electronics today INTERNATIONAL

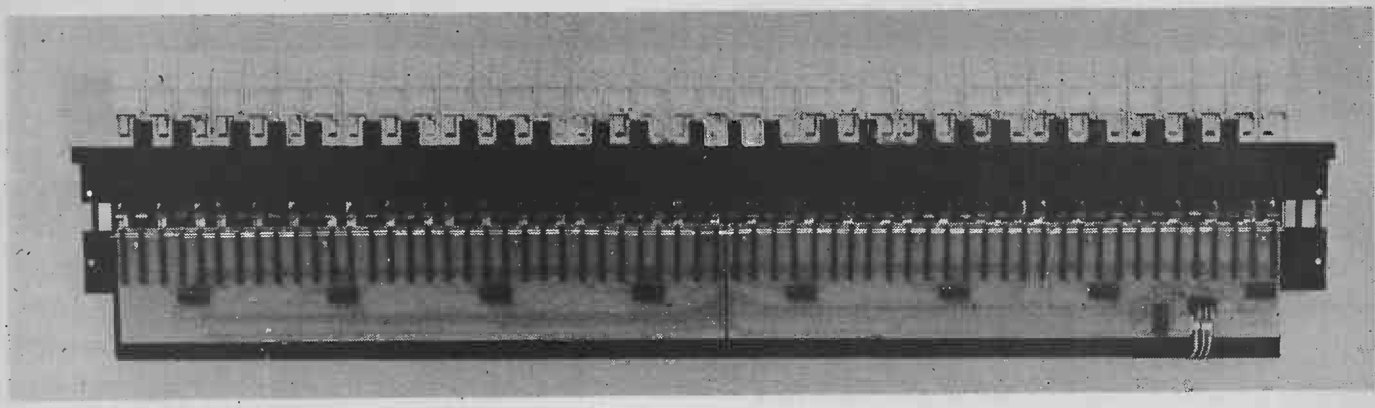
AUGUST 1979

50p

PLAY AWAY WITH ETI's STRING THING

AUDIO DISPLAY
CHEAP TRICK
MICROSENSE
BENCH AMP

...NEWS....PROJECTS....MICROPROCESSORS....AUDIO...



Keyboard with multiplex boards fitted. These carry the 61 contact assemblies through which the two bus bars pass. Connection to the dynamics board is made by DIL plug-on ribbon cable (bottom right).

suitable hole diameter for the self tapping screws. Screw the keyboard assembly into position and then check each contact wire and plunger. When the key is not pressed there should be about one twentieth of an inch gap between the wire and plunger. The wire can be bent with long nose pliers to obtain this spacing. Make sure that when each note is pressed the contact wire makes a firm contact with the +5V bus bar. If there are any dirty contact problems, then use a non residue cleaning spray to clean the contact blocks. I usually use Freon T TF112 (trichlorotri fluoreothane) which, although I can't pronounce it, seems to work OK.

Chorus—Ensemble Unit

Natural sounds tend to be more interesting than those generated electronically. This is mainly due to the fact that natural sounds have a great many changing parameters that make our 'forever analysing' ears sit up and take notice of them. Electronic sound structures can be given added interest by processing them with an ensemble unit (Fig. 6). This is a complex phasing unit that produces three layers of constantly moving comb frequency responses. The notches in the comb frequency response cancel out any harmonics that occur at that same frequency, but because the notches are continually moving this cancellation is not static. The overall effect of this on the sound structure is similar to the effect of several acoustic instruments trying to play the same piece of music, where a complex process of cancellation and addition is continually in operation. The ensemble unit simulates another parameter in the synthesis of the sound giving one more accoustic clue to its real identity.

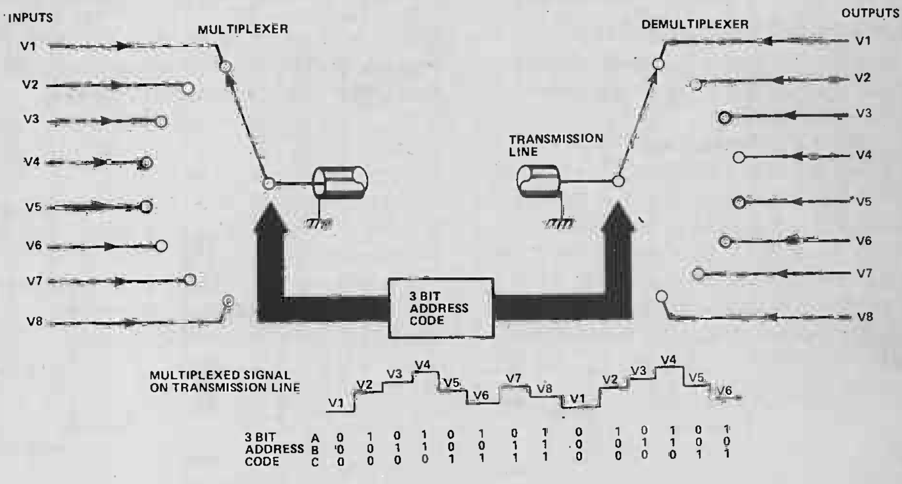


Fig. 2. The principle of the multiplexing/demultiplexing system.

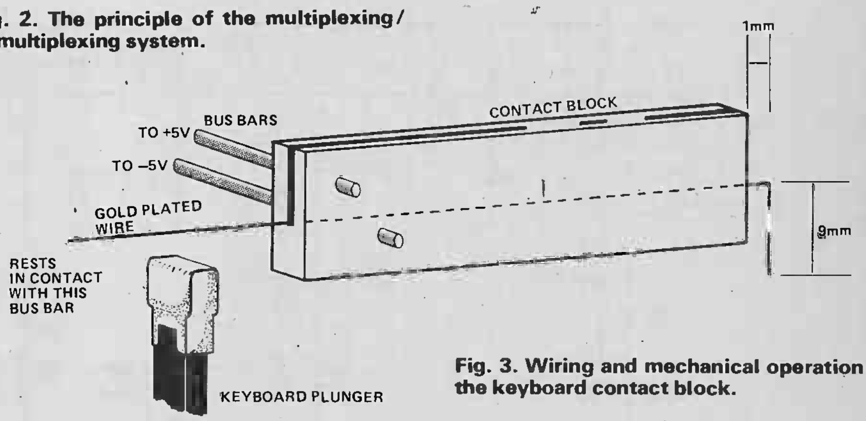


Fig. 3. Wiring and mechanical operation of the keyboard contact block.

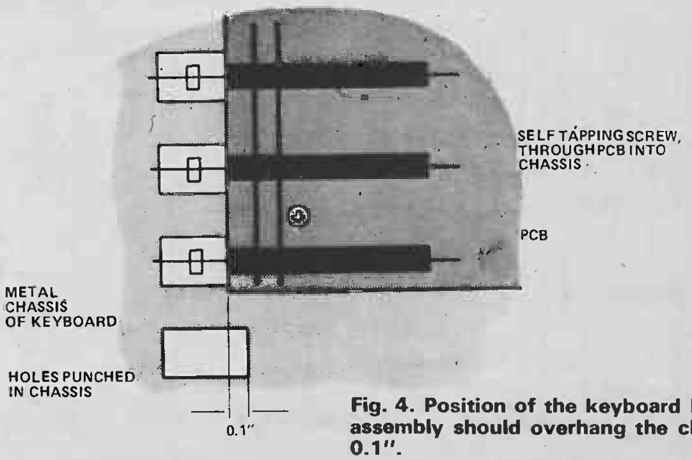


Fig. 4. Position of the keyboard PCB. The assembly should overhang the chassis by 0.1".

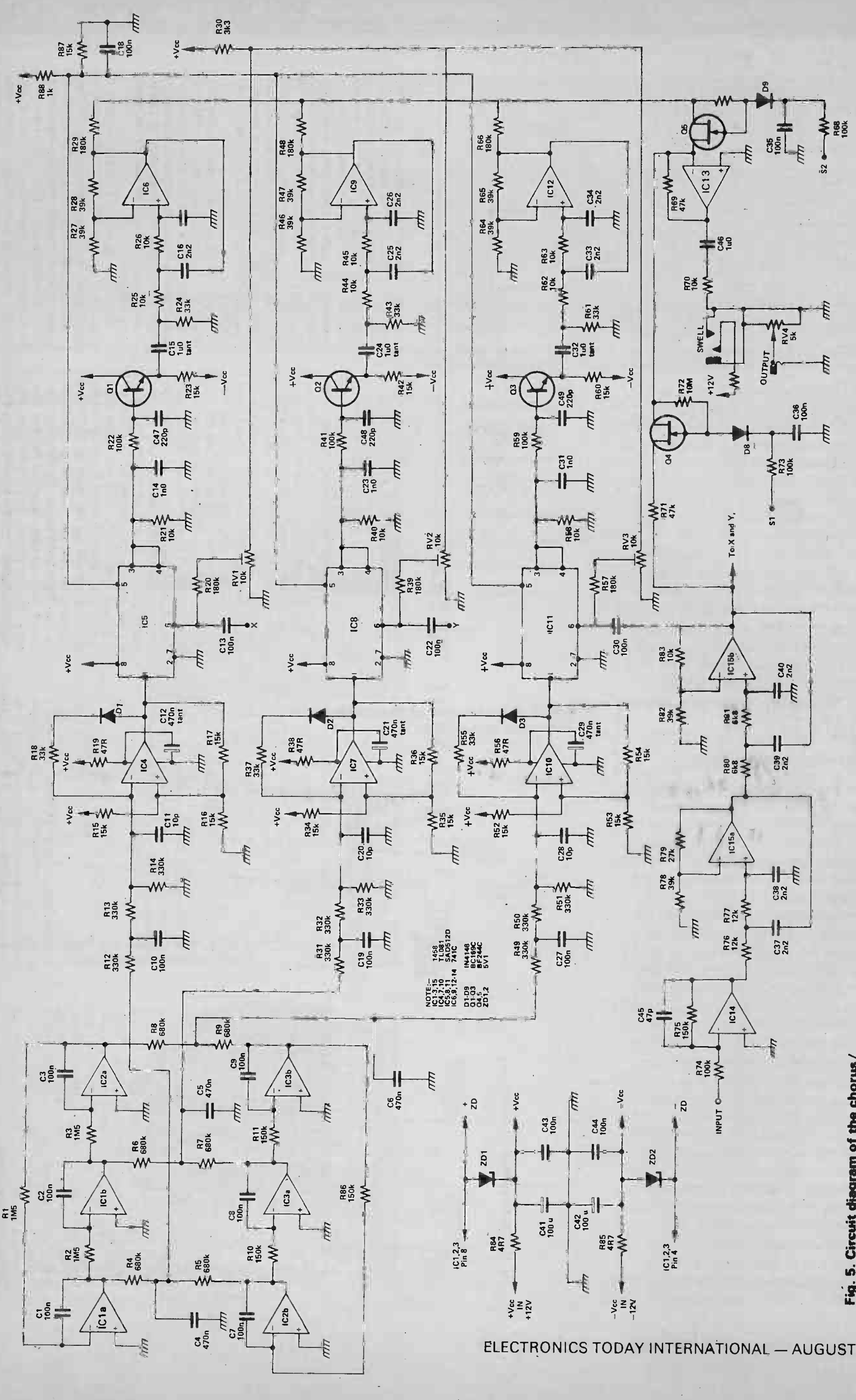


Fig. 5. Circuit diagram of the chorus / ensemble unit.

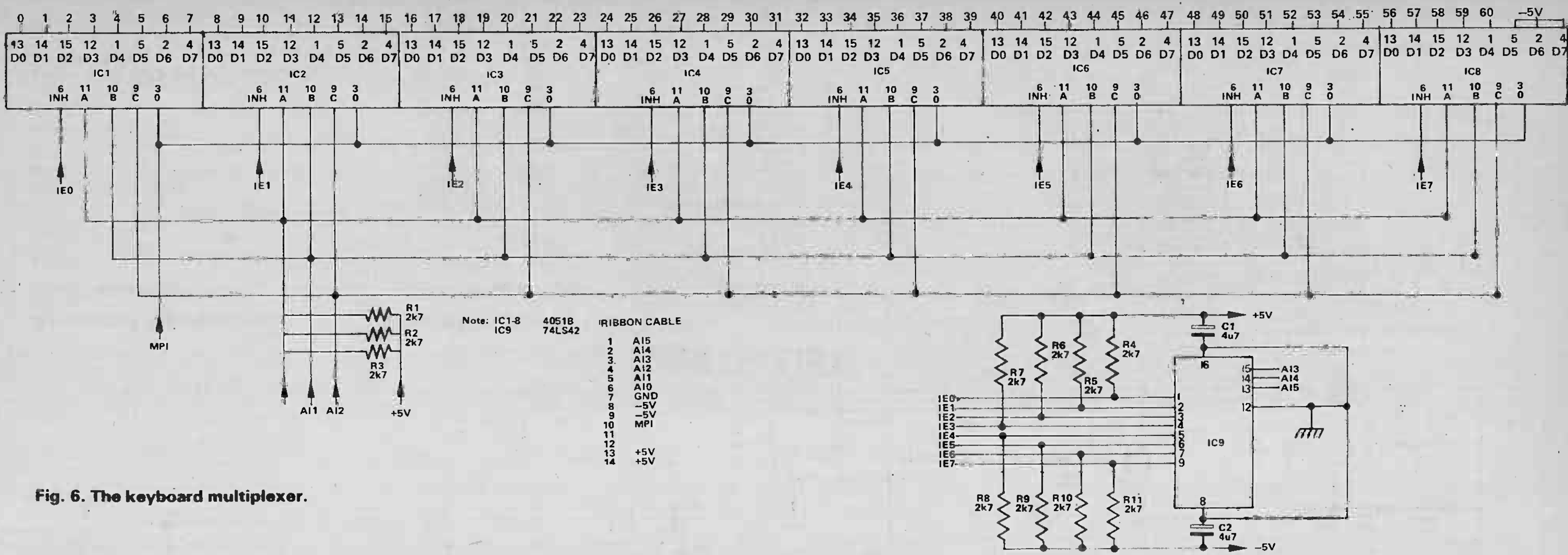


Fig. 6. The keyboard multiplexer.

HOW IT WORKS

The Op amps IC1, 2, 3 form a couple of three phase oscillators. Each oscillator is made up out of three integrators wired up in a loop. The overall DC loop phase is inverting, so it will never become latched up, but the circuit is inherently unstable and so will always oscillate. The output waveforms are trapezoidal in shape, each output being one third of a cycle behind its predecessor. One of the oscillators is set to run at 0.6 Hz, the other at 6 Hz. Pairs of outputs are mixed together and filtered by a simple RC lowpass filter. This removes most of the harmonics of the trapezoids producing reasonably pure sinusoids. The resulting waveform is a large 0.6 Hz sinewave with a smaller 6 Hz sinewave superimposed on top. This is then used to frequency modulate a fast running oscillator which in turn determines the position of the comb notches. The larger the modulation depth, the more pronounced is the ensemble effect. A milder effect is obtained by reducing the power supply voltage to the three phase oscillator (by introducing ZD1, 2 into the supply lines), which reduces the sinewave amplitudes.

The fast running oscillators, (IC4, 7, 10), are based around TL 081 op amps. These have the same pinout as a 741 but are very fast having a slew rate of 13 V/uS. This enables them to be used as relaxation oscillators running in this case at frequencies of 100 to 200 kHz and generating pulse waveform with fast edges. The oscillator is a standard one op amp device that combines a Schmitt trigger and an integrator in the feedback route. The oscillation frequency is controlled by the modulation signal because this robs a varying amount of charging current from the 10 p timing capacitor.

Complex phasing is produced by passing the audio signal through the three delay lines, the output signals of which are mixed together. The time delay is controlled by the clock frequency which is calculated using the formula,

$$\text{Time delay} = \frac{512}{\text{Clock frequency}}$$

A clock frequency of 100 kHz will give a delay time of 5.12 mS, and 200 kHz gives 2.56 mS. The delay lines can be thought of as being analogue shift registers. On every clock pulse, the analogue signal is sampled and shifted along one position in the register. After 512 clock periods, the original input signal appears at the output and so it can be correctly claimed that a time delay of 512 clock periods has been produced. The signal is not continuous, but is quantized into time intervals. This can result in a phenomena known as aliasing, which sounds rather like ring modulation, whereby the audio signal intermodulates with the clock (sampling) frequency. This generates a new set of signals (sidebands), some of which may fold back into the audio spectrum and cause annoyance. A lowpass filter (IC 15), is used to prevent these aliasing effects by band limiting the input signal to 7.5 kHz. The signals that appear at the delay line outputs (IC5, 8, 11, pins 3 and 4), are quantized in time and are restored to their former continuous shape by third order lowpass filters (Q1, IC6 for example). There is a preset control for each delay line that provides a DC bias level. This is adjusted so that the SAD 512D produces an unclipped signal at its output. The preset has enough range to enable clipping to occur on both positive and negative signal excursions but should be adjusted so that it is intermediate between these two extremes.

The continual modulation of the three time delays and the subsequent mixing of the signals produces a constantly moving frequency response that has several notches. This turns a relatively flat electronic sound into something that has a chorus or ensemble characteristic about it, which can be used to enhance the string, brass and even the piano output. The ensemble effect can be turned off and the original single only can be heard by use of electronic signal routing on the PCB.

This is achieved by using a couple of FET's, (Q4, 5) as voltage controlled switches, which obtain their command signals from the control panel. The output signal level can be controlled by both a manual volume control and by an optional swell pedal.

This device uses a lamp photo-cell variable optical slit to produce a foot operated variable resistor. As the foot pedal is rotated, more light falls onto the photocell via the slit and this reduces the cell's resistance. The life-time and smoothness of operation of this system is much better than that of a conventional pot with a rack and pinion linkage mechanism.

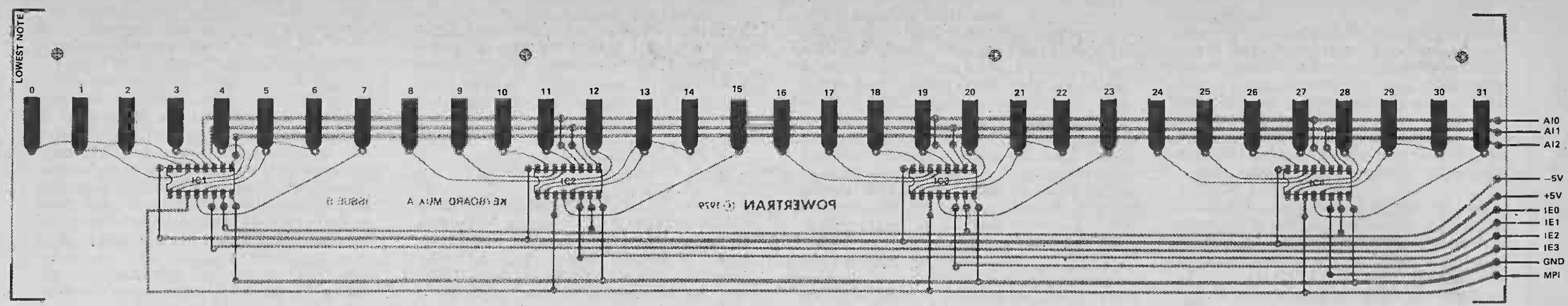
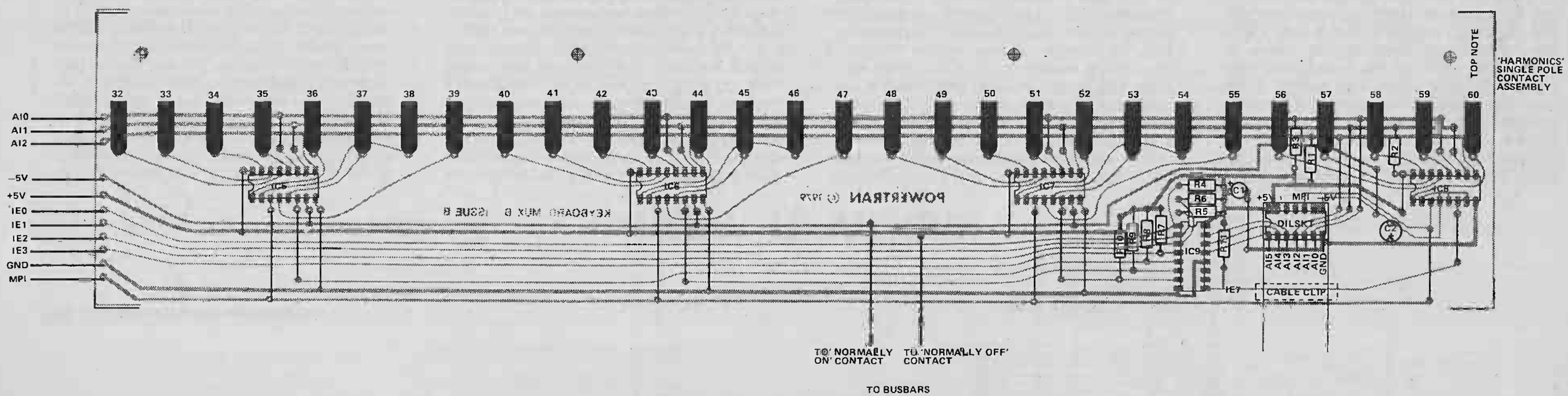


Fig. 7a (above) and 7b (below) show the component overlays for the two boards which go to make up the keyboard and multiplexer.



PARTS LIST

Keyboard Multiplexer

RESISTORS all $^1/_5$W 5%

R1-11	2k7

CAPACITORS

C1, 2	4u7 16V tantalum

SEMICONDUCTORS

IC1-8	4051B
IC9	74LS42

MISCELLANEOUS
Keyboard multiplexer PCBs A and B, harmonics contact assemblies (single pole), 5 octave length of bus bar 1.4mm diam., 9 off 16 pin DIL sockets, one off 14 pin DIL socket, cable clamp (8 way ribbon), 14 way ribbon cable connector lead.

Ensemble Chorus Unit

RESISTORS all $^1/_5$W 5%

R1,2,3	1M5
R4-9	680k
R10,11,75,86	150k
R12,13,14,31 32,33,49,50 51	330k
R15,16,17,23 34,35,36,42, 52,53,54,60, 87	15k
R18,24,37,43, 55,61	33k
R19,38,56	47R
R20,29,39,48, 57,66	180k
R21,25,26,40, 44,45,58,62, 63,83	10k
R22,41,59,68, 73,74	100k
R27,28,46,47, 64,65,78,82	39k
R30,70	3k3
R31,32,33,49, 50,51	330k
R67,72	10M
R69,71	47k
R76,77	12k
R79	27k
R80,81	6k8
R84,85	4R7
R88	1k

POTENTIOMETERS

RV1,2,3	10k
RV4	5k

CAPACITORS

C1,2,3,7,8,9, 10,13,18,19, 22,27,30,35, 36,43,44	100n
C4,5,6	470n
C11,20,28	10p
C12,21,29	470n 35V tantalum
C14,23,31	1n0
C15,24,32	1u0 35V tantalum
C16,17,25,26, 33,34,37,38 39,40	2n2
C41,42	100u 25V electrolytic
C45	47p polystyrene
C46	1u0
C47,48,49	220p ceramic

SEMICONDUCTORS

IC1,2,3,15	MC1458
IC4,7,10	TL081
IC5,8,11	SAD512D
IC6,9,12,13,14	741C
Q1-3	BC169C
Q4-5	BF244C
D1-9	1N4148
ZD1,2	5V1 400mW.

MISCELLANEOUS
Chorus board PCB, PC pins, 9 way connector, 15 off 8-pin DIL sockets.

