by the system.

To reduce these effects the cabinet is filled with a loose packing of fibrous material. BAF wadding, cotton wool, fibre glass and wool fibre have all been used for this purpose.

The filling, damping the effect of the elasticity of the air, reduces distortion due to non-linear movement of the voice coil. It also reduces reflections from the interior walls and damps standing waves.

THE CONE

The cone of a loudspeaker acts as a piston which pumps air. It is designed to follow, as accurately as possible, the electrical signal fed to its voice coil. In order to keep the voice coil centred within the poles of the magnet, a spider or diaphragm is needed. Peripheral suspensions provides a restoring force for cone movements.

Both these devices reduce the ability of the cone to follow the electrical signal applied to the voice coil. This non-linearity gives rise to distortion which only careful design can reduce. In a small enclosure the cone is of small diameter and, in order to pump a useful volume of air comparable to its bigger brothers in other systems, it has to travel back and forth with greater amplitude.

This is also a cause of non-linear distortion and its effect is reduced by using special soft Neoprene or rubber roll cone suspensions and very flexible spiders or diaphragms.

The pole pieces of the magnet also have to be longer to maintain the magnetic flux acting upon the voice coil during its long incursions. To maintain this flux over the longer poles, more powerful magnets are required. Ceramic magnets, with their higher flux-to-weight ratio, are commonly used.

These speakers are called "long throw" drive units.

To summarise, a sealed enclosure or infinite baffle loudspeaker needs specially designed long throw drive units. The cabinet also has to be lagged adequately to reduce reflections, standing waves and to damp the effects of the elasticity of the air sealed in the enclosure.

A long throw loudspeaker is designed to suit a cabinet of given volume. Provided the cabinet is of that volume, its general shape is of little importance. Ideally the front/back dimension is kept around $1\frac{1}{2}$ times the diameter of the bass drive unit.

DESIGN

It is possible to design single speaker drive units to cover the entire audio spectrum but due to the compromises made in such units to give a response that is well maintained throughout, it is more common to use specialised speakers for various parts of the sound spectrum. The simplest form is to use a bass drive unit together with a high frequency speaker.

A network is used to divide the spectrum electrically to feed each speaker with its particular frequency range as shown in Fig. 5.2. The spectrum is sometimes split into three parts with a bass unit, a mid-range unit, a high frequency unit and a suitable network to feed them (Fig. 5.3). Even more complex methods can be used to provide specialised speakers for various parts of the audible spectrum. Crossover networks for such systems become very complex. The bass, mid-range and high frequency speakers are called woofers, squawkers and tweeters respectively.

Fig. 5.4 shows the relative acoustic power plotted against frequency in speech and music. Most of the power is in the range 10Hz to 300Hz with a smaller proportion in the range 300Hz to 5kHz and an even smaller proportion in the range above 5kHz.

The human ear is at its most sensitive in the mid-range from 300Hz to 5kHz and good midrange quality is thus essential together with a smooth crossover from bass to midrange.

The Rondo enclosure utilises two identical bass drive units, each capable of good response up to 5kHz. Both are used in the range up to 300Hz whilst only one continues up to 5kHz.

This provides extra power in the lower range by the use of two units to overcome the bass response deficiency of the infinite baffle enclosure.

Additionally, a smooth crossover to the mid-range is achieved by using speakers of the same tonal

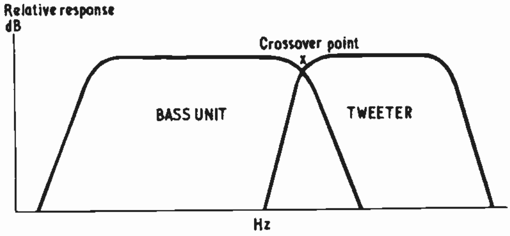


Fig. 5.2. Simplified illustration of the division of the frequency spectrum to the two speakers in a double-driver system

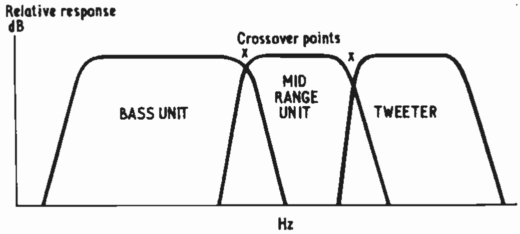


Fig. 5.3. The spectrum division used to feed a three-driver system.

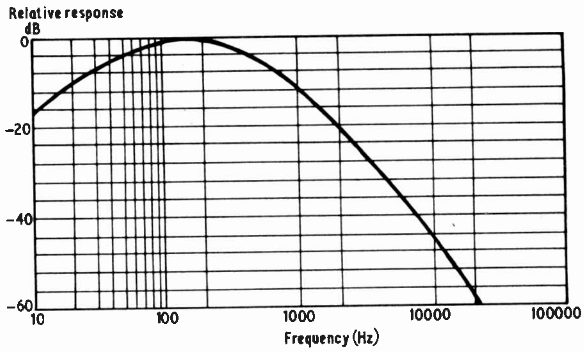


Fig. 5.4. The relative accoustic power present in average speech and music, plotted against frequency.

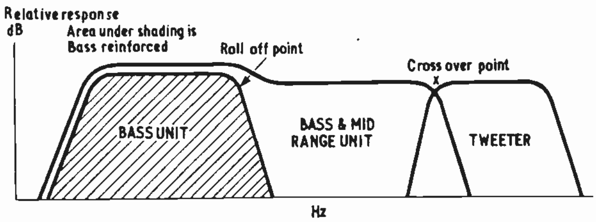


Fig. 5.5. The theoretical response curve of the driver units

character. The upper range is covered by two tweeters in parallel. The crossover network shown in Fig. 5.7 provides the correct range to each unit.

The bass and mid-range units are in fact HIF 13J's with an impedance of 8Ω, a flux density of 44,000 Maxwells, fundamental resonance of 35Hz, 10W sine wave power capacity and a frequency range of from 30Hz to 5kHz at the 3dB points. The tweeters are TW6Bi units with an impedance of 15Ω to 16Ω, flux density of 13,200 Maxwells, fundamental resonance at 2kHz, 2W sine wave power capacity and a frequency range from 3kHz to 20kHz at the 4dB points.

Fig. 5.5 shows the theoretical overall response curves for the drivers.

THE PRACTICAL DESIGN

The cabinets should be as solidly built as possible. Rigidity of the cabinet wall is essential to avoid coloration caused by sounds emitted by the walls. High density chipboard, plywood or hard timber is advisable for a cabinet of the volume of the Rondo system. The thicker the material the better but 15mm is a good minimum value from the constructional point of view.

The author does not recommend veneered chipboard offered under various trade names. Many of these makes of board are of low density and are difficult to work due to the fibrous nature of the chipboard core. If chipboard is used it is essential to ensure that the board is of high density material.

The front baffle must be cut or formed so that the speakers can be mounted from the front. This precaution is important for both the mid-range unit and the tweeters as mounting from the back reduces the upper frequency response of the drive units by an effect known as "tunnel effect." In the case of the tweeter it also reduces the polar response. The polar response of the two tweeters properly mounted is wide but if mounted wrongly it will be limited to a narrow beam.

Fig. 5.6 and Table 5.1 shows the overall dimensions and directions for making the speaker enclosure.

Provided that a strong, reasonably air-tight and rigid cabinet is made, the constructor may fabricate it from raw materials and can use an assembly method suited to his particular tool kit, materials and skills. The two methods shown here exemplify the simpler forms of a fairly wide range available.

COVERING

The choice of material for covering the front of the speaker is rather important. Only materials specifically manufactured for use in covering loudspeaker fronts should be used. Tygan and Vynair are two commonly available. Expanded aluminium mesh is also good, although perhaps a little dated in style. It is most important to back expanded aluminium with soft foam or cloth, with the appropriate apertures for the drive units cut out. This reduces vibration of the metal.

In recent months a new material called Declon has been introduced. It has all the best features for speaker fronts. It is an open pore foam that virtually passes all sounds in the audio spectrum without attenuation. It is black, but can be lightly sprayed with an aerosol paint to suit the constructor's taste. It is washable and seems the perfect solution to speaker fronts. A number of major speaker manufacturers are now using Declon, in high quality and expensive units. In addition, it can easily be held in place using one of the modern hooked plastic retainers such as Velcro strip.

FILLING

Undoubtedly the best material for lagging is long hair wool followed by best quality cotton wool. It has been found that bonded acetate fibres (BAF) and materials such as Dacron and Terylene in similar form, give satisfactory results. They are easier to handle and can be contained within the cabinet without restraining bags (to stop loose hairs and fibres encroaching on the drive units). Six pieces cut to the size of the front baffle, 2 inches thick, are

ENCLOSURE MATERIALS

13mm or thicker high density chipboard, blockboard or hard timber.
3mm hardboard (If front baffle not routed from one part)
Outer coating material if used (PVC, Rexine, wood veneer, etc.)
Internal lagging material (see text), 6 lengths 2in thick and area of front baffle
Front cover material, Delcron or like to suit, same area as front baffle. Velcro strip to fit if required.
2 Bass and Mid-range speakers, HIF 13J, 8 ohm, 10W, 5⅛in nominal dia.
2 Tweeters, TW6Bi, 15–16 ohm, 2W, 2 5/16in nominal dia.
Independent parts or complete kits of parts are available from various advertisers.

Table 5.1: ASSEMBLY SEQUENCE

1. Bond front baffle and facia together firmly
2. Mount speakers securely from front using 13mm × No. 6 gauge Rd.Hd. screws applying Sealastic prior to assembly if needed
3. Mount crossover network board to terminal board on rear baffle and set aside for final assembly
4. Apply adhesive to top and bottom edges of sides and to corresponding areas of top and bottom panels
5. Offer the parts up together making certain they are square and finalise the joints using 13mm panel pins
6. Allow adhesive to set then offer up front baffle to the assembly using adhesive and pins as before
7. Connect the crossover network outputs to their respective speakers using fairly long flying leads to allow for insertion of the filling material
8. Insert filling material in rolls as shown
9. Caulk the rear enclosure opening using Sealastic type material and offer up the rear baffle. Screw into place using 38mm, No. 6 gauge C.S. woodscrews
10. Apply speaker covering or grille and finish enclosure to taste

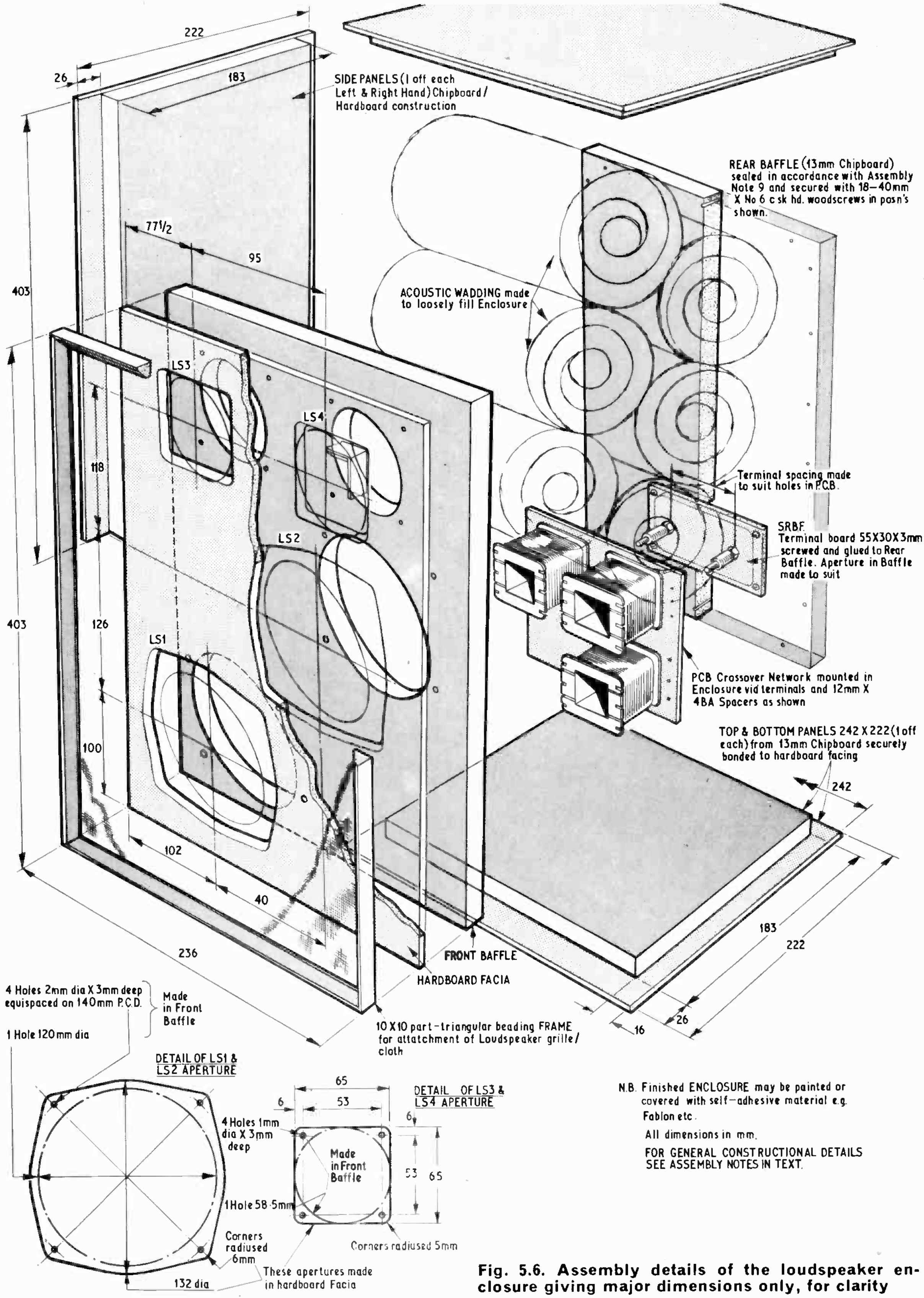


Fig. 5.6. Assembly details of the loudspeaker enclosure giving major dimensions only, for clarity

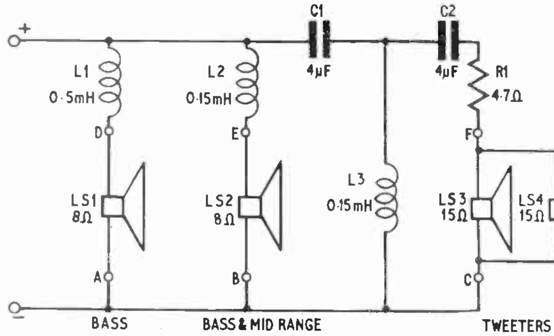


Fig. 5.7. The Rondo crossover network circuit diagram

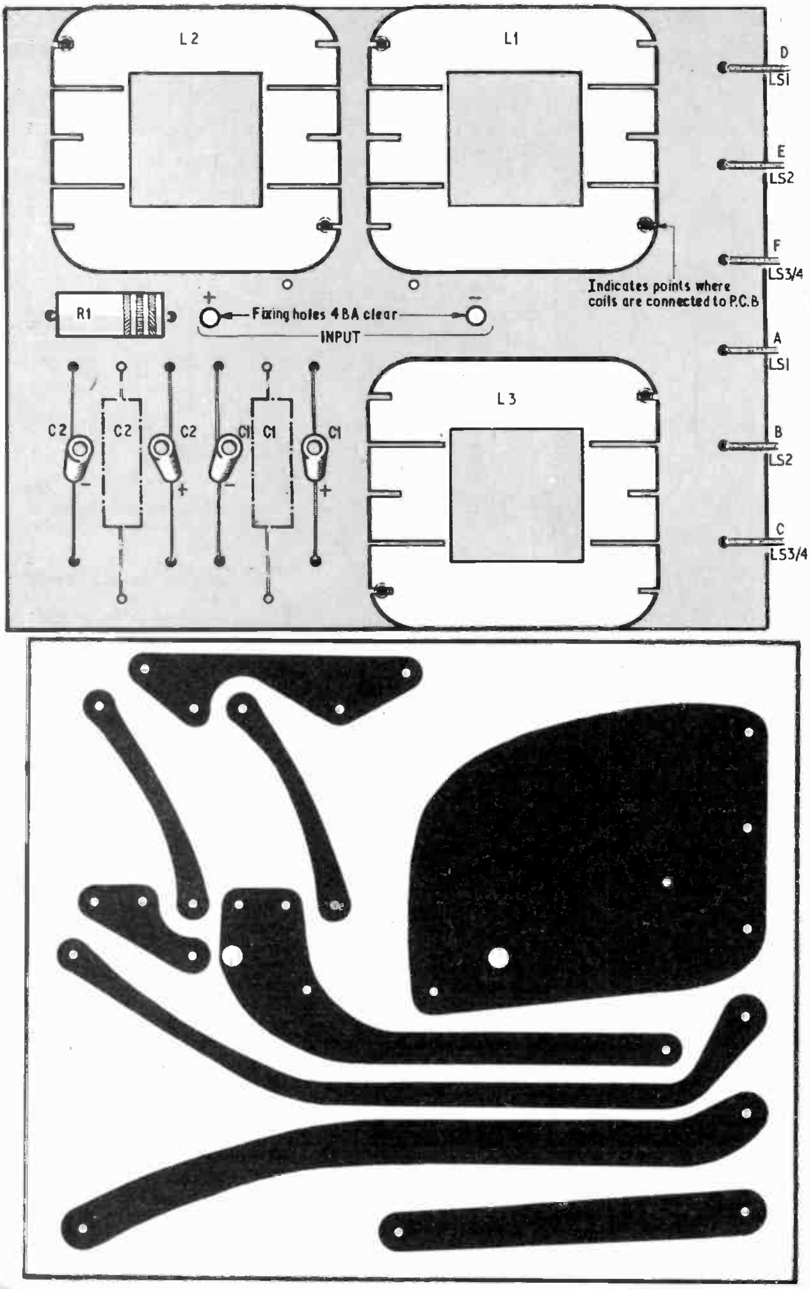


Fig. 5.8. Printed circuit master for the crossover network and board assembly

Table 5.2:

L1	**155 Turns**	**0·9mm wire ¾in former 0·5mH**
L2 & L3	**85 Turns**	**1·0mm wire ¾in former 0·15mH**

COMPONENTS . . .

CROSSOVER NETWORK

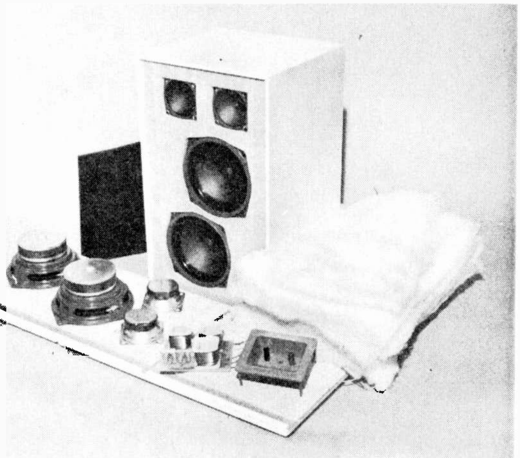
Capacitors
C1 & 2 4µF paper, polyester or non-polarised electrolytics, *or* 10µF, 16V (or above) electrolytics connected back-to-back to give required value

Inductors
L1 0·5mH (see Table 5.2)
L2 & 3 0·15mH (see Table 5.2)

Resistors
R1 4·7Ω 2W carbon non-inductive

Miscellaneous
3 Coilformers ¾in square (GKN Type BA35–12 suit)
8m of 1mm enam. copper wire
28m of 0·9mm enam. copper wire
Copper clad laminate etched to suit

PE RONDO



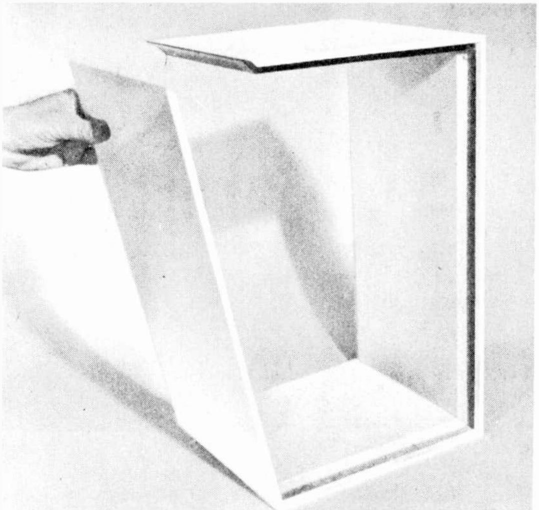


Fig. 5.9. Alternative method of assembly using carefully mitred joints and the backing material as an assembly support element.

ideal. They are rolled loosely and set in the cabinet in two layers of three.

THE CROSSOVER

The crossover network circuit diagram is shown in Fig. 5.7 and its printed circuit and layout in Fig. 5.8. The coil winding data is shown in Table 5.2. The bobbins can readily be wound by hand. If the coils are neat and tight then anchoring to the PC board using the slots in the bobbins as guides will hold them in place. If the windings are rather loose or sloppy then masking tape can be used to bind them firmly in position.

The PC board layout used provides space for either two non-polarised polyester, paper or similar good quality capacitors, or two reversible electrolytic capacitors, or two pairs of polarised electrolytic capacitors back to back as shown in the layout.

The crossover network is placed in the back of the cabinet, firmly secured to the walls or back. It may be supported by the terminals used to connect the crossover electrically to the signal supply lines and indeed the PCB is suited to drilling for just this purpose as shown in Fig. 5.8.

The inputs may also be wired to a DIN socket and the outputs are connected to the appropriate speaker drive units.

If one uses the method of construction shown in Fig. 5.9, where the corner joints are mitred and in fact the assembly is facilitated using a "skin" of plastic or veneer material this will require machines capable of producing perfect mitred joints in the main chipboard core leaving only the veneered surface uncut. The veneered surface is finished and polished with a flexible polisher, or cabinets may be finished with flexible coloured vinyl surfaces or the like.

Grooves for the front and back, together with the mitre grooves, are coated wih PVA glue and the skin is then simply "wrapped" round the front and back baffles. The whole comes together precisely, giving mitre and front-back seals. The operation is descriptively called "wrapping" and the product a "wrap-round".

Such an assembly will require fairly sophisticated woodworking equipment.

As it is important to ensure an airtight assembly it is quite easy to seal any small holes or gaps with a modern bath caulking material such as Sealastic.

Note: *The mounting socket for suitable pick-up input/s was not shown in Fig. 3.4. Thus one or two holes are required for a Philips stereo socket or two Phono sockets with associated wiring internally of the trough to the pre-amplifier inputs.*

Next month: Pick-ups and Turntables for Quadraphonics

DECODER TESTING

Constructors who have the necessary test equipment may wish to carry out the performance verification test detailed below.

EQUIPMENT REQUIRED

(a) An audio oscillator capable of 1·5V r.m.s. output at 2·2kHz.

(b) An a.c. millivoltmeter with 1MΩ input impedance minimum.

(c) A 600 Ω, ½W, 5% resistor (two 1·2k Ω in parallel may be easier to obtain).

With the decoder totally disconnected from any equipment other than the test equipment and a +20V well-smoothed d.c. supply connect the audio oscillator to L_T and the a.c. millivoltmeter to L_F. Connect R_T to earth through the 600 Ω resistor and set the audio oscillator to 2·2kHz and adjust its output, as measured by the a.c. millivoltmeter, to 1·0V r.m.s.

Disconnect the millivoltmeter from L_F and with it measure the other outputs, L_B, R_B, R_F, which should be:

L_B, 630mV ± 80mV; R_B, 630mV ± 80mV; R_F, between 50mV and 100mV.

Repeat the above steps with oscillator connected to R_T and L_T connected to earth through the 600 Ω resistor. Outputs should now be, with R_F set 1·0V r.m.s.: R_B, 630mV ± 80mV; L_B, 630mV ± 80mV; L_F, between 50mV and 100mV.

If the results noted are not attainable careful re-examination of the board layout will most probably show wrong component insertion.

PE Sound Synthesiser 12

KEYBOARD

By G.D. SHAW

LAST month circuits for the keyboard unit divider network, hold circuits, modulation amplifiers and mixer were included. In Fig. 12.1 assembly details are given for these. The envelope shapers are mounted on a separate board shown in Fig. 12.2 which is, in turn, mounted on a small sub-chassis below the control panel. Constructional details of the control panel and envelope shaper sub-chassis are given in Figs. 12.4/3 respectively, while Fig. 12.5 shows the component and wiring arrangement of the control panel.

ADJUSTING THE MAIN CIRCUIT BOARD

Power supply links are fitted only to IC1 and IC2 of the divider circuit then this procedure should be followed.

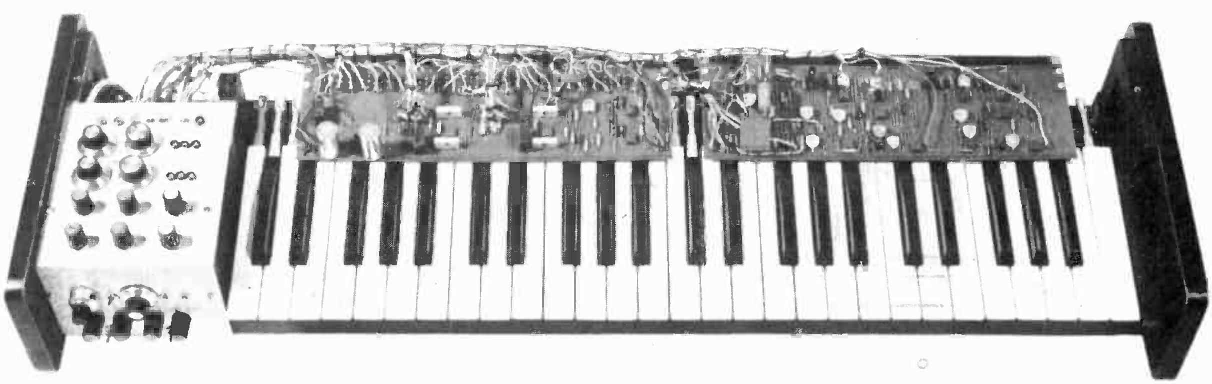
Temporarily connect VR1 (Tune) and VR2 (Span) potentiometers and S1. With power on the board set S1 to bring VR2 into circuit and, monitoring the output of IC1, check that full rotation of VR1 gives an output voltage swing of about 8 volts. Note that the position of VR2 will affect the actual value of the maximum and minimum voltages monitored but will have no effect on the range of VR1.