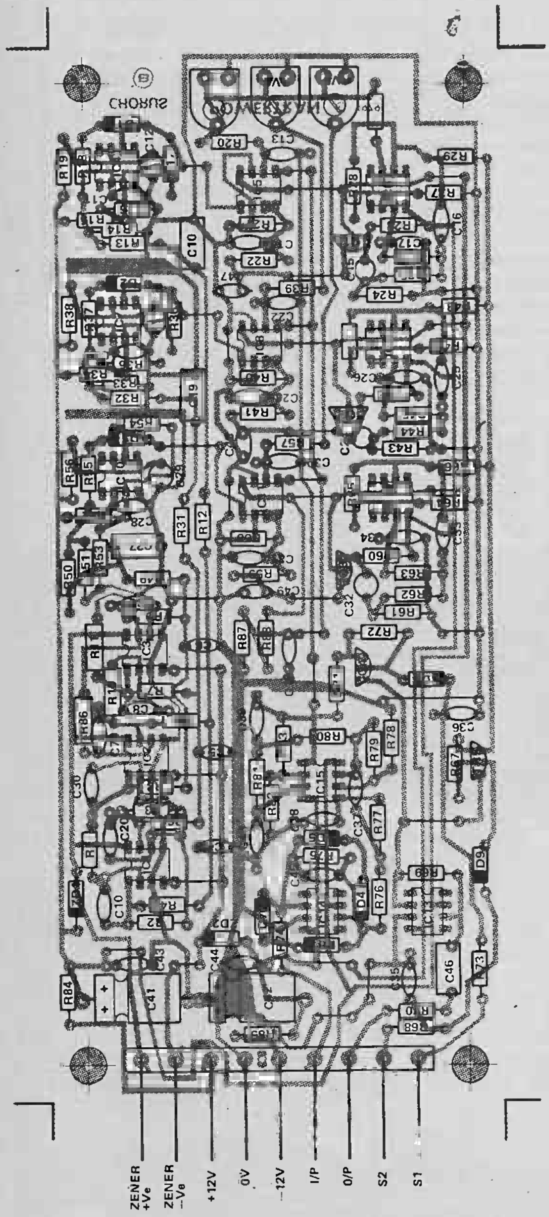
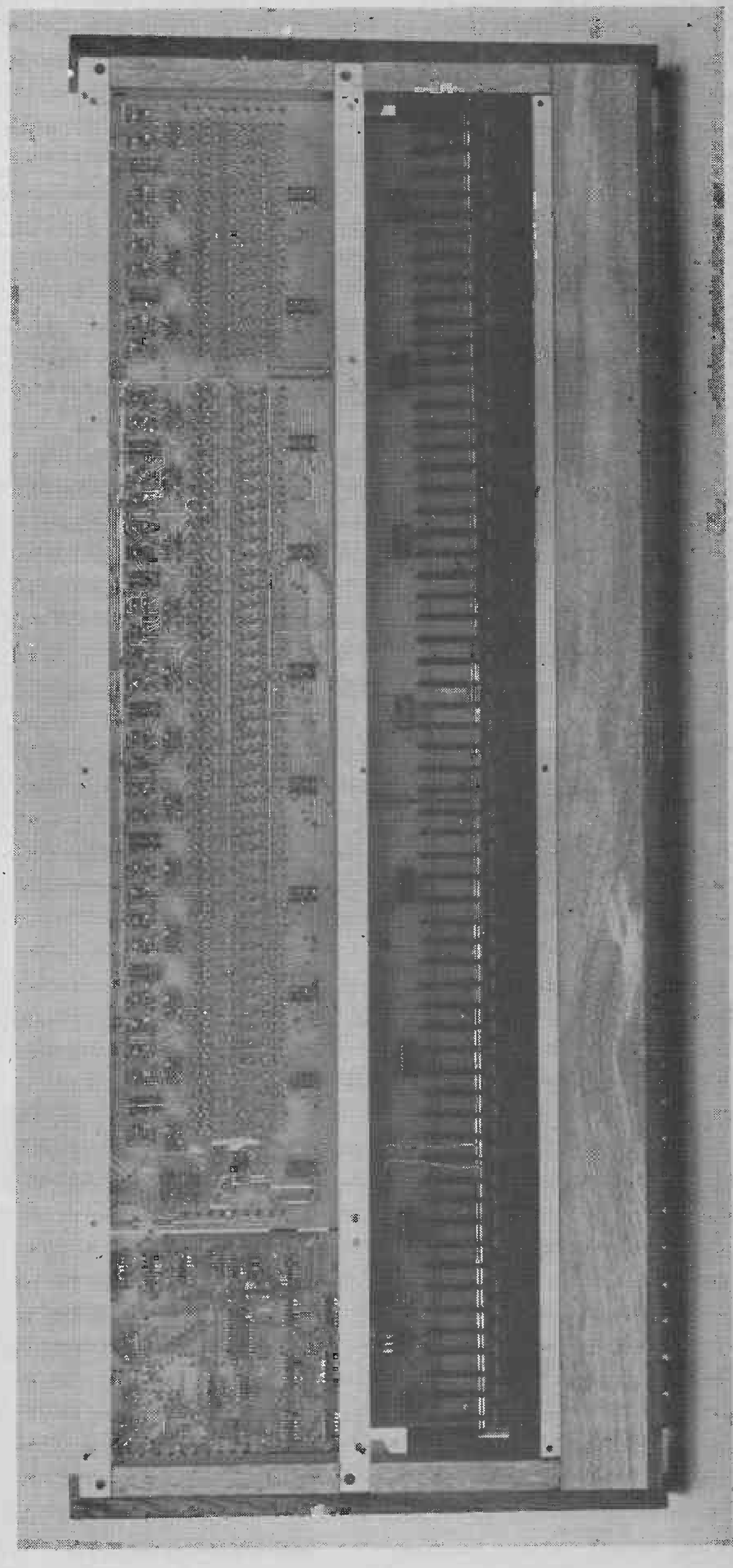


Fig. 8 (above). Component overlay for the chorus/ensemble board.
(Right) With the base plate removed, the multiplex boards can be seen under the keyboard.



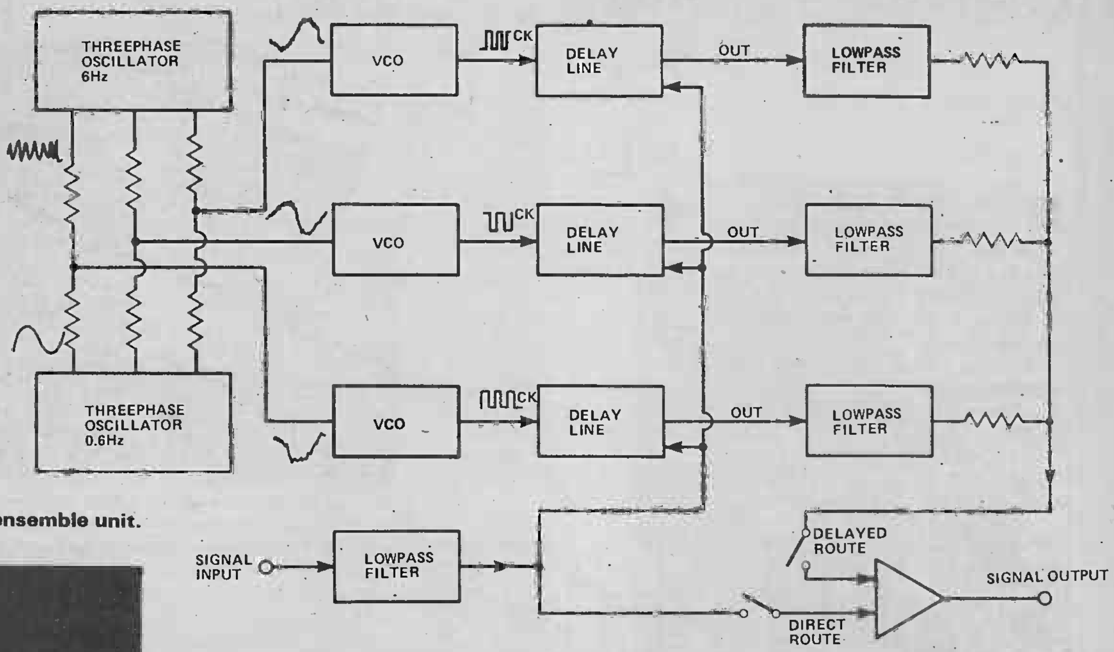
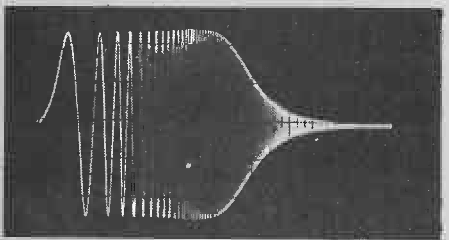
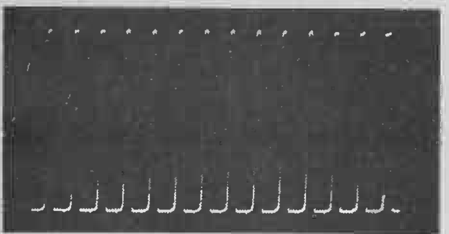


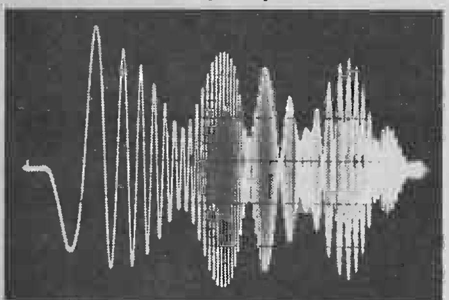
Fig. 5. Block diagram of the ensemble unit.



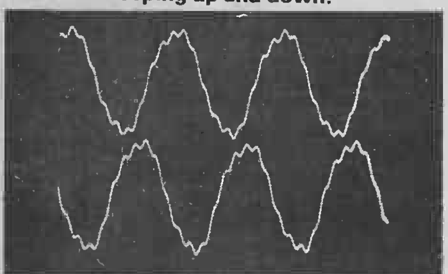
Frequency response of lowpass filters used in the chorus board.



Clock waveform of the high frequency oscillators used in the chorus board, sweep the delay frequency = 200 kHz.



Frequency response of the chorus unit. This pattern is constantly changing with the notches sweeping up and down.



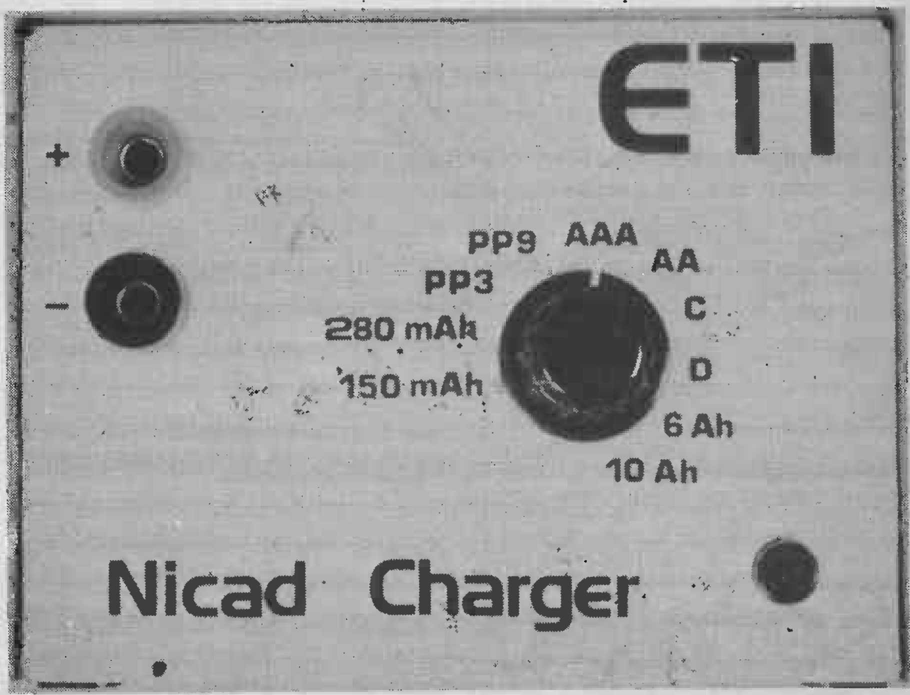
Two of the three control voltages that sweep the delay lines in the chorus unit.

Ni~Cd CHARGER

Not content with giving you the best value for money, we now come up with a good method of saving it!

IF YOU OWN OR use battery powered equipment then the price of batteries and the monotonous regularity with which replacements are necessary must surely cause manical depressions as well as burn holes in the proverbial pocket.

One answer is to buy Nicad cells — although you may have to arrange a second mortgage initially, because they are pretty expensive (about three times the cost of yer average cell). Their great advantage is that they are rechargeable and can have a working life of well over 500 recharges. Just think of all that money you could save!!!



Being Constant

Nicads need to be charged with a more or less constant current. This current is derived as a function of the capacity of a cell and the length of time being charged. To clarify this point we can take for an example a cell — size AA (equivalent to U11, HP11 etc). Capacities of cells vary from manufacturer to manufacturer but an AA sized nicad has an approximate capacity of 0.5Ah. Simply speaking, if 500 mA is drawn from the cell it will provide power for one hour. If 50 mA is drawn then the cell will provide power for 10 hours. Similarly, to recharge the cell to full capacity (assuming 100% efficiency) it would take 500mA for one hour or 250mA for two hours, etc.

Problems Problems

This is where the basic problem lies. Because of the make-up of the cell, if an overcharge is given eg 250mA for 3 hours, then permanent damage can be caused to it.

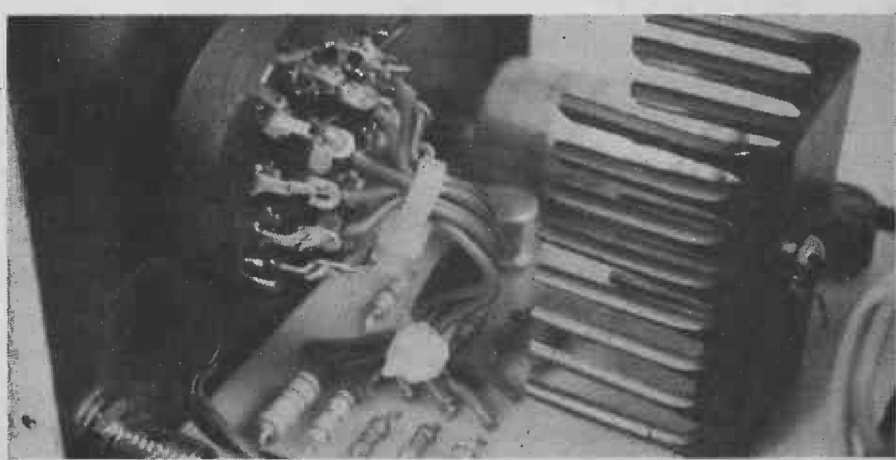
So, at any given charging current the cell must be disconnected at the time of full charge, or so it would appear. It is, however, a little known fact that at currents less than $\frac{C}{16}$ (where C is the capacity of the cell then no permanent damage can occur, no matter how long the cells are connected to the charger. The ETI nicad charger is designed with this criteria in mind. It will comfortably charge up to six cells in series (of the same type) at a rate of $\frac{C}{16}$ amps

The values given for R2-11 were theoretical, derived from Ohm's law. The charging current can be checked easily by connecting an ammeter across the Output (the current remains constant whatever the load) and take readings with each resistor in circuit and change if necessary.

Building Up To It

Construction is simple — there are only 6 components in the main part of the circuit (not counting the current setting resistors R2 to R11).

Note the transistors Q2 needs a reasonable heatsink. ▶



HOW IT WORKS

One of the most convenient methods of obtaining a constant current is to use a voltage regulator and a current limiting resistor, as in Fig. 1.

R1 determines the current. If a five volt regulator is in use then a constant 5V is held across it. From Ohm's law the current $I = V/r$. The common connection is essentially a negative feedback loop, acting to maintain a constant current through the resistor and into the load.

A slight disadvantage of this sort of circuit is the power dissipated from the resistor. With 5V across it and say a current of 500mA through it, the power P,

P = IV = ½ amp x 5 volts
= ½ watts.

This means the use of a large and quite expensive resistor.

The circuit used in the ETI Nicad Charger uses a fairly standard type voltage regulator, formed by Q1 and Q2, but the current limiting resistor R2 (Fig. 2) only has the V_{BE} of Q1 across it — 0.6 volts for silicon transistors. If the V_{BE} of Q1 drops then its collector voltage increases, increasing the base voltage of Q2, whose emitter voltage therefore increases (and vice versa if V_{BE} of Q1 increases). A negative feedback loop has been formed, which maintains a relatively constant voltage across R2, of OV6.

The current through R2 is also the current through the load so Ohm's law gives the correct resistance for the required current, identical to that already discussed, but with the advantage that lower power resistors can be used (due to the lower voltage), even at high currents.

eg. P = IV = 500 mA x 0.6 volts
= 0.3 watts.

It is simply now, a matter of choosing the required current and calculating the resistance.

TABLE 1

Position	Resistor	Current	Type of cell & Capacity
1	R2	9mA	150 mA Hour Button cell
2	R3	17mA	280 mA Hour Button cell
3	R4	5.5mA	90 mA Hour PP3
4	R5	75mA	1.2 A Hour PP9
5	R6	11mA	0.18 A Hour AAA
6	R7	31mA	0.5 A Hour AA
7	R8	125mA	2 A Hour C
8	R9	250mA	4 A Hour D
9	R10	375mA	6 A Hour
10	R11	625mA	10 AHour

Table 1. Showing switch SW1 positions related to cells under charge.

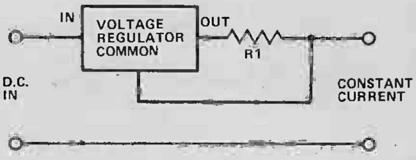


Fig. 1. A Standard method of providing a constant current, using a voltage regulator, resistor and feedback.

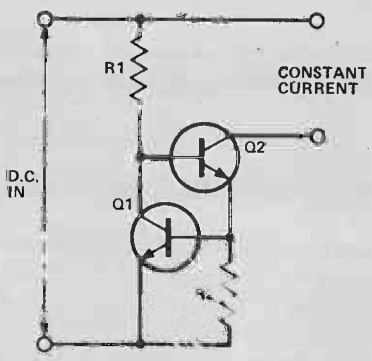
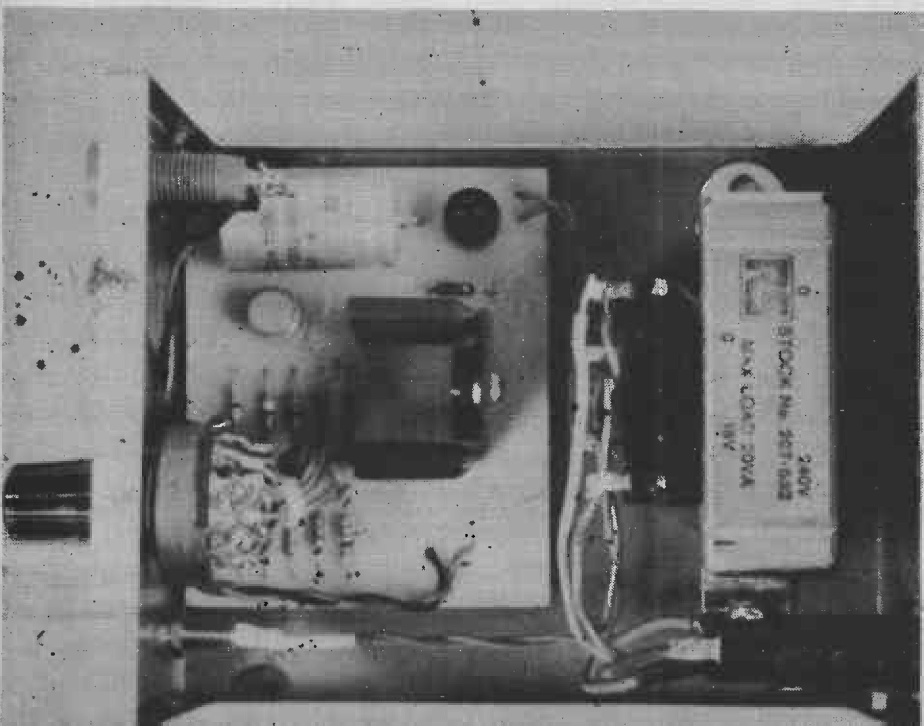


Fig 2. Improved constant current source.



PARTS LIST

RESISTORS
(all ¼W, 5% except where shown)

R1	1K
R2	68R
R3	39R
R4	120R
R5	10R
R6	56R
R7	22R
R8	5R6
R9	2R7 ½ watt
R10	1R8 ½ watt
R11	1RO ½ watt

CAPACITORS

C1	1000u 25V

SEMICONDUCTORS

Q1	BFY 50
Q2	TIP 33A
BR1	1Amp 50V

MISCELLANEOUS
FS1 + Holder
TR1 12 V 1 Amp mains transformer
SW1 1-Pole 10-way Rotary Switch
Suitable connections to cells
Case to suit.

BUYLINES

There should be no problems in obtaining any of the components from any stockist.

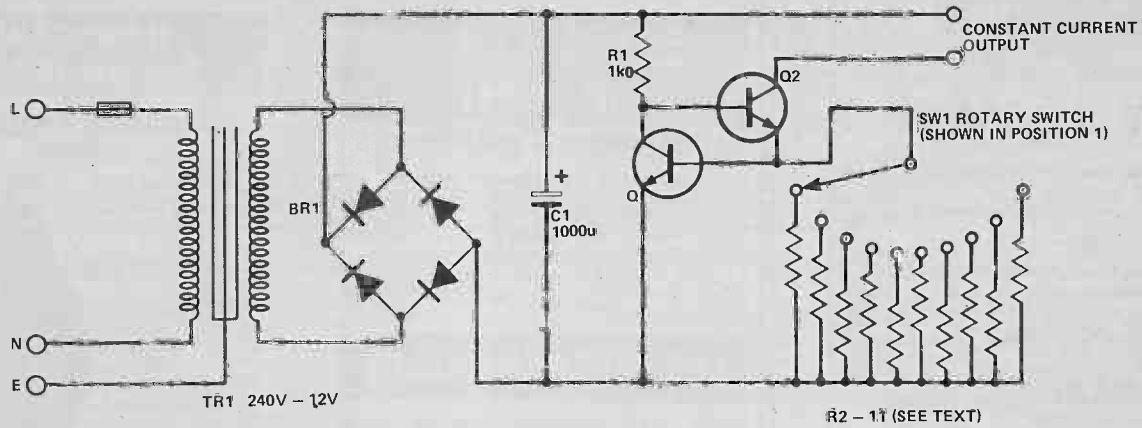


Fig 3. Circuit diagram for the ETI Charger. Resistor values are given in the text for the charger resistors.

per hour, therefore enabling them to be constantly trickle charged and kept at full capacity day and night. If the cells are partially discharged on connection they will take up to 16 hours to reach full capacity.

PP3 and PAP9 type nicads can also be charged but only one at a time, unlike the lower voltage types.

ETI

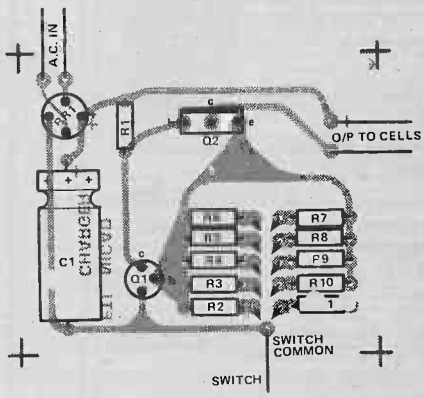


Fig. 4. Component overlay for the Ni-Cd Charger design.

A FEW CHEAP TRICKS!

Want a stable low voltage? Want to fire a thyristor without using unijunctions, or even make a thyristor? Whatever your semiconductor problem there is probably a cheap way round it.

When you look over all the circuits that are published in the time of one month, you might imagine you'd need several rooms just to hold all the semiconductors that are needed. It's not really so and the cunning experimenter can use several dodges to get by with a very limited stock indeed. There are several project designers, for example, who manage to test out their ideas using no more than two transistor types, a 2N2219 and a 2N2905. These are silicon switching transistors which look exactly alike and differ only in polarity — the 2219 is NPN and the 2905 is PNP. How's it done? Read on.

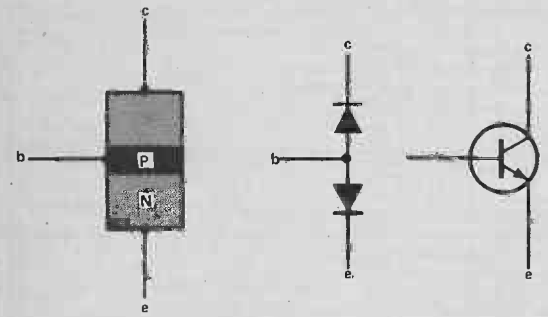


Fig. 1. Structure of a transistor. (a) The semiconductor sandwich, (b) connection of two diodes which gives the same readings when connected to resistance meters, (c) symbol (NPN illustrated).

Basically, a transistor is constructed like two back-to-back diodes (Fig. 1), the difference being that both diodes form part of one crystal. We can, therefore, use a transistor to substitute as a diode. Which bit do we use? The collector and base terminals form one diode, a high reverse voltage diode which will pass quite large currents. Transistors of the 2N2219 variety will dissipate 0.8W at the collector, so that their collector base diodes can be quite happily used in bridge rectifier circuits for up to 30 V supplies, keeping the emitter open circuit or shorted to the base.

A Bit Of Bias

The base-emitter diode, on the other hand, is much more of a small signal diode, more suited to low current, low

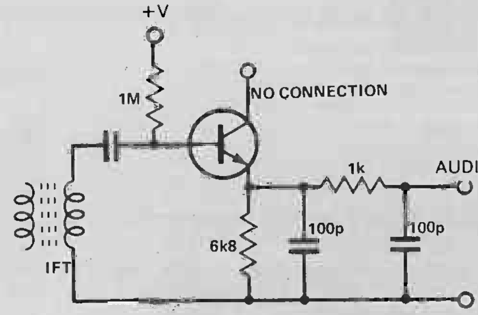


Fig. 2. Using the base/emitter junction of a transistor as a detector diode. The 1M resistor keeps the junction slightly conducting, so increasing the sensitivity.

voltage work. One minor drawback is that you can't approach the small forward voltage of a germanium diode, but there's no law to say you can't apply a bit of bias, as in Fig. 2. This makes the base emitter diode into a good, sensitive detector. While we're on the subject of detectors, why not be different and use an emitter follower detector, as in Fig. 3? It's a darn sight more linear than a straightforward diode, and has a low output impedance and high input impedance as well.

The circuit is a simple one. A capacitor is connected across the emitter resistor of an emitter follower. The size of the capacitor should be such that the time constant of emitter resistor x capacitor is small compared to the time of an audio wave but large compared to the time of the

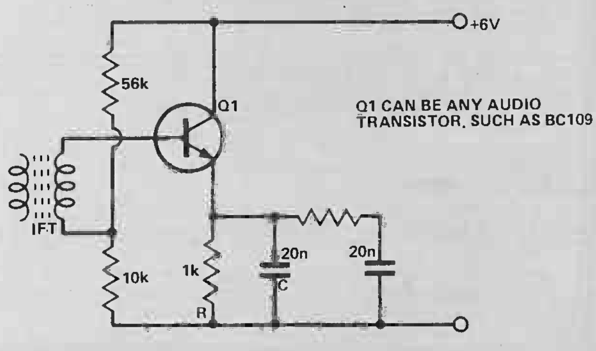
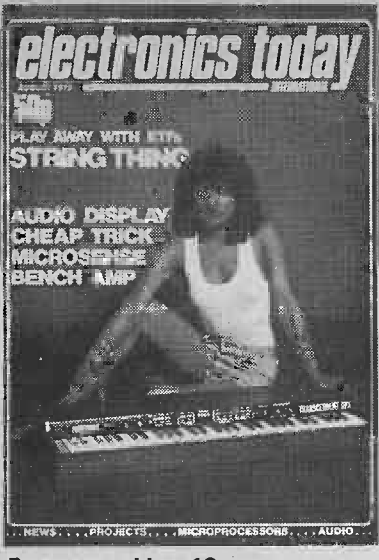


Fig. 3. The emitter-follower detector.

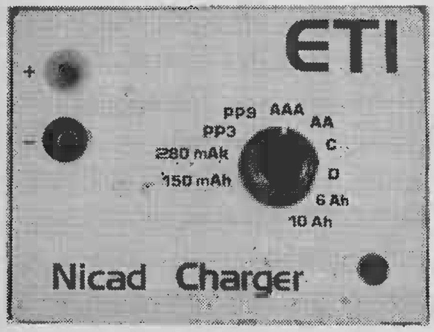
electronics today INTERNATIONAL

AUGUST 1979 VOL 8 NO 8



Be an ensemble p.18

Amplify a beach p.67



Make a charge p.29

FEATURES

PROJECTS

INFORMATION

INTERNATIONAL EDITIONS

AUSTRALIA Collyn Rivers Publisher, Roger Harrison Acting Editor

HOLLAND Anton Kriegsman Editor-in-Chief

CANADA Graham Wideman Editor

GERMANY Udo Wittig Editor

ABC

EDITORIAL AND ADVERTISEMENT OFFICE
25-27 Oxford Street, London W1R 1RF. Telephone 01-434 1781/2. Telex 8811896

Ron Harris, B.Sc	Editor
Ian Graham B.Sc.	Editorial Assistant
Diego M. Rincon	Art Director
Pete Howells	Production
Paul Edwards, Tony Strakas	Technical Illustrators
Ray Marston	Project Editor
Keith Brindley, John Fitzgerald	Project Engineer
Steve Ramsahadeo	Project Development
Margaret Hewitt	Administration
Lorraine Stout	Editorial Secretary
Christopher Surgenor (Manager),	Advertising
Halvor Moorshead	Editorial Director

PUBLISHED BY	Modmags Ltd., 145 Charing Cross Road
DISTRIBUTED BY	Argus Distribution Ltd. (British Isles)
	Gordon & Gotch Ltd. (Overseas)
PRINTED BY	QB Limited, Colchester

Electronics Today International is normally published on the first Friday of the month prior to the cover date

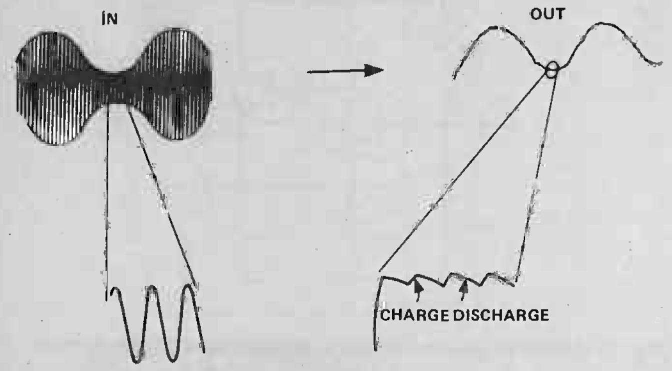


Fig. 4. Action of the emitter-follower detector. Capacitor C is charged by the current through Q1 during the positive part of a cycle, but can discharge only slowly through R. The voltage across C follows audio frequency changes, but not radio frequency changes.

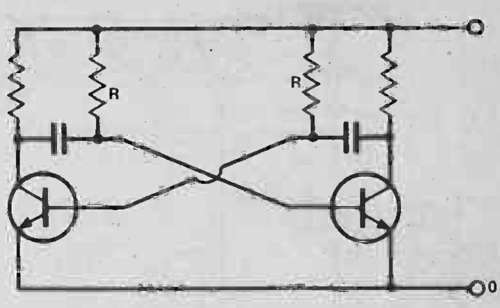


Fig. 6. Conventional multivibrator circuit.

RF wave. Time constants of 10 to 100 uS are usually suitable for AM radio circuits, so that a typical circuit might use 1k emitter resistance and 20n (that's 0.02u capacitance. The action is also straightforward (Fig. 4). The positive RF wave makes the transistor conduct, so that C1 charges up to the positive peak of the wave. Because the time constant is large compared to the time of one RF wave, though, the voltage at the emitter drops only slightly as the wave goes through the remainder of its cycle and the transistor cuts off until around the peak of the next RF wave. The AF modulation, however, makes the peaks of the RF signal occur at different voltages, tracing out the audio waveform, so that the audio signal appears at the emitter, with very little trace of RF so that nothing much in the way of filtering is needed. The emitter-follower detector also has lower distortion than the conventional diode detector.

Transistor Zener

We're not finished with diodes, though. The base-emitter diode of most planar silicon transistors (and that means most 'modern' silicon transistors manufactured in the last 15 years) will act as a zener diode. The circuit of Fig. 5 shows how this can be checked. The voltage across the base-emitter junction will stabilise at anything from 7 V to 18 V, depending on the construction of the transistor, when power is applied. You don't need to keep a drawer full of zener diodes, just make these 2N2219's work for their living.

This zener diode action, incidentally, can cause some odd effects in circuits where a negative pulse is applied to the base of a transistor. Multivibrator circuits, for example, operating on voltages greater than 7 V, suffer from this. Theory says that the time period of the MV is 1.4CR(Fig. 6), because the capacitor always charges up from —V to about 0V whatever the value of V. The reason is that when one transistor conducts its collector voltage shoots down by about V volts, and the capacitor coupling to the next base makes that base move from about 0V to —V. Since the transistor switches on again at just above 0V, the capacitor always charges to half way between —V and +V, no matter what the value of V is. That theory doesn't apply if the base-emitter junction zeners, because the voltage at the base will be clipped by the zener action. We find therefore, that the frequency of the MV increases as we increase the voltage, whatever the books say about it!

Want a stable value of low voltage? Try the circuits of Fig. 7. The voltage between collector and emitter of a transistor is always low when the transistor is bottomed, with the base positive (NPN transistor) and a load resistor limiting the amount of current that can pass between collector and emitter. With the transistor the conventional way round, the voltage between collector and emitter can go as low as 0.2 V, but even lower voltages can be obtained if the transistor is inverted, with the emitter connected through the load resistor to the positive line and the collector to the negative rail. This, for example, can be very useful for clamping circuits if a small DC 'offset' is needed, but care should be taken to keep the currents low. Transistors are much more easily damaged when they are operated this way round.

Paint-scraping Saves

A few circuits specify phototransistors, which aren't always easy to obtain and sometimes (shop around!) costly. Now there isn't much you can do to make ▶

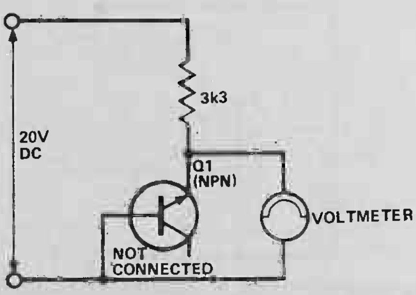


Fig. 5. Checking the zener voltages of a silicon transistor.

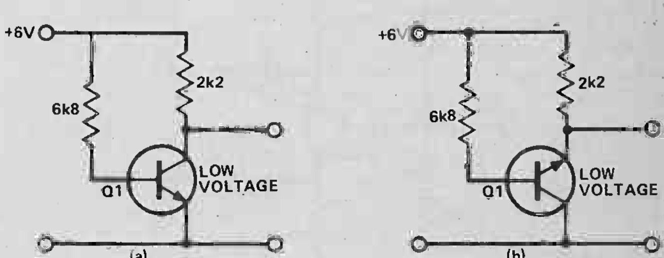


Fig. 7. Obtaining very low stabilised voltages (a) conventional method, (b) using an 'inverted' transistor for lower voltage output.

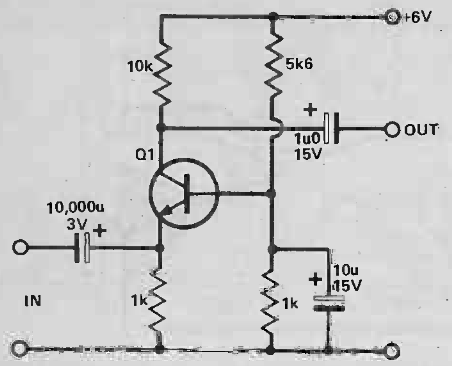


Fig. 8. Using a common-base amplifier. Note that the input capacitor must be of a very large value.

phototransistors out of modern silicon metal or plastic cased transistors, because light just doesn't pass through these materials. The old germanium transistors, like the OC72 series, were packaged in glass cases, however, and the cases then painted over. The reason for the paint is simple — any transistor junction will act as a light detector, so that a transistor in a glass case will be a phototransistor unless it is covered up! Scrape the paint off, and you have the phototransistor you need. Since old OC72's can often be got in lots at pennies, each, and the photo version, the OCP72, seems to fetch nearly a pound, it certainly saves money to do some paint scraping!

Ever want to drive a transistor amplifier from a really low-impedance source? There aren't many home-made ribbon microphones around, but a moving coil loudspeaker makes a useful microphone apart from its low resistance of 3R or so. Remedy here is to make use of the first type of transistor amplifying circuit that was ever used, the common-base circuit. In a common-base amplifier, the base is decoupled, with no signal input. The signal is fed into the emitter circuit, and taken in the usual way from the collector, using capacitors to keep the bias voltages correct. Advantages? There's voltage gain for a start, but the main advantage is that the input resistance is very low, offering a better match to the low resistance of the 'microphone'. Incidentally, a transistor operated this way round will amplify and oscillate at higher frequencies than is usually possible in the normal (common emitter) configuration.

Phase Splitting

This is an example of using a transistor to match impedances, like a transformer. The other impedance —

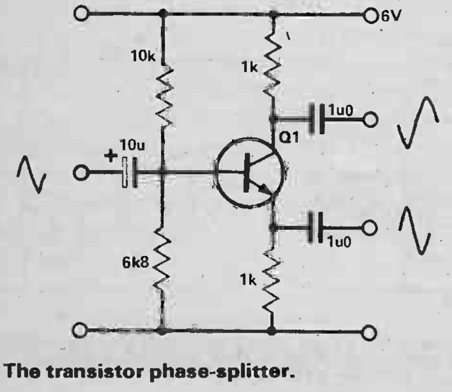


Fig. 9. The transistor phase-splitter.

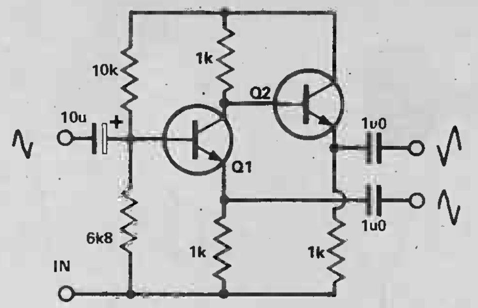


Fig. 10. Modified phase-splitter with equal output resistances.

transforming circuit is, of course, the well known emitter follower, with a high input impedance and low output impedance. If you need the phase splitter action of a transformer, but don't have a suitable transformer, don't get wound up, just try the circuit of Fig. 9. If you're driving signals into a low impedance of course, you may find that the difference between the impedance level at the collector and at the emitter causes bother (the impedance at the collector is equal to the collector load resistor, the impedance at the emitter is only a few ohms; roughly 25 ohms when the steady bias current is 1mA). In that case, another transistor added to the circuit equalises things a bit, as shown in Fig. 10.

You might think that the possibilities of the transistor were about exhausted; but we've only been using them in ones so far. When we start using transistors in twos and threes, we can substitute a lot more devices.

Unijunctions

Unijunctions, for example. Who's got a set of unijunctions around? Useful little devices. In circuits like Fig. 11 they provide an oscillator which gives a pulse output ideal for firing thyristors. The wiley experimenter doesn't worry if the unijunction drawer is empty, though. He connects up the circuit of Fig 12, which does pretty well all that a single-package unijunction will do, with the additional advantage that the firing voltage can be variable.

The action is like this. Point B, where the base of Q1 is connected to the collector of Q2 is connected to a potential divider, resistors R1 and R2. For most applications, these resistors will be equal, using (typically) 47k to 10k values. The circuit will pass no current while the voltage at point A, the emitter of Q1, is less than the voltage at point B, because Q1 is cut off (PNP,

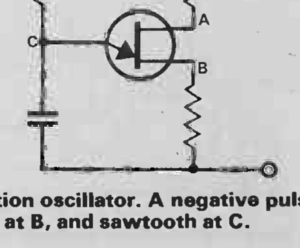


Fig. 11. A unijunction oscillator. A negative pulse is obtained at A, a positive pulse at B, and sawtooth at C.

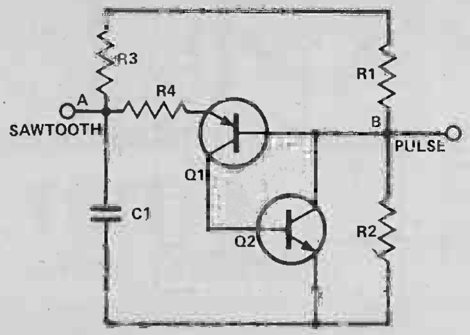


Fig. 12. A two-transistor equivalent of a unijunction.

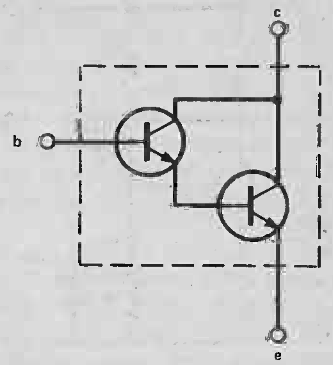


Fig. 14. The Darlington pair circuit — this behaves like one single transistor with a very high value of current gain.

remember), and it holds Q2 cut off as well. When point A reaches a voltage around 0.5 V higher than the voltage at point B, though, Q1 starts to conduct, and current starts to flow into the base of Q2, causing Q2 also to conduct. With Q2 conducting, the extra voltage drop across R1 causes the voltage at B to drop, dragging the voltage of point A with it. If the base current of Q1, is likely to be exceeded (as usually happens if there is a capacitor connected to point A), a small series resistor R4 (about 100R) is a good protective system. Note, by the way, that when a unijunction or this replacement is used in a timebase circuit, the value of the charging resistor, R3, must not be too low, otherwise the circuit can 'stick', not oscillating. A value of around 47k is usually regarded as a safe minimum, so that if the frequency is controlled by a variable, a 47k should be connected in series. The firing point of the unijunction substitute can be varied to some extent by making the voltage at point B variable, using a preset potentiometer, in place of R1, R2.

There is a limit, however, to the voltage range which can be used — if the voltage is too high, the circuit may not fire, if it's too low the circuit passes current continuously.

Another advantage, of course, of the circuit of Fig. 12 is that power transistors can be used. In this way, higher current pulses can be obtained than we can get from small unijunctions.

DIY Thyristor

You don't have to be stuck for lack of a thyristor, either. The circuit of Fig. 13 simulates the action of a thyristor, with the anode, cathode and gate connections as marked. With the 'gate' at cathode voltage, Q2 is shut off, so that its collector voltage is high. With the collector voltage of Q2 high, the base voltage of Q1 is also high. Since Q1 is a PNP type, having the base high means keeping Q1 shut off. Now when the 'gate' lead is made more positive, so that Q2 starts to draw current, the current through the collector of Q2 is drawn through the base of Q1, ensuring that Q1 conducts. This in turn means that the base of Q2 is connected to the positive supply through the collector of Q1, keeping the pair of transistors switched on.

Don't expect to replace a large thyristor with this circuit, because the current between 'anode' and 'cathode' all passes through the base-emitter junctions. For medium-power transistors, such as the 2N2219 or BFY50 the absolute maximum base current is about 100 mA, and 50 mA is a safer limit. Power transistors such as the BD131, BD132 will stand up to 0.5 A through the base-emitter junction. The circuit will, incidentally, switch off if a negative pulse is applied to the 'gate' from a low impedance. In this respect, the circuit is similar to that of a small thyristor, most of which can also be switched off in the same way.

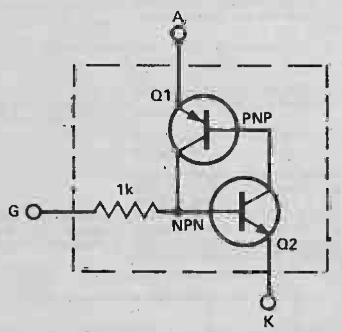


Fig. 13. Using two transistors in place of a thyristor.

Changing Bias

Transistors in bunches can also be used to solve awkward problems. Suppose you want to substitute a transistor with another type which needs much more bias current. One way round, of course, is to adjust all the bias circuits. A much easier method is to make use of two transistors, with one emitter driving the base of the

▶

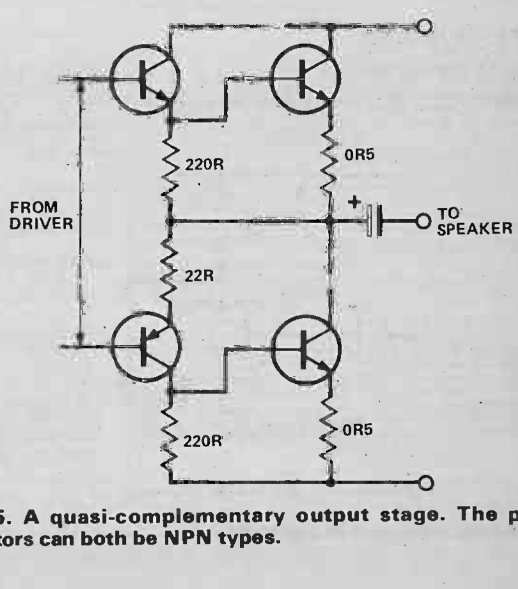


Fig. 15. A quasi-complementary output stage. The power transistors can both be NPN types.

next (Fig. 14). If the two share the same collector lead, this circuit is called the Darlington pair, but if the collector of the first transistor is returned directly to the power supply the circuit is simply an emitter follower feeding a common emitter amplifier. The difference between the two is that in the Darlington pair circuit, signal can feedback from the collector of Q2 through Q1 to the base of Q2, so reducing the voltage gain of the circuit considerably.

A two-transistor circuit can also be used to 'create' a PNP power transistor from an NPN one. The circuit uses a PNP medium power transistor (such as the 2N2905) coupled to the NPN power transistor, so that the combination behaves like a PNP power transistor. Like all two-transistor circuits, though, there is a penalty in the form of a change in DC levels. When two NPN's (or 2 PNP's) are coupled in a Darlington circuit, the voltage between the first base and the second emitter is more than 1V, when the circuit is correctly biased, instead of the 0.55 — 0.6 V we assume for a single transistor. For the PNP — NPN pair, the voltage is *less* than that for a single transistor — the base voltage of the power transistor will be 0.7 V or so above its emitter voltage, but the base voltage of the PNP transistor will be 0.6 V or so *less*, so that the DC input to the base of the PNP transistor is very close to the DC emitter voltage of the NPN one. The base-emitter voltages of these two will never be identical because the NPN power transistor will always be passing a much larger current than the PNP transistor.

Tapehead Drivers

We're still not finished with the two-transistor arrangements. Fig. 16 shows what is called a cascade circuit, with a common-emitter transistor Q1 driving a common-base stage Q2 directly coupled to it. This arrangement can also be treated as if it were one single transistor with the high gain of a common emitter transistor and the very high output resistance of a common-base transistor. It's an ideal arrangement for driving tuned circuits (because the high output resistance places very little load on the circuit) or tapeheads (because the high output resistance can ensure that the current signal into the tapehead is almost constant over a wide frequency range).

Circuits such as these described here make full use of transistors, exploiting more of their potential than the usual run of common emitter and emitter follower circuits. Make them work harder! ETI

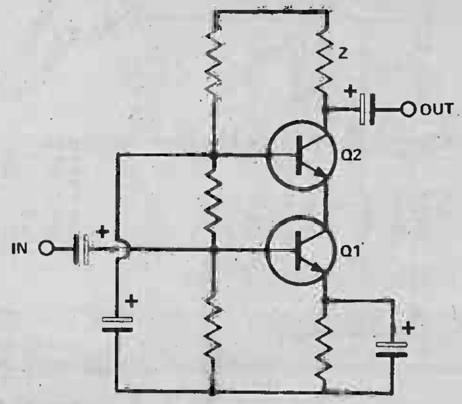


Fig. 16. A cascade stage. The load Z can be a tuned circuit or a high-value resistor providing the bias resistors are chosen to suit.

PLEASE SEE V.A.T. ADVERTISEMENT ON PAGE 15 BEFORE ORDERING GOODS FROM ADVERTISERS!

TELETEXT SYSTEM

PART TWO: in this concluding part we give full constructional details for this superb design from GMT Electronics.

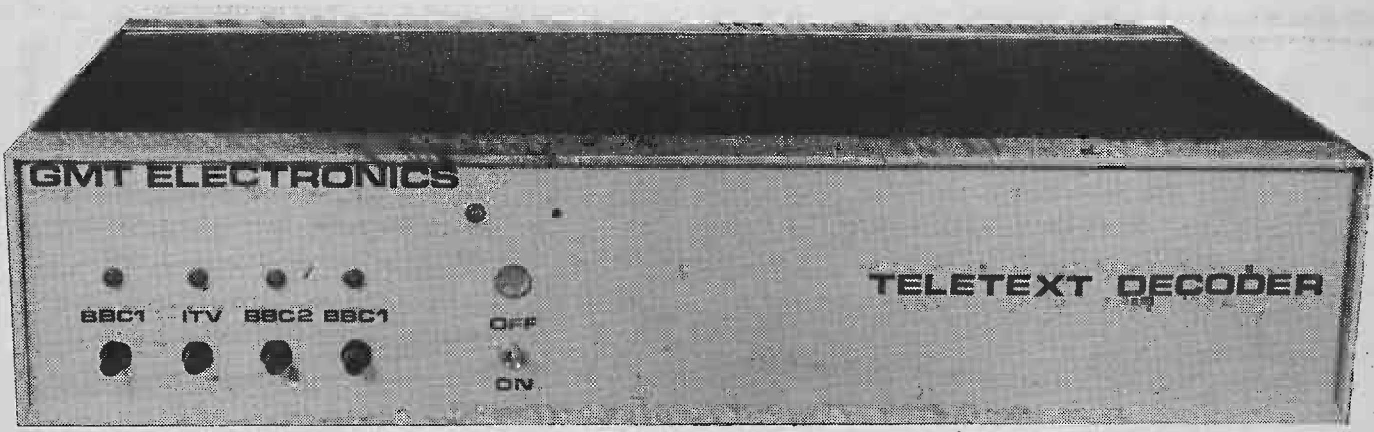
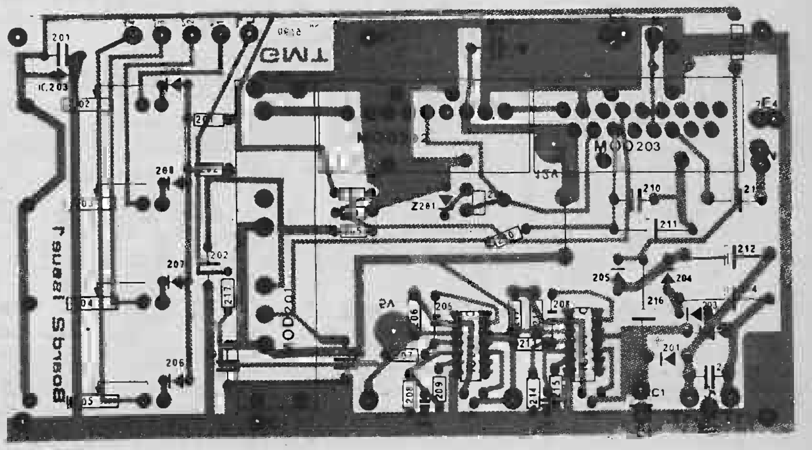


Fig. 1. Board two overlay.