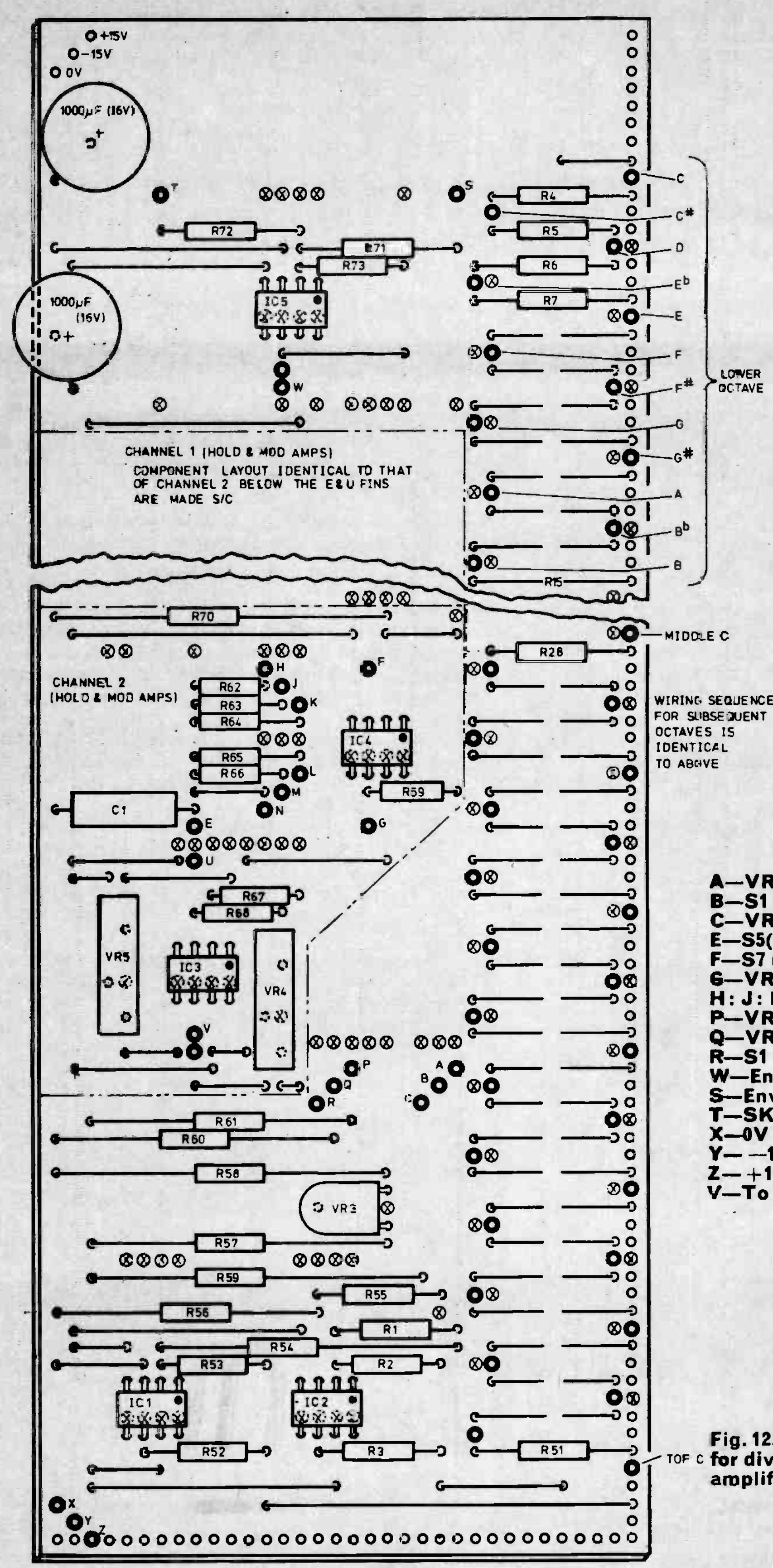
Next, monitor the output of IC2 whilst swinging VR2 through its full range. Here again the output voltage swing should be of the order of 8 volts. Set S1 to the fixed span position and adjust VR1 so that the voltage at the junction of R51-R52 is 6 volts. Transfer the voltmeter leads so that they are now measuring the potential between the junctions of R3-R4 and R51-R52 and adjust VR3 so that a reading of 4 volts is obtained. Adjustment of VR1 should have no effect on this latter reading. The final tuning of the divider network will be described later in this article.

Setting up the hold circuits should follow the pattern described in Part 11 of the series after first connecting the power supply links to the i.c.s concerned. The relative simplicity of the modulation amplifiers and mixer is such that no particular setting up is required.

Note that VR1 is specified as being a semi-precision wirewound potentiometer. For the majority of purposes this type of control will be found to be quite adequate but when the keyboard is to be matched with other musical instruments of the acoustic type it will be found that the ease of matching is greatly facilitated by the substitution of a ten-turn potentiometer for the specified type.

Prototype keyboard unit with cover removed. The circuit board to the left is that detailed in Fig. 12.1, and to the right the v.c.o. assembly





A—**VR1w**
B—**S1**
C—**VR2**
E—**S5(a)**
F—**S7 (1)**
G—**VR7 (1)**
H: J: K: L: M: N—**S4 (1)**
P—**VR1**
Q—**VR1**
R—**S1**
W—**Env. shaper 1**
S—**Env. shaper 2**
T—**SK6 and kbd junction block**
X—**0V**
Y—**−15V**
Z—**+15V**
(X, Y, Z:) **All to V.C.O. board**
V—**To R10 input (V.C.O. 2) and SK1 (2)**

Fig. 12.1. Circuit board layout for divider; hold; modulation amplifiers and mixer

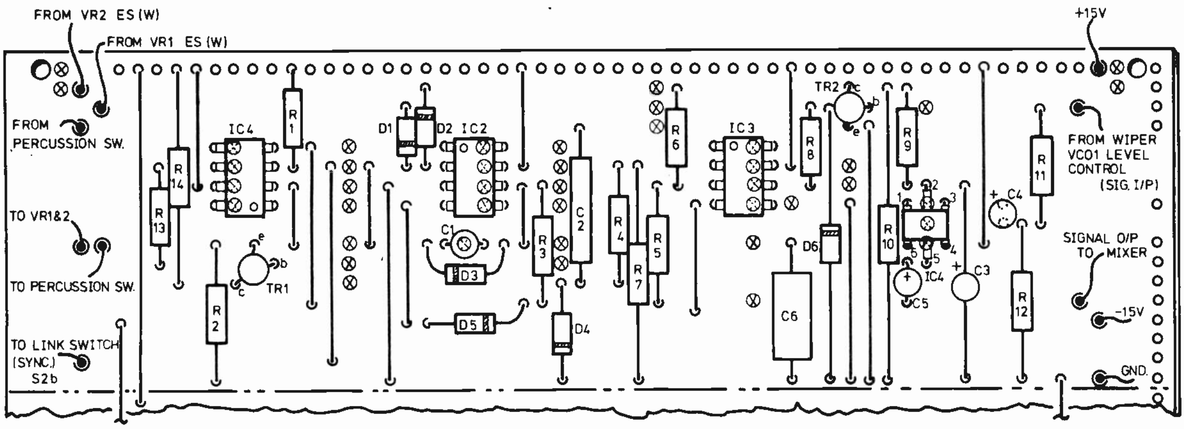


Fig. 12.2. Circuit board layout for keyboard envelope shaper and v.c.a. Only one channel is shown. The second channel is identical

ENVELOPE SHAPER ADJUSTMENT

On completion of assembly of the envelope shaper components make temporary connections to VR1, VR2 and S1, and, with power applied, measure the voltage at pin 2 of the MFC6040. This should be +6V under quiescent conditions, and, with S1 off and −15V applied to the non-inverting input of IC4, will fall to about 4·3V. Monitor pin 2 of the MFC 6040 on the oscilloscope, set VR2, the attack control, to maximum and close S1.

The transient application of −15V to the non-inverting input of IC4 will now result in a negative going pulse at IC4 control input. The pulse width should be about 37·5mS and depth about 2·3V.

With both envelope shapers operating satisfactorily the circuit board may be assembled into its sub-chassis and permanent wire links made with the attack and decay controls.

CONTROL PANEL AND MAIN WIRING HARNESS

Position the control panel components as shown in Fig. 12.5 and complete the component inter-wiring.

Making up and connecting the main harness requires the manipulation of a considerable number of wires and it is perhaps best to try and complete the operation at one sitting. Failing this it will be necessary to make a meticulous record of connections/colour codings in order to avoid the possibility of error.

The wiring operation is simplified if the main harness is broken down into a number of sub-harnesses. It was found expedient to have all the wires one metre in length and then to trim them as and when final connections were made. Connect all the wiring to the control panel first of all and bind

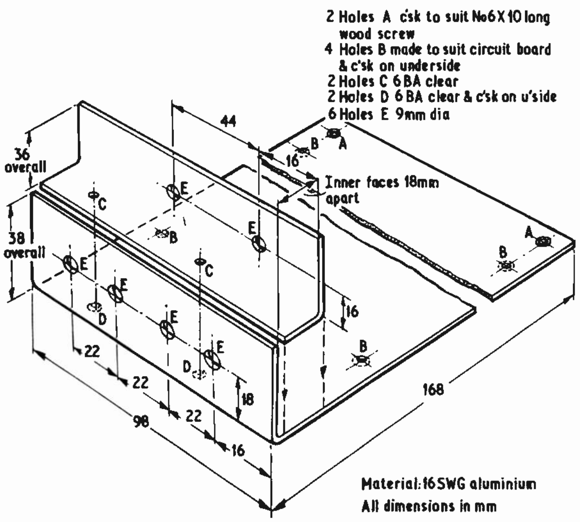
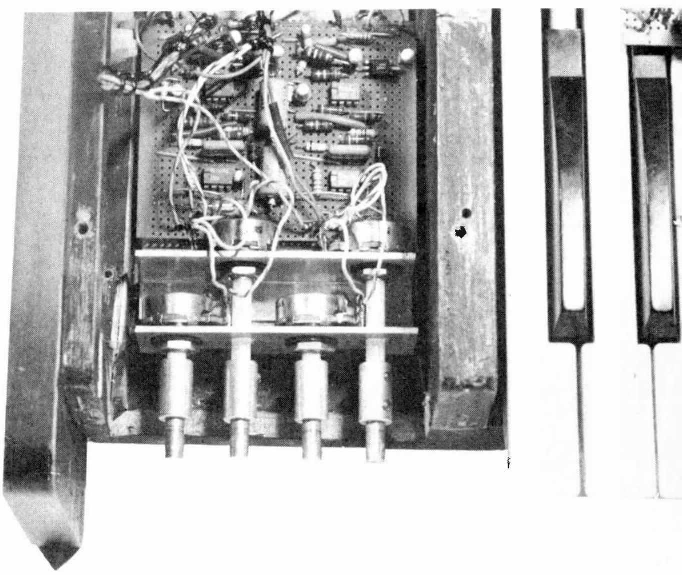


Fig. 12.3. Drilling details of envelope shaper sub-chassis



Showing how the potentiometers are arranged on envelope shaper sub-chassis

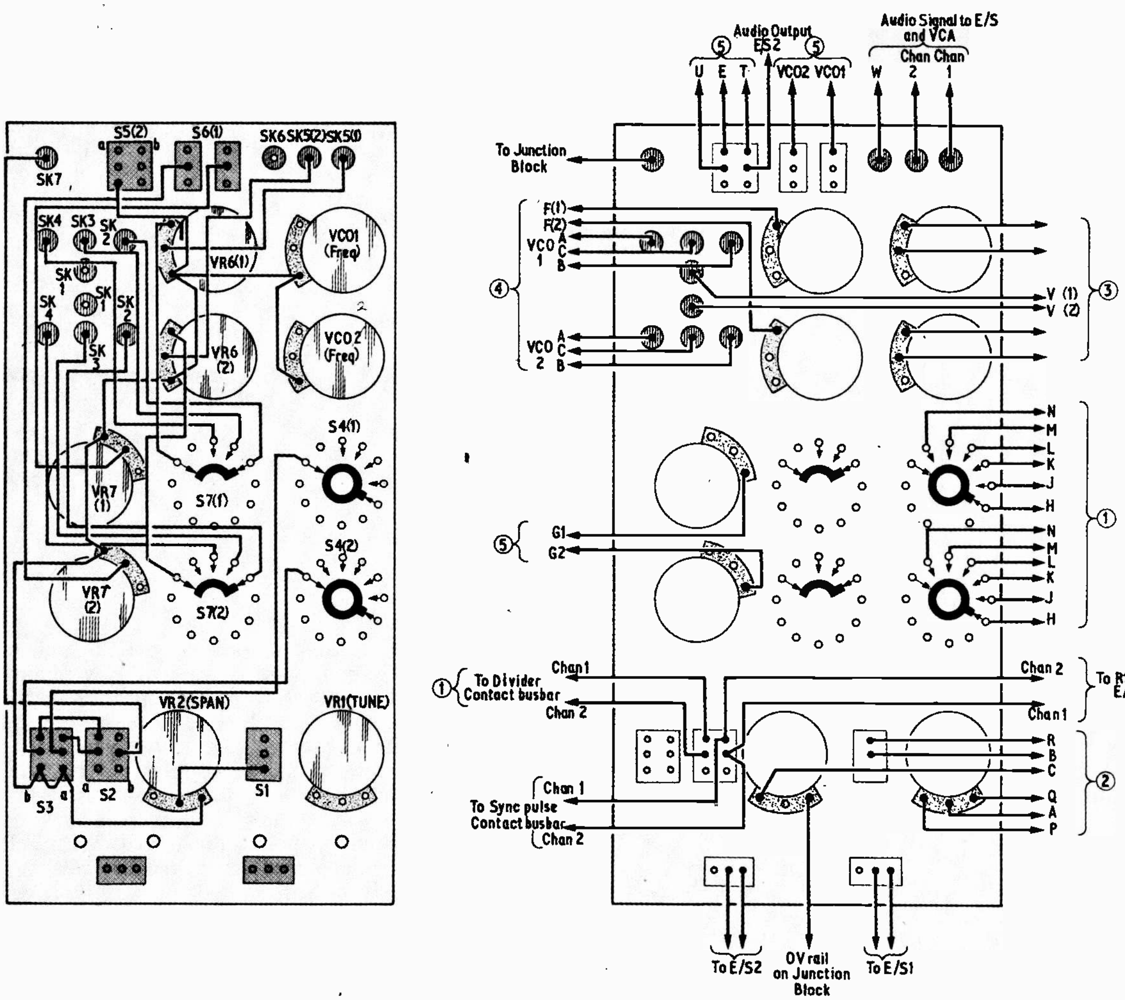


Fig. 12.5. Component layout and wiring of keyboard control panel

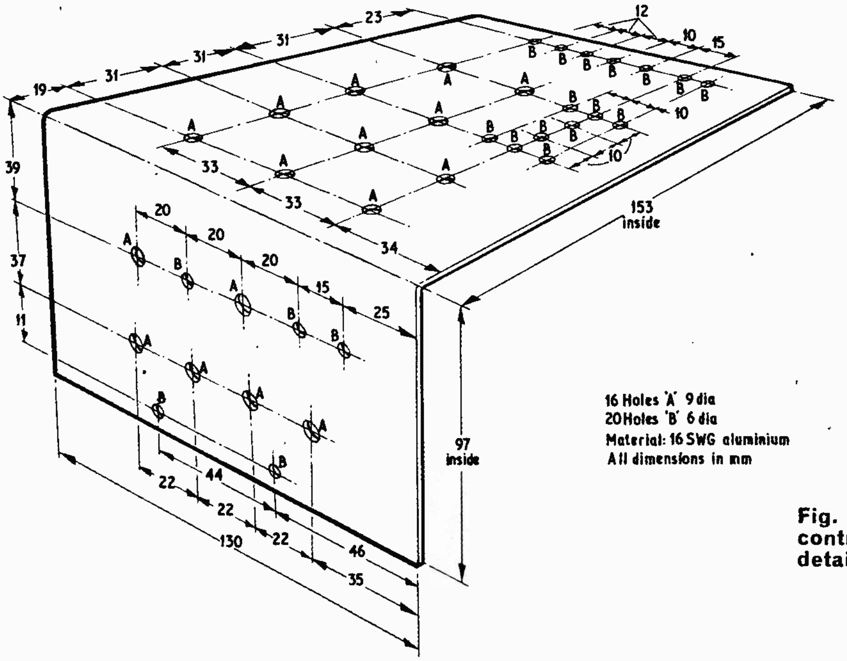


Fig. 12.4. Keyboard control panel drilling details

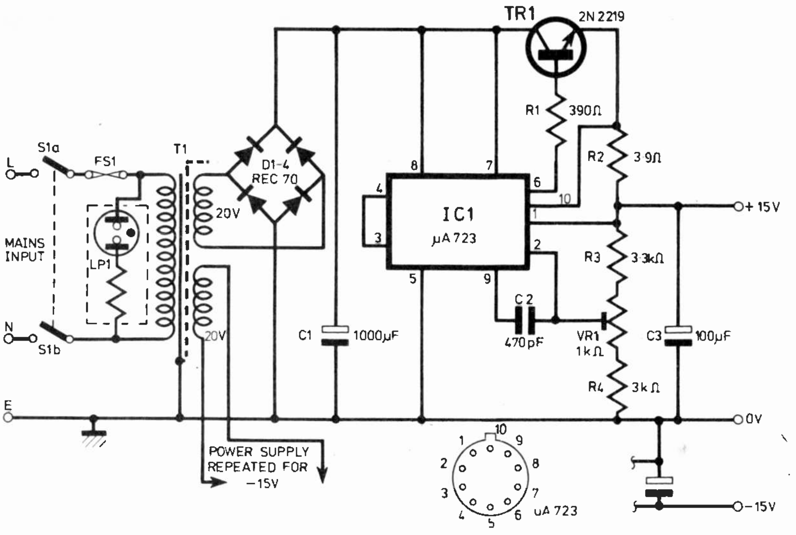
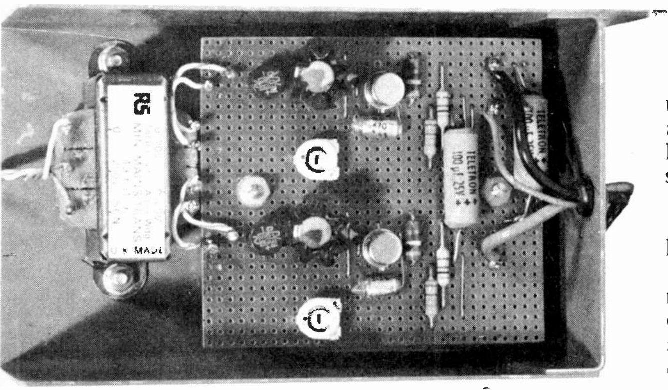


Fig. 12.6. Circuit diagram of one half of keyboard p.s.u. The negative rail half is identical. T1 is a miniature mains transformer with two separate 20V secondaries each rated at 3VA. Resistors are ½W 5% carbon film and the electrolytics at 50V



The completed power supply unit. The metal surround should be grounded to obviate hum pick-up

POWER SUPPLY UNIT

Where it is decided to operate the keyboard as a unit independent of or separate to the modular unit a small power supply unit may be installed within the keyboard housing. In this latter case the output signal from the keyboard may be taken from SK6.

The circuit of the power supply unit is shown in Fig. 12.6. Because there is nothing critical about layout board wiring details are omitted.

The power supply unit, in its casing, should be mounted to the rear of the envelope shaper sub-chassis so that its associated mains plug will be shielded by the casing and thus reduce the possibility of inducting hum into the keyboard circuitry.

Next month: Keyboard housing and final tuning

them loosely into the groups shown. Try to ensure that there are no two wires of the same colour in any one group.

The wiring groups should be brought out of the control panel on the long axis and passing over S6 (1) and (2). With the control panel upside down and with the front face away from the constructor, bend the wire groups at the near edge of the control panel so that they run to the right, and place the assembly to the rear of the keyboard housing with the control panel edge against the baseboard and directly in line with its normal position. In other words the control panel should present the appearance of having been hinged back from its normal, fixed position, and laid on the table. Starting with sub-group 1 the wiring may now be trimmed and soldered individually to its respective pins.

When all groups have been dealt with carefully check each connection and when satisfied of the correctness of each, bind them tightly together into a common harness. Wiring to the envelope shapers should be grouped with the signal input and output leads separate from those carrying the sync pulse and percussive attack signal.

MARKET PLACE

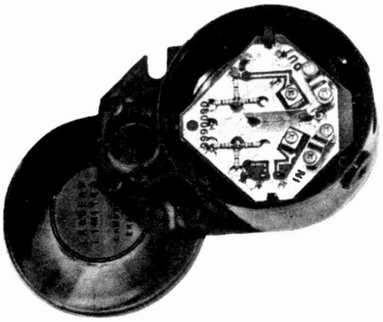
Items mentioned in this feature are usually available from electronic equipment and component retailers advertising in this magazine. However, where a full address is given, enquiries and orders should then be made direct to the firm concerned.

TV AND UHF SIGNAL BOOSTER

Ideally suited for readers in poor signal areas, **Labgear Ltd.** have just introduced a new high gain u.h.f. booster covering all TV and f.m. radio transmissions on bands I to V.

This masthead pre-amplifier has a gain of 22dB and a typical noise level of 3·5dB. Suitable for most standard u.h.f. Vagi aerials of 75 ohm impedance the maximum output for 1 per cent cross modulation is claimed to be 189mV.

Further technical details of the CM6030 signal booster (price £11) and list of nearest stockists can be obtained from Labgear Ltd., Abbey Walk, Cambridge.



F.M. and TV Signal Booster from Labgear

PRINTED WIRING BOARD

A quick and easy method of transferring circuits to practical layouts is claimed by **Ringboard** for their new Ringboard printed circuit.

Made from glass fibre material, the copper backing has areas of circular copper "islands" or rings which take the components that form junction points in the circuit diagram. The two remaining large copper areas on the board can be used as the supply lines.

The method of layout is as follows: where two or more components intersect on the circuit diagram a pencil mark should be made. Where these pencil circles appear it represents a copper ring. When the circuit diagram has been completely marked the components are joined from ring to ring or supply line.

In practice it was found ideal for simple circuits and add-on boards can be used for mounting integrated circuits.

Full particulars can be obtained from Ringboard, 259 Chesterfield Road, Sheffield S8 0RT.

MULTIMETER

Just released onto the U.K. market is a range of high quality test instruments from **Chinaglia Elettrocostruzioni,** one of Italy's leading test gear manufacturers.

Amongst their new products is the Cortina Minor multimeter which should interest readers. Priced at £13, including VAT, this meter has a sensitivity of 20kΩ/V d.c. and 4kΩ/V a.c. and covers 39 ranges. The d.c. voltages covered range from 0-100mV to 0-1500V in eight switched ranges. The a.c. voltages are 0-7·5V to 0-1500V in six switched ranges. The d.c. current measurement available is 0-50μA to 0-2·5A, in five switched ranges, and a.c. current range is 0-25mA to 12·5A, in four switched ranges.

The ohmmeter coverage is in two switched ranges from 0·5Ω up to 10MΩ. The power reading facility ranges from −10dB up to +69dB. A further facility of the meter is a capacitance range from 100 to 100,000μF.

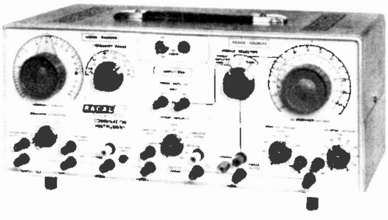
Supplied with each instrument is a shockproof carrying case, two test leads and a detailed instruction booklet. Also available as an extra (£7·80) is a 30kV high voltage probe. This increases the range of the meter and makes it suitable for television work and other high voltage work.

A catalogue covering the full range of test gear and any further information can be obtained from Chinaglia (UK) Ltd., 19, Mulbery Walk, London.

TEST GEAR

Test equipment can, at times, seem, almost by virtue of its nature, to be both expensive and repetitious. Thus any efforts by manufacturers to reduce one or both of these factors is to be applauded.

In this context **Racal Instruments** have developed a laboratory test piece capable of providing one signal generator, two amplifiers and three power sources all in the one case. Identified as the BWD Model 602, this unit is claimed to be capable of replacing more expensive and sophisticated equipment in both laboratory and workshop.



Racal BWD 602 Test Set

The 602 includes a sine/square wave generator covering 0·5Hz to 500kHz; an amplifier with variable gain from 5 to 100, over a bandwidth from 1Hz to 50kHz; an 8 watt d.c. to 20kHz amplifier; a high voltage d.c. stabilised power supply giving +300V at 35mA and −50V at 1mA; a low voltage d.c. supply for 1 to 12V at 2A or 12 to 24V at 1A and finally an a.c. supply giving 55V, 15V and 6·3V all at 1A.

Inputs and outputs of the various items are available both at the front panel and, via an octal plug, at the rear for convenience in wiring in for semi-permanent set-ups.

The various sections can be linked up to form, for example, a 0·5Hz to 20kHz oscillator and an 8W square wave generator.

The Model 602 is available at £150, not unreasonable for precision instrumentation of this multiplicity, and full details can be obtained from Racal Instruments Ltd., Duke Street, Windsor, Berks, SL4 1SB.

QUADRAPHONIC HEADPHONES

Readers may be interested to note that among the many new products from **Eagle International** is a new four-channel headphone.

Quadraphonic Headphones from Eagle

Designated type FF.29 the four transducers in the head sets are, it is claimed, carefully angled in such a way that the effect achieved is similar to strategically placed loudspeakers.

Compatible with practically all quadraphonic systems the 'phones have a frequency range of 20Hz to 20kHz. The impedance of the FF.29 is 8 ohms per channel and the matching impedance is 8 to 16 ohms.