Since we published the first part of their design last month, GMT have made some improvements to the kit for the Teletext decoder.

Thre main change is a combining of boards three and four into one. Effectively board four has ceased to exist! This simplifies construction still further and has our endorsement. We are republishing the combined circuits here to make things clear.

Construction

Putting together the unit should be very straightforward. The PCBs should be carefully assembled, following the overlays shown here. Check IC orientation especially closely as that chip set is *very* expensive to blow just because you didn't want to spend five more minutes doing that boring bit of re-checking.

When completed the boards should be interconnected following the wiring schedule given in this article. Check this carefully also.

Setting Up

Once the boards are assembled, follow the setting up procedure given in last month's article to complete the unit. It is worth remembering that to be sure of a good Teletext picture, you need a strong signal at the input. In areas of poor reception it is well worth investing in that better aerial wot you never got 'round to getting. . . .

PARTS LIST

Board Two

RESISTORS all ¼W 5% unless specified	
R201	150k
R202, 203, 204	47k
R205	1M5
R206, 211, 212	1R0 ¼ watt
R207, 213	4k7
R208	5k1
R209	2k2
R210	120R
R214	6k8
R215	2k7
R216	10k ½ watt
R217	1k0
POTENTIOMETERS	
RV201	2k2 min. preset horizontal
RV202-205	100k VPN
CAPACITORS	
C201-204, 209, 210, 215	100n polyester
C205, 208	470p ceramic
C206, 207	22u 16V tantalum
C211	220u 16V electrolytic
C212	100u 40V electrolytic
C213	1u0 63V electrolytic
C214	100u 25V electrolytic
C216	47u 63V electrolytic
SEMICONDUCTORS	
IC201, 202	LM723CN
IC203	TAA550
Q201, 202	TLP31
D201-205	1N4001
D206-209	1N4148
ZD201	BZY88C3V6
MISCELLANEOUS	
MOD201	U321
MOD202	BY01910
MOD203	BY00905
PCB	

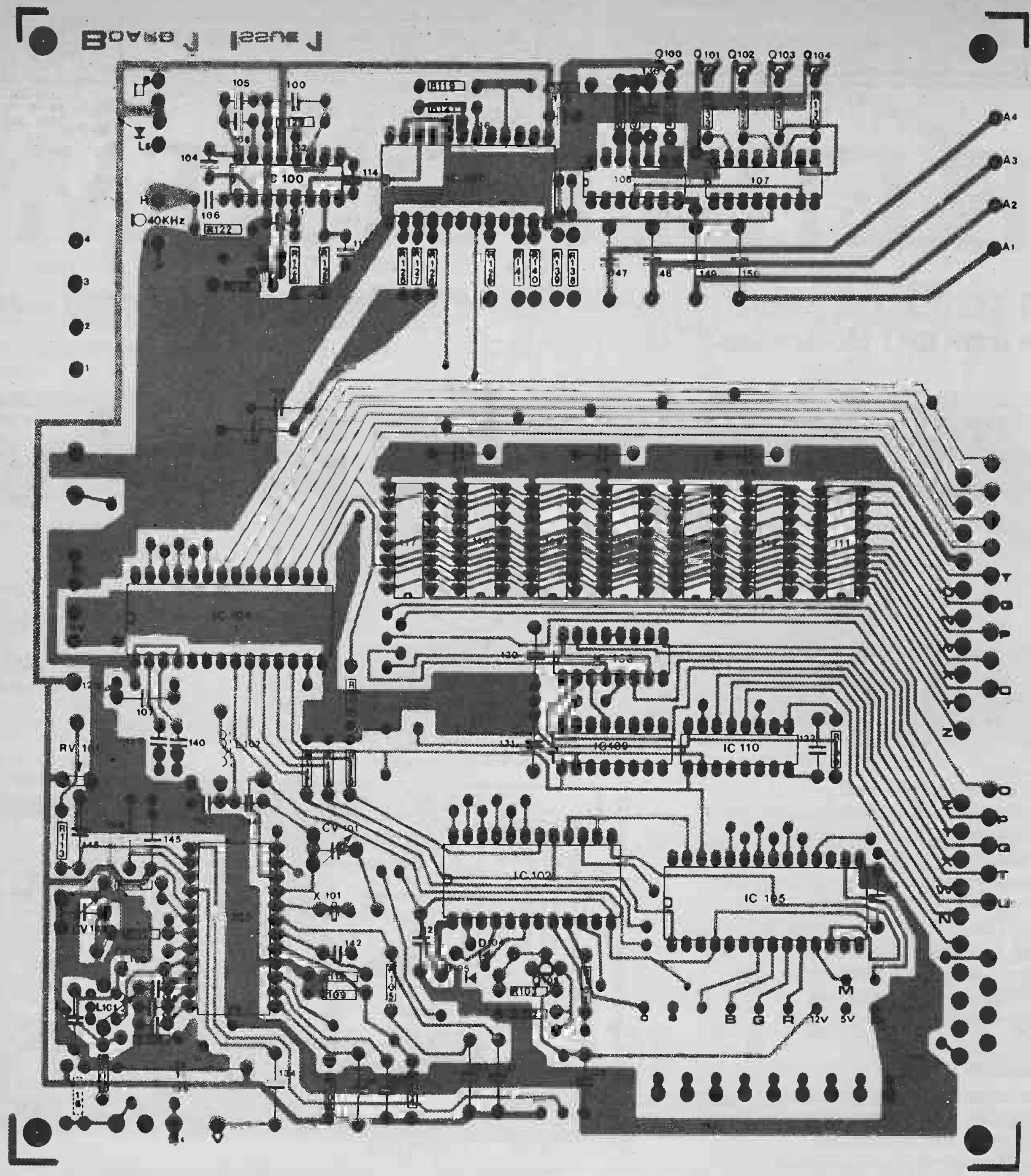


Fig. 2. Component overlay, board one.

PARTS LIST

Board One

RESISTORS (¼W 5%)

R100, 102, 105, 118	1k
R101, 109, 122	6k8
R103, 126-129	10k
R104	47k
R106	100k
R107	680R
R108	1k5
R110	1k2
R113	33k
R119, 130-133	4k7
R120, 121	27k
R123	68k
R124	820k
R125	1M

CAPACITORS

C100-103, 117-130, 145	100n
C104, 105, 109	6u8
C106	1n8
C107	470n
C108	4u7
C110	22n
C111	22u
C112, 144	10n
C113	560p
C114	390p
C115	
C116	27p
C131, 134, 136	1u0 63V
C132, 133	10u 25V
C135	100u
C137, 140, 141, 142	1n
C138	330p
C139	47p
C143	68p
C146	3n3
TC101, 102	5-65p trimmer

INDUCTORS

L100	33uH
L101	Clock coil
L102	10uH

SEMICONDUCTORS

IC100	TDB1033
IC101-105	SAA5010-5050
IC106	HEF4001
IC107	HEF4017
IC108	74LS83
IC109-110	74LS161
IC111-117	2102
IC118	74LS11
Q100-Q103	BC548
Q104	BC148
D100-103	1N4148
D104, 105	BAW62

MISCELLANEOUS

X101 — 6MHz, PCB, IC sockets, mounting hardware

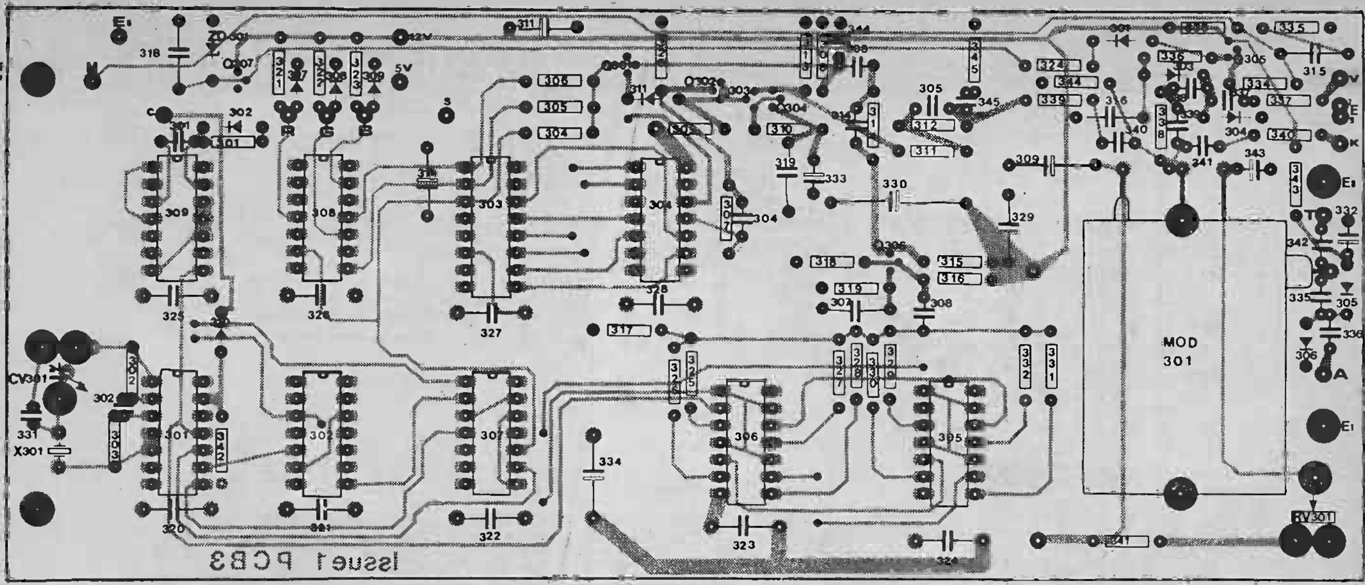


Fig. 3. Component overlay, board three.

BOARD INTERCONNECTION WIRING

FROM	LOCATION –BOARD	TO	LOCATION –BOARD	COLOUR	CABLE TYPE	COMMENTS
AE.SKT.	CHASSIS	E1	2	–	COAX	OUTER
AE.SKT.	CHASSIS	MOD 201	2	–	COAX	INNER
E2	2	–VE C1	CHASSIS	BLACK		
P	2	–VE C1	CHASSIS	RED		
E3	2	TR 1	CHASSIS	BLACK		INNER SEC TAGS
TR1	2	TR 1	CHASSIS			OUTER SEC TAGS
TR2	2	TR 1	CHASSIS			OUTER SEC TAGS
E4	2	E4	1	–	COAX	OUTER
V	2	V	1	–	COAX	INNER
E5	2	E5	1	BLACK		
E9	2	E9	3	–	COAX	OUTER
K	2	K	3	–	COAX	INNER
E7	2	E7	3	–	COAX	OUTER
V	2	V	3	–	COAX	INNER
E8	3	O/P SKT	CHASSIS	–	COAX	OUTER
T	3	O/P SKT	CHASSIS	–	COAX	INNER
E1	3	E1	1	–	COAX	OUTER
A	3	MOD 201	1	–	COAX	INNER
E6	1	E6	3	BLACK		
5V	2	5V	1	YELLOW		UNDER BOARD
12V	2	12V	1	PINK		UNDER BOARD
5V	1	5V	3	YELLOW		BY IC105
12V	1	12V	3	PINK		BY IC105
R	1	R	3	RED		BY IC105
G	1	G	3	GREEN		BY IC105
B	1	B	3	BLUE		BY IC105
S	1	S	3	GREY		BY IC105
C	1	C	3	BROWN		BY IC105
M	1	M	3	ORANGE		BY IC105
1	1	1	2			
1	2	LED 1	CHASSIS			
2	1	2	2			
2	1	LED 2	CHASSIS			
3	1	3	2			
3	2	LED 3	CHASSIS			
4	1	4	2			
4	2	LED 4	CHASSIS			
L	2	LED 1 to 4	CHASSIS			
O	1	O	1	WHITE		
P	1	P	1	WHITE		
Q	1	Q	1	WHITE		
T	1	T	1	WHITE		
U	1	U	1	WHITE		
N	1	N	1	WHITE		
W	1	W	1	WHITE		
X	1	X	1	WHITE		
Y	1	Y	1	WHITE		
Z	1	Z	1	WHITE		
B	1	*EARPIECE	CHASSIS			
L5	1	LED 5	CHASSIS			
H	1	TRANS-DUCER	CHASSIS			
E	1	TRANS-DUCER	CHASSIS	BLACK		TRANS-DUCER CASE
12V	1	*EARPIECE	CHASSIS			
12V	1	LED 5	CHASSIS	PINK		

PARTS LIST

Board Three

RESISTORS all ¼ W 5%

R301, 344	5k6
R302, 303	680R
R304, 307, 320-324, 334	3k3
R305	1k8
R306, 314, 316, 343	10k
R308	820R
R309, 315, 336, 341	1k0
R310	220R
R311, 325	68R
R312, 318	4k7
R313, 317	56R
R319	470R
R326, 331, 332	10R
R327, 330	180R
R328, 335, 340	100R
R329	150R
R333	18k
R337	6k8
R338, 339	2k2
R342	47k

POTENTIOMETER

RV301	470R min. preset horizontal

CAPACITORS

C301	2n2 ceramic
C302, 304, 308, 314, 339	82p ceramic
C303	56p ceramic
C305, 341, 342	27p ceramic
C307, 315, 316, 318-329	100n polyester
C309, 310, 334	33u 16V electrolytic
C311	10u 25V electrolytic
C331	18p ceramic
C332, 337, 338, 340, 343	6u8 25V tantalum
C335, 336	1p8 ceramic

Note C319-329 are decoupling components and are not shown on the circuit diagram.

VARIABLE CAPACITOR

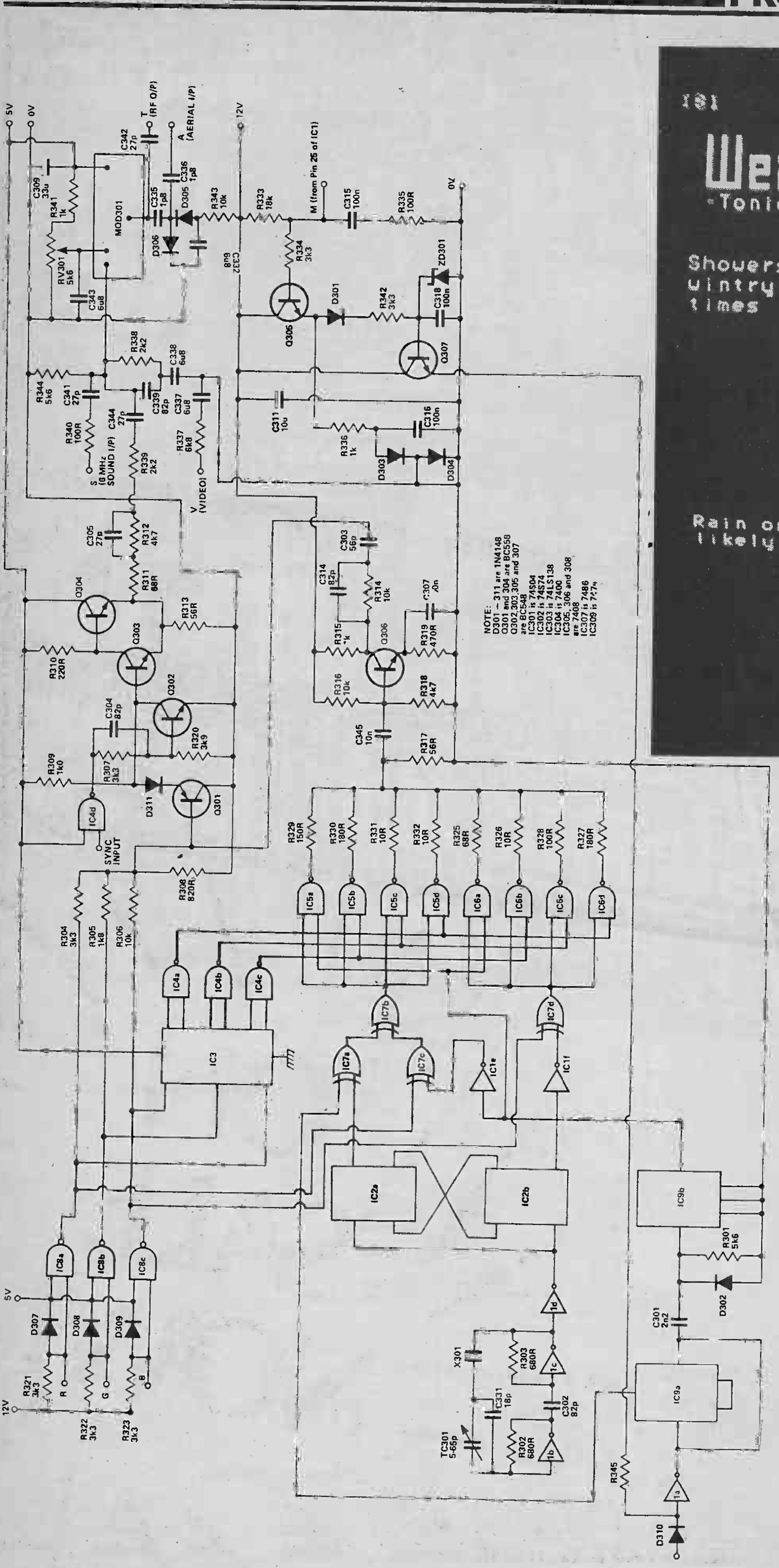
CV301	22p

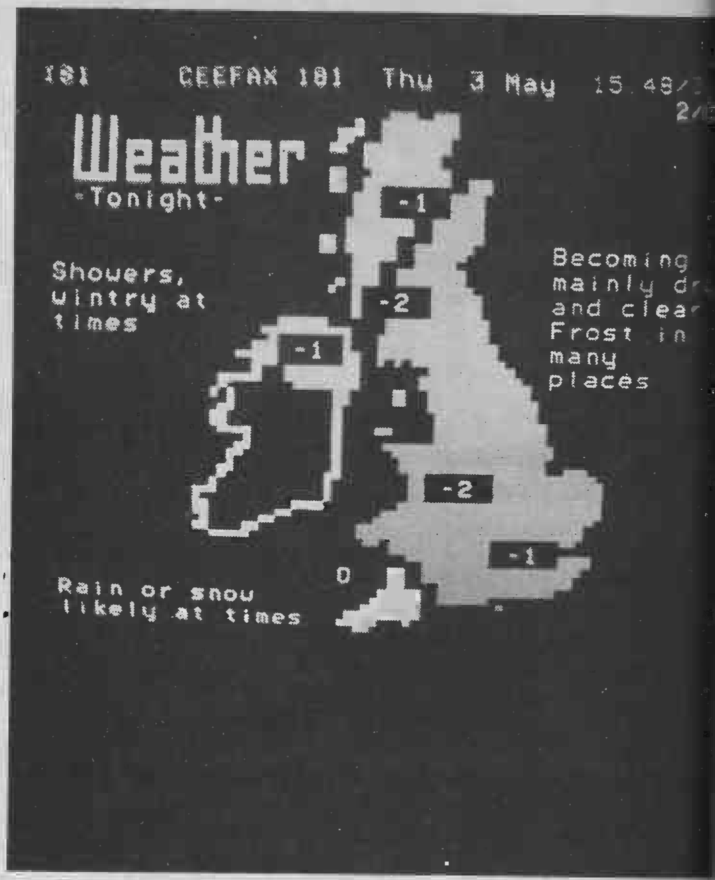
SEMICONDUCTORS

IC301	74S04
IC302	74S74
IC303	74LS138
IC304	7400
IC305, 306, 308	7408
IC307	7486
IC309	7474
Q301, 304	BC558
Q302, 303, 305, 307	BC548
Q306	BSX20
D301-311	1N4148
ZD301	BZY88/BZX70C5V6

MISCELLANEOUS

X301	17.73447 MHz
MOD301	UM1231 Astec
PCB	





Above: Find out when it is supposed to rain. All you need os Teletext!

Fig. 4. (Left) The renumbered board three circuit.

BUYLINES

The designers of this project — GMT — have a complete kit of parts available. This includes all metalwork, PCBs and hardware. A manual is also included. Cost is £155 plus VAT (total £178 inc p&p).

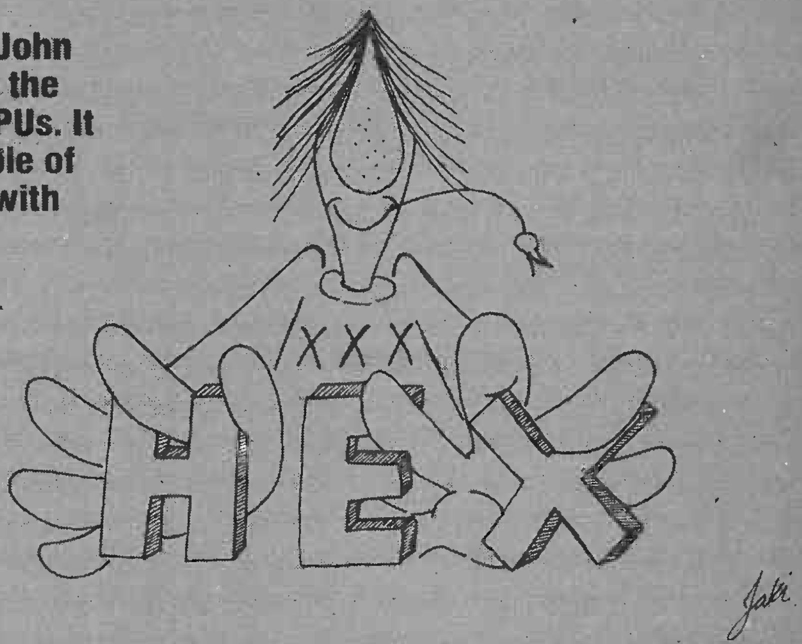
As an alternative the teletext decoder board and control system is available separately at £125 for those who wish to wire into their own television.

PCBs and chip sets are available separately also — but are PoA.

See advert on page 6 for address.

MICROSENSE

PART ONE: a short series from John Miller Kirkpatrick designed to lead the reader gently into the realms of MPUs. It is designed to be of use to all people of all levels of knowledge. We begin with the hex system of counting . . .



Hexadecimal counting Systems

THE BINARY COUNTING system uses a set of 1s and 0s to indicate a particular number, in our example above 0101 0111 represents 87. Obviously it is faster to write 87 than it is to write 0101 0111 each time. It is not very easy to convert long binary numbers to decimal and vice versa, for example the binary number 1010 1010 1010 1010 represents the decimal number 43690 mode up from:

1010	is	ten units of 1	=	10 or $2^4=8+2^1=2$ Total 10
1010 0000	is	ten tenths of 16	=	160 or $2^7=128+2^5=32$ Total 160
1010 0000 0000	is	ten units of 256	=	$2560=29+2^{11}$
1010 0000 0000 0000	is	ten units of 4096	=	$4096=2^{13}+2^{15}$ thus the total
1010 1010 1010 1010	represents the decimal 43690.			

Another way of showing this value is to write down one character for each set of four fingers.
This is obvious for the values from 0-15 which can be exporessed as a single character. The Binary decimal as new codes are —

0000=0 Written as 0.	0100=4 Written as 4.	1000= 8 Written as 8.	1100=12 Written as C.
0001=1 Written as 1.	0101=5 Written as 5.	1001= 9 Written as 9.	1101=13 Written as D.
0010=2 Written as 2.	0110=6 Written as 6.	1010=10 Written as A.	1110=14 Written as E.
0011=3 Written as 3.	0111=7 Written as 7.	1011=11 Written as B.	1111=15 Written as F.

Thus our large binary number can now be expressed as
1010 1010 1010 1010 or decimal 43960 or as AAAA in our new format.
The new format is called Hexadecimal from HEX=six and DEC=10, which is a counting system based on units of 16 rather than units of 1 or 10.
The hexadecimal system can be easily converted from the binary system by simply breaking up the binary into groups of four binary digits (one hand full of four fingers) and converting each group into a single hex character. For example the binary 0010 0011 0101 0111 becomes hexadecimal 2357. Numbers in hex form are usually referred to by putting × '2357' to denote that this is Hex 2357 rather than decimal 2357. The binary 1010 1011 1100 1101 becomes 'ABCD' which does not require any differentiation from decimal.

A Cardboard Microprocessor

Microprocessor jargon includes bits, bytes, registers, RAM, ports, software and hardware. To help you understand all of this here is your own processor made out of paper.
Cut out the PC/MP (Paper and Cardboard MicroProcessor) or copy it and glue it onto a piece of card. Cover the card with something like clear 'Fablon' so that you can write on it with a felt tipped pen and then clean it off again. You are now ready for your first terminology lesson (PCMP is figure 1). ▶

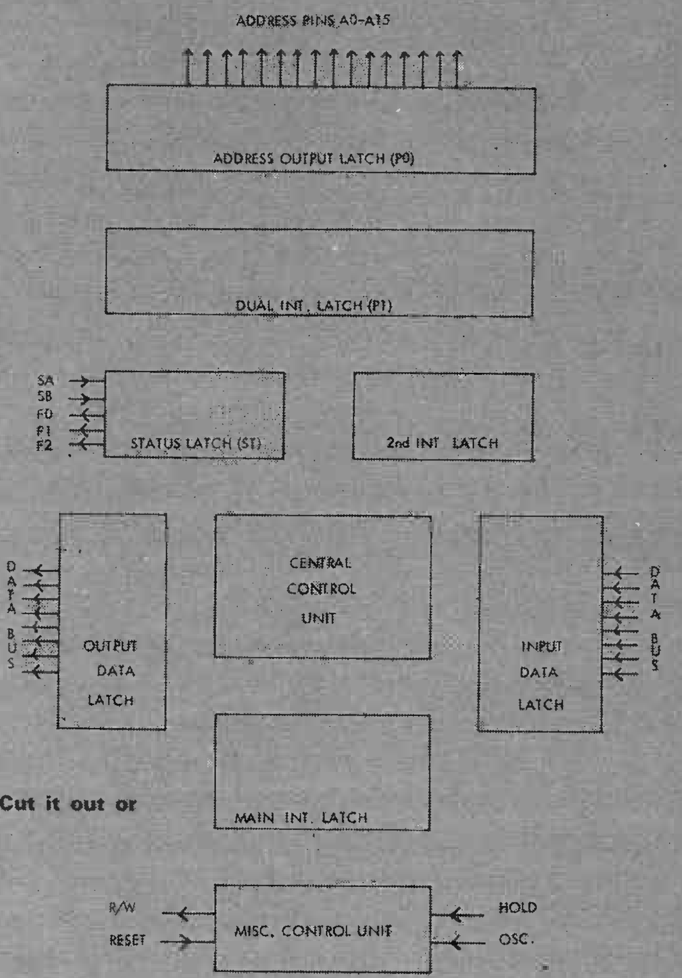


Figure 1. The PCMP processor. Cut it out or trace it carefully.

Bits and Bytes

A bit is a very small piece of information which can be in only one of two states, for example, assuming that there are not alternatives, put a 1 in box 1 over leaf if you are male a zero if you are female.
Thus one Bit can carry a value of 1 or 0 which a microprocessor can look at in two ways —

a) As a numeric value of 1 or 0.

b) As a True/False indicator where 1 is True and 0 is False.

Obviously the microprocessor is going to need to deal with numbers other than 1 or 0 and it does this by using a form of Binary arithmetic called Hexadecimal. In this way large numbers can be stored

For example write down your chest measurement in inches on a piece of paper, e.g. 39 inches. Now divide by two and put the remainder (1 or 0) in box 8, take the answer, and divide by two and put the remainder (1 or 0) in box 7, take the answer and divide by two and put the remainder (1 or 0) in box six, take the answer and divide by two and put the remainder (1 or0) in box 5, take the answer and divide by two and put the remainder (1 or 0) in box 4, take the answer and divide by two and put the remainder (1 or 0) in box 3, take the answer it should be zero (unless you have a chest measurement larger than 63 inches!), write the answer (0 or 1) in box 2.

1	2	3	4	5	6	7	8

You should now have filled in all of the boxes and you have thus formed a Byte of data. A Byte is a unit of data which usually consists of 8 bits of data, the byte above defines your sex and chest size.

Note that Bit and Byte refer to the size of the data portion rather than its contents, thus the amount of storage area or memory attached to a microprocessor is counted in Bits and Bytes.

As these areas tend to be quite large they are counted in thousands of bytes or millions of bytes (Kilobytes and

........news digest........

MONITORING SCOPEX

Scopex have announced the introduction of their first purpose-built monitor, the 4MI.

At £175 plus VAT, Scopex claim that the 4MI is probably less than a quarter of the price of its nearest competitor.

Introduced as a result of market demands, the 4MI has been designed to meet the diverse requirements of the OEM market for an XYZ display unit with a high degree of built-in versatility.

The matched vertical and horizontal systems both have a sensitivity of 100mV/cm (internal preset permits adjustment of ±10%) over a bandwidth of DC 1MHz (—3dB) with an accuracy of ±3% (of the preset sensitivity).

The vertical and horizontal shift controls use plug-in spindle potentiometers so that either front panel or internal preset operation may be selected.

For further details of the 4MI, contact Scopex Sales, Pixmore Avenue, Letchworth, Hertfordshire SG6 1JJ.

JUST ARRIVED

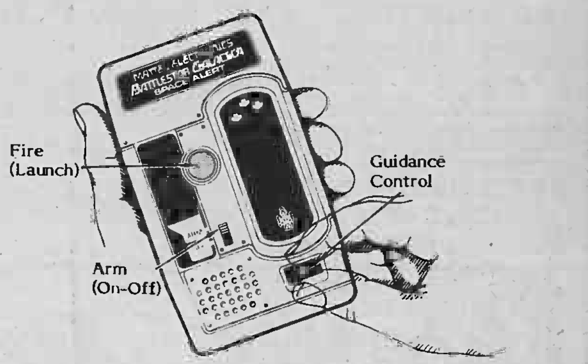
Following on the heels of the film 'Battlestar Galactica' is 'Mattel Electronics' hand held 'Space Alert' game.

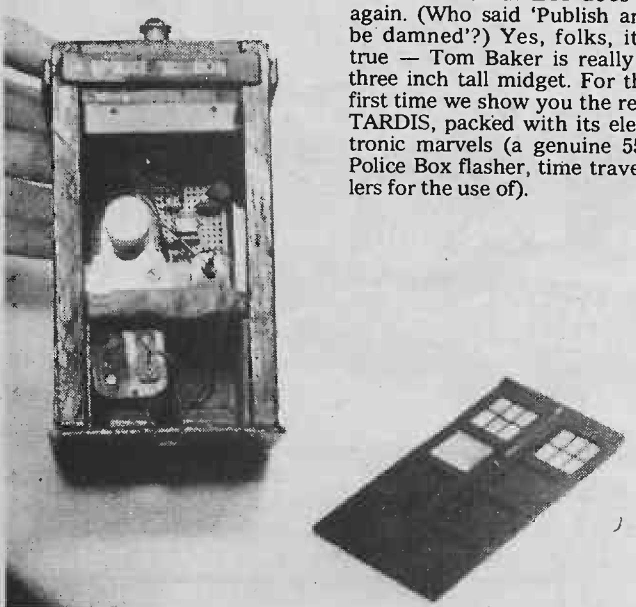
Your object is to intercept as many of the Cylon raiders as possible. The further away from your Battlestar you blast them, the more points you score. The game naturally features launch, impact, win and lose sound effects.

What's that? You don't know what a Cylon raider is. You are sentenced to one evening at the nearest cinema showing Battlestar Galactica.

Also from Mattel and new to the UK is Auto Race. You have to successfully complete four laps of the circuit in the shortest possible time, steering round obstacles at four speeds from slow to just-a-blur. Full sound effects are featured.

The games are available at £15.90 each from N.I.C. Models, 27 Sidney Road, London N22 4LT, who will shortly be adding a soccer game to their range. It is expected to sell at £21.30.





Be prepared to have your illusions shattered. ETI does it again. (Who said 'Publish and be damned'?) Yes, folks, it's true — Tom Baker is really a three inch tall midget. For the first time we show you the real TARDIS, packed with its electronic marvels (a genuine 555 Police Box flasher, time travellers for the use of).

POLYPHONIC KEYBOARD

We made a few errors in this article last month. To start with we credited the design to Tim Orr, when in fact Tony Keene of Arak should have received the accolades.

In addition to this we missed out the Buylines, which contained the details of the all-important designs kit from Arak Sound. Our apologies to them for our omission. For the missing details please consult the Arak ad on page 97 of this issue.

COURSE REGISTER

New from NCR, yes the cash register people, is their 'Basic Electronics Course With Experiments'. The 430 page paperback is a self-study course in both electronics theory and practical application.

The book is intended for use with an equipment kit including something called an op amp designer and, unfortunately, an oscilloscope. Unfortunately, because the sort of person likely to want to use this book is just the person who will not have a scope and probably doesn't know where to borrow one.

Although a scope is necessary for some experiments, it is possible to cover most of the work without one. Arm yourself with the necessary components, a breadboard, a multimeter and if you can lay your hands on one, a function generator and you're away.

The book is a useful introduction to basic electronics with sections and written tests covering everything from simple atomic structure to transistor amplifiers. Don't cheat by looking up the answers.

The NCR Basic Electronics Course With Experiments costs £6.95.

Megabytes). With microprocessors you get an added bonus because 1K bytes of memory is not 1000 bytes as you would expect but 1024 bytes, an extra 24 for free! Similarly with 1M byte you get an extra 48,576 bytes free, this is simply because these are the nearest Hexadecimal equivalents to 1000 and 1,000,000 and the MPU prefers to count in Hex.

Data and Address Buses

A bus is a set of wires or other connectors which carries a set of data between one part of the circuit and another. Each wire can carry a positive voltage to indicate a logic 1 or no voltage to indicate a logic 0.

To carry the information in our sample byte from above we would need an 8 bit bus or 8 wires, one of the main buses on a microprocessor carries data from one part of the circuit to another, most microprocessor use an 8 bit data bus. The second main microprocessor bus is needed to inform the system where to send the data or where to get it from, an 8 bit bus can only define 256 addresses which is not much for a microprocessor. Two bytes are used to carry the data for an address thus giving a maximum of 65,536 address locations note that 65,536 is 64 × 1024 and is thus usually referred to as 64K.

A third microprocessor bus carries control signals the simplest of which is a signal to indicate whether we are Reading data or Writing data. This is referred to as a Read/Write control line or simply R/W (more nmemonics)

Other controls on a microprocessor include:

RESET	restart programm from address location 1.
HOLD	Suspend execution as long as this function is enabled.
OSC	Each oscillator pulse performs one machine cycle (NB several machine cycles make up one operation).
SENSE	Inputs to sense buttons or single bit data.
FLAGS	Single bit outputs used for driving lamps, buzzer, etc.

The PC/MP Microprocessor

The PC/MP consists of several areas of cardboard (defined as latches). These may be thought of as a form of 'pigeon hole' storage. Any information may be written into these boxes as required in the form of an 8 bit (or 16 bit) byte of data. The information can be copied into any other box (which overwrites any previous information in the second box). Some of the boxes allow communication of data in the box to outside the PC/MP.

As an example of an operation of the PC/MP assume that we instruct the PC/MP to READ our sample byte into its Main Internal Latch. It will do this by setting the R/W line to read data and inputting the data to the INPUT DATA LATCH, the data will then be copied to the MAIN INTERNAL LATCH. A second type of instruction can move data around inside the PC/MP, for example copy the data in the MAIN INTERNAL LATCH to the 2ND INTERNAL LATCH. Now enter the byte 0011 0000 into the MAIN INTERNAL LATCH via the INPUT DATA LATCH. You should now have you data byte in the 2ND LATCH and 0011 0000 in the MAIN LATCH.

The PC/MP can perform three operation types on these two data bytes

a) LOGICAL operations (AND, OR, NOT, XOR)
b) ARITHMETIC operations (ADD, COMPLEMENT, COMPLEMENT and ADD)
c) SHIFT operations (SHIFT LEFT or RIGHT, ROTATE LEFT or RIGHT).

Firstly lets look at an AND operation, here if there is a 1 in one latch and a 1 in the same location in the second latch then there will be a 1 in that location in the result (the result ends up in the MAIN LATCH). Thus an AND operation means 1 AND 1 gives 1, otherwise 0.

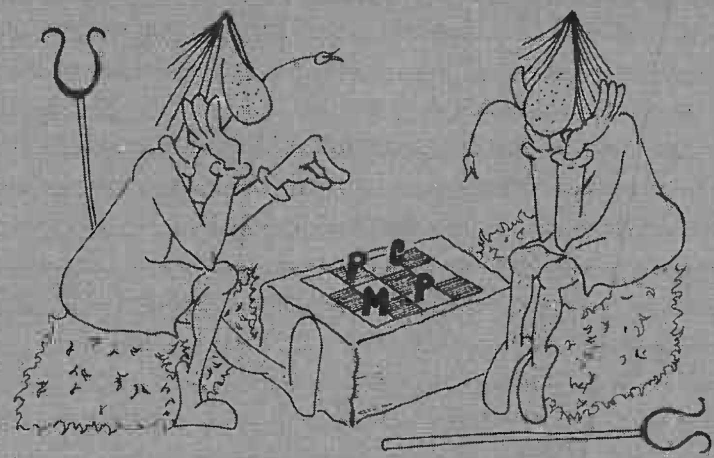
AND together the MAIN LATCH and the 2ND LATCH and put the result in the MAIN LATCH, the result should be either 0000 0000, 0010 000, 0001 0000 or 0011 0000. Of the two possible locations of a 1 the first represents a unit of 32 inches chest measurement and the second a unit of 16 inches chest measurement. Thus the four possible results tell us:

000 0000	Your chest measurement is either less than 16 inches or greater than 63 inches.
0010 0000	Your chest measurement is at least 32 inches and less than 48 inches.
0001 0000	Your chest measurement is between 16 inches and 32 inches.
0011 0000	Your chest measurement is at least 48 inches.

Let us assume that the PC/MP is to be used to define the shelf on which to find an overall in a clothing depot. The shelves are set out as

Top Shelf 7	Gents overalls sizes 48 inches to 63 inches
Shelf 6	Gents overalls sizes 32 inches to 47 inches
Shelf 5	Gents overalls sizes under 32 inches
Shelf 4	Overalls sizes under 32 inches
Shelf 4	Overalls either larger than 63 inches or under 16 inches.
Shelf 3	Ladies overalls sizes 48 inches to 63 inches
Shelf 2	Ladies overalls sizes 32 inches to 47 inches.
Shelf 1	Ladies overalls size under 32 inches.

▶



If your results from the AND was all o's, read the following:- (otherwise go to next paragraph).
This is an example of the conditional jump instruction of the PC/MP. If you are still reading this paragraph then your chest size is, I am sure you will agree, somewhat unusual. In such cases it would seem to make very little difference whether you are male or female when ordering an overall! To help make up for this we will teach you what an OR instruction does, the others will have to wait until later. Copy the data in the MAIN LATCH into the right hand half of the DUAL LATCH and then input the byte 1000 0000 into the MAIN LATCH via the INPUT LATCH. You are now ready to OR. The OR instruction states that if there is a 1 in one latch or a 1 in the other latch then the result will have a 1 in the ensuing location.
THUS: 1 OR 1 gives 1 otherwise 0. If you OR the MAIN LATCH and the 2ND LATCH and put the result in the MAIN LATCH then the data in the MAIN LATCH should now have a 1 in the first position. After this little detour we need to make sure that you have the same data in the same latches as those people who bypassed this paragraph. Copy the MAIN LATCH into the 2ND LATCH and the copy the right hand half of the DUAL LATCH into the MAIN LATCH.

Here we are all together again in this paragraph, those of you who bypassed the instructions in the previous paragraph should read it but not actually *do* the operations.

Now lets learn about SHIFTs and ROTATES.

A SHIFT causes all of the bits in a byte to change their location by one position, the new empty location will be filled with a 0 and the location at the other end drops off the end and is thus lost. With the ROTATE the data is shifted but in this case the new empty location becomes filled with the data bit from the other end. As an example:
SHIFT LEFT 1011 11010 gives 0111 0100 and again gives 1110 1000
ROTATE LEFT 1011 1010 gives 0111 0101 and again gives 1110 1010
SHIFT RIGHT 2ND LATCH seven times to move the Male/Female bit from box 8 to box 1 and fill the rest with zeros
Now ROTATE RIGHT 2ND LATCH twice to put this bit at box 7.
Now OR the MAIN LATCH with 2ND LATCH put result in MAIN LATCH and you should have 0xxx 000 where x can be 0 or 1. SHIFT RIGHT four times the MAIN LATCH and this should be 000 0xxx.
To get the answer take the bit value in box 3 of the MAIN LATCH, multiply it by two and add it to the value in bit 2. Multiply this result by two and then add the value in box 1, the result should be a value in the range 1-7. The result calculation is an example of binary to decimal conversion and is the opposite of the calculation used to calculate your chest size in binary. Normally the MPU would output this RESULT via the OUTPUT DATA LATCH to an address where it would find a device which would display the result to the operator, an example would be a seven segment display plus decoder. All the foregoing is repeated in tabular form with a MALE chest size of 36 inches as follows:-

BYTE OF INFORMATION	1010	0111	SHOWS SEX AND CHEST SIZE
ENTER BYTE	1010	0111	TO INPUT DATA LATCH, COPY
TO MAIN INT LATCH	1010	0111	COPY
To 2ND INT LATCH	1010	0111	STOP
ENTER	0011	0000	TO INPUT DATA LATCH, COPY
TO MAIN INT LATCH	0011	0000	STOP NOW
AND MAIN INT LATCH	0011	0111	WITH
2ND INT LATCH	1010	0111	RESULT OF *AND*NOW IN MAIN LATCH
0010 0000 STOP			

CONDITIONAL JUMP INSTRUCTION

DATA IN MAIN LATCH	0000	0000	COPY
TO RT. HALF OF DUAL LATCH	0000	0000	STOP
ENTER	1000	0000	TO INPUT DATA LATCH, COPY
TO MAIN INT LATCH	1000	0000	STOP NOW

E

OR MAIN INT LATCH	1000	0000	WITH
2ND INT LATCH	0000	0000	RESULT OF *OR*
NOW IN MAIN LATCH	1000	0000	COPY
TO 2ND INT LATCH	1000	0000	STOP COPY
RT. HALF DUAL LATCH	0000	0000	TO
MAIN LATCH	0000	0000	NOW
AND MAIN LATCH	0000	0000	WITH
2ND INT LATCH	1000	0000	RESULT
NOW IN MAIN LATCH	0000	0000	STOP

Instructions and Program Memory

The above example gives a generalised idea of what goes on inside a microprocessor assuming that it is given the correct instructions in the correct sequence. It must also input these instructions as well as inputting data, the instructions are input as a form of data which is recognised by the microprocessor in a very simple way. The microprocessor first looks on the input data bus for an instruction, this instruction will tell the microprocessor whether it must next get data or another instruction, thus there is a marker inherent in the instruction code which informs the microprocessor what to do next.

SHIFT RT. 2ND INT LATCH	1010	0111	7 TIMES
BECOMES	0000	0001	NOW
ROTATE RIGHT ONCE BECOMES	1000	0000	ROTATE RIGHT AGAIN
BECOMES	0100	0000	(ROTATED TWICE) STOP
DATA IN MAIN LATCH	0010	0000	STOP
DATA IN 2ND LATCH	0100	0000	STOP NEW
OR DATA IN MAIN LATCH	0010	0000	WITH
DATA IN 2ND LATCH	0100	0000	RESULT OF *OR*
NOW IN MAIN LATCH	0110	0000	STOP NOW
SHIFT RIGHT MAIN LATCH	0110	0000	4 TIMES
BECOMES	0000	0110	$=2^1+2^2=6$ Size of Male Overall required is on shelf No. 6.

We must define an area of memory addresses which hold the instructions, for this we will reserve the first 256 memory locations on address lines 0000 0000 0000 0000 to 0000 0000 1111 1111 (0-255 in decimal, 0000 00FF in Hex). The first instruction will be fetched from location 1, the next from 2, etc.

We must also define addresses at which we have a set of switches or a keyboard for input of the parameters and an address at which there is a display and decoder. We can use the upper half of the address to define that address. An upper byte code of 000 0000 will access the program, any address with an upper byte code of 0000 0001 will access the keyboard and an address with an upper byte code of 0000 0010 will access the display. Note that in the second two cases the value in the lower address byte does not matter.

We need to define a set of instructions for the PC/MP, such as:

0000 0 000	00	Activate the HALT feature and this suspend operation until the HALT input is pulsed.
0000 0001	01	Exchange the values in the MAIN LATCH and the 2ND LATCH
0000 0010	02	SHIFT LEFT MAIN LATCH
0000 0011	03	SHIFT RIGHT MAIN LATCH
0000 0100	04	ROTATE LEFT MAIN LATCH
0000 0101	05	ROTATE RIGHT MAIN LATCH
0000 0110	06	Exchange the values in the MAIN LATCH and the DUAL LATCH RIGHT
0000 0111	07	Exchange the values in the MAIN LATCH and the DUAL LATCH LEFT
0000 1000	08	Exchange the values in the ADDRESS OUTPUT LATCH with that in the DUAL INTERNAL LATCH, note this is a 16 bit exchange.
0000 1001	09	Exchange address OUTPUT LATCH and DUAL LATCH, copy MAIN LATCH to OUTPUT DATA LATCH and pulse R/W to indicate WRITE, re-exchange ADDRESS OUTPUT LATCH and DUAL LATCH (i.e. WRITE the data in MAIN LATCH to the address in DUAL LATCH).
0000 1010	0A	Exchange ADDRESS OUTPUT LATCH and DUAL LATCH, pulse R/W for a READ, copy the data in the INPUT DATA LATCH into MAIN LATCH, re-exchange ADDRESS LATCH and DUAL LATCH. (i.e. READ from the address in DUAL LATCH into MAIN LATCH).
0000 1011	0B	READ the data at the next address and copy it into MAIN LATCH
0000 1100	0C	AND MAIN LATCH and 2ND LATCH, put result in MAIN
0000 1101	0D	OR MAIN LATCH and 2ND LATCH, put result in MAIN.
0000 1110	0E	The data following this instruction indicates the number of instructions following it which can be ignored.
0000 1111	0F	As 0A but only if the value in MAIN is all zeros.
0001 000	10	As 0A but only if the value in MAIN is not all zeros.

ETI

Next month: Programming the PCMP and taking down some addresses!

microfile

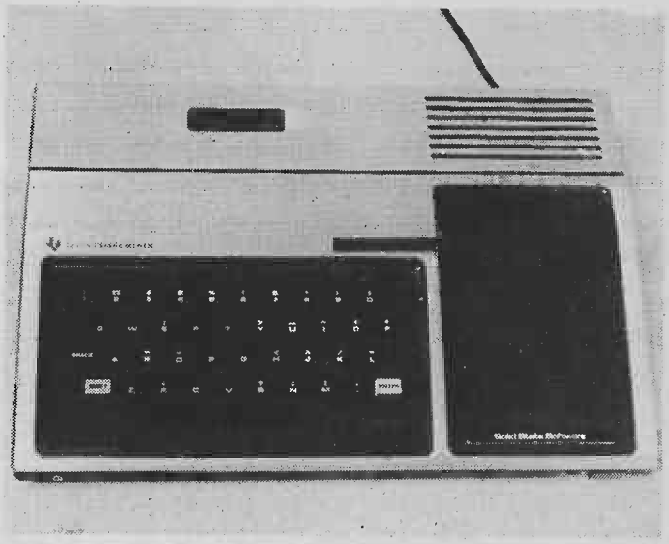
This month the ever present Henry Budgett drools over the finally announced Texas Instruments System. Between time he looks at a more down to earth training system called the Nano-computer.

WELL, IT is here at last, or rather TI is! Launched at the Consumer Electronics Show in Chicago on Sunday June 3rd the Texas Instruments home computer is with us. There are no real surprises unfortunately but the machine will probably provide a real challenge to both Apple and Compucolor. Based on the 990 series 16 bit microprocessor the system is built into a neat desktop console which measures 15″ by 10″ by 2½″.

Configured with 16K of RAM, a sound generator which covers four full octaves, full 16 colour graphics and an extended BASIC. The machine will drive any black and white TV or monitor and any NTSC colour monitor with video input. Hopefully a PAL version will be available for Europe as at the moment it will cost about £400 for a suitable monitor. The machine uses an extension of the calculator Solid State Software system with up to five ROM chips in a module. A variety of these will be available for the UK launch in September including Pre-school learning, Video Chess, Home Budgeting and Video Games. Prices for the various packages will vary between £15 and £45. The main advantages of the Solid State system is the high speed of program loading and interchange.

Peripherals for the system will be announced in due course and should include a printer, disk drive, RS232 interface and a Speech Synthesiser. The synthesiser is based on the Speak and Spell chip set and has a vocabulary of 200 words, these can be called from user programs to give messages, instructions etc. The BASIC on the system is a 13 digit version with full floating point, ANSI compatible and has 24 basic statements, 14 commands and the colour graphics.