The price of the Eagle FF.29 headphones is £16·80 excluding VAT and they are available from most audio shops.

AUDIO FESTIVAL AND FAIR

A look at the 1973 International Audio Fair held at Olympia, London

THIS year's Audio Fair has managed to present the public with a surprising number of new developments spread over the arts of both sound production and aesthetic appeal despite a rather slow start to the week. Indeed, the initial Trade and Press opening at Olympia was delayed by a matter of hours on the opening day whilst various labour problems were sorted out, and even then very few of the stands and displays were completed before the following day. In fact, it is understood that stand painting was still being completed as late as the Thursday, quite a tribute to the exhibitors who still managed to present a cheerful face and working exhibits despite such problems.

The show was the largest so far held, with a floor area of over 17,000 square metres, some 11,000 of which were taken up with stands. Not really surprising with the market turnover topping the £100 million in 1973. In fact audio is one of the big growth areas of the electronics industry at present.

In conjunction with the exhibition there was a series of lectures and demonstrations covering a wide range of interests, including the P.E. Sound Synthesiser by Douglas Shaw. Other subjects included quadraphonics, recent developments in sound reproduction, the current (and indeed fast growing) broadcast scene and demonstrations of pop music as well as the classics.

LARGE VARIETY

The visitor could be forgiven if he were to have limited his stay to only a few stands in the exhibition hall, not because the displays were poor but for quite the reverse reason. In fact there was all too much to see, extending from cassette equipments to a multiplicity of new tuners and power amplifiers.

All tastes were catered for both in audio quality terms and styling. For example, provided only a sufficiency of cash one could examine and possibly purchase a set of headphones and associated amplifier for £104 obtaining, for this outlay, one of the best sounding headsets ever sampled. However, £104 is rather a lot. The unit in question was the Stax SR-X Mk II Superphone.

In the same sort of price range but as a total system rather than a part, there was the Dynatron 'Gunchest' HFC 65 tuner/amplifier and separate speakers, all housed in units resembling the duelling pistol cases of an earlier age. However, to achieve this sort of elegance one has to set aside £198 and attractive as such equipment is that does seem rather a lot.

However, in the same range from Dynatron there is even more opulence in the form of the "Dorchester" complete home entertainment centre. A tuner/amplifier and Lenco GL 78 transcription deck with a cassette stereo recorder/player unit, all housed in a Queen Anne style cabinet and with associated similarly styled speaker enclosures. All that for a mere £387.

It is always difficult to imagine a large market for such equipments but no doubt quite a few must be sold to justify their manufacture.

KITS IN EVIDENCE

It was very interesting to note the upswing in the general electronic constructor kit market which is clearly gaining momentum. Josty were there in strength with a very wide range of kits extending from industrial control, through instrumentation to the audio, hi-fi and broadcast reception areas and the household gadget market. To support their effort they were introducing a book on electronics covering the areas occupied by their kits.

Similarly equipped with an equally wide range of kits and some interesting cases and associated bits of hardware for the home constructor were Amtron. Indeed there are over 200 kits in the Amtron range, extending from a simple single transistor amplifier up to a digital clock.

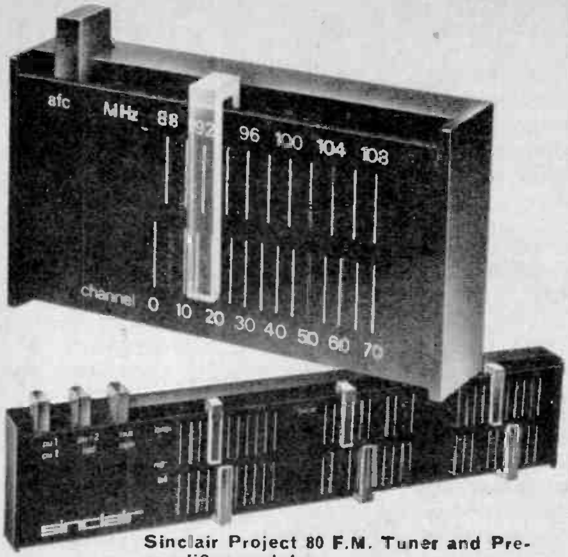
Perhaps not quite considered as kit suppliers are Connoisseur (A. R. Sugden) who were showing both kit and pre-built units including the ever popular BD1 assembly and the latest SAU2 pick-up arm which has a rather attractive lowering mechanism and is, interestingly enough, suited to use with the BD1 and the P.E. Rondo quadraphonic system.

Both KEF and Wharfedale were displaying their ranges of loudspeaker kits including the Glendale 3 and Kingsdale 3 equipments from Wharfedale capable of handling 40 and 60 W respectively.

NEW MODULE RANGE

Turning to amplification equipment, Sinclair used the exhibition as an opportunity to publicise their new Project 80 modules, intended to replace the well-known Project 60 range. The new Project 80 is a series of modules of very attractive form and style which may be used singly or together to form a complete system. They include a pre-amplifier and control unit, an active filter unit, two power amplifiers, three power supply units and the Project 80 f.m. tuner and stereo decoder.

Also new from the same stable is the System 4000 amplifier and a tuner. Both are designed as rugged equipments with attractive modern styling. The amplifier is capable of giving up to 60 W per channel stereo of music power



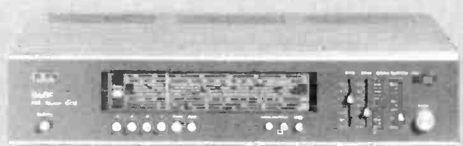
Sinclair Project 80 F.M. Tuner and Pre-amplifier modules

The Scan-Dyna Tuner/Amplifier system and 1400 Deck

This JVC Cassette equipment caters for Quadraphonics

The Stax SR-X earphone system is something to hear even at £104

QAS market this glass-bowl 30W speaker



A Saba 8035 stereo Tuner/Amplifier system

One of the Italian A.P. Selmi "see-thru" speakers

The Ferrograph 20–20 Stereo Amplifier

into 4 ohms. A constant power balance control gives improved volume control without the need for adjustment of balance.

We understand that Sinclair are setting up a new distribution organisation which will involve using major distributors supplying up to 250 official retail stockists and supporting this with an increased field sales team and service back up.

FOUR CHANNEL EQUIPMENT

It goes almost without saying that quadraphonics was of interest to many visitors and exhibitors. There were several interesting (though often not too impressive) demonstrations and it seems clear that this is a section of the market which has yet to settle down with established techniques and equipments.

Of interest in this area was an 8-track, 4-channel cassette deck from JVC using standard 0·15 inch tape. This equipment is indicative of the direction technology is taking sound reproduction in terms of size and capability. The specification includes crosstalk figures of 25dB at 1kHz which is quite something in the circumstances. To do this it uses a special circuit using phase shift and cancellation techniques.

In addition the tape hiss and noise which must arise from using such small tracks is catered for using automatic noise reduction to give a signal-to-noise of 48dB in the 4-channel mode.

Clearly cassettes are the area of the future in many minds. One of the latest developments is a so-called transcription cassette recorder (NEAL model 102) from North East Audio which uses a 3M Wollensak deck and Dolby B to achieve wow and flutter figures of less than 0·15 per cent r.m.s. DIN weighted. Record and replay amplifiers are claimed to have less than 0·1 per cent distortion and crosstalk is said to be better than 45dB. With bandwidth figures of 35Hz to 12kHz, +1 to −3dB for ferric oxide tape and extended to 15kHz for chromium dioxide this is quite a specification to live up to.

NEW TREND

One factor stands out quite strongly from the exhibits, the inclusion of tuners in the basic amplifier equipment. With the advent of the varicap tuner system, phase locked loops, and integrated circuit decoders, it is now more the rule to find equipments, and indeed kits, offered as including the tuner.

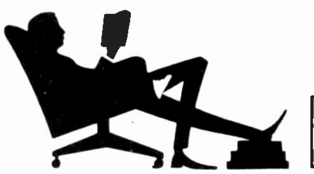
Japanese exhibitions figured strongly in new four-channel tuner/amplifiers with all systems facilities (QS, SQ and CD-4). As we have come to expect from this sector styling and control handling were, in the main, impeccable.

PERSPECTIVE STEREO

Stereo and quad are not to be left to battle it out alone! A three-speaker system demonstrated on the Brahms Manufacturing and Development Co. stand may well appeal to many audiophiles as a sensible compromise.

Described as a new concept in sound the Orthoperspecta system has been developed by Finland's largest audio manufacturers, Salora. A full range speaker placed centrally facing the listeners is reinforced by the outputs from two smaller "directional" speakers positioned either side of the listeners. The side units operate over a restricted range 300Hz to 3,000Hz and the strong reflection at these frequencies enhances the sound pattern and creates an impression of diffused sound, reminiscent of the concert hall.

The model 3000 Orthoperspecta tuner-amplifier employs a matrix system to obtain the necessary signal phasing for diffused sound from normal stereo programme sources. ★



BOOK REVIEWS

SEMICONDUCTORS FROM A TO Z
By Phillip Dahlen
Published by Foulsham-Tab Ltd.
265 pages, 5½ × 8½in. Price £1·50

THIS book is for the man who wants to have everything he needs to know about the semiconductor "family" from the simplest diode to the most complex integrated circuit.

The author begins by defining semiconductors and adds a helpful chapter determining their various characteristics—current gain, voltage drops etc.

Succeeding chapters describe in detail the characteristics and then the applications of field-effect devices such as MOS f.e.t.s; tunnel diodes; varicaps; light-sensitive devices; unijunction transistors; Zener diodes, thyristors; diacs and triacs.

Modern developments are covered very well and even include a chapter on fibre optics!

It is important to note that this book was originally written in America which could cause one or two misunderstandings to the British reader because the mains input voltages towards the end of the book are shown in accordance with American rather than British standard supplies.

Also confusing is the fact that *current* flow is shown as negative to positive in circuit diagrams instead of vice-versa as is usual in this country. However, there is a special chapter at the beginning of the book directed at the British reader clearing up any points which may arise.

At £1·50 this book is good value for money and a useful addition to the constructor's library.

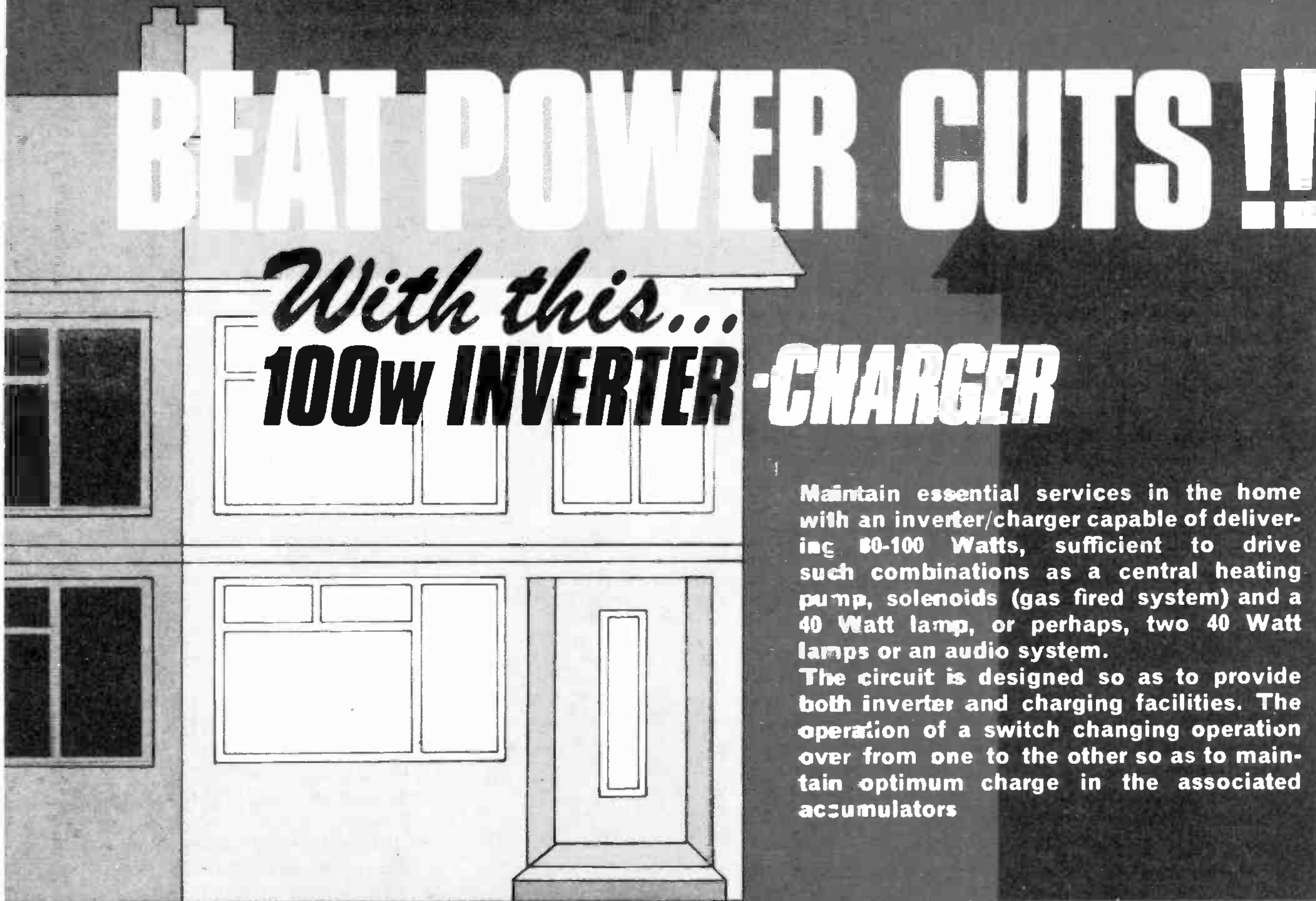
I.L.

RAPID SERVICING OF TRANSISTOR EQUIPMENT (2nd Ed)
By Gordon J. King
Published by Newnes-Butterworths
171 pages, 8½in × 5½in. Price £1·90

FIRST published in 1966 this handbook has now been updated to take into account modern developments. A section on integrated circuits has been included and all reference to valves has been removed.

This book concentrates mainly on the servicing of domestic equipment with numerous hints on rapid fault diagnosis. Some fundamental theory of electronics is included in the earlier part of the book so that some understanding of the circuits can be attained.

Though biased towards fault-finding this book provides a simple introduction to electronics and some useful practical advice. S.R.L.



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PRACTICAL

ELECTRONICS

FEBRUARY ISSUE ON SALE JANUARY 11, 1974

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Assembly time is about 3 hours.

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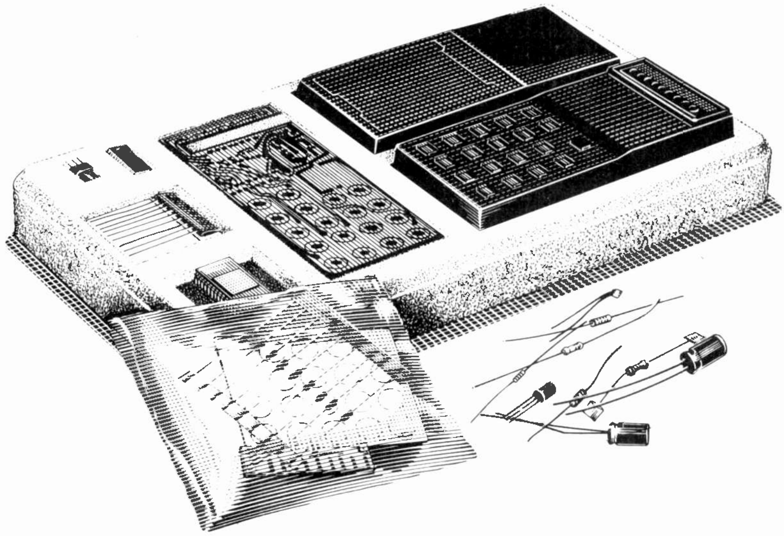
3. Interface chip.
4. Thick-film resistor pack.
5. Case mouldings, with buttons, window and light-up display in position.
6. Printed circuit board.
7. Keyboard panel.
8. Electronic components pack (diodes, resistors, capacitors, transistor).
9. Battery clips and on/off switch.
10. Soft wallet.



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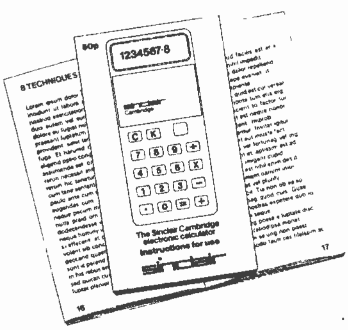
But if you want to get even more out of it, you can go one step further and learn how to unlock the full potential of this piece of electronic technology.



How? It's all explained in this unique booklet, written by a leading calculator design consultant. In its fact-packed 32 pages it explains, step by step, how you can use the Sinclair Cambridge to carry out complex calculations like:

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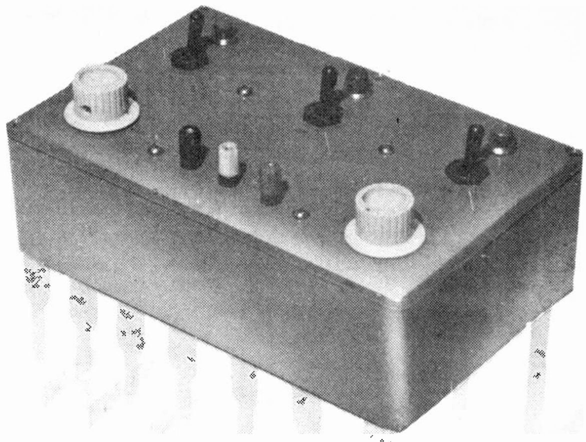
PLEASE PRINT

POWER SUPPLY for I.C's

By J. LEWIS B.Sc.



Now that the cost of integrated circuits is so low many constructors are using them in projects and general experimentation.

The main difficulty which most people encounter is supplying power to the integrated circuits (i.c.s), as most of the linear types require a dual supply rail whose values can range from ±6 to ±18 volts with various combinations of these voltages (for instance the 702 requires $+12$ and -6 volts).

Dry batteries are expensive and can destroy an i.c. as they have no inherent current limitation. To overcome these disadvantages it was decided to build a small unit capable of providing the necessary voltages in the dual range of 5 to 18 volts with a built-in current limiting device.

Required voltages are selected by a switch, ensuring greater accuracy than a potentiometer control. The current limit trips at a preset level (nominally 100mA) turning off the supply rail and lighting an indicator lamp.

TRIP CIRCUIT

The circuit of the complete power supply is shown in Fig. 1. The circuit is duplicated for positive and negative rails and so only the positive side is drawn.

Transistors TR1 to TR4 form the current trip circuit and indicator, and TR5 and IC1 form the voltage regulator.

To follow the operation of the circuit let us first consider the trip circuit. As the current through R4 increases, the voltage drop across this resistor will also increase. The potentiometer VR1 is used to tap off a preset fraction of this voltage and apply it to the base of TR2, the emitter of which is connected to the more positive side of VR1.

As the voltage drop increases a point will be reached where there is about 0·6 volts across the base-emitter junction of TR2 causing it to go from a non-conducting to a conducting state, which causes TR1, TR3 and TR4 to conduct also. TR1 has the indicator lamp as its collector load. TR3 keeps the circuit latched in the tripped condition by

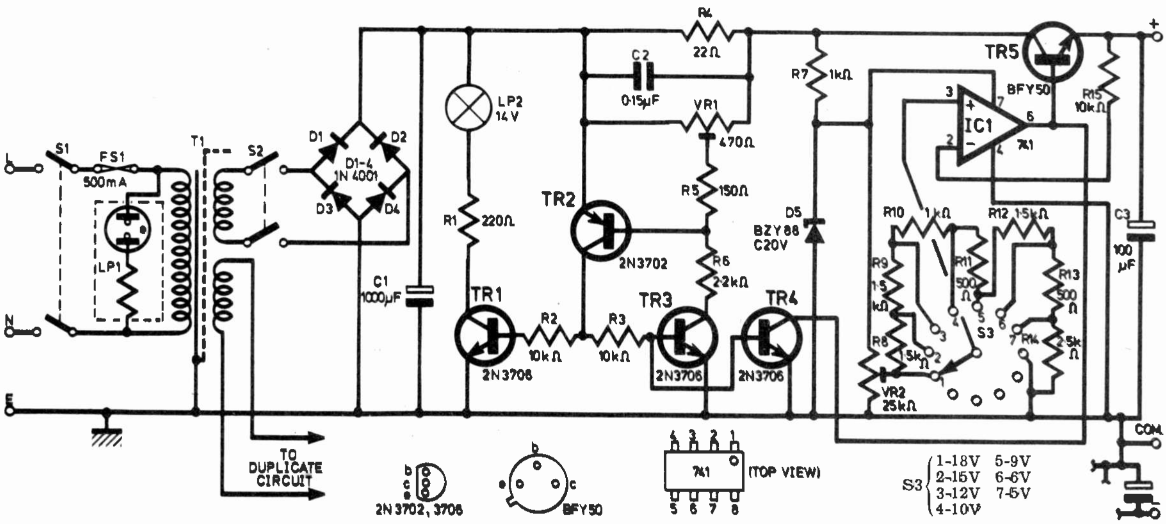


Fig. 1. Circuit diagram of the Power Supply for i.c.s. Note that the circuit to the right of the transformer should be duplicated if a dual power supply is required. Position 8 of S3 is only used to anchor R14, the switch should be stopped at 7 positions

supplying base current to TR2 as it switches on, maintaining this state by regenerative action.

TR4 is also switched on by TR2 and this causes the base of the main regulator transistor (TR5) to be taken to near ground potential, thus reducing the output to near zero volts.

REGULATOR CIRCUIT ACTION

The regulation circuit is of the common series type. IC1 acts as an error detector and its output is used to control the power transistor TR5.

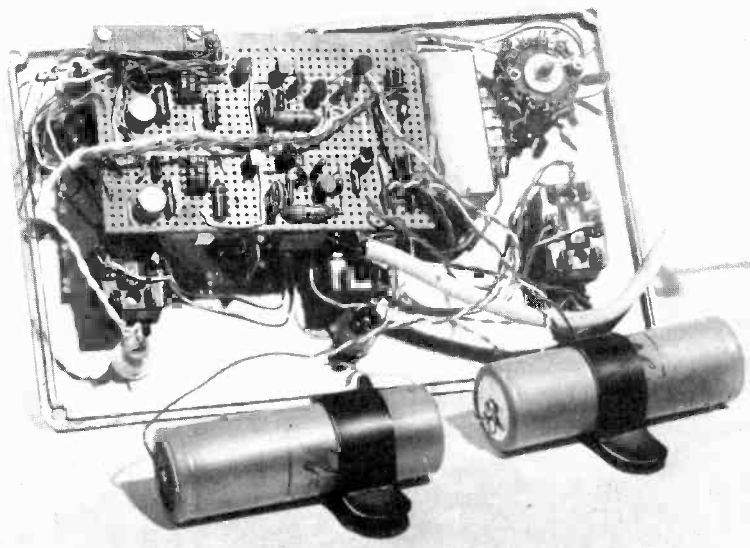
It will be seen that the inverting (−) input of the i.c. is directly coupled to the output *via* R15, whilst the non-inverting (+) input is connected to a reference voltage produced by the resistor chain R8 to R14.

Any difference between these two inputs is amplified by IC1 and fed to the base of TR5 which acts as an emitter follower, maintaining the output voltage at a level near the reference voltage (minus the base-emitter voltage of TR5).

The reference voltage is derived from Zener diode D5 which also supplies current to IC1. Because this diode only has a nominal rating of 20V its actual value may lie between 18·9 and 21·2 volts. Potentiometer VR2 was thus included to bring the voltage at the top of the resistor chain to 18V.

The resistors in the chain should be 1 per cent types, though if you have a large selection of, say, 5 per cent types and an ohmmeter, you may find some of the required values.

Regulation is better than 1 per cent. This means that the output voltage only changes by 1 per cent as the output current is varied from zero to maximum.



Photograph showing the completed power supply viewed from the rear. The rotary switches support the resistor chain and the output terminals support the C3s

COMPONENTS . . .

Resistors

R1	220Ω	R8	1·5kΩ	1%
R2	10kΩ	R9	1·5kΩ	1%
R3	10kΩ	R10	1kΩ	1%
R4	22Ω	R11	500Ω	1%
R5	150Ω	R12	1·5kΩ	1%
R6	2·2kΩ	R13	500Ω	1%
R7	1kΩ	R14	2·5kΩ	1%
		R15	10kΩ	

All 10% $\frac{1}{4}$W unless otherwise stated

Potentiometers

VR1 470Ω vertical skeleton preset
VR2 25kΩ (multiturn type, if available)

Capacitors

C1 1,000μF 50V elect
C2 0·15μF
C3 100μF 20V elect

Semiconductors

TR1, TR3, TR4 2N3706 (3 off)
TR2 2N3702
TR5 BFY50
D1–D4 1N4001 (4 off)
D5 BZY88 C20V
IC1 741 (8 pin dual in line type)

The components above are for one half of the dual power supply. Twice the number of components above are needed for the unit

Transformer

T1 Mains primary, 0–20 0–20V r.m.s. 6VA secondary (R.S. miniature mains type)

Switches

S1 Double pole mains on/off toggle
S2 Double pole double throw toggle (2 off)
S3 1-pole 7-way rotary (Use R.S. miniature Makaswitch components with 1-pole 12-way wafer) (2 off)

Miscellaneous

LP1 Mains indicator neon with integral resistor
LP2 14V 0·75W filament l.e.s. with holder (R.S.) (2 off)
FS1 500mA fuse with holder
4$\frac{1}{2}$in × 7$\frac{1}{4}$in diecast box
Terminals (3 off)
Veroboard 0·1in matrix 2$\frac{3}{8}$in × 3$\frac{3}{4}$in
Capacitor clips to fit C1
4BA and 6BA nuts and bolts, grommets, knobs

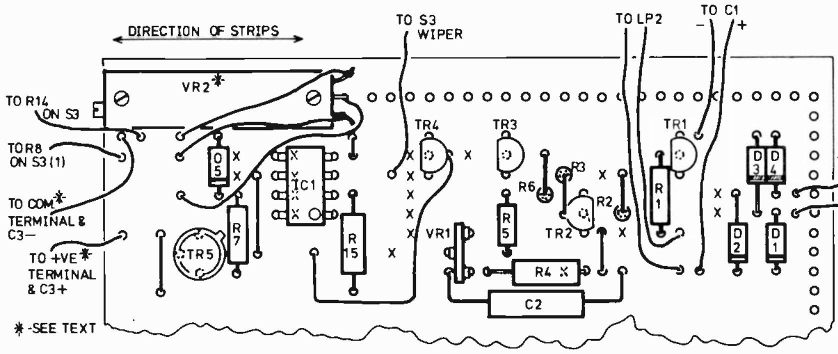


Fig. 2. Construction of the Power Supply for i.c.s. As with the circuit diagram only half of the complete circuit has been shown, the other half being identical to this. The heading photo shows a suggested front panel layout with the S2s mounted either side of S1 and their associated lamps above

CONSTRUCTION

The prototype was built into a diecast box, the majority of the components being mounted on a piece of 0·1in matrix Veroboard as shown in Fig. 2. Note that only one of the two circuits needed is shown, the other being identical.

The prototype used multi-turn pots for VR2 as these enable the 18V to be set with accuracy. In Fig. 2 both VR2s are bolted together at the top edge of the board. Skeleton pots may be used for economy but more care is needed in setting up.

Components can be mounted on the front panel as suggested in the photographs of the prototype, and the Veroboard mounted on a small aluminium bracket using nylon bolts or insulating washers to make sure that the board does not come into contact with the metal box which should be earthed.

Table 1: APPROXIMATE VOLTAGES IN THE CIRCUIT

Location		Voltage (S3 set to 15V) Untripped	Tripped
TR1	e	35	29
	b	35	28·1
	c	0	29
TR2	e	0	0
	b	0	0·75
	c	35	23·3
TR3	e	0	0
	b	0	0·75
	c	35	23·3
TR4	e	0	0
	b	0	0·75
	c	11·4	0·15
TR5	e	15	0
	b	11·4	0·15
	c	35	28·5
IC1	pin 1	0	0
	2	15	0
	3	15	7
	4	0	0
	5	0	0.
	6	11·4	0·15
	7	20·4	9·2
	8	0	0

Capacitor C3 is mounted directly on the output terminals. Note that in Fig. 2 C3 of the unseen half of the board has its positive terminal to common and negative to the negative terminal. The resistors of the reference voltage chain, R8 to R14, are mounted on the switches which are seven-way types using R.S. Makaswitch components.

Take particular care when setting up as there are mains voltages present within the case.

SETTING UP

Setting up is best done with the circuit not fixed in its case. Using a voltmeter, adjust VR2 until the voltage across the resistor chain is as near as possible to 18V. At the same time check that the voltages at points along the chain are those required. Repeat this operation for both supplies.

Connect an ammeter in series with a 3W wirewound potentiometer and connect these across one supply. Switch the supply on and decrease the pot from maximum until the light comes on.

Adjust VR1 until the circuit just trips at 100mA (or as required). Some time may be needed on this stage as the setting of VR1 is quite critical. Repeat for the other supply.

Disconnect the dummy load and place the voltmeter across the outputs in turn and see that the voltages are those required. If not a slight adjustment of VR2 may be needed.

If a fault is suspected the voltages given in Table 1 may be helpful in locating it. The voltages shown are those which would be expected with the output set to 15V, both before and after the circuit has been tripped.

The 741 has output short circuit protection and is unlikely to be the cause of trouble. Suspect other components first.

APPLICATIONS

The resulting power unit is very compact and versatile. It can be used for powering both linear and logic, i.c.s or, indeed, normal transistor circuits, as there is no need to switch both sides of the supply.

At 80mA the ripple on the output was measured as being 5mV peak to peak.

One point to note is that the circuit will trip if a mains borne transient occurs. It may also trip when the voltage setting is being changed. The best procedure to adopt when switching back on is mains off, rails on then mains on. ★

PART 4: MORE INTEGRATED CIRCUIT APPLICATIONS INCLUDING STEREO DECODING

PHASE LOCKED LOOPS

BY J.B. DANCE M.Sc.

LAST month we looked at some applications of phase locked loop integrated circuits concentrating on devices manufactured by Signetics. In this final part devices from other manufacturers will be described with more applications, in particular the use of phase locked loops in stereo decoders.

HARRIS SEMICONDUCTORS

The Harris Semiconductor Company manufacture a range of phase locked loop integrated circuits. They produce two high frequency phase locked loops, types HA-2800 and HA-2805. These devices are essentially similar to one another, but the more expensive HA-2800 can be used over a much wider temperature range and has closer tolerances on some of its parameters.

Both devices are supplied in a 16 pin dual-in-line encapsulation with the connections shown in Fig. 4.1.

The maximum operating frequency of a typical device is 30MHz, but all HA-2800 devices are guaranteed to operate up to at least 25MHz and all HA-2805 devices up to at least 20MHz. These upper frequency limits are set by internal and external stray capacitance.

The manufacturers quote the low frequency limit as about 1kHz, since extremely stable, low leakage capacitors cannot normally be obtained with a value exceeding about 10μF. The variation of the centre frequency with the timing capacitor value is shown in Fig. 4.2.

A special feature of these loops is the high impedance phase detector output which acts as a current source. This is connected externally to the current controlled oscillator (in contrast to the voltage controlled oscillator employed by most other manufacturers).

POWER SUPPLIES

The HA-2800 and HA-2805 are operated from a dual power supply of between $\pm$5V and the absolute maximum rating of $\pm$15V. The devices should not be operated with either power supply absent and each supply should be decoupled close to the device with a capacitor of not less than 0·1μF. The current taken from each of the power supplies is typically 8mA. The absolute maximum permissible power dissipation is 500mW.

INPUT

The input impedance to the phase detector is about 2kΩ. The maximum input voltage is 2V r.m.s.

These phase locked loops are claimed to have a particularly low frequency drift with changes of supply voltage and with temperature.

LOW FREQUENCY PLLs

Harris Semiconductor produce two low frequency phase locked loops, the HA-2825 and an equivalent type, the HA-2820, which can be used over a much wider temperature range.

These devices are produced in a 14 pin dual-in-line encapsulation for the frequency range of 0·01Hz to greater than 3MHz (up to 5MHz for a typical device). The normal power supplies are in the range $\pm$6V to $\pm$12V, the absolute maximum permissible total voltage across the device being 27V.

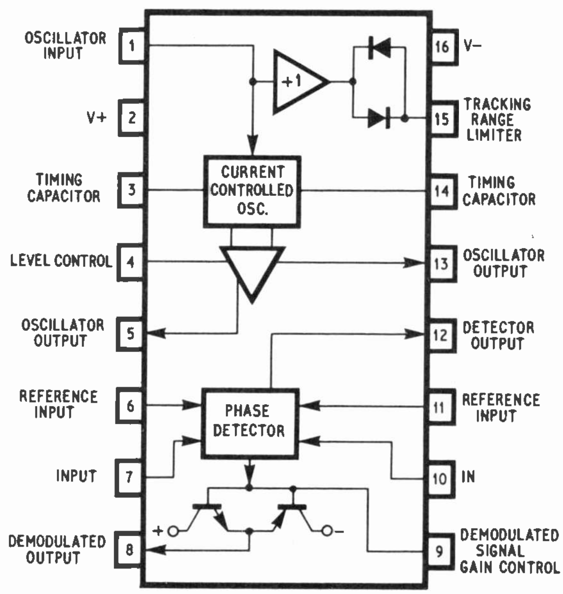


Fig. 4.1. Internal block diagram of Harris Semiconductors phase locked loops type HA-2800 and HA-2805

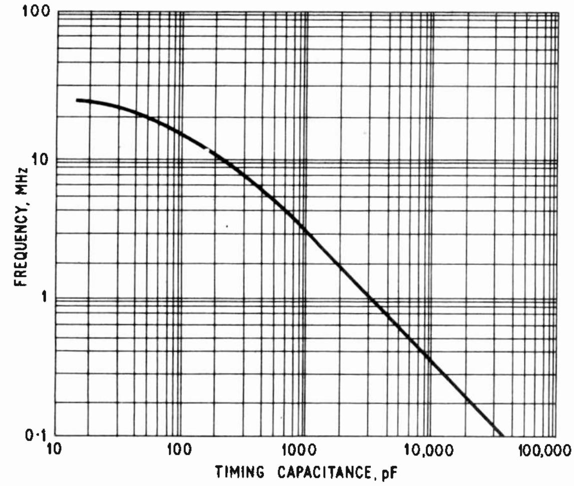


Fig. 4.2. Variation of centre frequency with timing capacitor in the Harris phase locked loop i.c.s

A 1μF capacitor will produce a frequency of about 300Hz when using a 540 ohm timing resistor. The frequency can be altered over a 10:1 range by changing the value of the timing resistor.

The phase detector employed in these devices has à high output impedance for connecting to the oscillator control input through a suitable low-pass filter. The two phase detector outputs are isolated from one another, so different filters can be employed in each output circuit without any interaction.

These devices can be employed in f.m. modulators and demodulators, frequency shift keying (f.s.k.) applications, frequency multiplication, industrial speed control, etc.

AVAILABILITY

The HA-2800 is available at £23·83, the HA-2805 at £10·34, and the HA-2825 at £6·66 from G.D.S. (Marketing) Ltd., Bath Road, Salt Hill, Slough, Buckinghamshire, together with some application reports.

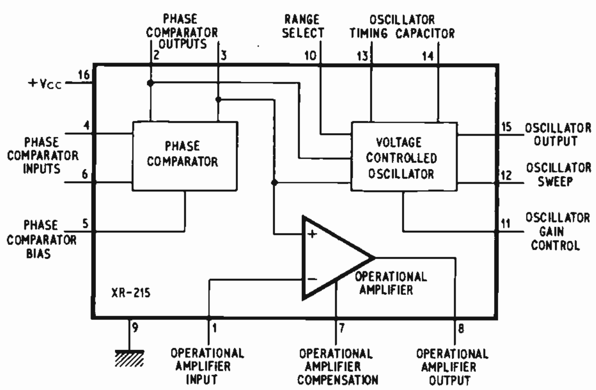


Fig. 4.3. Internal block diagram of the Exar XR-215 phase locked loop integrated circuit

THE XR-215

Another type of high frequency phase locked loop, the XR-215, is manufactured by EXAR Integrated Systems Incorporated. The maximum typical operating frequency is 35MHz (minimum value 20MHz for any device of this type). The minimum practical operating frequency is quoted as 0·5Hz, when the timing capacitor is about 500μF.

The XR-215 device is supplied as a 16 pin dual-in-line integrated circuit, as in Fig. 4.3.

The XR-215 can be made into a complete loop by capacitively coupling the output of the voltage controlled oscillator to either of the phase comparator inputs and adding a low-pass filter across the phase comparator output terminals.

A special feature of the XR-215 is the internal operational amplifier it contains. This can be used as an audio pre-amplifier when the device is used as an f.m. demodulator or as a high speed comparator in frequency shift keying demodulators.

The voltage controlled oscillator has frequency sweep, on/off keying, synchronisation and digital programming facilities. Its frequency is very stable and is determined by a single external capacitor.

POWER SUPPLY

The XR-215 has an absolute maximum power supply voltage rating of 26V, but it can operate from a supply as low as 5V. The current consumption is 8 to 15mA at 12V.

The absolute maximum power dissipation is 750mW at 25°C.

FREQUENCY

The variation of the free-running frequency of the voltage controlled oscillator with the value of the capacitor connected between pins 13 and 14 is shown in Fig. 4.4 for two circuit conditions. The frequency is given by the approximate equation:

$$f = \frac{200}{C}(1 + \frac{0{\cdot}6}{R_x})$$

where C is the value of the capacitor connected between pins 13 and 14 in microfarads and R_X is the value of the resistor connected between pins 9 and 10.

The tracking range is adjustable from ±1 per cent to ±15 per cent of the centre frequency.

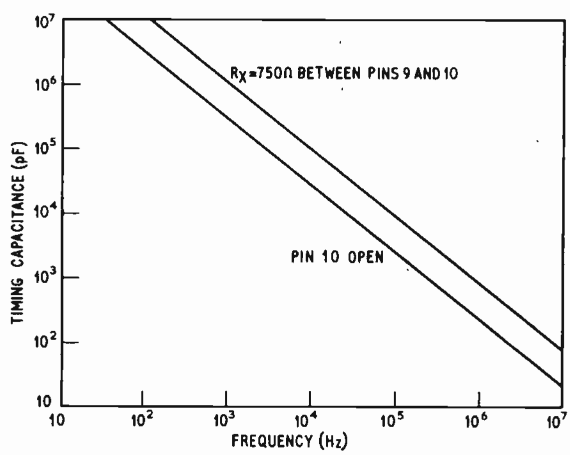


Fig. 4.4. Variation of centre frequency with timing capacitor in the XR-215

PHASE COMPARATOR INPUTS

The input signal is fed to one input of the phase comparator and the other input should be connected to the output of the voltage controlled oscillator to close the loop. Both phase comparator inputs should be returned to a potential mid-way between the supply line voltages.

FREQUENCY SWEEP

The voltage controlled oscillator frequency can be swept over a wide range by applying a varying voltage to pin 12 of the device. The impedance looking into this pin is 50 ohm and a current limiting resistor should therefore be connected in series with this terminal when the facility is used. The maximum current which can safely be drawn from pin 12 is 5mA.

If pin 10 is open circuited, the voltage controlled oscillator can be switched off by applying a positive pulse to pin 12.

FREQUENCY SYNTHESIS

The circuit of Fig. 4.5 shows how the XR-215 can be employed in a frequency synthesiser. A SN7493 (or an equivalent type) 4-bit binary counter is used to divide the output from the voltage controlled oscillator by a certain chosen factor; the output from this frequency divider is fed to the phase comparator. The loop locks when the input frequency is less than the oscillator frequently by this factor.

The low-pass filter capacitors, C3 and C5, are normally chosen to provide a cut-off frequency equal to 0·1 to 2 per cent of the signal frequency. The digital or analogue tuning characteristics of the voltage controlled oscillator can be used to extend the available range of frequencies of the system for any one value of the capacitor C4.

AVAILABILITY

The XR-215 is manufactured in the U.S.A., but is available (together with a detailed data sheet) from Rastra Electronics Ltd., 275-281 King Street, Hammersmith, London, W6 9NF at about £15·20 each in small quantities.

THE XR-210

The XR-210 is another type of phase locked loop available from the same source at £5·25 in small quantities. It has been designed especially for use as a frequency shift keying modulator/demodulator in the frequency range 0·5Hz to 20MHz, but can also be used for f.m. demodulation, frequency synthesis, etc. It is produced as a 16 pin dual-in-line device and has many features similar to the XR-215.

COS/MOS LOOP

A special feature of the RCA phase locked loop type CD4046A is its very low power consumption. The operating voltage range is 5 to 15V, but the current required is only about 100μA from a 6V supply when the operating frequency is 10kHz. This is of the order of one hundred times less than the current required by most other monolithic loops. At 100kHz the power supply current is 350μA from a 6V supply and 630μA from a 10V supply. This device is ideal for use with battery powered equipment.

The low power consumption is achieved by the use of COS/MOS (complementary symmetry metal oxide semiconductor) circuits. This type of circuitry has many other applications where low power and small size are necessary—such as in quartz controlled wrist-watches.

The CD4046A contains a linear voltage controlled oscillator, two different types of phase comparator, a source follower and a 5·4V Zener diode for power supply regulation.

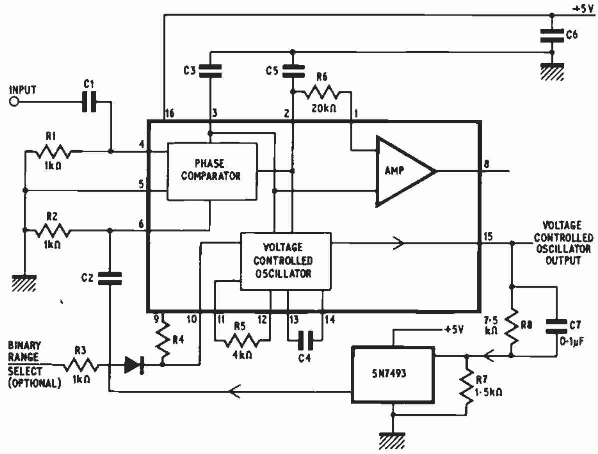


Fig. 4.5. Diagram of the XR-215 used with a TTL divider to form a frequency synthesiser

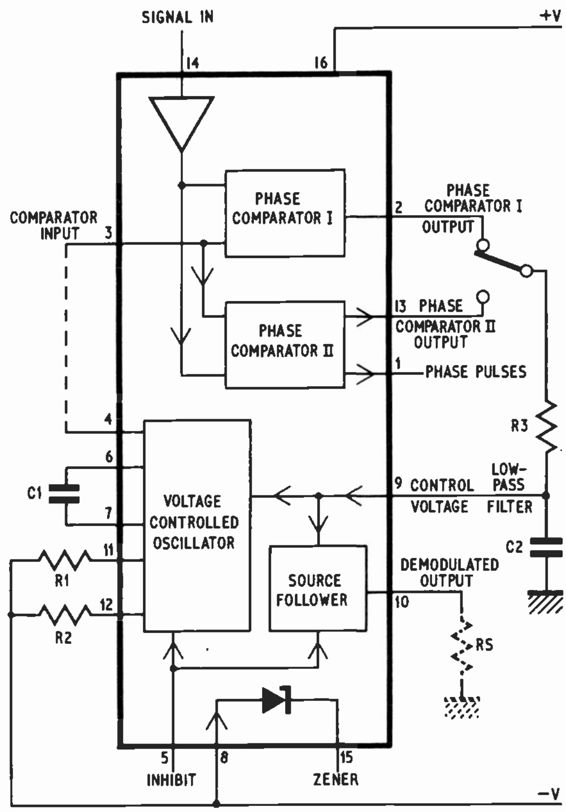


Fig. 4.6. Internal block diagram of the R.C.A. CD4046A phase locked loop with the necessary external components to complete circuit

The CD4046AE is encapsulated in a 16 pin dual-in-line plastic package and is priced at about £3·46. Electrically equivalent devices are available in a dual-in-line ceramic package (CD4046AD) and as a flat pack (CD4046AK).

BASIC CIRCUIT

The basic circuit of the CD4046A is shown in Fig. 4.6. An external timing capacitor, C1, and one or two external resistors (R1 or R1 and R2) are connected in the oscillator circuit. R1 and C1 determine the oscillator frequency range, whilst R2 enables the frequency to be offset if this is required. The typical maximum frequency is 500kHz.

The input impedance of the voltage controlled oscillator is extremely high (one million megohms) and this simplifies the low-pass filter design. The output of the oscillator (pin 4) may be connected directly to the phase comparator input (pin 3) or through a COS/MOS frequency divider such as the RCA type CD4018AE presettable divide-by-"N" circuit. A very low power frequency synthesiser can thus be made.

THE PHASE COMPARATORS

Most phase comparators used in phase locked loops employ analogue amplifiers, but it is not easy to make such amplifiers with well-controlled gain characteristics when using COS/MOS technology. Digital phase comparators are therefore employed in the CD4046A.

Phase comparator I is an exclusive-OR network. When no noise or signal is present at the input, the mean output voltage from this comparator is the average of the supply line potentials. Thus under no signal conditions the oscillator operates at its centre frequency.

When phase comparator II is used under no signal conditions, however, the output of this comparator feeds a control signal to the low-pass filter which causes the oscillator to operate at the minimum frequency of the band.

STEREO DECODERS

Many of the modern types of stereo decoder circuits employ a phase locked loop. In order to understand the operation of such circuits, we must first consider the nature of the stereo multiplex signal which must be decoded.

The demodulated f.m. stereo signal comprises the following parts, as depicted in Fig. 4.7:

(a) An audio signal containing the sum of the left- and right-hand audio channel signals; the maximum frequency contained in these signals is 15kHz. If monaural reception is required, this signal is used as the audio output.

(b) A "left minus right" signal which is modulated onto a 38kHz sub-carrier.
The sub-carrier itself is suppressed to an amplitude of less than one per cent.

(c) A low level 19kHz "pilot tone" which is synchronised with the 38kHz suppressed sub-carrier.

This pilot tone is used to indicate that a stereo signal is being transmitted, but it is also employed as a reference signal by means of which the 38kHz sub-carrier can be generated in the receiver. This sub-carrier signal is required for use in the stereo signal decoder.

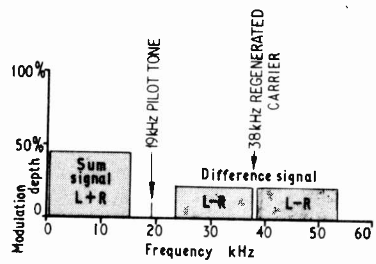


Fig. 4.7. Frequency spectrum of an f.m. stereo signal

The pilot tone is not present when a monaural signal is being transmitted.

Various forms of stereo decoding circuits have been designed which provide "left" and "right" audio signals from the demodulated f.m. signal. In the "switching" type of decoder, the 19kHz pilot tone is extracted by means of a tuned circuit, doubled in frequency to 38kHz and the resulting signal is used to switch the multiplexed input signal.

Such systems suffer from the disadvantage that optimum channel separation cannot be achieved and the inductors required are inconvenient circuit components.

The use of a phase locked loop decoder eliminates problems in setting up the circuit. Any reasonable changes of the component values with time or temperature will not matter, since the loop frequency will be locked to the input frequency.

MONOLITHIC DECODERS

During the past two years, a number of manufacturers have introduced monolithic phase locked loops which have been especially designed for stereo decoding. They offer excellent channel separation (typically better than 40dB) and many of them require no inductors in the external circuit.

THE CA3090

The RCA phase locked loop stereo decoder type CA3090 was introduced in 1971. It is available as the 16 pin CA3090Q quad-in-line device and also as the 16 pin dual-in-line device type CA3090E at about £4·20. Devices of this type can be used in a simple decoding circuit consuming about 22mA, but one adjustable 2mH inductor must be employed.

The internal circuit of the CA3090 (which contains 128 transistors) is shown in block form in Fig. 4.8 together with the external components required to form a complete stereo decoder circuit.

The demodulated multiplexed signal is applied to pin 1 of the CA3090 where the input impedance is about 50 kilohm. The signal is amplified before being fed to both the 19kHz and the 38kHz synchronous detectors.

The phase locked loop itself consists of a voltage controlled oscillator, two "divide-by-two" stages and a 19kHz phase-lock detector (or phase comparator). The free-running frequency of the voltage controlled oscillator is set to 76kHz by the circuit connected to pins 15 and 16.

CIRCUIT OPERATION

The 76kHz signal is divided in frequency to produce a 38kHz signal and two 19kHz signals in phase quadrature with one another. The 19kHz signal present at the input is compared with one of the internally generated 19kHz signals by the phase-lock detector and the phase difference signal is used to lock the oscillator to the pilot tone frequency in the normal way. The loop is thus employed to generate the 38kHz suppressed sub-carrier.

A 19kHz synchronous detector senses the presence of the pilot tone; it switches the Schmitt trigger when the level of this tone exceeds a certain amplitude determined by the resistor connected between pins 7 and 8. The Schmitt trigger circuit causes the lamp in the pin 12 circuit to be illuminated showing that a stereo signal is being received. In addition, the Schmitt trigger activates the 38kHz synchronous "L-R" detector and switches the whole circuit to stereo operation.

A light emitting diode is used as the stereo indicator in the pin 12 circuit of Fig. 4.8. The maximum current which can be passed by the pin 12 circuit is about 14mA, but a transistor amplifier can be used if it is desired to drive a lamp requiring more current. The circuit switches to stereo operation when the pilot tone level at the input is at least 4mV with the values shown, but greater sensitivity can be obtained if necessary. However, at low signal levels monaural operation is to be preferred, since a better signal to noise ratio can be obtained.

OUTPUTS

The output signal from the 38kHz detector and the multiplex input signal are applied to a matrix circuit which provides the required left and right channel outputs. The internal amplifier in each channel provides enough gain for the output to be able to drive most types of amplifier directly. The channel separation is typically 40dB and the total harmonic distortion 0·45 per cent.