The cost of the machine is quoted at £645 but the change in VAT may mean a slight increase by the Autumn. For further details you should contact Roger Tilbury at Texas Instruments, Manton Lane, Bedford MK41 7PN. We will be reviewing the system as soon as we can lay our hands on one and I will keep you informed of any further developments through both ETI and CT.



Above: At last! The Texas Instruments home computer system. Along time in the making . . . . . .

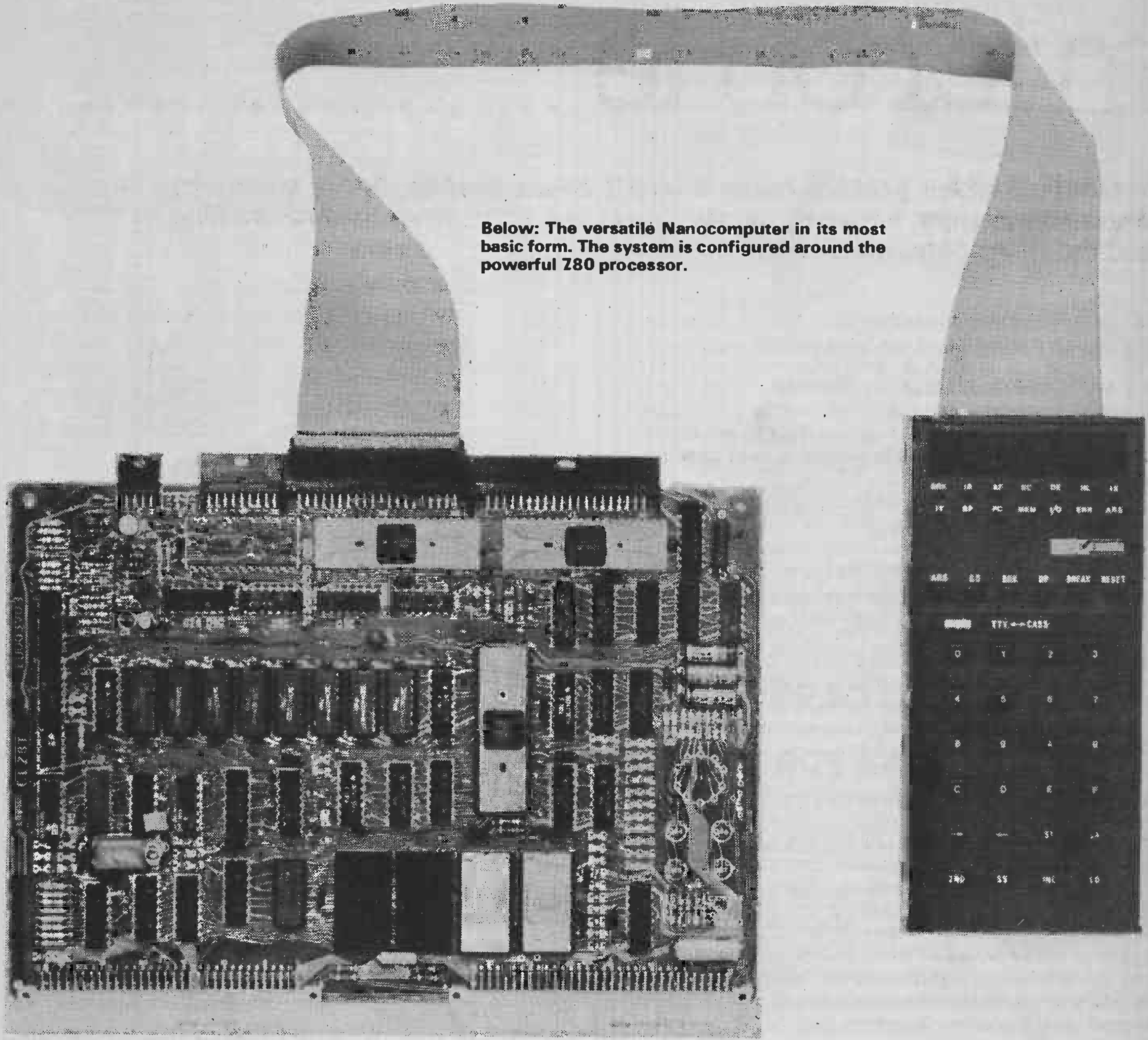
New Training System

Newly arrived in our offices is a new training and educational system called the Nanocomputer. Definitely not to be confused with a popular TV show! Based on the Z80 the system is fully expandable from a single board with a hand held keypad right up to a full system and you can select the level at which you start. The unit is supplied in a case with a power supply and the keypad and a training manual. This takes you through the machine code programming of the Z80 and you can then go on to the experimental kits. For these one plugs onto the end of the board a prototyping kit which allows you to learn about interfacing to the system, amongst other things. The final stage is to upgrade the board to a full system in a card frame with a variety of peripherals such as a full ASCII keyboard, printer, VDU and disks.

A range of software is also available including various monitors, Editor Assemblers and an 8K BASIC. The unit is extremely well constructed on a double sided, plated through PCB and all interconnections are made with high quality header sockets thus eliminating the usual lash ups. A full review of the system will be appearing in the August issue of CT but for more information before then please contact Mr David Watson of the Midwich Computer Company at Hillsborough House, Churchgate Street, Old Harlow, Essex. The price of a basic system is £260, the full Experimental kit is around £430.

Club Forum

A varied bunch in this month's mailbag. Micro44 of Woking have formed an Exidy Sorcerer Users Group to be run by Andy Marshall. The group will be run as a division of the US group and will both take and contribute material to them. Membership fees are £5 a year to cover costs and a monthly newsletter will be produced. Contact Andy at Micro44, 44 Arthurs Bridge Road, Woking GU21 4NT or ring 04862-66084. Another club is being formed in the Nottingham area, primarily for Nascom users but anyone will be welcome. Meetings will be monthly, no dates are yet arranged and



Below: The versatile Nanocomputer in its most basic form. The system is configured around the powerful Z80 processor.

it is hoped to produce a newsletter and offer program exchange. For those interested please contact Mr K S Swainson at 9 Brayton Crescent, Highbury Vale Estate, Bulwell, Nottingham NG6 9DZ.

Ware Of The Soft Kind

A TRS 80 software exchange service is being planned by Chris Cain, if anyone is interested. He handles programs and tests them in any TRS 80 format and anyone interested should contact him at ENG Wing, RAF West Drayton, Middlesex. Please enclose an SAE. The final item is a request for our younger readers. If anyone who is into the SCMP micro and BASIC programming would like to help form a young persons computer club would they please get in touch with N. Sutcliffe Esq of 1 Suncliffe Road, Higher Reedley, Nr Burnley, Lancashire BB9 5EP and enclose an SAE.

ETI

IMPEDANCE AND PHASE

Life would be a lot easier if all components behaved like resistors. Inductors and capacitors make life difficult by separating voltage and current, so how do you find the voltage or current at any point in a circuit? Phase diagrams to the rescue.

In electronics, one often needs to know what the voltage of current at some part of a circuit will be, without actually building it to find out. When dealing with DC, this is usually pretty straightforward, using Ohm's law and a few rules of thumb, but AC signals in a circuit are a different matter, often reacting in totally different ways, predictable only by using impedance theory and phase diagrams. It is this type of theory, and the calculations used to find voltages, etc., in circuits, that concern this article.

AC Signals

First let's remind ourselves what an AC signal actually is. Plotting voltage against time for a typical signal would give us a graph like that in Fig. 1. This particular variety of round wave is known as a sine wave and in order to fully describe it, we must outline two quantities: its rms value and its frequency. The former is a measure of the amplitude, or height of the wave, and for reasons that need not be gone into here, is, in the case of a sine wave, 0.707 times the maximum value of the wave. For instance, if, as in Fig. 1, the wave has a maximum value of 6 volts, the rms value of the signal is $0.707 \times 6 = 4.24$ volts. The other measure of the wave is the frequency. Take the interval between, say, A and B on Fig. 1. This interval, from one point to the next point where the voltage is acting in exactly the same way (in this case, from a point where it is zero and decreasing to the next point where it is both zero and decreasing) is called the period of the wave and is measured in seconds. During one period, the wave is said to have gone through one full cycle. The frequency of the wave, we can now say, is the number of cycles per second.

Impedance

Impedance can be described as the opposition to electrical current given by a circuit. Of course, we know about ordinary resistance, but there are other varieties. For instance, a capacitor may have a very high opposition to DC current, but a very low opposition to AC signals of a suitably high frequency. This obviously isn't ordinary resistance, because if it was, it would remain the same for AC and DC. In fact, the amount of opposition given to a signal by a capacitor is measured by the

Fig. 1. A voltager/time graph for a typical AC signal.

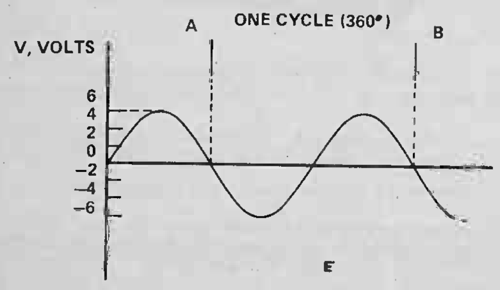
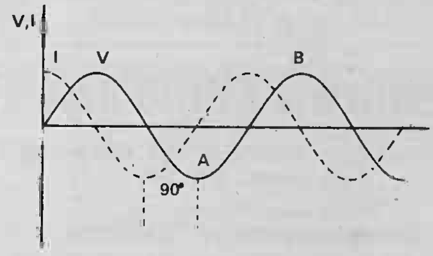


Fig. 2. Current and voltage plots for a capacitor, showing a phase difference between the two.



ratio of voltage across it to current through it. (V/I). This ratio is called the 'capacitative reactance' of the component, and it is given the symbol X_c. Like resistance, reactance is measured in ohms. Capacitative reactance may be calculated from the value of a capacitor by using the formula $X_c = 1/2\pi fC$, where π is the Greek letter Pi, and represents the number 3.14 . . ., f is the frequency of the signal being applied, and C is the value of the capacitor in Farads. Note that, as stated earlier, the opposition (reactance) of the capacitor becomes very small at high frequencies, but to DC (where the frequency is effectively zero) or to very low frequency signals, it becomes effectively infinite.

Inductors, too, have a variable reactance; in this case, the inductive reactance, X_L, which may be obtained from the value, L, in Henries of the inductor, from the formula $X_L = 2\pi fL$. Note that this reactance also varies with frequency, but here, it becomes greater at high frequencies, approaching zero only when f is very low, or when DC is encountered. Again, X_L is the ratio V/I in the inductor, and thus, given either the voltage or the current, it is possible to calculate the other in either a capacitor or an inductor, if we know the frequency at which the circuit is operating.

To conclude this section, we now give a rather more adequate definition of impedance than that which we began with. Impedance is the combined opposition to AC signals in a circuit given by the resistance and reactance of the circuit. If we represent it by Z, the resistance by R, and the reactance by X, then $Z = \sqrt{R^2 + X^2}$. We find that, in a combination circuit of several components, Z=V/I.

Phase Differences

In addition to information about voltages and currents in circuits, phase diagrams also give us information about phase differences in these circuits. What in the world is a phase difference? To answer that, we must return to the capacitor and inductor. Suppose that we are applying an AC voltage across a specimen of the former type of component. If we now look at the current flowing through it, we find that it is 'leading' the voltage by a quarter cycle. That is, although it goes up and down in the same way that the voltage does, the two quantities are not in time with each other. If the voltage has, say, gone up (as from point A to point B in Fig. 2), then the current did so 90°, or a quarter of a cycle earlier. (The figure 90° is used because a full cycle is taken as being divided into 360 degrees, as a circle is, and one quarter of a cycle is, therefore, represented by $\frac{1}{4} \times 360 = 90$. The reason for dividing a cycle into 360 degrees will become apparent later.) If we superimpose a graph of current against time on top of one of voltage against time, we get something like Fig. 2.

In the inductor, a similar effect occurs, but here it is voltage which leads current by 90°, rather than vice versa. The 'phase difference', as it is called, is given both in the case of the capacitor and the inductor, the symbol ϕ — the Greek letter phi — and may also be measured in terms of radians, another unit of angle, rather than degrees.

To help remember that voltage leads current in the indicator, whereas current leads voltage in the capacitor, the mnemonic CIVIL is used. In a capacitor, (C) current (I) leads voltage (V), but voltage leads current, (I) in an inductor (L). Taken in order, the one-letter symbols for the components, voltages and currents spell CIVIL. (All right,. I didn't think of it.)

Phase Diagrams

So far we have seen how voltage and current are related in terms of magnitude (size) and phase, in individual components. What happens, though, if we put two different components — a resistor and inductor, for example, in series or parallel? This is where the phase diagrams step in, folks. Let us suppose that these two components, each of known value, are connected in series, and that we know the current which is flowing through the combination, and this current's frequency. We wish to find the size and phase of the total voltage across the two components, and we might be misled into thinking that it would just be the sum of the two individual voltages across the individual components, but in fact, this will not be so. The current and voltage will be exactly 'in phase' in the resistor, but in the inductor, the voltage will be 90° out of phase; you can't just add voltages unless they are in phase with each other. Of course, we could find the magnitude of the total voltage by finding the total impedance of the circuit and multiplying this by the current, but we still wouldn't know the phase of this voltage with respect to the current, so a phase diagram is really our only option.

Which Reference

For our diagram, we shall want some quantity, either voltage or current, which will be the same for both components. Well, as we have just seen, the voltages across the individual components are definitely different, so that only leaves current. In fact, current serves as our 'reference quantity' in any series circuit, and voltage is used in parallel circuits. To represent the current, draw an arrow, pointing to the right. Now we ▶

Fig. 3. A series circuit with a resistor and an inductor. Do you use voltage or current as the reference quantity?

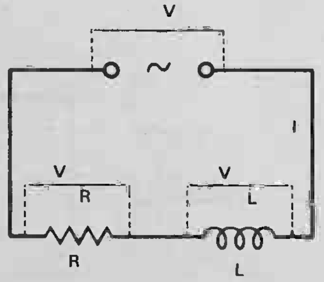
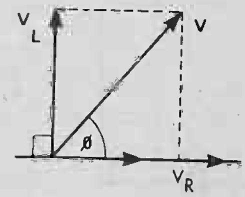


Fig. 4. The voltages across the resistor and inductor can be used to find the total voltage across the two components.



must draw in arrows to represent the voltages across individual components. The lengths of these arrows will be made, using a suitable scale, to represent the rms values of the voltages, and the phase of each voltage with respect to the current will be indicated by the angle, going anti-clockwise, which the voltage's arrow makes with that of the current, when both have their tails at the same place. Thus, the voltage across the resistor, which can be calculated by multiplying the current by the resistance, will be represented by an arrow actually on top of that showing the current, because the voltage and current here are in phase, so that the angle, ϕ, is zero. The voltage across the inductor can be calculated by finding the reactance of the component, and multiplying this by the current. This arrow will be placed at an angle of 90° to that representing the current (i.e. it will point straight up), because the voltage in an inductor leads the current by 90°. Were the component a capacitor, ϕ would be $-90°$, because the voltage here lags by a quarter cycle, which is equivalent to saying that it leads by $-90°$. The arrow would, then, point down, rather than up, as it does now.

If we imagine our two voltage arrows to be two sides of a parallelogram (in this case, a rectangle, because we know that one of the angles is 90°), and draw in the other two sides parallel to the ones we have, as in Fig. 4, we find that the diagonal of the rectangle, drawn in as an arrow starting at the same place as do all the others, has a length that, on whatever scale we have used to draw the lengths of our arrows, gives the total voltage across the two components. In addition to this (yes, you guessed it . . .), we find that the angle which this diagonal arrow makes with the horizontal gives the phase of the total voltage across the circuit, with respect to the current!

In fact, if we use Pythagoras' famous theorem about the squares of the lengths of the sides of a right angled triangle (whew!), to find the length of this diagonal, we find that, if we call the voltage across the resistor V_R, and that across the inductor V_L, then the total voltage, V, is given by the formula:—

$$V = \sqrt{V_R^2 + V_L^2}$$

Looking back to the section on impedance, we notice that this formula bears a remarkable resemblance to the one stated to give the combined impedance of a resistance and reactance; in fact, if we divide both sides of the

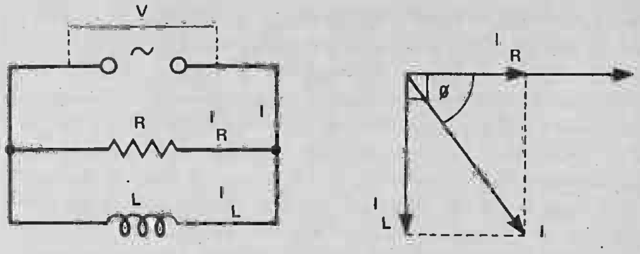


Fig. 5. (a) A resistor and an inductor in parallel. In this case voltage is used as the reference quantity. (b) The phase diagram for a parallel L-R circuit.

equation by the current, I, then V becomes Z, V_R becomes R and V_L becomes X_L (since Z, R and X_L are all defined to be equal to V/I) and the two equations become one and the same (Howzatt!!!).

The phase of the voltage can also be calculated, rather than measured directly from the diagram. The appropriate formula is:—

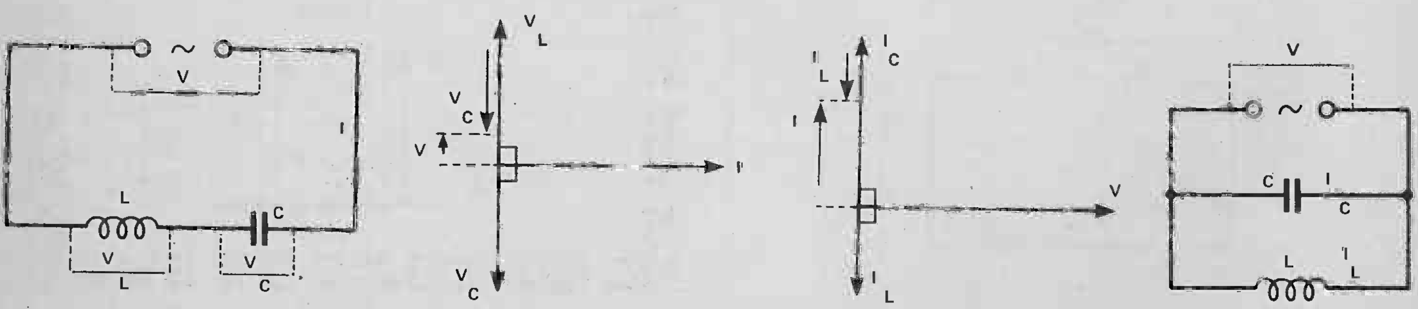
$$\phi = \tan^{-1} V_L/V_R.$$

What about parallel circuits? The procedure this time is pretty much the same as for series circuits, but now the 'reference' arrow, pointing to the right, represents the total voltage, not the current. The individual arrows represent the currents through the individual components, rather than the voltages, and the diagonal arrow gives the total current, and the angle by which the current leads the voltage. Note that if this angle is multiplied by -1, it then gives the angle by which voltage leads the current.

LC Circuits

There are two more circuits, that should really be treated by themselves. These are the combination of capacitor and inductor in series or parallel, and they possess some rather interesting properties. If we draw a phase diagram for either of these two types of circuit, we find that the two arrows representing voltages or currents, as the case may be, in the individual components point in exactly oppsoite directions. To find the arrow that is the combination of these, we place the arrows end to end. That

Fig. 6. (a) A series L-C circuit, where current is the reference. (b) Phase diagram for the series L-C circuit. Inductor and capacitor voltages are 180° out of phase. (c) A parallel L-C circuit. (d) With voltage as reference, inductor and capacitor currents are 180° out of phase.



is, we place the tail of one of them at the head of the other, keeping them pointing in the same directions. An arrow starting at the beginning of the first individual one, and ending where the second arrow does, gives the total voltage, or current. It can be seen from this that if $V_C=V_L$, then the two will exactly cancel out, and in a series, circuit, there will be no voltage across the two components, and the circuit will be effectively shorted across. In a parallel circuit, there will be no current flowing, and the total impedance of the circuit will be effectively infinite. Under what circumstances, then we may ask, will the two voltage (or current) arrows be of equal length, and cancel? It turns out that this is so if $X_c=X_L$, and using the formulae for the reactances of the components, from the section on impedance, we find that $2\pi fL$ must equal $1/2\pi fC$. Here we notice that for any named combination of values for L and C, it should be possible to find some frequency — the so called **resonant frequency** — for which the circuits should react in the way described above. Manipulating the equations, we come up with the formula:—

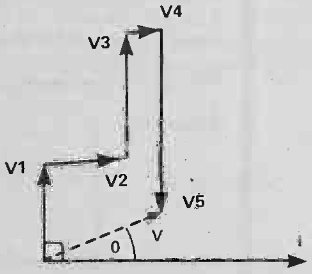
$$f=1/2\pi\sqrt{LC}$$

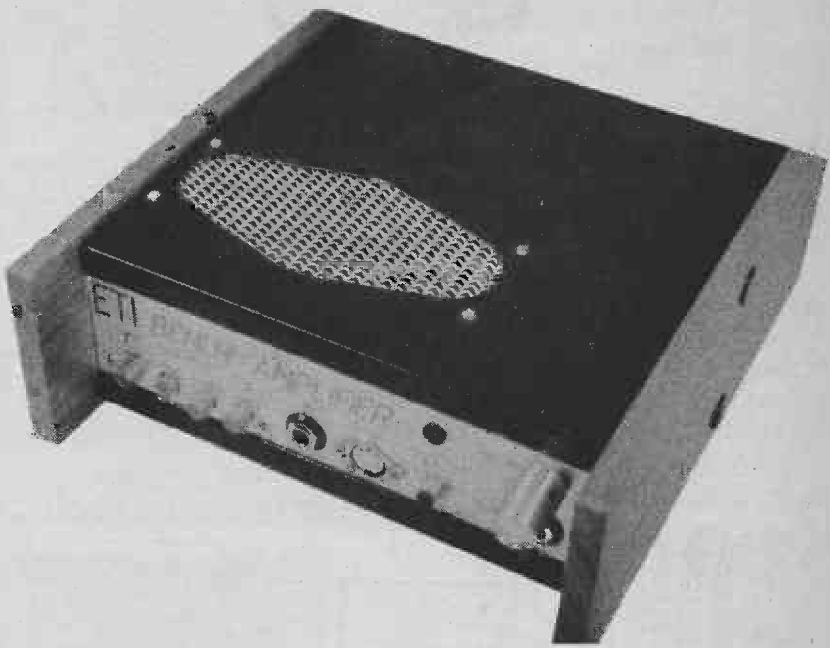
Thus, in a series circuit, signals at this, and only this, frequency, will be able to pass through the circuit unimpeded, whereas in a parallel circuit, any other frequency will be allowed to pass. These circuits are called, respectively, a notch filter and a tuned circuit. The latter is of great use in radio receivers, where it is often used to short all signals at frequencies other than those wanted to earth, thus effectively sorting out wanted signals to be amplified and listened to. The frequency required may be selected by adjusting one or other of the two components, and, in fact, the capacitor in the tuned circuit of a radio is usually a variable type, and forms the tuning control.

Two's Company . . .

Of course, you may want to find voltages or currents in circuits with more than two components, but this isn't as difficult as you might think. Just find the individual arrows of the separate components, and put them all end to end, as in Fig. 7. The final arrow, giving the total voltage or current, starts at the beginning of the first and ends where the last of the separate arrows does. ETI

Fig. 7. In circuits with more than two components, the voltage or current arrows for the individual components can be found, then the final arrow will give the total voltage or current. It's easy when you know how.





A useful item of test gear designed with the audio constructor in mind.

BENCH AMPLIFIER

AN ESSENTIAL PIECE of equipment for any electronics workshop is an audio amplifier — useful for testing and checking other audio circuits. Ideally the amplifier should allow for a reasonably wide range of input signals and be adaptable for various outputs. The bench amplifier described here fulfills these criteria.

There are four inputs: (i) a high gain, flat response, intended for use with microphone or guitar, (ii) a phono (disc) input with RIAA equalisation, (iii) a medium gain, flat response for ceramic cartridge or tuner, (iv) an attenuated, flat response, for tape output.

Coupled with the master volume control the preamplifier section should cater for most audio signals.

A pre-amplifier output is obtainable (see case photograph) and also an extension speaker outlet via necessary output sockets on the rear panel. Also provided is a low level power output suitable for headphones.

Construction

The prototype was constructed with various input connectors wired in parallel, 5 pin Din, ¼ inch Jack and Phono. This means that an input can be accepted from a signal lead with any of those three connector plugs. More can be added to personal preference, but it was felt that the chosen three would cover the majority of input functions.

The PCB is relatively uncluttered. Links l and 2 are provided to cut off the power supply to IC2 and IC3, the pre-amp and power amp stages. This may be useful in setting up and testing which can be done in three stages — the power supply, the power amplifier and finally the pre-amplifier.

Note that IC2 and IC3 are inserted into the board in opposite directions.

SW2 consists of four two pole changeover switches soldered directly onto the PCB, thus alleviating wiring-up problems. Different sizes are obtainable so make sure that you obtain the correct ones.