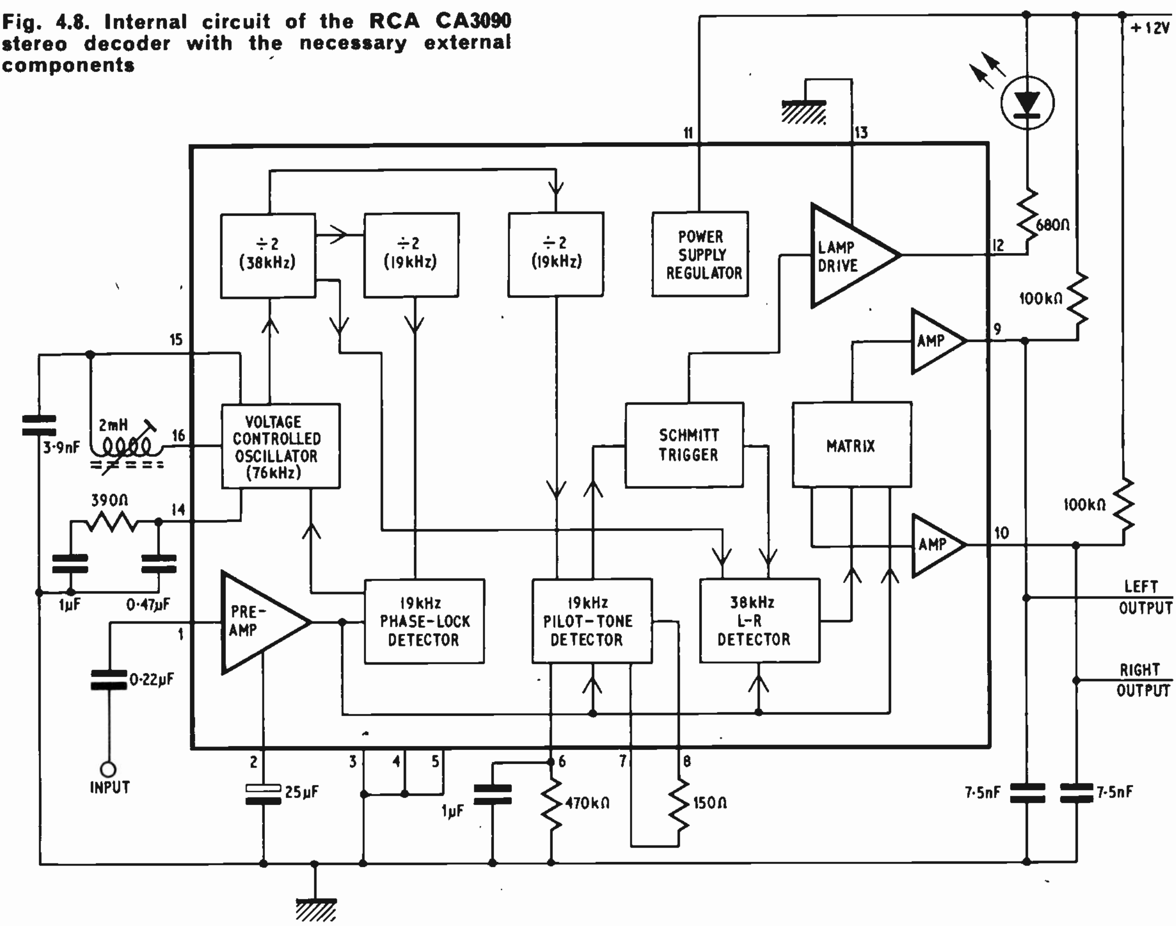
The core of the 2mH inductance is set half way between the points at which the indicator lamp becomes illuminated as the core adjustment is varied. The centre frequency of the voltage controlled oscillator is then very close to 76kHz. The capture range of the loop is typically ±10 per cent of the centre frequency.

MC1310P/SN76115N/LM1310

The Motorola MC1310P is a phase locked loop stereo decoder first introduced in 1972. It is available as a 14 pin dual-in-line plastic device at approximately £3. Equivalent devices are the Texas Instruments' SN76115N and the National Semiconductor type LM1310.

These devices have the advantage that no inductors are required in the external circuit with which

Fig. 4.8. Internal circuit of the RCA CA3090 stereo decoder with the necessary external components



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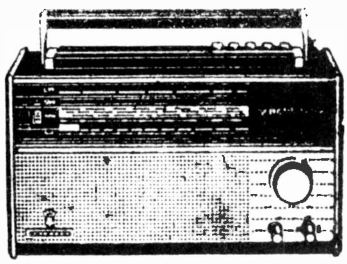

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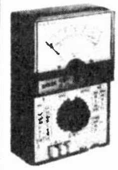

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they are used. This removes the possibility of unwanted coupIng and the inconvenience of coil design. The only components required other than the integrated circuit itself are eight capacitors, four resistors, a variable resistor and an indicator lamp.

The functioning of these devices is essentially similar to that of the CA3090 and therefore it will not be described in detail. The voltage controlled oscillator operates at 76kHz. Its frequency is determined by the values of a capacitor and a variable resistor in the pin 14 circuit (see Fig. 4.9). The oscillator signal is frequency divided to produce two 19kHz signals in phase quadrature to each other and the 38kHz signal required for the decoding.

CIRCUIT ADJUSTMENTS

When the circuit is first used, the potentiometer VR1 of Fig. 4.9 must be adjusted so that the oscillator free running frequency is close to 76kHz. (This operation is comparable with the adjustment of the core of the inductance of Fig. 4.8.)

The frequency adjustment may be carried out by connecting pin 10 to a frequency counter and altering the value of VR1 until the frequency at this pin (3V peak) is 19kHz. If a frequency counter is not available, VR1 should be adjusted to the point at which the indicator lamp remains illuminated at the lowest possible signal amplitude.

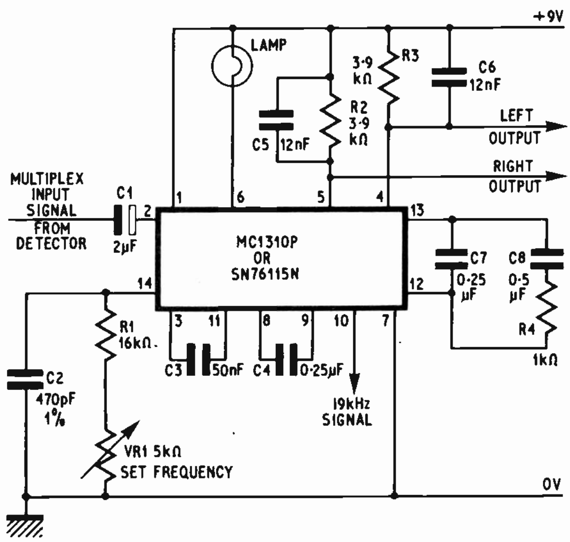

Fig. 4.9. Diagram showing the MC1310P (or an equivalent) used as a stereo decoder

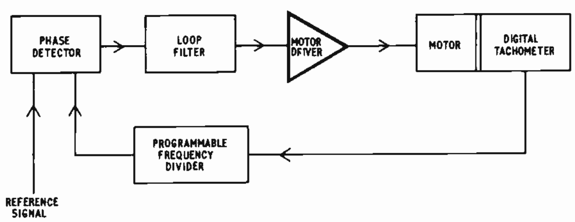

Fig. 4.10. Block diagram showing how the phase locked loop can be used in motor speed control

The capture range is typically ± 3 per cent. It may be increased by reducing C2 and increasing R1 and VR1 in proportion, but this will result in increased beat note distortion at high signal levels due to oscillator phase jitter. Ideally the temperature coefficient of the time constant of C1, R1 and VR1 should be minus 200 parts per million.

The capacitor C4 controls the stereo/monaural switching delay. The switching time constant is equal to C4 multiplied by about 53 kilohm. If pin 8 is earthed, the circuit will operate in the monaural mode only.

INDICATOR LAMP

The MC1310P circuit can drive an indicator lamp in the pin 6 circuit which requires up to 75mA. (A surge limiting circuit is incorporated in the device which restricts the lamp current to about 250mA when the lamp is cold.) The circuit switches to stereo operation when the amplitude of the pilot tone exceeds 16mV at the input.

If a simpler circuit is required at the expense of performance, C7 may be omitted if R4 is reduced to 100 ohm and C8 to 0·25µF.

The audio outputs are 485mV r.m.s. when the input is 560mV. The total harmonic distortion is typically 0·3 per cent and the channel separation 40dB at 1kHz. The input impedance of the device is 50 kilohm.

The minimum value of the load resistors R2 and R3 is determined by the power supply voltage. It is 2·7kΩ, 4·5kΩ and 6·2kΩ for supplies of 8, 10 and 12V respectively. C5 and C6 are the de-emphasis capacitors; their values should be chosen so that they give the desired time constant with R2 and R3 (50µs in the U.K.). If R2 = R3 = 2·7kΩ, C5 = C6 = 18nF, whilst if R2 = R3 = 6·2kΩ, C5 = C6 = 8nF.

MOTOR SPEED CONTROL

A basic circuit suitable for motor speed control is shown in block form in Fig. 4.10. The speed of rotation of the motor is "sensed" by a digital tachometer; the latter produces an output pulse frequency related to the motor speed. The phase detector compares a signal derived from the tachometer output with a very stable reference frequency (such as that from a crystal oscillator). The motor speed can thus be made as stable as the frequency of the reference source.

CONCLUSIONS

Readers who have followed the whole of this series will begin to appreciate the vast number of applications for which phase locked loops can be employed. Indeed, the number of applications is limited only by the ingenuity of the user. Thus the relatively new devices which are coming onto the market offer a real challenge to the amateur experimenter as well as to the professional engineer.

It is difficult to forecast future progress in a field such as electronics, but the writer feels that phase locked loops will form part of many types of radio receivers in the future, including high fidelity systems, car radio receivers and communications receivers. From the point of view of the amateur enthusiast, applications in radio receivers are probably the most significant ones, but the professional circuit designer will find many other fields for phase locked loops also. ★

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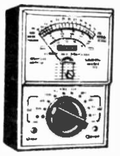


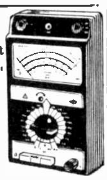
Top value 1,000 o.p.v. pocket multimeter. Ranges: 0/10/50/250/1,000V. A.C. and D.C. D.C. Current 0-1mA/100mA. Resistance: 0/150 K ohms. Decibels: −10 to +22dB. Size: 90 × 60 × 28mm. Complete with test leads. £3·95. Post 15p.

RUSSIAN 22 RANGE MULTIMETER

Model U437 10,000 O.P.V. A first class versatile instrument manufactured in U.S.S.R. to the highest standards. Ranges: 2·5/10/50/250/500/1,000V d.c. 2·5/10/50/250/500/1,000V a.c. D.C. current 100μA/1/10/100mA/1A. Resistance 300 ohms/3/30/300K/3mΩ. Complete with batteries, test leads, instructions and sturdy steel carrying case. OUR PRICE £4·95. Post 25p.

MODEL 500 30,000 O.P.V. with overload protection mirror scale 0/0·5/2·5/20/25/100/250/500/1,000V d.c. 0/2·5/10/25/100/250/500/1,000V a.c. 0/50μA/5/50/500mA. 12 amp. d.c. 0/60/K/6 Meg./60 MegΩ. £10·50. Post paid. Leather case £1·75.

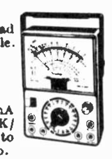
U4312 MULTIMETER



Extremely sturdy instrument for general electrical use, 667 O.P.V. 0/0·3/1·5/7·5/30/60/150/300/600/900V d.c. and 75mV. 0/0·3/1·5/7·5/30/60/150/300/600/900V a.c. 0/300μA/1·5/6/15/60/150/600MA/1·5/6 amp. d.c. 0/1·5/15/60/150/600MA/1·5/6 amp. a.c. 0/200Ω/3k/30kΩ. Accuracy Knife edge pointer, mirror scale. Complete with sturdy metal carrying case, leads and instructions. £9·75. Post 25p.

HIOKI MODEL 700X

100,000 O.P.V. Overload protection. Mirror scale. 0·3/0·6/1·2/1·5/3/6/12/30/60/120/300/600/1,200V d.c. 1·5/3/6/12/30/60/150/300/600/1,200V a.c. 15/30μA/3/6/30/60/150/300mA 6/12 amp. d.c. 2K/200K/2 Meg/20 Meg ohm −20 to +63dB. £14·95. Post 20p.

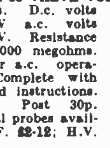


MODEL C-7080 EN

Giant 6in mirror scale. 20,000 O.P.V. 0/0·25/1/2·5/10/50/250/1,000/5,000V d.c. 0/2·5/10/50/250/1,000/5,000V a.c. 0/50μA/1/10/100/500mA/10 amp. d.c. 0/2K/200K/20 meg. −20 to +50dB. £13·95. Post 35p.

TMK MODEL TW-50K 46 ranges, mirror scale, 50K/V d.c. 5K/V a.c. D.c.: Volts 0·125, 0·25, 1·25, 2·5, 5, 10, 25, 50, 125, 250, 500, 1,000V. A.c. Volts: 1·5, 3, 5, 10, 25, 50, 125, 250, 500, 1,000V. D.c. Current: 25, 50μA, 2·5, 5, 25, 50, 250, 500mA. 5, 10 amp. Resistance: 10K, 100K, 1 MEG, 10 MEG Ω. Decibels: −20 to +81·5dB. £8·50. Post 17p.

TE-65 VALVE VOLTMETER



28 ranges. D.c. volts 1·5–1,500V a.c. volts 1·5–1,500V. Resistance up to 1,000 megohms. 200/240V a.c. operation. Complete with probe and instructions. £17·50. Post 30p. Additional probes available: R.F. £2·12; H.V. £2·50.

TE16A Transistorised Signal Generator. 5 ranges 400kHz—30MHz. An inexpensive instrument for the handyman. Operates on 9V battery. Wide easy to read scale. 800kHz modulation. 5¼ × 5¼in × 3¼in. Complete with instructions and leads. £6·97. Post 25p.

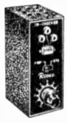
ALL PRICES ARE SUBJECT TO 10% VAT

Model S-100TR MULTIMETER/TRANSISTOR TESTER. 100,000 O.P.V. mirror scale/overload protection. 0/0·12/0·6/3/12/30/120/600V d.c. 0/6/30/120/600V a.c. 0/12/600μA/12/300mA/12 amp. d.c. 0/10 K/1 MEG/100 MEG. −20 to +50dB. 0·01–2 MFD. Transistor tester measures Alpha, beta and Ico. Complete with batteries, instructions and leads. £14·95. Post 25p.

LB3 TRANSISTOR TESTER

Tests ICO and B. *Pnp/npn*. Operates from 9V battery. Complete with all instructions, etc. £3·95. Post 20p.

LB4 TRANSISTOR TESTER



Tests PNP or NPN transistors, Audio indication. Operates on two 1·5V batteries. Complete with all instructions, etc. £4·50. Post 20p.

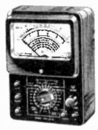
KAMODEN HM720B F.E.T. V.O.M.

Input impedance 10MΩ. Ranges: 0/0·25/1/2·5/10/50/250/1,000V d.c. 0/2·5/10/50/250/1,000V a.c. 0/25μA/2·5/25/250MA d.c. −20 to +62dB. 0/5k/50k/500k/5MΩ/500MΩ. £14·95. Post 30p.

KAMODEN 72.200 MULTITESTER

High sensitivity tester. 200,000 o.p.v. Overload protection. Mirror scale. Ranges: 0/0·06/0·3/3/30/120/600/1,200V d.c., 0/3/12/60/300/11,200V a.c. 0/6μA/1·2mA/120mA/600mA/12A d.c. 0/12A a.c. −20 to +63dB. 0/2kΩ/200kΩ/2MΩ/200MΩ. £16·95. Post 30p.

370 WTR MULTIMETER



Features a.c. current ranges. 20,000 O.P.V. 0/0·5/2·5/10/50/250/500/1,000V d.c. 0/2·5/10/50/250/500/1,000V a.c. 0/50μA/1/10/100mA/1/10 amp. d.c. 0/100mA/1/10 amp. a.c. 0/5K/50K/500K/5MEG/50MEG. −20 +62dB. £17·50. Post 25p.

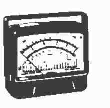
KAMODEN HM-350 TRANSISTOR TESTER

High quality instrument to test Reverse Leak current and D.C. current. Amplification factor of NPN, PNP, transistors, diodes, SCR's, etc. 4" × 4½" clear scale meter. Operates from internal batteries. Complete with instructions, leads and carrying handle. £12·50. Post 30p.

MODEL TE15 GRID DIP METER

Transistorised. Operates as Grid Dip, Oscillator, Absorption Wave Meter and Oscillating Detector. Frequency range 440kHz-280MHz in 6 coils. 500μA meter. 9V battery operation. Size 180mm × 80mm × 40mm. £15·00. Post 20p.

TMK LAB TESTER



100,000 O.P.V. 6½in scale buzzer short circuit check. Sensitivity: 100,000 OPV d.c. 5/Volt a.c. D.c. volts: 0·5, 2·5, 10, 50, 250, 1,000V. A.c. volts: 3, 10, 50, 250, 500, 1,000V. D.c. current: 10, 100μA, 10, 100, 500mA, 2·5, 10A. Resistance: 1K, 10K, 100K, 10 meg. 100 meg. Decibels: −10 to +49dB. Plastic case with carrying handle. size 7½in × 6½in × 3½in. £19·95. P. & P. 25p.

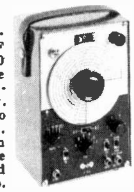
240° Wide Angle Ima Meters

MW1-6 60mm square £3·97
MW1-8 80mm square £4·97
P. & P. 15p.

TE22 SINE SQUARE WAVE AUDIO GENERATORS

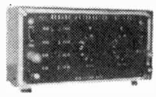
Sine: 20c/s to 200 kc/s on 4 bands. Square: 20c/s to 30 kc/s. Output impedance 5,000 ohms. 200/250V a.c. Supplied brand new and guaranteed with instruction manual and leads. £17·50. Carr. 37p.

ARF-300 AF/RF SIGNAL GENERATOR



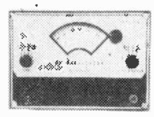
All transistorised, compact, fully portable. AF sine wave 18 Hz to 220 KHz. AF square wave 18 Hz to 100 KHz. Output sine/square 10v. P-P. RF 100 KHz to 200 MHz. Output 1v. maximum. Operation 220/240v. AC. Complete with instructions and leads. £29·95. Post 50p.

MODEL AT201 DECADE ATTENUATOR



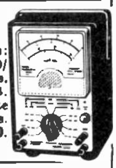
Frequency range 0-200kHz. Attenuator 0-111dB, 0·1dB step. Impedance 600 ohms. Max. Input power 30dBm. Size 180mm × 90mm × 55mm. £12·50. Post 37p.

BELCO AF-5A SOLID STATE SINE SQUARE WAVE C.R. OSCILLATOR



Sine 18-200,000 Hz: Square 18-50,000 Hz. Output max. +10dB (10 K ohms) Operation internal batteries. Attractive 2-tone case 7½in × 5in × 2in. Price £17·50. Carr. 17p.

TE-40 HIGH SENSITIVITY A.C. VOLTMETER

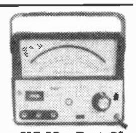


10 meg. input 10 ranges: 01/·003/·1/·3/1/3/10/30/100/300V. R.M.S. 4cps.-1·2 Mc/s. Decibels −40 to +50dB. Supplied brand new complete with leads and instructions. Operation 230V. a.c. £17·50. Carr. 25p.

TMK MODEL 117 F.E.T. ELECTRONIC VOLTMETER

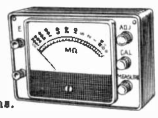
Battery-operated, 11 meg input. 26 ranges. Large 4½in mirror scale. Size 5¼in × 4¾in × 2¼in. D.c. volts 0·3–1,200V. A.c. volts 3–300V R.M.S. 8·0–800V P-P. D.c. Current 0·12–12MA. Resistance up to 2,000M ohm. Decibels −20 to +51dB. Complete with leads/instructions. £17·50. P. & P. 20p.

MODEL 449A IN CIRCUIT TRANSISTOR TESTER



Checks true a.c beta in/out. Checks Icbo. Checks diodes in/out. Checks SCR, etc. Beta HI 10—500 LO 2—50 Ibco 0·5000μA. 220/240V a.c. operation. £17·50. Post 25p.

KAMODEN HMG-500 INSULATION RESISTANCE TESTER



Range 0–1,000 Megohms, 500 Volt. Battery operated. Wide range clear meter 4½" × 4". Complete with de-luxe carrying case, batteries, instructions. £19·95. Post 30p.

MODEL U4311 SUB-STANDARD MULTI-RANGE VOLT AMMETER

Sensitivity 330 ohms/Volt a.c. and d.c. Accuracy 0·5% d.c. 1% a.c Scale length 165mm. 0/300/750μA/1·5/3/7·5/15/30/75/150/300/750mA/1·5/3/7·5 amp. d.c. 0/3/7·5/15/30/75/150/300/750mA/1·5/3/7·5 amp. a.c. 0/75/150/300/750mV/1·5/3/7·5·15·30/75/150/300/750V d.c. 0/750mV/1·5/3/7·5/15/30/75/150/300/750V a.c. Automatic cut out. Supplied complete with test leads, manual and test certificates. £49. Post 50p.

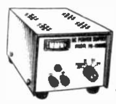
MCA.230 AUTOMATIC VOLTAGE STABILISER

Input 88–125V a.c. or 176–250V a.c. Output 120V a.c. or 240V a.c. 200VA rating. £11·97. Post 50p.

PS.200 REGULATED P.S.U.

Solid state. Variable output 5–20V d.c. up to 2 amp. Independent meters to monitor voltage and current. Output 220/240V. a.c. Size 7¼in. × 5½in. × 3½in. £19·95. Post 25p.

PS.100B REGULATED POWER SUPPLY

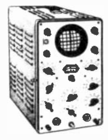


Solid state. Output 6, 9 or 12V d.c. up to 3 amps. Meter to monitor current. Input 220/240V a.c. Size 4in. × 3¼in. × 6½in. £11·97. Post 25p.

MODEL TE-300. 30,000 O.P.V. Mirror scale, overload protection 0/0·6/3/15/60/300/1,200V d.c. 0/6/30/120/600/1,200V a.c. 0/30/μA/6mA/60mA/300mA/600mA. 0/8K/80K/800K/8, meg. ohm—20 to +63dB. £7·50. Post 15p.

MODEL TE-200. 20,000 O.P.V. Mirror scale, overload protection. 0/5/25/125/1,000V d.c. 0/10/50/250/1,000V a.c. 0/50μA/250mA. 0/60K/6 meg Ω.—20 to +62dB. £4·95. Post 15p.

CI-5 PULSE OSCILLOSCOPE



For display of pulsed and periodic waveforms in electronic circuits VERT. AMP. Bandwidth 10MHz. Sensitivity at 100kHz V RMS/mm. 0·1-25; HOR. AMP. Bandwidth 500kHz. Sensitivity at 100kHz, V RMS/mm. 0·3-25; Pre-set triggered sweep 1-3,000μsec.; free running 20-200,000Hz in nine ranges. Calibrator pips. 220mm × 360mm × 430mm, 115-230V a.c. operation. £39. Carr. paid.

TO-3 PORTABLE OSCILLOSCOPE

3in tube, Y amp. Sensitivity 0·1V p-p/CM. Bandwidth 1·5cps-1·5MHz. Input imp. 2 meg Ω 25pF X amp. sensitivity 0·9V. p-p/CM. Bandwidth 1·5cps-800kHz. Input imp. 2 meg Ω 20pF. Time base. 5 ranges 10cps-300kHz. Synchronisation. Internal/external. Illuminated scale 140mm × 215mm × 330mm. Weight 15½lb. 220/240V a.c. Supplied brand new with handbook. £52·50. Carr. 50p.

RUSSIAN CI-16 DOUBLE BEAM OSCILLOSCOPE

5MHz Pass Band. Separate Y1 and Y2 amplifiers. Rectangular 5in × 4in C.R.T. Calibrated triggered sweep from 0·2μ/sec to 100 milli-sec per cm. Free running time base 50 Hz-1MHz. Built-in time base calibrator and amplitude calibrator. Supplied complete with all accessories and instruction manual £87. Carr. paid.

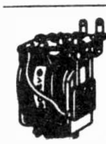
POWER RHEOSTATS

High quality ceramic construction. Windings embedded in vitreous enamel. Heavy duty brush wiper. Continuous rating. Wide range available ex-stock. Single hole fixing, ¼in dia. shafts. Bulk quantities available.

25 WATT. 10/25/50/100/250/500/1000 ohms £1·15. P. & P. 10p.

50 WATT. 10/25/50/100/250/500/1000/2500 or 5000 ohms. £1·62. P. & P. 10p.

100 WATT. 1·5/10/25/50/100/250/500/1000 or 2500 ohms. £2·34. P. & P. 15p.



230 VOLT A.C. 50 CYCLES

RELAYS

Brand new. 3 sets of changeover contacts at 5 amp. rating. 40p each. Post 12p (100 lots £30) Quantities available.

HIGH QUALITY CONSTRUCTION KITS
Appointed stockists at all branches
Complete with comprehensive, easy to follow instructions, and covered by full guarantee
Post and packing 15p per kit

AF20	Mono Transistor Amplifier	£4·80
AF30	Mono Transistor Pre-Amplifier	£2·61
AF310	Mono Amplifier (use two for stereo)	£5·91
AT5	Automatic Light Control	£2·58
AT30	Photo Cell Switching Unit	£5·70
AT50	400W Triac Light Dimmer/Speed Control	£4·80
AT55	1300W Triac Light Dimmer/Speed Control	£5·70
AT56	2200W Triac Light Dimmer/Speed Control	£6·90
AT60	Psychedelic Light Control, Single Channel	£7·80
AT65	Psychedelic Light Control, 3 Channel	£14·55
HF61	Medium Wave Transistor Radio	£3·33
HF75	FM Transistor Receiver	£2·88
HF310	FM Tuner Unit	£15·81
HF325	Deluxe FM Tuner Unit	£24·12
HF330	Stereo Decoder for HF310/HF325	£9·96
HF395	Aerial Amplifier for AM/FM Bands 1, 2 & 3	£1·77
GP310	Stereo Pre-Amp for use with 2 × AF310	£21·27
GU330	Tremolo Unit for Guitars, etc.	£7·50
NT10	Power Supply 100mA, 9V Stab. 12V Unstab.	£6·15
NT300	Professional Stabilised Power Supply 2 × 30V, 2·2 Amp	£12·51
NT305	Transistor Convertor 12/15V a.c./d.c. to 6V, 7·5V or 9V d.c.	£4·50
NT310	Power Supply 240V a.c. to 2 × 18V d.c. at 2 amps	£4·80
NT315	Power Supply 240V a.c. to 4·5–15V d.c. at 500mA	£9·57
AE1	100mW Output Stage	£1·65
AE2	Pre-Amplifier	£1·26
AE3	Diode Receiver	£2·00
AE4	Flasher	£1·09
AE5	Astable Multivibrator	£1·05
AE6	Monostable Multivibrator	£1·02
AE7	RC Generator	£1·06
AE8	Bass Filter	99p
AE9	Treble Filter	99p
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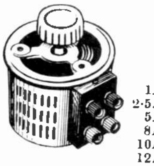
IDEAL GIFT FOR ALL AGES! AMATEUR ELECTRONICS
The professional book for the amateur—covers the subject from basic theories to the advanced electronics of today. 347 pages of invaluable information and diagrams. Complete with free circuit board for building 10 of the projects described in the book. (Components extra). OUR PRICE £3·20 (No VAT). P. & P. 25p plus VAT.

"YAMABISHI" VARIABLE VOLTAGE TRANSFORMERS

Excellent quality at low cost. All models—Input 230v. 50/60 c/s. Variable output 0-260v.

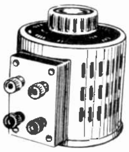
MODEL S-260 GENERAL PURPOSE BENCH MOUNTING



1A	£8·75	(30p)
2·5A	£10·00	(35p)
5A	£14·70	(37p)
8A	£25·30	(50p)
10A	£28·10	(75p)
12A	£29·50	(£1)
20A	£72·50	(£1·25)
25A	£72·50	(£1·30)
40A	£103·10	(£1·50)

MODEL S-260B

Panel mounting



1A	£8·75	(30p)
2·5A	£10·00	(35p)

(Postage and packing is shown in brackets)

AUTO TRANSFORMERS
0/115/230V. Step up or step down. Fully shrouded.

80W	£2·35	P. & P. 18p
150W	£3·00	P. & P. 18p
300W	£4·00	P. & P. 23p
500W	£5·80	P. & P. 33p
1000W	£8·25	P. & P. 38p
1500W	£11·25	P. & P. 43p
2250W	£19·00	P. & P. 50p
5000W	£40·00	P. £1P.&

REFLEX HORN SPEAKER RUH.6

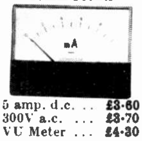
Built in driver unit. Impedance 16 ohm. Power rating 10W. Response 380–7,000Hz. Approx. size 6in × 6in. Weatherproof and shock proof.
OUR PRICE £4.97 P. & P. 30p

SEW CLEAR PLASTIC PANEL METERS

USED EXTENSIVELY BY INDUSTRY, GOVT. DEPTS., EDUCATIONAL AUTHORITIES, ETC.

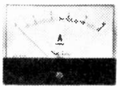
Over 200 ranges in stock—other ranges to order. Quantity discounts available. Send for fully illustrated brochure.

TYPE SW.100 100mm × 80mm Fronts



50µA	£4·15	5 amp. d.c.	£3·60
50-0-50µA	£3·95	300V a.c.	£3·70
100µA	£3·95	VU Meter	£4·30
100-0-100µA	£3·90		
500µA	£3·70		
1mA	£3·60		
20V d.c.	£3·60		
50V d.c.	£3·60		
300V d.c.	£3·60		
1 amp. d.c.	£3·60		

Type SD.830 82·5mm × 110mm Fronts



50µA	£3·40	10mA	£3·10
50-0-50µA	£3·40	50mA	£3·10
100µA	£3·35	100mA	£3·10
100-0-100µA	£3·35	500mA	£3·10
200µA	£3·30	1 amp.	£3·10
500µA	£3·15	5 amp.	£3·10
1mA	£3·10	10 amp.	£3·10
5mA	£3·10	5V d.c.	£3·10
		10V d.c.	£3·10
		20V d.c.	£3·10
		50V d.c.	£3·10
		300V d.c.	£3·10
		15V a.c.	£3·30
		300V a.c.	£3·30
		VU Meter	£3·50

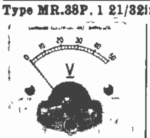
Type SD.460 46mm × 59·5mm Fronts

50µA	£2·80	1 amp.	£2·60
50-0-50µA	£2·80	5 amp.	£2·60
100µA	£2·75	10 amp.	£2·60
100-0-100µA	£2·75	5V d.c.	£2·60
200µA	£2·70	10V d.c.	£2·60
500µA	£2·55	20V d.c.	£2·60
1mA	£2·60	50V d.c.	£2·60
5mA	£2·60	300V d.c.	£2·60
10mA	£2·60	15V a.c.	£2·70
50mA	£2·60	300V a.c.	£2·70
100mA	£2·60	VU Meter	£2·90
500mA	£2·60		

Type MR.45P. 2in. square Fronts.

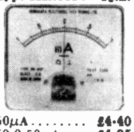
50µA	£2·70	5 amp.	£2·40
50-0-50µA	£2·65	10V d.c.	£2·40
100µA	£2·60	20V d.c.	£2·40
100-0-100µA	£2·50	50V d.c.	£2·40
200µA	£2·50	300V d.c.	£2·40
500µA	£2·45	15V d.c.	£2·40
500-0-500µA	£2·40	300V d.c.	£2·40
1mA	£2·40	S Meter 1mA.	£2·50
5mA	£2·40	VU Meter	£2·70
10mA	£2·40	1 amp. a.c.*	£2·40
50mA	£2·40	5 amp. a.c.*	£2·40
100mA	£2·40	10 amp. a.c.*	£2·40
500mA	£2·40	20 amp. a.c.*	£2·40
1 amp.	£2·40	30 amp. a.c.*	£2·40

Type MR.38P. 1 21/32in. square Fronts.



		200mA	£2·25
		300mA	£2·25
		500mA	£2·25
		750mA	£2·25
		1 amp.	£2·25
		2 amp.	£2·25
		5 amp.	£2·25
		10 amp.	£2.25
		3V d.c.	£2·25
50µA	£2·55	10V d.c.	£2·25
50-0-50µA	£2·50	15V d.c.	£2·25
100µA	£2·45	20V d.c.	£2·25
100-0-100µA	£2·40	50V d.c.	£2·25
200µA	£2·25	100V d.c.	£2·25
500µA	£2·25	150V d.c.	£2·25
500-0-500µA	£2·25	300V d.c.	£2·25
1mA	£2·25	500V d.c.	£2·25
1-0-1mA	£2·25	750V d.c.	£2·25
2mA	£2·25	15V a.c.	£2·35
5mA	£2·25	50V d.c.	£2·30
10mA	£2·25	150V a.c.	£2·30
20mA	£2·25	300V a.c.	£2·30
50mA	£2·25	500V a.c.	£2·30
100mA	£2·25	S Meter 1mA.	£2·30
150mA	£2·25	VU Meter	£2·65

Type MR.85P. 4¼in. × 4¼in. Fronts



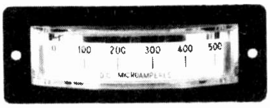
		100mA	£3·90
		500mA	£3·90
		1 amp.	£3·90
		5 amp.	£3·90
		15 amp.	£3·90
		30 amp.	£3·95
		10V d.c.	£3·90
		20V d.c.	£3·90
50µA	£4·40	50V d.c.	£3·90
50-0-50µA	£4·25	150V d.c.	£3·90
100µA	£4·25	300V d.c.	£3·90
100-0-100µA	£4·05	15V a.c.	£3·95
200µA	£4·05	300V a.c.	£3·95
500µA	£3·90	S Meter 1mA.	£3·90
5000-500µA	£3·90	VU Meter	£4·55
1mA	£3·90	1 amp. a.c.*	£3·90
1-0-1mA	£3·90	5 amp. a.c.*	£3·90
5mA	£3·90	10 amp. a.c.*	£3·90
10mA	£3·90	20 amp. a.c.*	£3·90
50mA	£3·90	30 amp. a.c.*	£3·90

Type SD.640 63·5mm × 85mm Fronts

50µA	£3·05	500mA	£2·90
50-0-50µA	£3·05	1 amp.	£2·90
100µA	£3·00	5 amp.	£2·90
100-0-100µA	£3·00	10 amp.	£2·90
200µA	£3·00	5V d.c.	£2·90
500µA	£2·95	20V d.c.	£2·90
1mA	£2·90	50V d.c.	£2·90
5mA	£2·90	300V d.c.	£2·90
10mA	£2·90	15V a.c.	£3·00
50mA	£2·90	300V a.c.	£3·00
100mA	£2·90	VU Meter	£3·15

Type MR.65P. 3½in. × 3¼in. Fronts

50µA	£3·70	10V d.c.	£2·60
50-0-50µA	£3·15	20V d.c.	£2·60
100µA	£3·15	50V d.c.	£2·60
100-0-100µA	£3·10	150V d.c.	£2·60
200µA	£3·05	300V d.c.	£2·60
500µA	£2·75	15V a.c.	£2·80
500-0500µA	£2·60	50V a.c.	£2·80
1mA	£2·60	150V a.c.	£2·80
5mA	£2·60	300V a.c.	£2·80
10mA	£2·60	500V a.c.	£2·80
50mA	£2·60	S Meter 1mA.	£2·85
100mA	£2·60	VU Meter	£3·70
500mA	£2·60	50mA a.c.*	£2·60
1 amp.	£2·60	100mA a.c.*	£2·60
5 amp.	£2·60	200mA a.c.*	£2·60
10 amp.	£2·60	500mA a.c.*	£2·60
15 amp.	£2·60	1 amp. a.c.*	£2·60
20 amp.	£2·60	5 amp. a.c.*	£2·60
30 amp.	£2·80	10 amp. a.c.*	£2·60
50 amp.	£2·90	20 amp. a.c.*	£2·60
5V d.c.	£2·60	30 amp. a.c.*	£2·60



"SEW" EDGEWISE METERS

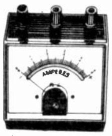
Type PE.70. 3 17/32in. × 1 15/32in. × 2¼in. deep.

50µA	£3·75	500µA	£3·20
50-0-50µA	£3·60	1mA	£3·20
100µA	£3·60	300V a.c.	£3·25
100-0-100µA	£3·50	VU Meter	£3.85
200µA	£3·40		

*MOVING IRON— ALL OTHERS MOVING COIL

Please add postage

"Sew" Educational Meters



Type ED.107. Size overall 100mm × 90mm × 108mm.
A new range of high quality moving coil instruments ideal for school experiments and other bench applications. 3in. mirror scale. The meter movement is easily accessible to demonstrate internal working. Available in the following ranges:

50µA	£6·90	15V d.c.	£5·95
100µA	£6·40	20V d.c.	£5·95
50-0-50µA	£6·40	50V d.c.	£5·95
1mA	£5·95	300V d.c.	£5·95
1-0-1mA	£5·95	Dual range	
1A d.c.	£5·95	500mA/5A d.c.	£7·00
5A d.c.	£5·95	1/15A d.c.	£7·00
5V d.c.	£5.95	5V/50V d.c.	£7·00
10V d.c.	£5·95	5/15V d.c.	£7·00

Type MR.52P. 2½in. square Fronts.

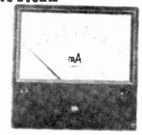
50µA	£3·50	10V d.c.	£2·50
50-0-50µA	£3·05	20V d.c.	£2·50
100µA	£3·00	50V d.c.	£2·50
100-0-100µA	£2·95	300V d.c.	£2·50
500µA	£2·65	15V a.c.	£2·60
1mA	£2·50	300V a.c.	£2·60
5mA	£2·50	S Meter 1mA.	£2·60
10mA	£2·50	VU Meter	£3·60
50mA	£2·50	1 amp. a.c.*	£2·50
100mA	£2·50	5 amp. a.c.*	£2·50
500mA	£2·50	10 amp. a.c.*	£2·50
1 amp.	£2·50	20 amp. a.c.*	£2·50
5 amp.	£2·50	30 amp. a.c.*	£2·50

"Sew" Bakelite Panel Meters

Type MR.65. 3½in. square Fronts.

		1 amp.	£2·60
		2 amp.	£2·60
		5 amp.	£2·60
		15 amp.	£2·60
		30 amp.	£2·60
		50 amp.	£2·60
		5V d.c.	£2·60
		10V d.c.	£2·60
		20V d.c.	£2·60
		50V d.c.	£2·60
		150V d.c.	£2·60
		300V d.c.	£2·60
		50mV d.c.	£2·90
25µA	£4·60	100mV d.c.	£2·90
50µA	£3·55	30V a.c.*	£2·65
50-0-50µA	£3·05	50V a.c.*	£2.65
100µA	£3·00	150V a.c.*	£2·65
100-0-100µA	£3·00	300V a.c.*	£2.65
500µA	£2·70	500V a.c.	£2·65
500-0-500µA	£2·60	500mA a.c.*	£2·60
1mA	£2·60	1 amp. a.c.*	£2·60
1-0-1mA	£2·60	5 amp. a.c.*	£2·60
5mA	£2·60	10 amp. a.c.*	£2·60
10mA	£2·60	20 amp. a.c.*	£2·60
50mA	£2·60	30 amp. a.c.*	£2·60
100mA	£2·60	50 amp. a.c.*	£2·60
500mA	£2·60	VU Meter	£3·65

Type S-80 80mm square Fronts



50µA	£3·50		
50-0-50µA	£3·40		
100µA	£3·40		
100-0-100µA	£3·30		
500µA	£3·05		
1mA	£3·00		
20V d.c.	£3·00		
50V d.c.	£3·00		
300V d.c.	£3·00		
1 amp. d.c.	£3·00	300V a.c.	£3·00
5 amp. d.c.	£3·00	VU Meter	£3·70

EA.41 REVERBERATION AMPLIFIER

Self contained, transistorised, battery operated. Simply plug in microphone, guitar, etc., and output into your amplifier. Volume control, depth of reverberation control. Beautiful walnut cabinet. 7¼in × 3in × 4¼in.
OUR PRICE £7·50 P. & P. 15p

MP7 MIXER PREAMPLIFIER

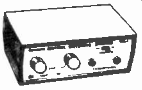
Battery operated. 9¼in × 5in × 3in. Inputs Mics: 3 × 3mV 50K; 2 × 3mV 600 ohm. Phono mag. 4mV 50K. Phono ceramic 100mV 1 meg. Output 250mV 100K.
OUR PRICE £8·97 P. & P. 20p

BVD.5 VERNIER TUNING DIAL

Approx. 7–1 ratio planetary drive vernier dials. Log scale 0–180 degrees. Blank scales 1 to 5. Scale width 4½in. Dial size 5in × 3in. Overall size 7¼in × 4¼in × 1½in deep including knob and coupling. ¼in dia. shaft.

OUR PRICE £1·62 P. & P. 15p

1021 STEREO LISTENING STATION



For balancing and gain selection of loudspks. with additional facility for stereo headphone switching. 2 gain controls, speaker on-off slide switch, stereo headphone sockets 6in × 4in × 2¼in.
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TRIO JR310 SSB RECEIVER
Covers 3·5, 7, 14, 21, 28, 28·5 and 29·1MHz bands, and WWV 15MHz. SSB, AM and CW. AF output more than 1W. Crystal controlled BFO for SSB. S meter. ANL, etc. A.c. 110/120-220/240V. Size 330 × 179 × 310mm.
OUR PRICE £75·00 Carr. Paid
TRIO TR2200 TRANSCEIVER
Fully transistorised portable VHF Transceiver. Will transmit and receive on 6 channels between 144-146MHz. 1W transmitter. 12V d.c. internal or external supply. Built in charger for ni-cad cells. Power/volume switch, squelch control, channel selector, mike socket, earphone/external speaker socket. Complete with microphone, 144·48, 144·72 and 145·32 crystals.
OUR PRICE £79·50 Carr. Paid
UR-1A RECEIVER
4 Bands covering 550kHz-30MHz. FET, S Meter. Variable BFO for SSB. Built-in Speaker. Bandspread. Sensitivity Control. 220/240V a.c. or 12V d.c. 12½ × 4½in × 7in. Brand new with instructions.
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Solid state mobile transceiver for 12V d.c. neg. use. Transmits and Receives on any 12 of 28 channels between 144 and 146MHz. Power output 10W and 1W switchable. Controls: Volume/on/off, squelch, channel selector. Internal 3in speaker. Complete with dynamic mike, PTT switch, three sets of crystals for 144·48MHz, 144·60MHz, 145·00MHz, mounting bracket and instructions.
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General coverage 150-400kHz, 550kHz-30MHz. FET front end, 2 mech. filters, product detector, variable BFO, noise limiter, S Meter Bandspread. RF Gain. 15in × 9½in × 8½in. 18 lb. 220/240V a.c. or 12V d.c. Brand new with instructions.
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4 track, 7½, 3¾, 1⅞ i.p.s. Stereo mono record/play. 7in reels. Inputs for dynamic mikes, radiogram. Complete with cover.
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Famous BSR 8 track chassis as used in Model TD8S complete with silver and black escutcheon ready to fit into cabinet. Output 125mV A.C. 240V. Overall size approx. 185 × 215 × 80mm.
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Battery operation. Volume and squelch controls. Call button and press to talk button. Telescopic Aerial. Complete with carrying cases.
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1 watt, £71·25 pair, post 50p.
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All silicon transistor amplifier operates from magnetic ceramic or tuner inputs with twin stereo headphone outputs and separate volume controls for each channel. Operates from 9V battery. Inputs 5mV/100mV. Output 50mV per channel.
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Covers AM 540—1600KHz. FM 88—108MHz with AFC. 24 hour leaf type digital clock with one minute division time change. Illuminated dial. 24 hour alarm setting. Wake up to the sound of music or loud buzzer. Unique sleep switch will automatically turn off radio when you have gone to sleep. Slider volume control. Internal speaker plus socket for earpiece or pillow speaker. A.c. 240V. Size 254 × 92 × 178mm. Complete with earpiece, and operating instructions.
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10 wavebands covering A.M.: 535 - 1605 kHz: L.W.: 150 - 380 kHz; M.B.: 1·6 - 4·0 MHz; S.W1. 4·0 - 8·0 MHz; S.W.2; 8·0-1·6MHz; S.W.3: 16-24MHz; P.S.B.1: 30-50MHz; P.S.B.2; 148-174MHz; F.M. 88-108MHz; A.I.R.: 108-136MHz. Features time zone map and timing dial. Large clear scale. Telescopic aerial and built-in aerial. A.F.C. on F.M. 6in × 4in speaker and personal earpiece. Battery/mains operation. Size: 345 × 133 × 305mm.
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Can be used with most hi-fi amplifiers. Push button track selector and illuminated track indicators. Attractive cabinet with black and silver trim. Output level 750mV. 220/240V a.c.
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	£p	£p	£p		£p	£p	£p		£p	£p	£p		£p	£p	£p
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7401	0·20	0·18	0·14	7441	0·81	0·78	0·70	7492	0·84	0·65	0·68	74163	4·84	4·54	4·23
7402	0·20	0·18	0·15	7442	0·81	0·78	0·70	7493	0·82	0·66	0·64	74164	2·73	2·63	2·58
7403	0·20	0·18	0·15	7443	1·40	1·32	1·28	7494	1·04	0·93	0·88	74165	2·73	2·63	2·58
7404	0·21	0·19	0·16	7444	1·57	1·52	1·45	7495	1·14	1·03	0·98	74166	4·28	3·94	3·68
7405	0·21	0·19	0·16	7445	2·31	2·18	2·11	7496	1·25	1·15	0·98	74174	2·78	2·66	2·54
7406	0·54	0·49	0·44	7446	2·31	2·18	2·11	74100	2·75	2·58	2·53	74175	1·94	1·81	1·69
7407	0·54	0·48	0·43	7447	1·48	1·37	1·15	74104	1·18	1·14	1·07	74176	1·99	1·87	1·69
7408	0·29	0·24	0·20	7448	1·98	1·81	1·75	74105	1·18	1·14	1·09	74177	2·75	2·64	2·55
7409	0·29	0·24	0·20	7450	0·20	0·16	0·15	74107	0·48	0·46	0·44	74180	2·75	2·64	2·55
7410	0·20	0·18	0·14	7451	0·20	0·19	0·18	74110	0·67	0·65	0·60	74181	6·49	6·05	5·83
7411	0·23	0·21	0·19	7453	0·20	0·19	0·18	74111	1·52	1·40	1·33	74182	2·16	2·02	1·89
7412	0·40	0·33	0·25	7454	0·20	0·18	0·16	74118	1·10	0·80	0·70	74184	2·69	2·42	2·29
7413	0·31	0·29	0·23	7460	0·20	0·18	0·16	74119	1·64	1·54	1·36	74190	3·08	2·69	2·42
7416	0·49	0·47	0·37	7470	0·33	0·27	0·26	74121	0·47	0·42	0·40	74191	2·30	2·24	2·18
7417	0·57	0·53	0·51	7472	0·33	0·30	0·26	74122	1·70	1·59	1·37	74192	2·53	2·30	2·25
7420	0·20	0·18	0·14	7473	0·46	0·42	0·26	74123	3·35	3·28	3·16	74193	2·53	2·30	2·18
7422	0·60	0·58	0·55	7474	0·44	0·40	0·34	74141	1·10	0·99	0·93	74194	3·27	3·15	3·02
7423	0·20	0·58	0·55	7475	0·63	0·57	0·54	74145	1·65	1·48	1·43	74195	2·42	2·30	2·18
7425	0·60	0·53	0·55	7476	0·55	0·51	0·46	74150	3·30	2·75	2·44	74196	2·18	2·06	1·94
7426	0·35	0·31	0·25	7480	1·10	0·99	0·93	74151	1·21	1·15	1·08	74197	2·18	2·06	1·94
7427	0·55	0·51	0·48	7481	1·37	1·26	1·17	74153	1·32	1·15	1·08	74198	6·65	6·05	5·44
7428	0·85	0·79	0·73	7482	1·10	0·99	0·93	74154	2·20	1·87	1·83	74199	6·65	6·05	5·44
7430	0·20	0·18	0·15	7483	1·32	1·29	1·17	74155	1·65	1·21	1·08	74200	26·40	21·12	
7432	0·42	0·33	0·29	7484	1·32	1·21	1·17	74156	1·65	1·21	1·08				16·90
7433	0·97	0·91	0·85	7485	2·75	2·64	2·53	74157	1·54	1·43	1·36				
7437	0·77	0·74	0·71	7486	0·49	0·41	0·36	74160	2·18	2·05	1·94				
7438	0·77	0·74	0·71	7489	4·95	4·29	4·07	74161	2·18	2·05	1·94				

Linear Integrated Circuits

301	DIL	0·50	307	TO99	0·69	710C	TO99	0·46	748C	DIL	0·52
301	TO99	0·55	307	8 Pin DIL	0·66	723C	DIL	0·99	748C	TO99	0·42
301	8 Pin DIL	0·48	308	TO99	£6·90	723C	TO99	£1·00	1437	DIL	£1·30
301A	DIL	0·69	308A	TO99	£7·40	741C	8 Pin DIL	0·35	1458	TO99	£1·30
301A	TO99	0·69	709C	DIL	0·35	741C	14 Pin DIL	0·36	3046	DIL	0·84
301A	8 Pin DIL	0·66	709C	TO99	0·34	741C	TO99	0·38			
307	DIL	0·69	710C	DIL	0·44	747C	DIL	0·80			

Electrolytic Capacitors

4 VOLT
47µF 6½p
100µF 6½p
220µF 6½p
330µF 6½p
1000µF 13p
4700µF 29p

6·3 VOLT
33µF 6½p
68µF 6½p
150µF 6½p
470µF 11p
680µF 13p
1500µF 18p
2200µF 18p
3300µF 26p
6800µF 40p

10 VOLT
22µF 6½p
47µF 6½p
100µF 6½p
220µF 8p
330µF 10p
470µF 10p
1000µF 11p
1500µF 20p
2200µF 24p

16 VOLT
15µF 6½p
33µF 6½p
68µF 6½p
150µF 8p
220µF 9p
680µF 17p

16 VOLT
1000µF 17p
1500µF 25p
2000µF 43p
3300µF 38p
6800µF 65p

25 VOLT
10µF 6½p
22µF 6½p
47µF 6½p
100µF 8p
150µF 8p
220µF 10p
470µF 13p
680µF 20p
1000µF 22p

25 VOLT
2200µF 39p
5000µF 68p

40 VOLT
6·8µF 6½p
15µF 6½p
33µF 6½p
47µF 6½p
100µF 9p
150µF 10p
220µF 11p
470µF 19p
680µF 25p
1000µF 25p
2200µF 44p
3300µF 65p

63 VOLT
1µF 6½p
2·2µF 6½p
4·7µF 6½p
6·8µF 6½p
10µF 6½p
22µF 6½p
68µF 10p
100µF 11p
150µF 13p
220µF 19p
330µF 22p
470µF 26p
1000µF 44p

Mullard Polyester's

MULLARD POLYESTER CAPACITORS C280 SERIES
250V P.C. mounting: 0·01µF, 0·015µF, 0·22µF, 3½p. 0·33µF, 0·047µF, 0·068µF, 4p. 0·1µF, 4½p. 0·15µF, 0·22µF, 5½p. 0·33µF, 7p. 0·47µF, 9½p. 0·68µF, 12p. 1·0µF, 14p. 1·5µF, 22p. 2·2µF, 27p.

MULLARD POLYESTER CAPACITORS C296 SERIES
400V: 0·001µF, 0·0015µF, 0·0022µF. 0·0033µF, 0·0047µF, 2½p. 0·0068µF, 0·01µF, 0·015µF, 0·022µF, 0·033µF, 3½p. 0·047µF, 0·068µF, 0·1µF, 4½p. 0·15µF, 6½p. 0·22µF, 8½p. 0·33µF, 12p. 0·47µF, 14p.
160V: 0·01µF, 0·015µF, 0·22µF, 0·033µF, 0·047µF, 0·068µF, 3p. 0·1µF 3½p. 0·15µF, 4½p. 0·22µF, 5½p. 0·33µF, 6½p. 0·47µF, 8½p. 0·68µF, 12p. 1·0µF, 14½p.

Popular Transistors and Diodes

(Many other types stocked)

AC107	16p	AD149	40p	BC157	13p	BFY50	17p	2N3053	26p	40636	66p	OA47	9p
AC126	14p	AD161	32p	BC158	12p	BFY51	17p	2N3054	50p	**DIODES**		OA81	9p
AC127	14p	AD162	32p	BC159	13p	BFY52	17p	2N3055	52p			OA55	11p
AC128	14p	AF114	15p	BC168	11p	MP8111	35p	2N3702	11p	1N914	8p	OA90	8p
AC142K	25p	AF115	15p	BC169	11p	OC28	40p	2N3703	11p	1N916	8p	OA91	8p
AC141K	26p	AF116	15p	BC182	12p	OC35	40p	2N3704	11p	1N4148	5p	OA95	8p
AC176	15p	AF117	15p	BC183	12p	OC36	45p	2N3705	11p	1N4001	4'p		
AC187	14p	BC107	9p	BC184	12p	OC44	14p	2N3706	11p	1N4002	4½p		
AC188	14p	BC108	9p	BC212	12p	OC45	14p	2N3707	11p	1N4003	5½p		
AC187K	25p	BC109	10p	BC213	12p	OC71	14p	2N3708	11p	1N4004	6½p		
AC188K	24p	BC147	11p	BC214	12p	OC81	14p	2N3709	11p	1N4005	8p		
ACY20	22p	BC148	11p	BF194	15p	TIP41A	79p	2N3710	11p	1N4006	9p		
AD140	40p	BC149	12p	BF195	17p	TIP42A	91p	2N3819	28p	1N4007	10p		

Volume controls

POTENTIOMETERS

Carbon track 500Ω to 2·2 meg Ω Log or Linear.
Single 13p. Dual gang (stereo) 44p.
Single type with D.P. switch 26p.