Use screened cable for input and pre-amp output and also for the lead to the volume control, to minimise mains hum.

Our finished amplifier had all input sockets, the selector switch, volume control, power indicator and the headphone socket on the front panel, with the output sockets on the rear. ▶

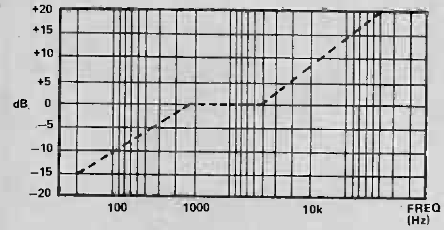


Fig. 1. Showing the variation of recorded signal with frequency.

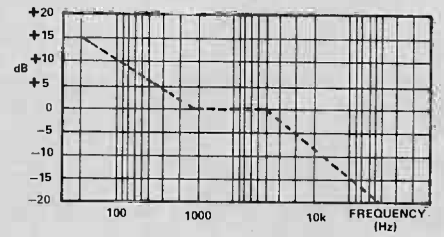


Fig. 2. Recorded playback signal attenuation with frequency.

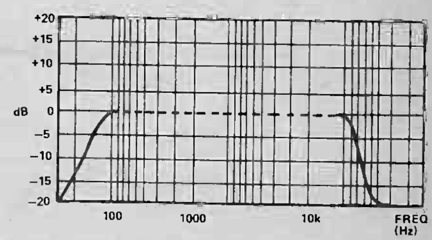
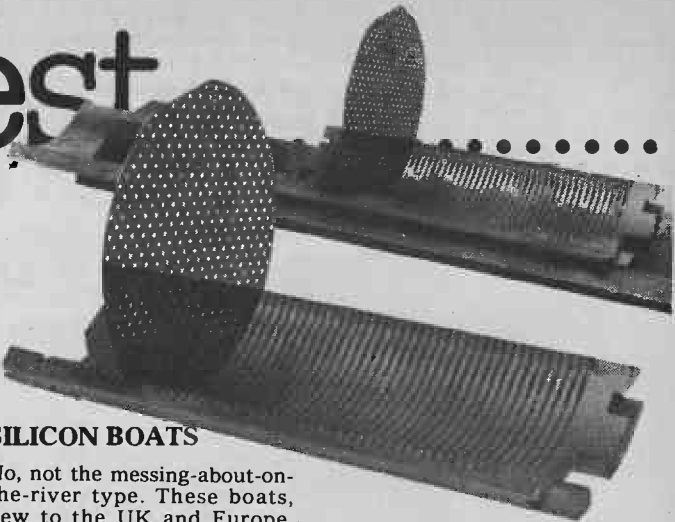


Fig. 3. Theoretical flat response output after pre-amp stage with associated equalization network.

news digest



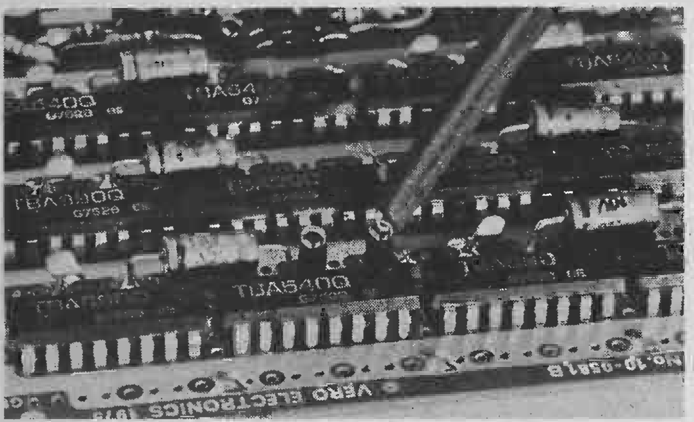
PCB EYE POSTS

You can use Vero Electronics' miniature terminal assemblies to attach scope probes to PCBs, or use them as input/output stations.

The unique spring design allows the terminals to be inserted into plated through boards without damage to the hole plating. The terminals will remain in place when the board is reversed for flow soldering.

Components can be fixed and replaced using the eye at the top of the terminal. The sintered glass bead has a recommended working temperature of 475°C and the terminals have a solder tinned finish.

For further details of the miniature terminal assemblies, contact Vero Electronics Ltd, Industrial Estate, Chandler's Ford, Eastleigh, Hampshire SO5 3ZR.



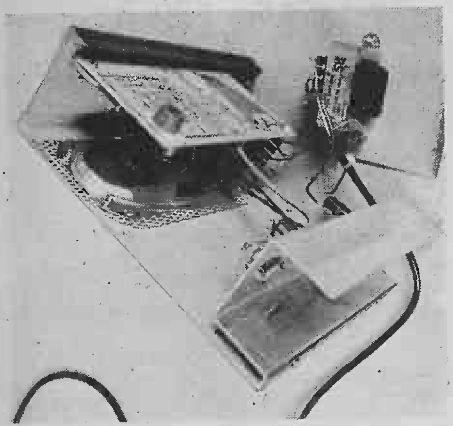
SILICON BOATS

No, not the messing-about-on-the-river type. These boats, new to the UK and Europe, could help semiconductor manufacturers boost their yields of the latest complex, high component density silicon chips.

Production of the latest generation of semiconductors demands critical handling during diffusion and oxidation processes. The new silicon boats, already in use in America, have several advantages over the conventional quartz boats. These include purity of the metal, four times that of quartz, and the lifetime of silicon, at least ten times that of quartz.

In addition, silicon boats will not devitrify, creating particles which can fuse into oxides causing yield losses. They can also be cleaned in HF solutions without degradation and minimum slot enlargement. As they have the same thermal coefficient of expansion as the slices they carry, warpage problems are eliminated. Rigidity is maintained up to 1400°C.

For further information contact Micro-Image Technology (Engineering) Ltd, Greenhill Industrial Estate, Riddings, Derby DE55 4DA.



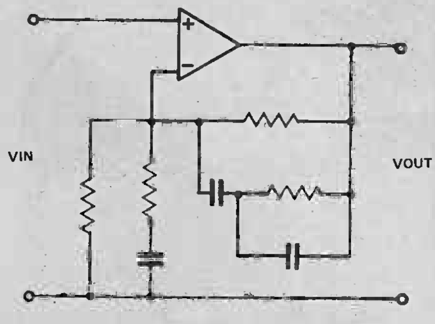


Fig. 4. An operational amplifier with equalization circuitry in its feedback loop.

HOW IT WORKS

The preamplifier section is formed around the LM 381 dual operational amplifier. One channel is used as a magnetic phono pre-amp with equalisation to RIAA characteristics. For the uninitiated amongst us, RIAA (Record Industry Association of America) equalisation is necessary in the playback stage of recordings made on record, to counteract the effect added to the signal in the recording stage. Figure 1 shows the kind of effect. It is a graph of recorded signal vs frequency.

On playback, it is now necessary to have an amplifying stage which has a diminishing response with higher frequency as in Fig. 2. The overall effect is to produce an output as shown in Fig. 3 where the signal amplitude does not vary (apart from the inaudible extremities) with frequency — a flat response. The underlying theory for such a complicated system is that of high frequency noise. When the recorded signal has its higher frequency sounds amplified its noise is not, whereas at the playback stage, all frequencies at the top end of the scale are diminished, noise included. The final output, therefore, has theoretically less noise i.e. the signal/noise ratio has been increased.

The usual way to reproduce the graph in Fig. 2 is to use an amplifier with frequency dependent components in its feedback loop so that it amplifies bass frequencies more than treble. (See Fig. 4).

The other half of the chip is used as a high gain amplifier with an essentially flat response. This input suits microphones or electric guitars.

The medium gain input from a ceramic cartridge or a tuner is fed straight through to the power amp, the line input being attenuated by R11, 12 before being taken to the power output stage.

Switch SW2 a, b provide necessary switching between the I/P and O/P of the preamplifier stage.

The power amplifier consists of a standard LM 380 IC power amp with the usual supply decoupling capacitor C14 and network R14, C16, to eliminate possible oscillations.

R15 drops the O/P power to a suitable level for headphones.

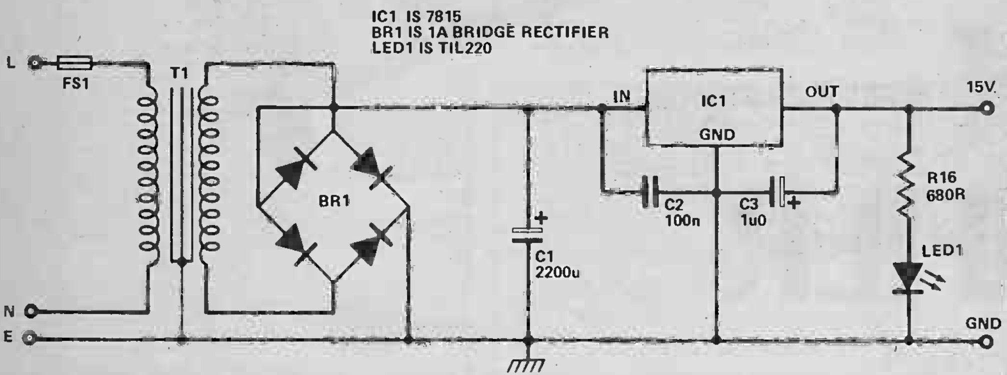
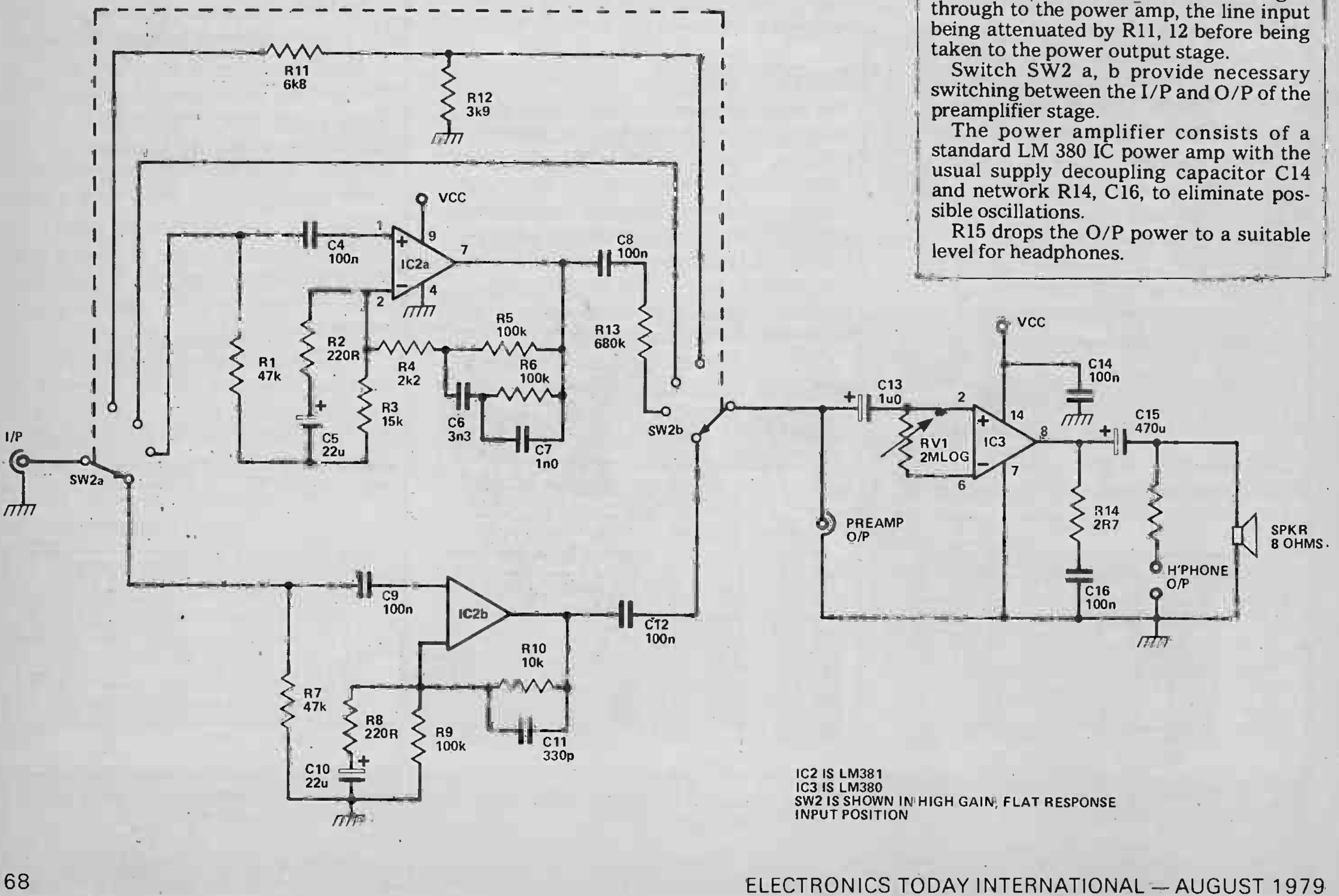
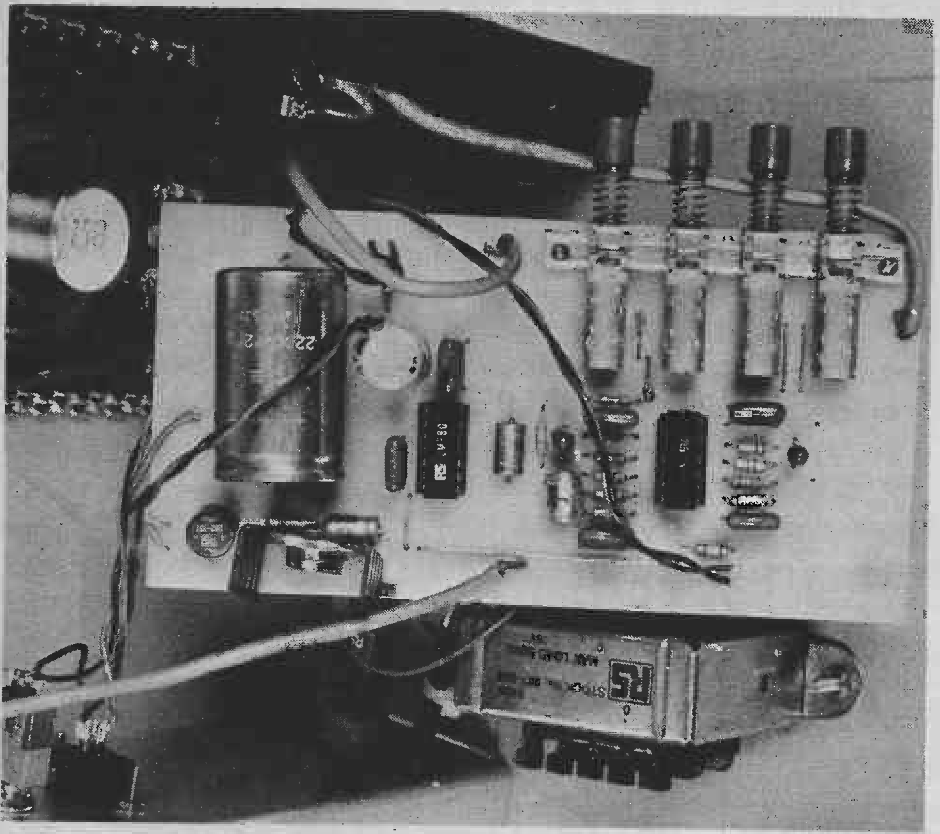


Fig. 5. Circuit diagram of the power supply.

Fig. 6. Main circuit diagram of the Bench Amplifier.





PARTS LIST

RESISTORS ALL ¼W 5%	
R1, 7	47k
R2, 8	220R
R3,	1.5k
R4	2k2
R5, 6, 9	100k
R10	10k
R11	6k8
R12	3k9
R13	680k
R14	2R7
R15	100R
R16	680R

POTENTIOMETERS	
RV1	2M Log

CAPACITORS	
C2, 4, 8, 9, 12, 14, 16	100n polyester
C3, 13	1u 16V electrolytic
C5, 10	22u 16V tantalum
C6	3n3 polyester
C7	1n polyester
C11	330p polystyrene
C15	470u 16V

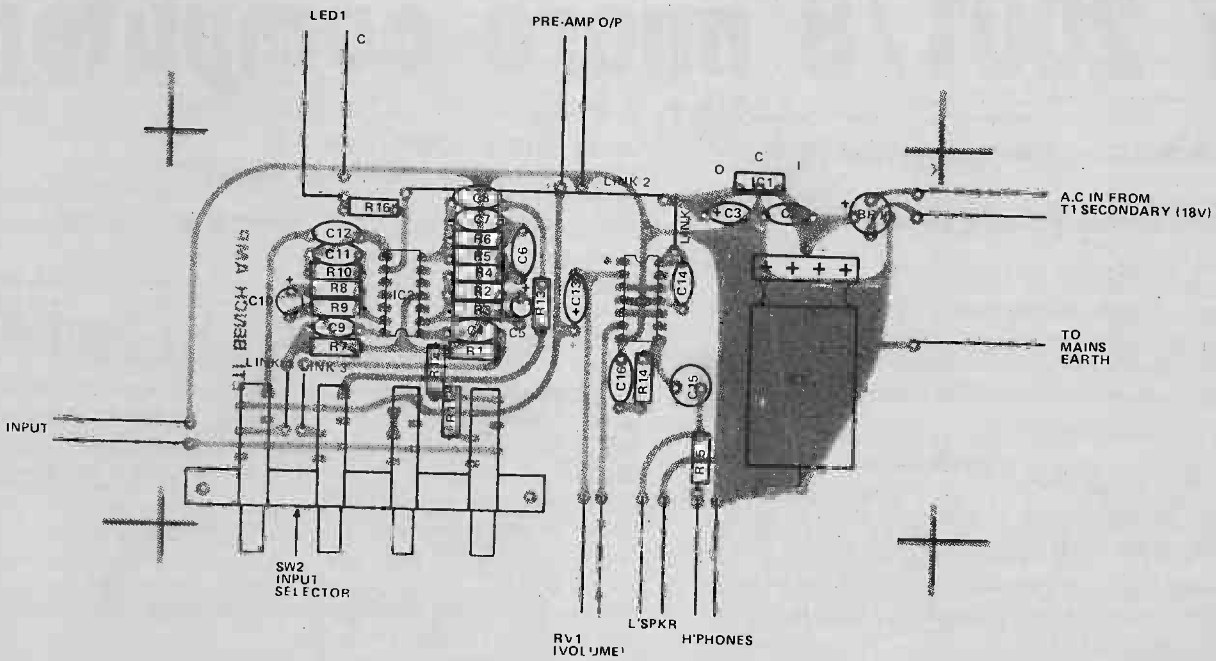
SEMICONDUCTORS	
IC1	7815
IC2	LM381
IC3	LM380
BR1	1A bridge rectifier
LED 1	TIL 220

MISCELLANEOUS	
T1	18V 1A mains transformer
FS1 and holder	250 mA
I/P and O/P sockets	
8 ohm speaker	
SW2	4 off 2 pole changeover push switches and mounting bracket case to suit

BUYLINES

There is nothing in the circuit which should present any difficulty in obtaining, except the correct size switches for SW2 a, b. We advise that you take your circuit board with you when you buy the switch, and then you will be certain of getting the right ones.

Fig. 7. Component overlay.



ODD ODES

A diode, the electronic one way street, is a versatile component. This tiny piece of crystal engineering can rectify AC signals, limit voltage, emit light or tune your radio. Ian Sinclair explains

IF YOU COMPARE a resistor to a crowded road and a capacitor to a multistory car park, then a diode is the nearest thing electronically to a one-way street. A diode has two terminals (the di-part of the name simply means two) and the current flows only when one of them, the anode, is more positive than the other, the cathode. This direction of current flow, anode to cathode, is called the forward direction and doesn't obey Ohm's Law. That means that we can't calculate how much current will flow simply by measuring the forward voltage and knowing a single figure of resistance of the diode, R. There are two features of the way in which a diode conducts which makes it quite different from a resistor. One is that current doesn't start to flow whenever the anode is positive to the cathode, only when the voltage is greater than about 0.5 V (for silicon diodes) or 0.15 V (for germanium diodes). The other feature is that, once the diode is conducting, its resistance drops as the current increase. The drop in resistance is so great that the voltage across a forward conducting diode is almost constant, around 0.55 V, even if the current changes considerably. For silicon diodes, a very useful rule of thumb is that the voltage changes by only 60 mV for a tenfold change of current. This means, for example, that if the voltage across a diode is 0.55 V when 1 mA is flowing, then increasing the diode current to 10 mA will raise the voltage by only 60 mV to 0.61 V. If the diode obeyed Ohm's Law, then a tenfold increase in current would cause a tenfold increase in voltage. In our example, a resistor which had a voltage of 0.55 V across it with 1 mA flowing (a 550R resistor) would have 5.5 V across it when 10 mA flowed. Diodes just don't behave that way.

Characteristics

If we can't use Ohm's Law then, what do we do? The answer is that we have to use characteristics, graphs which show how much current flows at each value of voltage. A full set of characteristics for a diode is quite an impressive sheaf of documents, but the two that are of most interest to us are the forward characteristic and the reverse characteristic. The forward characteristic shows how much current will flow at each value of forward voltage and at what voltage current can be expected to start flowing. The reverse characteristic shows how much reverse or leakage current will flow when the diode is reverse biased (cathode positive, anode negative) to various voltages. This reverse characteristic usually has a turnover (Fig. 3) and in the normal use of a diode we try to avoid applying a reverse voltage large enough to reach this turnover point. Why? Well, unless there's enough resistance in the circuit to make sure that the current which can flow in the reverse direction is very small, enough power will be dissipated to overheat the diode and destroy it. The power converted to heat (in milliwatts) is given by volts × milliamps. If the diode can just safely pass 20 mA in the forward direction, when the forward volt is, say, 0V6 then the power it can handle ▶

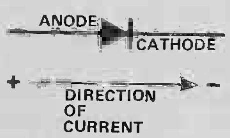


Fig. 1. Symbol for a diode. The arrowhead on the symbol shows the conventional direction of current (+ to —) through the diode.

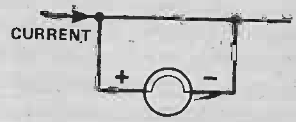


Fig. 2. Measuring the forward voltage for a conducting diode. This is always around 0V5 for a silicon diode. 0V2 for a germanium diode.

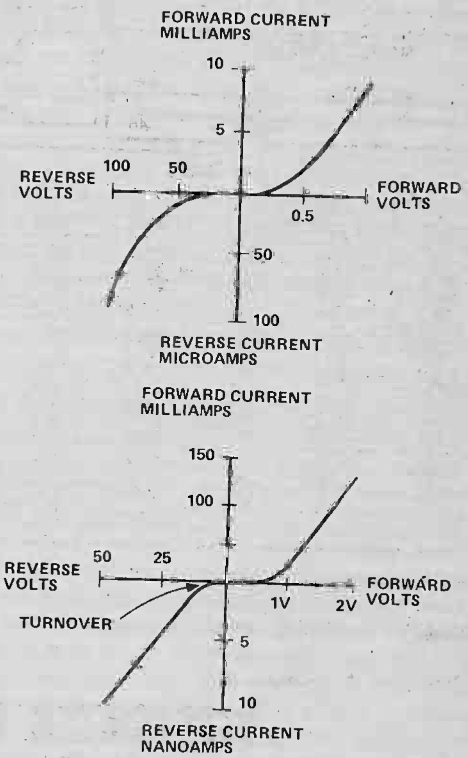


Fig. 3. Forward and reverse characteristics plotted on one graph. (a) Germanium diode, (b) Silicon diode. Notice that the scales for reverse voltage and current are *not* the same as the scales for forward voltage and current. This has to be done so as to get the two different characteristics on the same graph.

is 0.6×20=12 mW. In the reverse direction, if the turnover is at —20 V, then the power which has to be dissipated at 20 mA is 20×20=400 mW — and it won't like it!

Why Diodes Do It

That's what a diode does, but why does it do it? The answer to that question is not so easy, because it needs some understanding of how materials are formed from atoms and molecules. Let's try to get by with a simple explanation on the understanding that there's a lot more to it. First of all, the materials that are used for making diodes or transistors are solid crystals. Crystals of a given material always have the same angles between faces, and the reason is that they are formed by the atoms of the material always carrying the themselves in the same pattern. This regular arrangement causes regular shape of crystals, and also makes it possible for a crystal to conduct electricity. For any material to conduct electricity, it must be well supplied with particles smaller than atoms which have an electric charge, positive or negative, and these particles must be able to move freely through the material.

The regular arrangement for atoms in crystals provides plenty of paths between the atoms for the easy movement of these charged particles, so that crystals only need a supply of particles to become conductors. The materials we call metals are crystals which can release about one charged particle from each atom, so they conduct electricity pretty well, though not equally well. Insulators, on the other hand, simply don't have many charged particles lying around and many of them aren't crystals either, making it doubly difficult for them to conduct. In between these two extremes are the curious materials called semiconductors, which form crystals but are not well supplied with the charged particles that are needed to make them into conductors.