Resistors

		100 plus
¼ watt 5% carbon ..	1p	0·7p
½ watt 5% carbon ..	1p	0·7p
1 watt 10% carbon ..	2½p	2p
range 10 ohms to 4·7 megohms.		
½ watt m/o 2%	3p	2·4p
range 10 ohms to 1 megohms.		

Carbon skeleton presets

Small high quality type (linear only)
All values 100—5 meg ohms.
0·1 watt 6p each
0·25 watt 7p each

Vereoboard

	0·15 matrix	0·1 matrix
2½ × 3¾	17p	22p
2½ × 5	22p	24p
3¾ × 3¾	22p	24p
3¾ × 5	28p	28p
2½ × 17	60p	79p
3¾ × 17	81p	£1·05
Pin insertion tool ..	—	82p
Spot face cutter	52p	52p
Pack of 36 pins	42p	42p
	20p	20p

P.E. RONDO KITS

Supplied to full specifications complete with top quality P.C. boards, components and solder.

CBS SQ Matrix Decoder (including licence fees) **£8·00** + 80p VAT.

Preamplifier Board £3·00 + 30p VAT.

Master Volume/Tone Controls/4 channel Balance Control Board £8·50 + 85p VAT.

Power Amplifier Board and Heat Sink (each board contains a stereo pair of amplifiers) **£7·50** + 75p VAT.

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Mains Smoother Capacitor	75p + 7p VAT.
Mains Transformer	£6·25 + 62p VAT.
Punched Chassis	£2·25 + 22p VAT.
Wooded Cased	£1·75 + 17p VAT.
Hardware Pack	£2·00 + 20p VAT.
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Complete Speaker System kit with Drive unit, crossover, wadding, etc. Each £19·50; P/P 50p; VAT £2. Per pair **£35·50; P/P £1**; VAT £3·65. Per four **£62**; **P/P£4**; VAT £6·40.

Built Loudspeaker units. Per pair **£42; P/P** £2; VAT **£4·40**.

Loudspeakers for those who want to build their own cabinets.
Bass units, 2 per cabinet **£3·95** each; VAT 39p.
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Cartridge Deutsche ELAC STS 144/17 £6·90; +69p.

All other kits and components used in P.E. Rondo will be Available as they appear in this Advert.

We are now Stockists of AMTRON High Quality Construction Kits (S.A.E. for full list)

		£
UK65	Transistor Tester	2·50
UK92	Telephone Amplifier	7·91
UK110	Stereo Amplifier 5 + 5w	11·07
UK115	Hi-Fi Amplifier 8w	4·31
UK120	Hi-Fi Amplifier 12w	5·20
UK125	Stereo Control Unit	6·30
UK160	I.C. Amplifier 8w	11·07
UK220	Signal Injector	2·57
UK235	Acoustic Alarm for Absent-minded Drivers	7·39
UK240	Parking Lights Automatic Switch	8.66
UK500	LW/MW/FM Radio Receiver	35·30
UK515	MW Radio Receiver	9·86
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TRA 1	24-hour Digital Clock	24·50

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ROCK BOTTOM PRICES

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SN7410	17p	SN7490	68p
SN7413	30p	SN7492	74p
SN7420	17p	SN7493	74p
SN7430	17p	SN74100	£1·82
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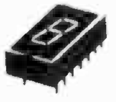

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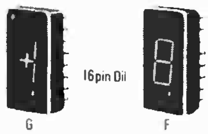

at BREAKTHROUGH PRICE £1·49

Veroboard

	Copperclad 0·1in	Plain 0·15in	0·15in	Extra P & P
2½in × 1in	6½p	6½p	—	—
2½in × 3¾in	22p	18p	11p	—
2½in × 5in	26½p	23p	13½p	—
3¾in × 3¾in	26½p	23p	—	—
3¾in × 5in	30p	30p	19p	—
17in × 2½in	74p	55p	41p	10p
17in × 3¾in	99p	77p	57½p	10p
17in × 5in	—	—	82½p	10p

DIP Breadboard, 4·15in × 6·15in, **110p.** Verostrip, 8·5in × 1·5in, **26½p.** Spot-Face Cutter, **40p.** Pin Injection tool (state 0·1in or 0·15in), **52p.** Terminal pins, **20p** (packs of 36)—state size.

I.C. SOCKETS

Dual-in-Line
8 pin **13½p** 16 pin **17½p** 36 pin **39½p**
14 pin **15½p** 24 pin **26½p** 40 pin **44p**
28 pin **30½p**

HEAT SINKS

TV2 for TO-66 15p. 5F for TO-5
TV3 for TO-3 16p. 18F for TO-18

51½p.

TV4 for TO-126
TV5 for TO-220

DIP 10/2 for SL403D
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14p

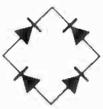
16p

10DN400 4 4Y-1 4

46p

35p

BRIDGE RECTIFIERS



P.I.V.	1 amp	R.M.S.	2 amp
100V	20p	50V	35p
200V	22p	100V	40p
600V	25p	200V	45p
1000V	38p	400V	50p

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P.I.V.	1 amp		3 amp	
50	1N4001	6½p	1N5400	15½p
100	1N4002	7½p	1N5401	16½p
200	1N4003	9p	1N5402	17½p
400	1N4004	9p	1N5404	22p
600	1N4005	11p	1N5406	26½p
800	1N4006	13½p	1N5407	30p
1000	1N4007	16½p	1N5408	33p

BY100	16½p	BY133	23p
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BY105	16½p	BY176	£1·65
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Cheapest Opto yet GaAsp LED's

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LED 2. 0·125" 26p
LED 3. 0·175" 17p

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LED 4. 0·125" 69p
LED 5. 0·175" 75p

Remember **Vat Inclusive Prices**

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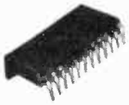

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50 or 60Hz operation
leading zero supression
single voltage supply
similar to DIGITRONIC in P.W. March 1973.
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With 6 LED's £20·75

CHROMASONIC electronics

RESISTORS

Rating	Type	Tolerance		Range	Price Each
⅛ watt	Carbon Film	±5%	E12 Series	51Ω to 330KΩ	1½p
½ watt	Metal Oxide Film	±2%	E24 Series	10Ω to 1MΩ	4½p
½ watt	Cermet Thick Film	±2%	E12 Series	56Ω to 150KΩ	8p
½ watt	Carbon Film	±5%	E24 Series	10Ω to 10MΩ	1½p
½ watt	Carbon Composition	±0·5Ω	2·2Ω 2·7Ω 3·3Ω 3·9Ω 4·7Ω		4½p
1 watt	Carbon Composition	±10%	5·6Ω 6·8Ω 8·2Ω		5½p
1 watt	Carbon Film	±5%	E12 Series	10Ω to 10MΩ	3p
2 watt	Carbon Film	±5%	E12 Series	10Ω to 10MΩ	6p
2½ watt	Wire Wound	±10%	E12 Series	0·22Ω to 0·47Ω	10p
2½ watt	Wire Wound	±5%	E12 Series	1Ω to 270Ω	10p
5 watt	Wire Wound	±5%	E12 Series	0·5Ω to 8·2KΩ	10p
10 watt	Wire Wound			0·5Ω to 6·8KΩ	11p
10 watt	Wire Wound	±5%	10KΩ 15KΩ 20KΩ 25KΩ		17p
15 watt	Wire Wound			10Ω to 6·8KΩ	13½p

DISCOUNTS: 10% on any 100 or more mixed value or wattage, 25% on any 100 or more same value and same wattage.

CAPACITORS

MULLARD C333, 629 and 630 series—Ceramic Plate. E12 series from 1·8pF to 0·022μF, **5½p.**

CERAMIC DISC—LOW VOLTAGE—0·01μF, 0·022μF, 0·047μF, **5½p;** 0·1μF, 0·22μF, 0·47μF, **6½p.**

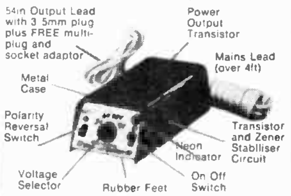
POLYSTYRENE (160V)—From 10pF to 0·01μF in multiples of 10pF; 15pF; 22pF; 33pF; 47pF and 68pF **3½p.**

MYLAR PLATE (100V)—1000 pF, 2000pF, 5000pF, **2½p,** 0·01μF, 0·02μF, 0·04μF, 0·05μF, **3½p;** 0·068μF, 0·1μF, **5p;** 0·2μF, **6½p.**

MULLARD C280 (250V POLYESTER)—0·01μF, 0·015μF, 0·022μF, 0·033μF, 0·047μF, **3½p;** 0·068μF, **4p;** 0·1μF, 0·15μF, **4½p;** 0·22μF, **5½p;** 0·33μF, **7p;** 0·47μF, **9p;** 0·68μF, **12p;** 1·0μF, **14½p;** 1·5μF, **22p;** 2·2μF, **26½p.**

new stabilised POWER PACK/CONVERTER

Switched 3, 6, 7½ or 9 volts.
Up to 400mA Output



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P. & P. on all models 16p.

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All 5% tolerance

BZY88, 400mW, 3·3V to 33V	11p
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TRANSISTORS and DIODES

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AC126	13p	AF239	41p	BC268	15p	BF178	29p	BSX21	22p	TIC226D	£1·97
AC127	13p	ASY26	33p	BC327	28½p	BF179	33p	BSY95A	13p	TIP41A	81p
AC128	13p	BC107	10p	BC328	24½p	BF180	33p	BU105	£1·75	TIP42A	99p
AC176	15p	BC108	10p	BCY70	17p	BF181	35½p	BU105 02	£1·92	TIS43	38½p
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AC187K	20p	BC114	15½p	BCZ10	28p	BF185	27½p	MJ4000	£1·49	TIS91	33p
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AC188K	20p	BC147	9p	BD115	74p	BF195	17p	MJE340	52p	2N706	13p
ACY17	24p	BC148	9p	BD124	82p	BF196	16½p	MJE2955	£1·82	2N708	16½p
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ACY20	22p	BC158	12p	BD131/2 PR	£1·49	BF220	27½p	MPF103	41p	2N1303	24p
AD140	40p	BC159	14p	BD133	83p	BF244B	27p	MPF104	45p	2N1304	24p
AD149	38p	BC168B	11p	BD135	42p	BF262	25p	MPF105	45p	2N1305	24p
AD161	29p	BC169	12p	BD136	50p	BF263	25p	MPF106	49½p	2N1306	24p
AD162	29p	BC171	20p	BD137	57½p	BF272	£1·21	OC28	45p	2N1307	27½p
AD161/2 PR	59p	BC172	17½p	BD138	74½p	BF390	37p	OC35	38p	2N1308	27½p
AF114	14p	BC174B	35p	BD139	78p	BFS28	£1·01	OC36	38p	2N1309	27½p
AF115	14p	BC177	22p	BD140	91½p	BFW10	67p	OC44	13½p	2N1613	22p
AF116	14p	BC178	22p	BD201	£1·55	BFW11	67p	OC45	13½p	2N1711	26p
AF117	14p	BC179	24p	BD202	£1·37	BFW87	38p	OC71	13½p	2N1893	52½p
AF118	92p	BC182L	11p	BD203	£1·55	BFX29	43p	OC72	13½p	2N2160	£1·54
AF124	24p	BC183L	10p	BD204	£1·37	BFX30	37½p	OC75	15p	2N2219	41p
AF125	22p	BC184L	11p	BF109	75p	BFX88	26p	OC81	13½p	2N2646	55p
AF126	22p	BC187	27½p	BF115	25p	BFY50	16½p	OC83	25p	2N2905	46p
AF127	22p	BC212L	12p	BF160	25½p	BFY51	16½p	OC140	22p	2N2924	18p
AF139	35p	BC213L	11p	BF167	27½p	BR100	43p	OC170	27½p	2N2926 all	10p
AF172	25p			BF173	22p	BRY39	44p	OC171	33p	2N3053	22p

2N3054	55p	2N4289	16½p	AAZ13	11p	BAX13	9p
2N3055	52p	2N4441	87p	BA100	10p	BAX16	10p
2N3391A	29p	2N4442	£1·06	BA102	27½p	BAY38	41p
2N3566	18p	2N4443	£1·45	BA110	45p	BB105	42p
2N3638	20p	2N4444	£2·09	BA111	55p	BB141	99p
2N3702	11p	2N4871	60p	BA112	99p	BB142	82p
2N3703	10p	2N5129	16½p	BA114	9p	OA5	99p
2N3704	11p	2N5172	9p	BA115	19p	OA10	94p
2N3705	10p	2N5459	36½p	BA116	9p	OA47	11p
2N3706	10p	2N5777	47p	BA128	11p	OA79	10p
2N3707	12p	2N6076	14p	BA129	23p	OA81	8p
2N3708	9p	3N140	£1·01	BA143U	75p	OA85	10p
2N3709	10p	3N141	89p	BA143V	67p	OA90	8p
2N3710	11p	3N152	101p	BA144	20p	OA91	8p
2N3711	11p	3N153	89p	BA145	22p	OA95	9p
2N3771	£1·82	40360	51p	BA148	22p	OA200	11p
2N3772	£2·75	40361	50p	BA154	20p	OA202	12p
2N3773	£2·20	40362	50p	BA155	15½p	OA210	19½p
2N3819	28p	40408	55p	BA156	16½p	OA211	30p
2N3823	99p	40430	£1·39	BA182	28½p	IN914	8p
2N3903	16½p	40432	£2·17	BA220	7p	IN916	10p
2N3904	19p	40673	55p	BA221	7p	IN4148	5½p
2N3905	23p	AA119	10p	BA222	7½p		
2N3906	25p	AA120	10p	BAV10	11p		
2N4058	13½p	AA129	10p	BAW62	10p		

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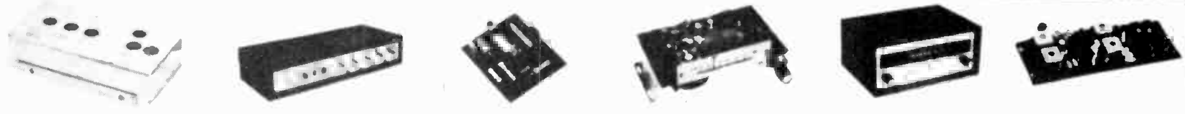
UNLESS SHOWN OTHERWISE P&P ON U.K. ORDERS IS 8p. OVERSEAS ORDERS AT COST



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Varactor diode tuned F.M. tuning heart. **£4·15**, as described in P.E. May 1973. LP1185 matching I.F. strip. **£4·85.**

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SGS EA1000
3 watt amplifier module Price including handbook and FREE heatsink. **Our price £2·49.** Quantity discounts.

A1005S
F.M. tuner chassis, fully transistorised. 9 Volt positive earth operation. **Our Price £6·35.**

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Multiplex Stereo Decoder, fully built and aligned, to match A1005S. **Our Price £5·95.**

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Audio I.C. Leaflet No. 12. FREE (only with I.C.'s—10p separately.

Pre-Amplifiers
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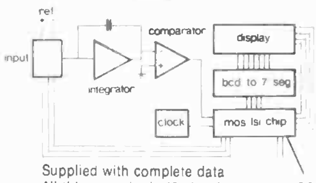
35 watt driver. NE540L **£1·32**
NEW SL414 pin for pin = SL403D 3 watt **£1·76**

3½ decade DVM



- Maximum Display + or − 1·999V
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Supplied with complete data
All this on a single 16 pin DIL packed MOS LSI Integrated Circuit
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711	—	45p	39p
723	—	96p	95p
741	42p	45p	43p
747	—	—	92p
748	42p	45p	43p

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LM301	£1·05	NE561B	£4·92
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Motorola MC1310, supplied complete with our FREE leaflet No. 11
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MC1312 decodes CBS. SQ. Free leaflet No. 11 gives full circuit and details.
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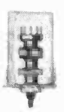

Transistor Range: Series 1T to 5T inclusive Blue, Yellow, Red and White all 44p each
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Dual Purpose Range: Series 1 to 7 inc Blue, Yellow, Red and White, **44p** each.
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NEW FERRANTI RANGE

ZN414 The Radio I.C. in a TO18 can. Supplied with our data leaflet No. 10. Giving circuits and component information. (Leaflet alone 10p.) **Our Price £1.32**

BFS59	15p	ZTX302	17p	ZTX450	17p	ZS121	10p	ZS272	18p
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		ZTX313	11p	ZTX504	43p	ZS142	33p	Zener	
ZTX107	9p	ZTX314	13p	ZTX510	17p	ZS170	10p	Series	
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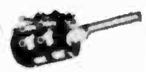
ZTX109	11p	ZTX330	15p	ZTX531	22p	ZS172	16p	BZY88	
ZTX212	14p	ZTX331	16p	ZTX550	17p	ZS174	17p	Series	
ZTX213	14p	ZTX341	22p	ZTX551	17p	ZS176	23p	11p	
ZTX214	15p	ZTX382	13p			ZS178	38p	each.	
ZTX300	12p	ZTX383	15p	DIODES		ZS270	11p		
ZTX301	13p	ZTX384	18p	ZS120	8p	ZS271	16p		

Potentiometers



5kΩ 250kΩ
10kΩ 500kΩ
25kΩ 1MΩ
50kΩ 2MΩ
100kΩ

Log or lin less switch (and 1kΩ lin)	13p
Log or lin with switch	26p
Dual less switch	44p
Dual with switch 10kΩ, 100kΩ and 1MΩ, log only	57p
10kΩ log + 10kΩ antilog less switch	44p

10kΩ, 25kΩ — Single **40p**
50kΩ, 100kΩ — Dual **60p**

New Silver and Black Knob. **16½p**

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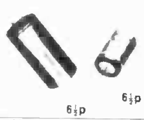
Vertical or Horizontal
0·1 watt **5½p** 0·25 watt **7p**

100Ω	1kΩ	10kΩ	100kΩ	1MΩ
250Ω	2·5kΩ	25kΩ	250kΩ	2·5MΩ
500Ω	5kΩ	50kΩ	500kΩ	5MΩ

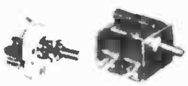
Cermet Type to 1MΩ only. **41p.**

ELECTROLYTICS



μF	4V	6·3V	10V	16V	25V	40V	63V	100V
1							6½p	8p
1·5							6½p	
2·2							6½p	
3·3							6½p	
4·7							6½p	8p
6·8						6½p	6½p	
10					6½p		6½p	9p
15				6½p		6½p		
22			6½p		6½p		6½p	11p
33		6½p		6½p		6½p		
47	6½p		6½p		6½p	6½p	8p	
68		6½p		6½p			10p	
100	6½p		6½p		6½p	8p	11p	23p
150		6½p		6½p	6½p	10p	13p	
220	6½p		6½p	8p	10p	11p	19p	31p
330	6½p		8p				22p	39p
470		6½p	10p		13p	19p	26p	48p
680		10p		13p	20p	23p		59p
1000	10p		11p	17p	22p	25p	44p	79p
1500		12p	20p	23p				
2200		18p	20p		36p	44p	79p	149p
3300		20p						
4700	29p			44p	68p	79p	149p	252p
6400				75p	93p			
10000							299p	333p

Tuning Gangs



Type C804
5pF 61p 50pF 66p
10pF 61p 60pF 79p
15pF 61p 75pF 79p
20pF 66p 100pF 75p
25pF 61p

Type 0
365pF 80p
365 + 365pF 96p

Type 00
208 + 176pF with screen and trimmers 99p

P. & P. all types 10p

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E298ED A265	11p	VA1053	11p
E298ED P268	11p	VA1055S	11p
E298ZZ 05	13p	VA1056S	11p
E298ZZ 06	11p	VA1066S	11p
E299DD P336	11p	VA1067S	16½p
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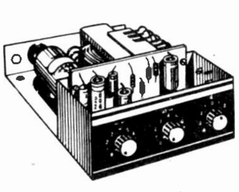
E299DD P342	11p	VA1098	21p
E299DD P348	11p	VA1104	29p
GL16	£1·10	VA1107	29p

Other types obtainable upon application

PRICES NOW INCLUDE VAT

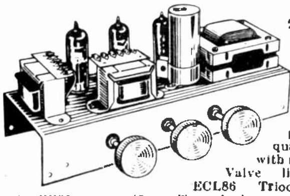
SUPERSOUND 13 HI-FI MONO AMPLIFIER



A superb solid state audio amplifier. Brand new components throughout. 5 silicon transistors plus 2 power output transistors in push-pull. Full wave rectification. Output approx. 13W r.m.s. into 8 ohm. 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 3in high × 6in wide × 7½in deep. A.C. 200/250V.

PRICE £11·60 P. & P. 40p.

DE LUXE STEREO AMPLIFIER



A.c. mains 200-240 volts. 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 300mV 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 11in. w × 4in. x. Overall height including valves 5in. Ready built and tested to a high standard. **Price £9·90.** P. & P. 50p.

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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 (1½ amp intermittent). Fitted insulated output terminals and pilot lamp indicator. Hammer finish metal case, overall size 6" × 3¾" × 2¼". Suitable for Transistor Radios, Tape Recorders, Amplifiers, etc., etc. Ready built and tested.

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Garrard SP25 Mk. III with heavy precision machined die cast turntable. £10·56. Carr. 55p.

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Beautifully constructed in heavy gauge "Colorcoat" plastic coated steel. Resonance free. Designed to take Garrard 1025, 2000, 2025TC, 2500, 3000, 3500, 5100, SP25 II and III, SL65B, AT60, etc., or B.S.R. C109, C129, A21, etc. Black leatherette finish. Size 12½in × 14¼in × 3½in high (approx. 7½in high, including rigid smoked acrylic cover). P. & P. 70p. **Now only £4·95**

LATEST ACOS GP91/18C Mono Compatible Cartridge with t/o stylus for LP/EP/78. Universal mounting bracket. £1·50. P. & P. 15p.
SONOTONE 9TAHC COMPATIBLE STEREO CARTRIDGE T/O stylus. Diamond Stereo LP and Sapphire 78. ONLY £2·30. P. & P. 10p. Also available fitted with twin Diamond T/O stylus for Stereo LP. £2·80. P. & P. 15p.
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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. w. × 3 d. × 6 h. Ready built and tested. PRICE £4·40. P. & P. 50p. ALSO AVAILABLE mounted on board with output transformer and speaker. PRICE £5·85. P. & P. 60p.

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HI-FI LOUDSPEAKER SYSTEM

Beautifully made teak finish enclosure with most attractive Tygan-Vynair front. Size 16in high × 10½in wide × 6in deep. Fitted with E.M.I. Ceramic Magnet 13in × 8in bass unit, two H.F. tweeter units and crossover. Max. power handling 10W. Available 3, 8 or 15 ohm impedance.

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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.

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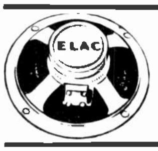
EMI CERAMIC MAGNET HEAVY DUTY TWEETER. pprox. 3½in. Av. 3 or 8 or 15 ohms. £1·25 plus 20p p. & p.
BRAND NEW. 12in 15w H/D Speakers, 3 or 15 ohm. Current production by well-known British maker. Now with Hiflux ceramic ferrobar magnet assembly £7·50. Guitar models: 25w £7·50. 35w £9·35. P. & P. 45p each.



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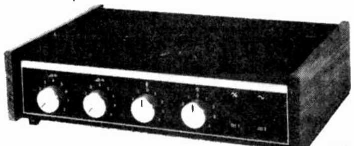

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Fully detailed 7-page construction manual and parts list free with kit or send 18p plus large S.A.E.

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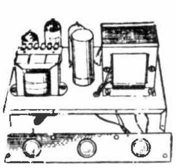
Note: The above amplifier is suitable for feeding two mono sources into inputs (e.g. mike, radio, twin record decks, etc.) and will then provide mixing and fading facilities for medium powered Hi-Fi Discotheque use, etc.

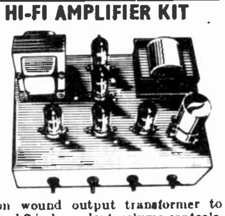
3-VALVE AUDIO AMP. HA34 MK II



Designed for Hi-Fi reproduction of records. A.C. Mains operation. Ready built on plated heavy gauge metal chassis, size 7½in w. × 4in. d. × 4½in. h. Incorporates ECC83, EL84, EZ80 valves. Heavy duty, double wound mains transformer and output transformer matched for 3 ohm speaker. Separate volume control and now with improved wide range tone controls giving bass and treble lift and cut. Negative feedback line. Output 4½ watts. Front panel can be detached and leads extended for remote mounting of controls. Complete with knobs, valves, etc., wired and tested for only £5·50. P. & P. 45p.

HSL "FOUR" AMPLIFIER KIT. Similar in appearance to HA34 above but employs entirely different and advanced circuitry. Complete set of parts, etc. £4·50. P. & P. 45p.

10/14 WATT HI-FI AMPLIFIER KIT



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2G302	0·15	2N3393	0·13	3N200	2·49	ASY50	0·20	BCY87	3·54	BFY17	0·90
2G303	0·25	2N3394	0·13	3N201	1·12	ASY55	0·15	BCY88	2·42	BFY18	0·35
2G306	0·30	2N3402	0·18	40050	0·78	BC107	0·16	BCY89	0·97	BFY19	0·35
2G309	0·30	2N3403	0·19	40251	0·81	BC108	0·15	BCZ10	0·35	BFY20	0·50
2G345B	0·25	2N3404	0·24	40309	0·30	BC109	0·19	BCZ11	0·50	BFY29	0·40
2G371	0·15	2N3405	0·27	40310	0·50	BC113	0·13	BD115	0·75	BFY37	0·20
2G374	0·15	2N3414	0·10	40313	0·92	BC114	0·12	BD116	0·75	BFY41	0·43
2N174	1·40	2N3415	0·10	40316	0·50	BC115	0·15	BD121	0·75	BFY43	0·65
2N404	0·43	2N3416	0·15	40318	0·92	BC116	0·15	BD123	0·82	BFY50	0·22½
2N456	0·75	2N3417	0·21	40360	0·46	BC116A	0·18	BD124	0·67	BFY51	0·18½
2N456A	0·75	2N3570	1·25	40361	0·48	BC117	0·21	BD131	0·40	BFY52	0·20½
2N457A	0·80	2N3571	1·12½	40362	0·50	BC118	0·11	BD132	0·50	BFY53	0·16
2N491	3·58	2N3572	0·97	40363	0·61	BC119	0·29	BD135	0·43	BFY56	0·34
2N696	0·15	2N3702	0·11	40389	0·46	BC121	0·23	BD136	0·49	BFY64	0·41½
2N697	0·15	2N3703	0·12	40394	0·56	BC125	0·15	BD137	0·55	BFY75	0·40
2N698	0·25	2N3704	0·14	40395	0·65	BC126	0·20	BD138	0·63	BFY76	0·22
2N699	0·29	2N3705	0·12	40406	0·44	BC132	0·30	BD139	0·71	BFY77	0·24
2N706	0·16	2N3706	0·09	40407	0·33	BC134	0·11	BD140	0·87	BFY78	0·36
2N706A	0·18	2N3707	0·13	40408	0·50	BC135	0·11	BDY10	1·25	BFY90	0·60
2N708	0·14½	2N3708	0·70	40409	0·52	BC136	0·15	BDY11	1·50	BRY39	0·28
2N709	0·38	2N3709	0·11	40410	0·52	BC137	0·15	BDY17	1·50	BSX19	0·13
2N711	0·30	2N3710	0·12	40411	2·25	BC138	0·24	BDY18	1·75	BSX20	0·20½
2N718	0·21	2N3711	0·11	40414	3·55	BC140	0·34	BDY19	1·97	BSX21	0·20½
2N718A	0·49	2N3712	0·96	40467	0·69	BC141	0·29	BDY20	1·05	BSX26	0·49
2N720	0·50	2N3713	1·20	40468A	0·44	BC142	0·23½	BDY38	0·65	BSX27	0·34
2N721	0·55	2N3714	1·38	40600	0·69	BC143	0·21	BDY60	0·85	BSX28	0·25
2N914	0·22	2N3715	1·50	40601	0·67	BC144	0·24	BDY61	1·25	BSX29	0·47
2N916	0·41	2N3716	1·80	40602	0·46	BC145	0·21	BDY62	1·00	BSX60	0·54
2N918	0·47	2N3773	2·65	40603	0·58	BC147	0·12	BF115	0·25	BSX61	0·42
2N929	0·30	2N3779	3·15	40604	0·56	BC148	0·13	BF116	0·23	BSX76	0·15
2N930	0·48	2N3790	2·40	40636	1·10	BC149	0·12	BF117	0·43	BSX77	0·20
2N1090	0·30	2N3791	2·35	40673	0·70	BC153	0·18	BF119	0·58	BSX78	0·25
2N1091	0·32	2N3792	2·69	AC107	0·25	BC154	0·18	BF121	0·25	BSW70	0·28
2N1132	0·54	2N3794	0·10	AC113	0·16	BC157	0·14	BF123	0·27	BSY24	0·20
2N1302	0·18½	2N3819	0·37	AC117	0·20	BC158	0·13	BF125	0·25	BSY25	0·20
2N1303	0·18½	2N3820	0·38	AC121	0·13	BC159	0·14	BF152	0·20	BSY26	0·20
2N1304	0·24	2N3823	1·42	AC126	0·25	BC160	0·37	BF153	0·21	BSY27	0·15
2N1305	0·24	2N3824	1·33	AC127	0·25	BC167B	0·13	BF154	0·16	BSY28	0·15
2N1306	0·31	2N3826	0·23	AC128	0·25	BC168B	0·13	BF158	0·23	BSY38	0·19½
2N1307	0·22	2N3854	0·18	AC141K	0·30	BC168C	0·11	BF159	0·27	BSY39	0·19½
2N1308	0·25	2N3854A	0·16	AC142K	0·25	BC169B	0·13	BF160	0·23	BSY51	0·25
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2N1893	0·81	2N3877	0·25	ACY18	0·24	BC186	0·25	BF182	0·40	BU105	2·25
2N2102	0·30	2N3877A	0·26	ACY19	0·27	BC187	0·27½	BF183	0·40	C111	0·53
2N2147	0·70	2N3900	0·21	ACY20	0·22	BC207	0·12	BF184	0·17	D40N3	0·55
2N2148	0·94	2N3900A	0·21	ACY21	0·26	BC208	0·11	BF185	0·17	GET111	0·45
2N2192	0·40	2N3901	0·32	ACY22	0·17	BC212K	0·10	BF194	0·16	GET113	0·25
2N2192A	0·40	2N3903	0·24	ACY28	0·20	BC212L	0·16	BF195	0·17	GET114	0·20
2N2913	0·40	2N3904	0·27	ACY30	0·42	BC214L	0·21	BF196	0·15	GET115	0·50
2N2193A	0·61	2N3905	0·24	ACY39	0·65½	BC237	0·09	BF197	0·15	GET119	0·35
2N2194	0·73	2N3906	0·27	ACY40	0·17	BC238	0·09	BF198	0·18	GET120	0·40
2N2194A	0·30	2N4036	0·62½	ACY41	0·17	BC239	0·09	BF199	0·18	GET535	0·20
2N2218A	0·86	2N4037	0·42	ACY44	0·31	BC251	0·20	BF200	0·40	GET536	0·20
2N2219	0·57	2N4058	0·16	AD136V	0·96	BC252	0·18	BF224J	0·14	GET538	0·20
2N2219A	0·86	2N4059	0·09	AD142	0·50	BC253	0·23	BF225J	0·19	GET873	0·12
2N2220	0·45	2N4060	0·11	AD143	0·45	BC257	0·09	BF237	0·22	GET875	0·16
2N2221	0·41	2N4061	0·11	AD149V	0·66	BC258	0·09	BF238	0·22	GET880	0·35
2N2221A	0·83	2N4062	0·11	AD150	0·63	BC259	0·13	BF244	0·16	GET883	0·20
2N2222	0·60	2N4302	0·25	AD161	0·45	BC261	0·20	BF245	0·33	GET887	0·20
2N2222A	0·91	2N4303	0·47	AD162	0·45	BC262	0·18	BF246	0·43	GET890	0·25
2N2368	0·31	2N4916	0·11	AD161 }	Pr.	BC263	0·23	BF247	0·49	GET895	0·25
2N2369	0·37	2N4917	0·17	AD162 }	1·05	BC300	2·12	BF254	0·16	TIP29A	0·49
2N2369A	0·41	2N4918	0·73	AF109R	0·40	BC301	0·34	BF255	0·17	TIP30A	0·58
2N2646	0·77	2N4919	0·84	AF114	0·25	BC302	0·29	BF257	0·47	TIP31A	0·62
2N2647	1·12	2N4920	0·99	AF115	0·24	BC303	0·54	BF258	0·59	TIP32A	0·74
2N2711	0·13	2N4921	0·73	AF116	0·25	BC307	0·10	BF259	0·55	TIP33A	1·01
2N2712	0·12	2N4922	0·84	AF117	0·20	BC307A	0·10	BF270	0·21	TIP34A	1·51
2N2713	0·17	2N4923	0·83	AF118	0·50	BC308	0·09	BF272	0·53	TIP35A	2·90
2N2714	0·18	2N5172	0·12	AF121	0·22	BC308A	0·12	BF273	0·15	TIP36A	3·70
2N2904	0·55	2N5174	0·22	AF124	0·24	BC308B	0·09	BF274	0·17	TIP41A	0·79
2N2904A	0·70	2N5175	0·26	AF125	0·20	BC309	0·10	BF457	0·53	TIP42A	0·90
2N2905	0·71	2N5176	0·32	AF126	0·19	BC309A	0·10	BF458	0·65	TIP2955	0·98
2N2905A	0·88	2N5190	0·92	AF127	0·20	BC309B	0·10	BF821A	2·30	TIP3055	0·60
2N2906	0·65	2N5191	0·95	AF139	0·38	BC327	0·21	BFS28	0·92	ME0401	0·18
2N2906A	0·70	2N5192	1·24	AF170	0·25	BC328	0·19	BFS61	0·27	ME0402	0·20
2N2907	0·38	2N5195	1·46	AF172	0·25	BC337	0·19	BFS98	0·20	ME0404	0·13
2N2907A	0·41	2N6245	0·43	AF178	0·55	BC338	0·19	BFW11	0·61	ME0411	0·17
2N2923	0·12	2N5457	0·49	AF179	0·65	BCY30	0·43	BFX13	0·23	ME0412	0·18
2N2924	0·14	2N5458	0·45	AF180	0·50	BCY31	0·51½	BFX29	0·30	ME0413	0·14
2N2925	0·17	2N5459	0·49	AF186	0·40	BCY32	1·15	BFX30	0·25	ME1120	0·25
2N2926		3N128	0·73	AF200	0·35	BCY33	0·34	BFX37	0·33	ME4001	0·09
Green	0·12	3N138	1·65	AF239	0·61	BCY34	0·36½	BFX44	0·33	ME4002	0·11
Yellow	0·11	3N139	1·42	AF240	0·72	BCY38	0·52½	BFX63	2·48	ME4003	0·14
Orange		3N140	0·92	AF279	0·54	BCY39	1·05	BFX68	0·30	ME6101	0·10
	0·11	3N141	0·81	AF280	0·54	BCY40	0·87	BFX84	0·24	ME4102	0·11
2N3053	0·32	3N142	0·58	AFY42	0·74	BCY42	0·15	BFX85	0·30	ME4103	0·10
2N3054	0·86	3N143	0·75	AL102	0·75	BCY43	0·15	BFX86	0·25½	ME4104	0·11
2N3055	0·75	3N152	0·92	AL103	0·70	BCY58	0·21	BFX87	0·28	ME4101	0·14
2N3390	0·26	3N153	0·81	ASY26	0·30	BCY59	0·22	BFX88	0·25	ME6102	0·16
2N3391	0·28	3N154	0·84	ASY27	0·36	BCY70	0·17	BFX89	0·45	ME8002	0·17
2N3391A	0·29	3N159	1·17	ASY28	0·28	BCY71	0·22	BFY10	0·35	ME8003	0·16

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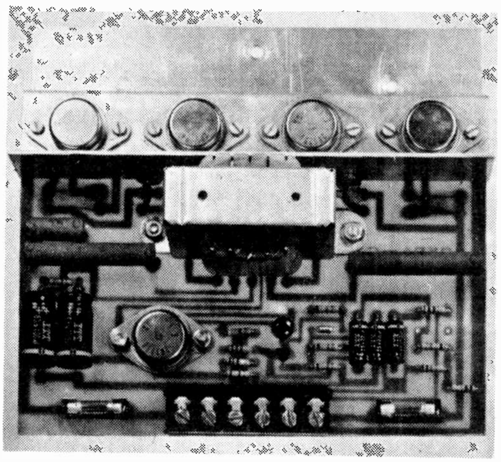

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¼	CF	22-2M2	1	0·8	0·65	0·62	0·55	0·5	0·45	3·9 × 10·5
½	CF	22-1M	1	0·8	0·65	0·62	0·55	0·5	0·45	5·5 × 16
⅛	MF	10-2M7	1	0·9	0·8	0·7	0·65	0·65	0·6	3 × 7
½	MF	10-2M2	1	0·9	0·8	0·7	0·65	0·65	0·6	4·2 × 10·8
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10µF	16V	6p	220µF	10V	6p
10µF	25V	6p	220µF	16V	8p
10µF	63V	6p	220µF	63V	21p
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15µF	63V	6p	330µF	63V	25p
16µF	40V	6p	470µF	6·4V	9p
22µF	25V	6p	470µF	40V	20p
22µF	63V	6p	680µF	16V	15p
32µF	10V	6p	680µF	40V	25p
33µF	16V	6p	1000µF	16V	20p
33µF	40V	6p	1000µF	25V	25p
32µF	63V	6p	1500µF	6·4	15p
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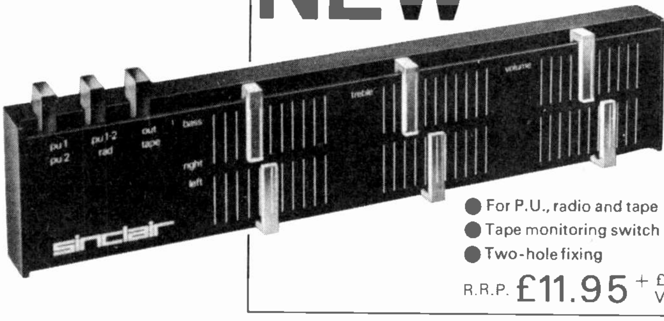
Project 80 new modules

Stereo 80 pre-amplifier and control unit

As with other Project 80 units, the Stereo 80 is mounted by means of two bolts fixed at the rear which pass through holes drilled in the wood or plastic on which modules are to be mounted. *All the electronics are contained within the ¾" deep front panel!* Connecting leads are taken away similarly out of sight. Each channel in the Stereo 80 has its own independent tone and volume controls operated by sliders. This enables exceptionally good environmental matching to be obtained. Provision is made for magnetic and ceramic pick-ups, radio and tape in and out. A virtual earth input stage forms part of the up-dated circuitry of the Stereo 80 to ensure the finest possible quality from all signal sources. Generous overload margins are allowed on all inputs. Clear instructions with template are supplied.

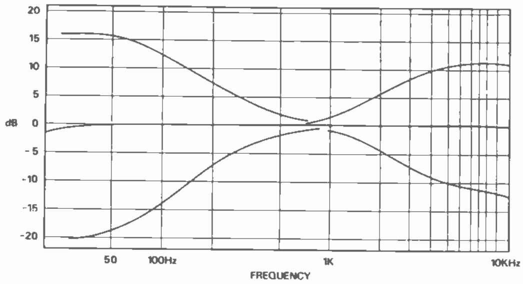
TECHNICAL SPECIFICATIONS
Size – 260 × 50 × 20mm (10¼ × 2 × ¾ins)
Finish – Black, with white markings
Inputs – Mag. P.U. 3mV RIAA corrected. Ceramic P.U. 300 mV
Radio 300 mV. Tape 30 mV
S/N ratio – 60db
Frequency range – 20Hz to 15KHz ± 1dB. 10Hz to 25KHz ± 3dB
Power requirements – 20 to 35 volts
Outputs – 100mV + AB monitoring for tape
Controls – Press button for tape, radio and P.U. selection. Volume, Bass + 12dB to – 14dB at 100Hz. Treble + 11dB to – 12dB at 10KHz

NEW



- For P.U., radio and tape
- Tape monitoring switch
- Two-hole fixing

R.R.P. £11.95 + £1.19 VAT

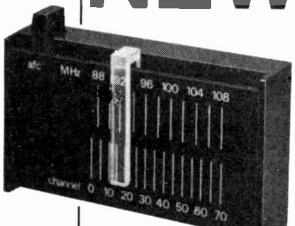


Project 80 FM tuner smaller, more efficient

A truly remarkable tuner in every way – its unbelievably compact size – its original circuitry – its dependable performance – all this in a boldly designed modern case measuring 85 × 50 × 20mm (3⅜ × 2 × ¾ins). Greater adaptability (and possibly financial convenience) results from the tuner and stereo decoder section being made available separately.

TECHNICAL SPECIFICATIONS
Size – 85 × 50 × 20mm (approx. 3⅜ × 2 × ¾ins)
Tuning range – 87 to 108 MHz
Detector – I.C. balanced coincidence, for good A.M. rejection
AFC – Switchable, with thermistor control to prevent from drift
One 26 transistor I.C.
Twin dual varicap tuning
Distortion – 0.3% at 1KHz for 75KHz deviation
Ceramic filter in I.F. section
Aerial impedance – 75 Ω or 240-300 Ω
Sensitivity – 4 microvolts for 30dB quieting
Power requirements – 12 to 45 volts

NEW



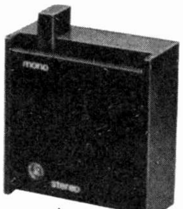
- AFC switch
- Twin dual varicap tuning
- 4-hole ceramic filter
- Slider tuning

R.R.P. £11.95 + £1.19 V.A.T.

Project 80 stereo decoder

Making the Project 80 decoder separate from the F.M. tuner gives the constructor a wider choice of systems as well as saving money in cases where stereo reception may not be required. This unit gives a 40dB channel separation with an output of 150mV per channel. The gallium arsenide light emitting beacon automatically lights up to show when a stereo transmission is tuned in. Designed essentially as an integral part of Project 80 systems, this multiplex stereo demodulator may be used in many cases with existing single channel frequency modulated tuners to provide stereo reception.
Size – 47 × 50 × 20mm (1⅞ × 2 × ¾ins)
One 19 transistor I.C.

NEW

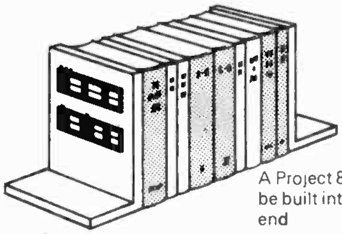


- Solid-state stereo indicating beacon
- Readily adaptable for use with other tuners

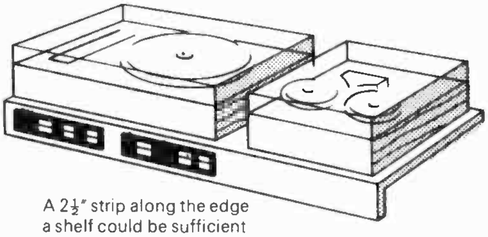
R.R.P. £7.45 + 0.74p V.A.T.

From Sinclair the worlds most advanced hi-fi modules

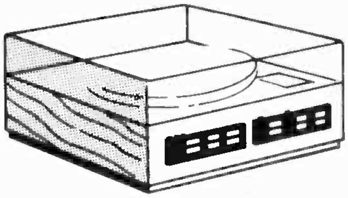
Sinclair Project 80 the ultra-modern non-obtrusive hi-fi



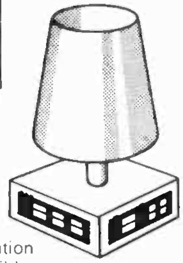
A Project 80 system could be built into a book-shelf end



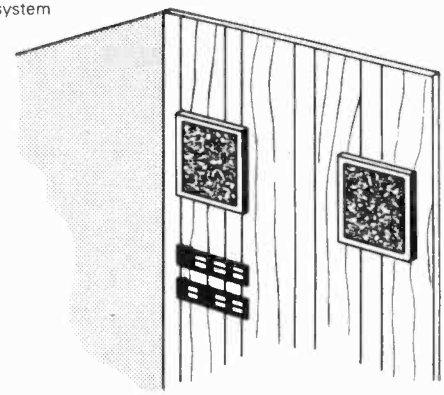
A 2½" strip along the edge a shelf could be sufficient to contain a complete system



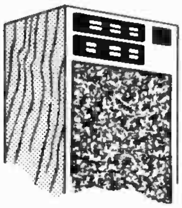
The modules mount very easily onto a playing plinth



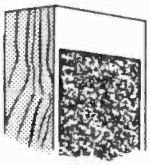
A novel application would be to build around the base of a lampshade



Two Sinclair Q.16 loudspeakers suitably positioned together with Project 80 could be mounted on to a false wall.



Project 80 could be easily mounted onto a loudspeaker cabinet



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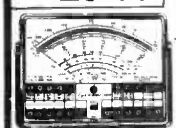

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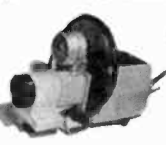

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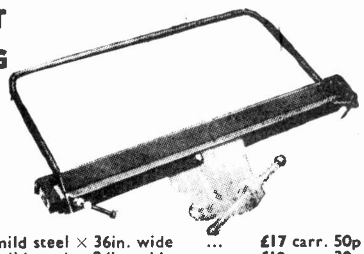

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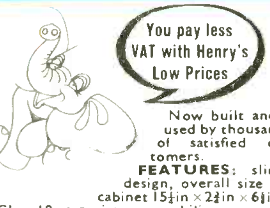

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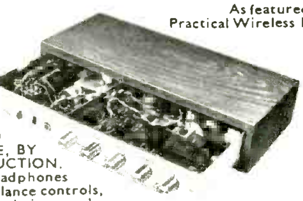

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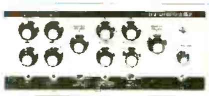

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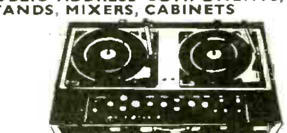

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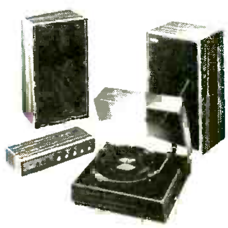

The Texan Stereo Systems include the high quality Texan Stereo amplifier assembled and ready to use. A pair of Type 200 20 watt Speaker-Tweeter systems, size 12 × 12 × 10in and a choice of Garrard players built into a plinth with cover with Goldring G800 magnetic cartridge. System 25 uses Garrard SP25 Mk.III and system 76 the Garrard AP76 de luxe turntable. All necessary leads are supplied.

SYSTEM 25 (list approx. £109) £79·50
SYSTEM 76 (list approx. £117) £89·50
(plus 10% VAT and plus £1·45 carr/packing).

BARCLAYCARD/ACCESS
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EASY TERMS FOR CALLERS

Stereo Preamplifier .. £11·95
Audio Filter Unit .. £6·95
Z40 15 watt Amplifier .. £5·45
Z60 25 watt Amplifier .. £6·95
PZ6 Mod. for 1 on 2 Z40 .. £4·98
PZ Mod. (S Tab) 1 on 2 Z40 .. £7·98
PZ8 Mod. (S Tab) 1 on 2 Z60 .. £7·98
TRANSFORMER FOR PZ8 .. £2·95
NEW FM TUNER .. £11·95
STEREO DECODER .. £7·45
All items post paid—Best price on request.

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A completely new high stability stereo FM tuner. Features variable capacity diode tuning, stabiliser power supply, IC Decoder, high gain low noise. IF stages. LED indicators, Tuning meter, AFC. Easy to construct and use. Mains operated. Slim modern design with fibre glass PC, teak cabinet, etc. Available as a kit to build or ready built. Overall size: 8in × 2¾in × 6¼in. Produced to give high performance with a realistic price. (Parts list and constructional details Ref. No. 5, 30p.) Henry's are sole distributors UK and Europe.

Kit Price **£21·00** (+ VAT)
or built and tested **£24·95** (+ VAT)

LIVING SOUND LOW NOISE TOP QUALITY CASSETTES MADE BY EMI TAPES LTD. TO INTERNATIONAL STANDARDS ESPECIALLY FOR HENRY'S. ALL POST PAID LESS THAN ½ REC. PRICES. COMPLETE WITH LIBRARY CASES.

	3 for	6 for	10 for	25 for
C60	£1·00	£1·80	£2·80	£6·75
C90	£1·33	£2·57	£4·20	£10·25
C120	£1·62	£3·15	£5·00	£12·25

Quantity and trade enquiries invited.

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LOW COST HI-FI SPEAKERS SPECIAL OFFERS

EMI 13in × 8in—full range speakers (post 20p each or 30p pair): *150TC—8 ohms Twin Cone 10 watt, **£2·20** each or **£4** pair; *450 10 watt c/o Twin Tweeters 3, 8 or 15 ohms, **£3·50** each or **£6·90** pair; EW 15 watt 8 ohms c/o Tweeter, **£4·30** each or **£7·90** pair; 350 20 watt c/o Tweeters 8 or 15 ohms, **£7·50** each or **£14·20** pair.
* Polished wood cabinet £4·60, post 35p.

8 ohms full range (post 20p)
FR4 4in 5 watt, **£4**; FR65 6½in 10 watt, **£5·50**; FR8 8in 15 watt, **£7·60**; FR23 9 × 6in 15 watt, **£6·00**.

BASS AND MID RANGE—8 ohms (post 20p)
AA12 5in 15 watt, **£3·20**; B110 5½in 15 watt, **£5·60**; B200 8in 15 watt, **£6·45**; B139/2 13in × 8in 30 watt LF, **£10·25**.

TWEETERS AND CROSSOVERS (post 20p)
K2006 10 watt 8 or 15 ohms, **£1·90**; FHT6 15 watt 8 ohms, **£3·20**; K2011 30 watt 8 ohms, **£3·75**; T27 KEF, **£4·25**; Axent 100 30 watt 8 ohms, **£4·90**; K4009 1kHz/5kHz c/o, **£2**; SN75 3kHz var. c/o, **£1·75**.

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20-2 8in 30 watt, **£10** each; 20-3 8in 40 watt, **£15** each; LINTON 2 20 watt, **£15·95** pair; GLENDALE 3 30 watt, **£28·95** pair; DOVEDALE 3 50 watt, **£42** pair; KEF KK2, **£20·40** each; KEF KK3, **£32** each.

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A complete kit, packaged in a polystyrene container and taking about 3 hours to assemble—that's the Sinclair Cambridge pocket calculator from Henry's. Some of the many features include interface chip, thick-film resistor pack, printed circuit board, electronic components pack. Size: 4⅓in long × 2in wide × 11/16in deep.
Free of charge with the kit for the more advanced technologist is a 32-page booklet explaining how to calculate Logs, Tangents, Sines, etc.

Price **£24·95** (+ VAT)
Also assembled ready to use **£27·22** (+ VAT)

10% VAT TO BE ADDED TO ALL ORDERS. Prices and descriptions correct at time of press E & O E. See pages 8, 9, and 10 of this magazine.

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