These are two ways in which we can supply these particles. One way is to heatthe materials. This causes a few atoms to shed one of their electrons (negatively charged particles), leaving behind a gap in the arrangement of particles in the crystal which we call a hole. The hole behaves like a positively charged particle and can slip from one atom to another. Raising the temperature of a semiconductor, therefore, makes it conduct, but the electrons will slip back into place again when the material cools so the change is not permanent.

Dope Charge

A permanent change can be caused by doping. Doping is adding a small amount of impurity to a semiconductor material. We don't use any old impurity, but materials whose atoms will fit nicely into the arrangement of atoms in the crystal. Some of these materials which fit perfectly into place have one electron more than is needed in the crystal. That electron is released from each impure atom, allowing the crystal to conduct electricity by movement of these electrons. A crystal doped in this way is called N-type. We can also dope with a material which has fewer electrons than its neighbours in the crystal, creating a hole and making the crystal conduct by hole movement. A crystal doped in this way is called P-type. When a semiconductor is made into a conductor by doping, the change is permanent because there are always electrons or holes which don't fit and can't just snap together again (recombine).

This business of doping is quite something, because

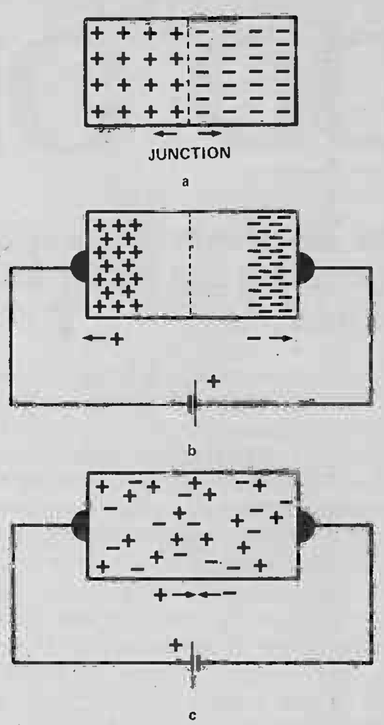


Fig. 4. When a junction is formed (a) the electrons and holes separate slightly at the junction. Reverse bias (b) makes the separation much greater so that the material can't conduct — there aren't any carriers. Forward bias (c) allows electrons and holes to cross the junction, making the material a conductor.

it allows us to do a bit of engineering on materials, creating crystals which can be fair conductors or good conductors, according to how much doping we use; or which are N-type or P-type according to what type of doping we use.

Attractive Likes

Now we've set the scene for learning why a diode works, and there's only one main point left. Charged particles, whatever their size, obey the laws of electrostatics. Of these laws, the important one for understanding the action of a diode is that two particles with the same sign of charge (two positives or two negatives) will repel each other, but particles with opposite signs (a positive and a negative) will attract each other. It's a simple enough law, but combined with what we now know about doping it's enough to explain what goes on inside a diode.

A diode is a single crystal with P-type doping at one end, or on one face, and N-type doping at the other end or face. Obviously, there's got to be a surface in the middle or thereabouts where these two types of doped material meet, and this surface is called the junction. The important thing about a junction is that it's somewhere inside a crystal with no break in the arrangement of the atoms. You can't make a junction by pressing a lump of P-type material up against a lump of N-type material — there's no chance that the rows of atoms would ever line up the way they do inside a crystal.

This arrangement is now a diode — a crystal with P-type material on one side of the junction and N-type material on the other. Remember what these terms mean — N-type material conducts because it has electrons free to move through the crystal. Because the crystal is in one piece, there's no reason why electrons or

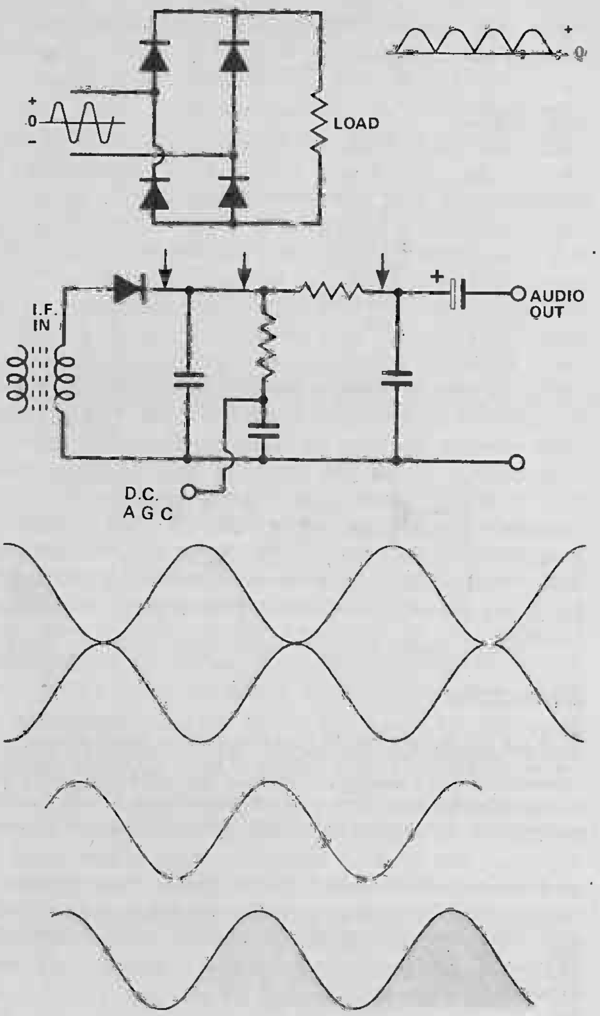


Fig. 5. Using diodes (a) for rectification (b) for radio signal detection. Both applications depend on the one-way flow of current through the diode.

holes should not move from one end of the crystal to the other, so the crystal can be made part of an electrical circuit.

Up The Junction

When the junction is formed, though, the free electrons of the N-type material at one side will be placed very close to the free holes in the P-type material on the other side and inevitably there's a bit of shuffling which ends up with some combination of electrons and holes. This leaves the junction without carriers and also causes the carriers to be pulled back a bit from the junction. The carriers are pulled back because the electrons removed from the N-type material leave a positive charge behind — originally there must be a positive charge for every electron — and the holes that are removed from the P-type material leave electrons (negatively charged) behind.

The affect of the remaining charges is to attract electrons and holes (carriers) away from the junction (Fig. 4a). The imbalance of charge also shows up as a voltage and this is what causes the 0V5 of so we need before we can make a silicon junction conduct in the forward direction. The bit of crystal around the junction that has no free carriers is called the depletion layer and we'll look at it again when we discuss varicap diodes.

Minority Groups

The action of the diode in a circuit now becomes a bit easier to understand. When the diode is reverse biased, the polarity of the power supply (Fig. 4b) acts to attract carriers away from the junction, making the depletion layer wider. The electrons of the N-type material and holes of the P-type material simply don't cross the junction because they are pulled in the opposite direction. The only carriers that can cross are what are called minority carriers, holes which appear in the N-type material and electrons which appear in the P-type material. These minority carriers come from splitting bits off atoms in the crystal, using energy from the action of temperature or light. The higher the temperature of the diode the faster these minority carriers are formed. If we make the reverse voltage across the depletion layer high enough, the effect will be to accelerate these minority carriers to high speeds, so that they bang into atoms, knock more carriers off, and so cause the whole junction to become conducting. When that happens, the junction has 'broken down', the diode conducts and it can be damaged.

When the bias is in the forward direction (Fig. 4c) the carriers are attracted towards and across the junction. First of all, though, the voltage caused by the depletion process has to be overcome. Once the forward voltage has reached this amount, current starts to flow. Only a few of all the possible carriers cross the junction when the voltage is low, but raising the voltage even by a very small amount is enough to cause a great increase in the number of carriers crossing over the junction, so that the resistance of the junction becomes much less as the voltage and current are increased.

Shedding Light

This picture of what is happening inside a diode explains pretty well the action of signal or rectifier diodes which are used in the circuits such as those shown in Fig. 5. What about some of the other diodes that we use, like photodiodes, varicaps, LED's, and Zeners? Let's start with photodiodes. The main difference between a photodiode and an ordinary signal diode is that we deliberately put a photodiode into a transparent case so that light can reach the junction. Photodiodes are used in circuits where they are reverse-biased, with a fairly wide depletion layer. Now in darkness, the amount of current that can flow is only that caused by minority carriers — the few holes and electrons that are split off by the heat of the surroundings. Light, however, is a wave which, like all waves, carries energy. The energy of light falling on the depleted layer around the junction can cause lots more electrons and holes to be split off.

They're still minority carriers, but there's a lot more of them now, and so a layer current flows despite the ▶

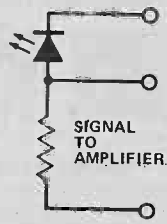


Fig. 6. Using a photo-diode as a light detector. The diode is reverse-biased, but will conduct slightly when light separates electrons from holes.

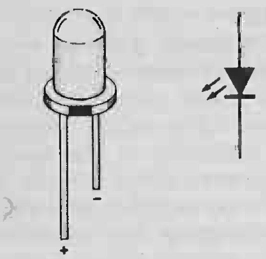


Fig. 7. The LED. When forward current flows, a glow of light is visible. Beware of reverse voltages — anything more than about 3V reverse will destroy the junction.

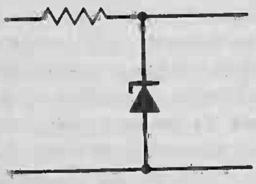


Fig. 8. The Zener diode used as a simple stabiliser. A load connected across the diode can draw current by reducing the current through the diode. Providing the diode current doesn't drop below about 2 mA, the voltage across the diode will remain constant.

reverse bias. Typically, the reverse current can change from around 0.1 uA in darkness to 100 uA in the light of a desk lamp. If the diode is forward biased, the change caused by light is hardly noticeable.

Togetherness

The LED has an action which is just the reverse of that of the photodiode. Instead of light falling on the junction and causing electrons and holes to split off, as happens in the photodiode, the LED depends on electrons and holes coming together again and giving out light. You can imagine these two processes more clearly when you think of separating two strong magnets. The force which holds them together means that you have difficulty separating them — you have to do some work to separate them. You can get that work back again when the magnets attract each other back; you could even make the magnetic force do something useful, like picking up a weight.

LED Light

LED's are made from semiconductors (such as Gallium phosphide) which are not heavily doped and don't conduct very well. Something like 2 V is needed across the junction of a typical LED to get current flowing and the movement of holes and electrons causes collisions which separate off more holes and electrons. On their way across the junction in opposite directions, holes and electrons collide — and release the energy it took to split them apart in the first place. The amount of energy is the same as that of a light wave and since the material is transparent a light wave is what we get. The colour of the light wave is decided by how much energy is released. Low energy gives red light, or the invisible infra-red. Higher energy gives yellow, green, blue light (in order of increasing energy), until we reach the invisible ultra-voilet radiation. The amount of energy is fixed by the material that is used as a semiconductor, though, and we can't alter it noticably by changing the voltage or current.

Avalanche

Zener diodes make use of the reverse breakdown which has already been described. Oddly enough, two effects cause this reverse breakdown, Zener effect and avalanche effect. The avalanche effect is the one we've described, in which minority carriers are accelerated so much by the reverse bias that they collide with atoms and split electrons and holes apart. This creates more carriers, which are in turn accelerated, splitting off yet more until the whole juntion becomes conducting. The avalanche effect occurs mainly in lightly doped material, at reverse voltages of 6 V or more. The other effect, Zener effect (named after Clarence Zener who discovered it) takes place in heavily doped materials, mainly when the reverse voltage is less than 6 V. Because of the large number of electrons and holes which are present, the depletion layer is very thin and it's comparatively easy for a carrier to shoot straight across. Diodes which made use of either or both of these effects are called

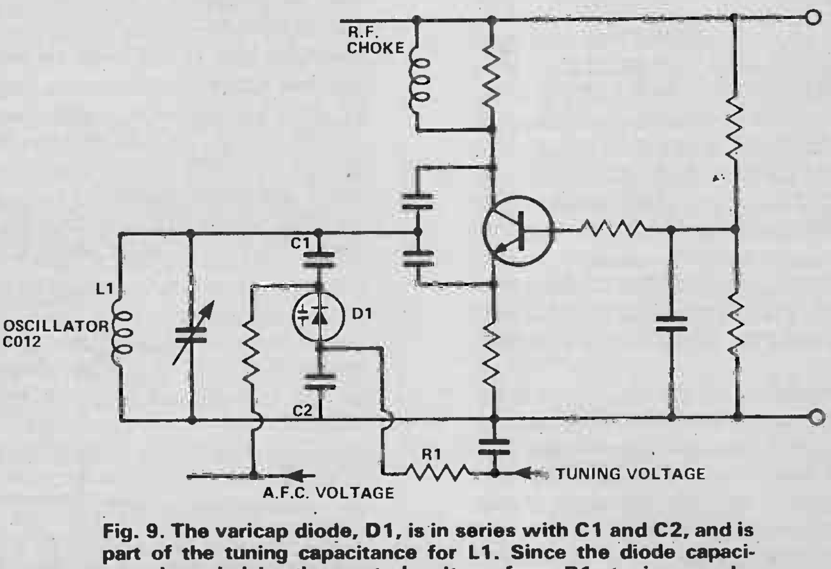


Fig. 9. The varicap diode, D1, is in series with C1 and C2, and is part of the tuning capacitance for L1. Since the diode capacitance is varied by the control voltage from R1, tuning can be carried out by altering this DC voltage.

Zener diodes, and we use them to stabilise voltage. The breakdown, particularly when it is caused by avalanche effect, takes place at a precise value of voltage, so that a Zener diode wired in the circuit of Fig. 8 will have an almost constant voltage across it, even if the current through it varies considerably.

Incidentally, avalanche effect has a positive temperature coefficient, which means that the voltage across the junction increases as the temperature is increased. Zener effect, by contrast, has a negative temperature coefficient, meaning that the voltage across the junction decreases as the temperature is increased. At voltages around 5V6, both effects take place, which means that the voltage is hardly affected by temperature. For this reason, 5V6 zener diodes are often specified rather than any other voltage.

Varicaps

Finally, among the diodes that are particularly useful, varicap diodes make use of the width of the depletion layer. The depletion layer, remember, is the part of the crystal around the junction which has had its carriers removed. The greater the reverse bias applied to the diode, the greater the attraction of carriers away from the junction and so the greater the width of the depletion layer.

Now a depletion layer is a chunk of insulating material which is sandwiched between two bits of conductor — the P and N materials. This is just the arrangement we know as a capacitor — an insulator between two conductors — so that the reverse-biased diode has a capacitance. It's a variable capacitance, though, because the width of the insulator — the depletion layer — can be varied by changing the bias voltage. Like any other variable capacitor, the capacitance value is greatest when the insulating layer is very thin, and the capacitance value is least when the insulating layer is thick. Now the diode has a thick depletion layer when the reverse voltage is large, so that its capacitance is low; but when the reverse bias is small, the depletion layer is thin and the capacitance is large.

Varicap diodes solve an awkward problem — how to tune radio circuits without having any moving parts. A varicap diode in the oscillator circuit (Fig. 9) arranged in series with a fixed capacitor so that it is only part of the tuning capacitance, has no DC connection to the oscillating circuit and can have its capacitance varied by a voltage supplied from a potentiometer. The potentiometer doesn't have to be anywhere near the tuned circuits, so long as the connecting wires are well decoupled and the tuned circuits can be sealed inside a can, undisturbed by any movements.

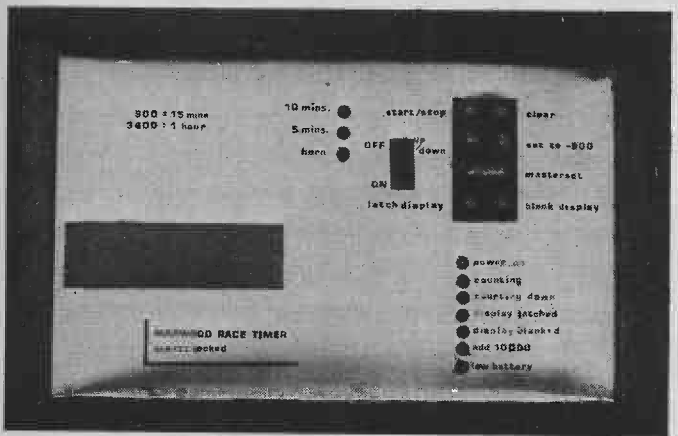
That's dealt with the most common diodes, though there are dozens of types we haven't mentioned, ranging from the diodes which generate microwave signals to the breakdown diodes we use in thyristor firing circuits. Once you've grasped the basic principles, though, there aren't many surprises left, and you are better able to understand how to make efficient use of these indispensible components.

ETI

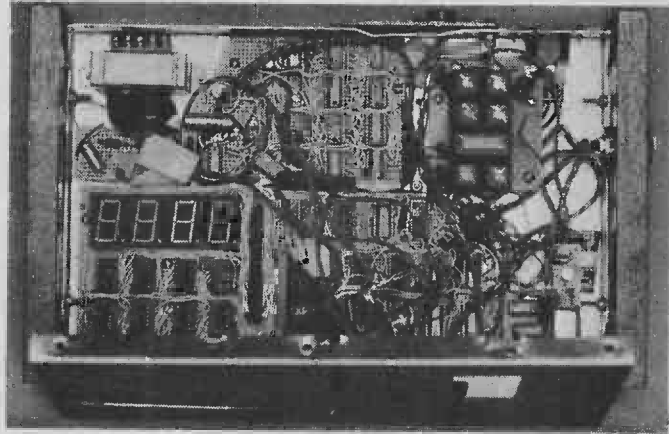
PLEASE SEE V.A.T. ADVERTISEMENT ON PAGE 15 BEFORE ORDERING GOODS FROM ADVERTISERS!

readers designs

SAILING CLUB RACING CLOCK Submitted by Mr K. P. Wood of Wakefield.



The business end of the completed race clock. The state of all clock facilities is repeated on the front panel.



Top view of the completed unit. The crystal oscillator can be seen, bottom right, and the switch bank, top right.

ANY YACHT RACE, whether for the America's Cup, or for the most minor sailing club's weekend dinghy racing, should be started with a definite sequence of signals. At ten minutes before the start, a flag is raised and a sound signal is given. At five minutes, another flap is raised and a further sound signal given, and at the start both flags are lowered and a third sound signal given.

Accurate Handicap

As a few seconds error at the start can make a very substantial difference to a boat's finishing position, far out of proportion to the actual timing error, it is essential that an accurate clock be used to time the signals. In addition, if the racing is on a handicap basis, each boat's finishing time must be taken accurately, for processing to establish a corrected time which sets each boat's final position in the results.

Until recently, the time was taken in minutes and seconds on an ordinary clock or watch, and the corrected time obtained by looking up tables with reference to each class of boat's handicap number.

With the advent of the inexpensive electronic calculator, the tables were dispensed with, and the boat's elapsed time converted to seconds, divided by it's handicap number and multiplied by 100 to obtain the corrected time.

One Pair of Hands

A race officer, working alone at the finish of the race, cannot watch both the finishing line and the clock to read the time whilst also giving a sound signal to let the boat's crew know that they have finished. I designed this clock, or more properly, seconds counter to simplify matters. Because it is crystal controlled, it is at least as accurate as any stopwatch which a helmsman may be using, and it counts in seconds to remove one operation from the corrected time calculations. The time can be latched by the race officer without watching the clock, and this can then be read later, up to the next boat finishing.

A preset button sets the clock to count down from 900 seconds, and the race officer gives his signals as the count passes through 600, 300 and zero. When the countdown reaches zero, the clock changes over and starts to count up. There is also a clear switch to set the count to zero, and a display blanking switch to conserve battery charge if this is critical.

Repeated Facilities

The large four digit display gives a straightforward count of over two hours, which is usually enough for a race, and an LED indicator on the front of the clock shows if this has been exceeded. The state of all the clock facilities is repeated on the front of the clock. The battery is maintained with a mains charger, and the clock can be used on either battery or mains. The count is unaffected by the changeover.

The timer was used in the condition described for one full season with complete success, and then the automatic start signal facility was added. Logic was added to the clock on an additional board which carries out the signalling for the race officer at the correct intervals. The CMOS logic operates relays through transistor drivers and a four pin socket on the body of the clock. The relays control two lights and a horn which are visible and audible from anywhere on the sailing water and operate in the same sequence as the more traditional flags and guns. The state of the start signals is repeated on the clock face with LEDs. At this time the low battery indicator was added.

Because the clock was designed and built in two separate stages, there is probably some duplication in the logic, and if it were to be made up complete from a standing start the logic would probably be simpler, particularly in the zero sensing area. As I find NAND and NOR gates easier to get, there are a lot of inverters, but as these are all made up from spare gates, and there have to be a lot of spares because of the variety of gates, I do not think that the use of AND and OR gates would reduce the chip count significantly. ▶

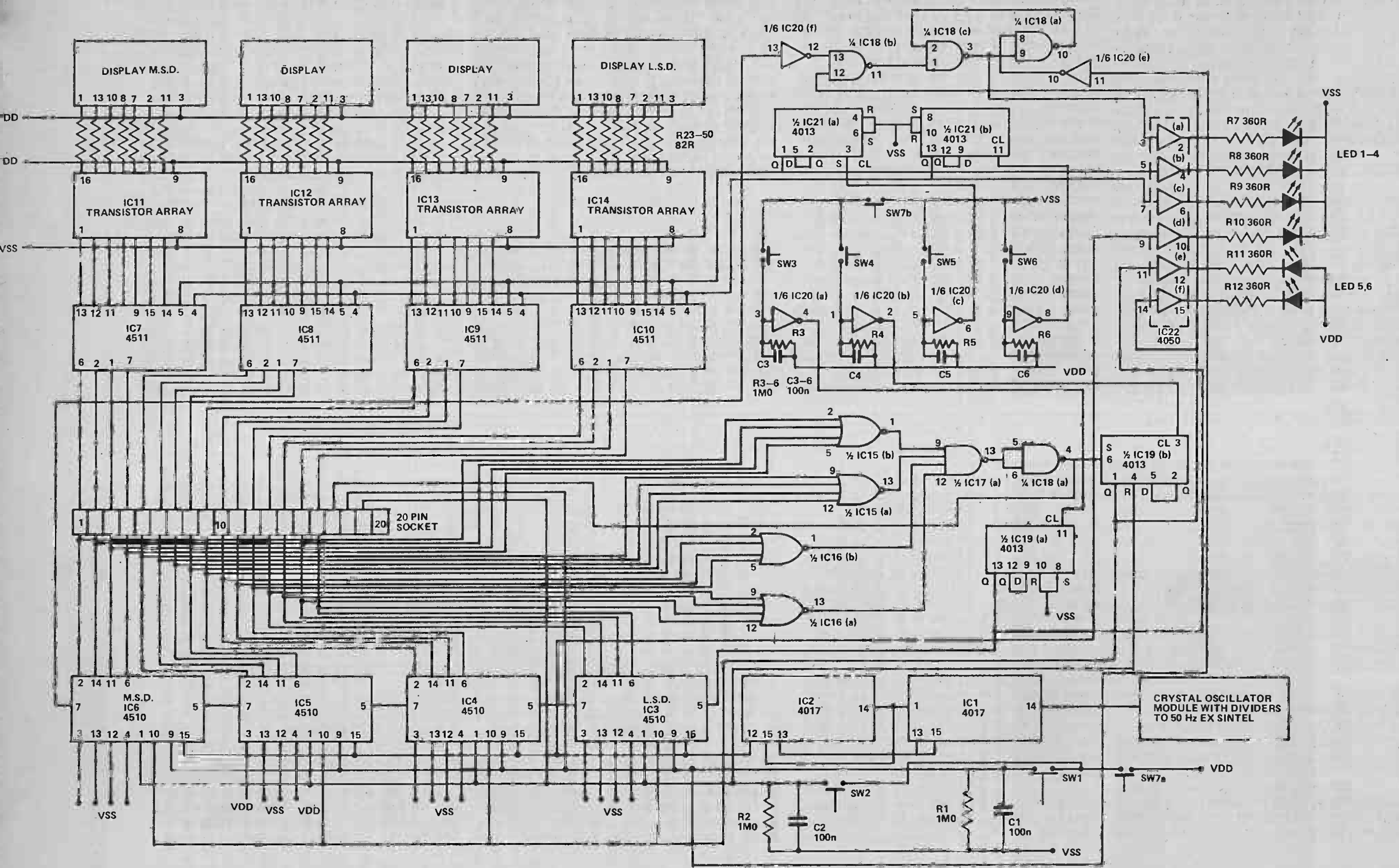


Fig 1. Circuit diagram of the main board. Part one of the How It Works refers to this.

HOW IT WORKS

PART 1 — the output from a 50 Hz crystal controlled oscillator-divider chain, made up from a Sintel kit, is further divided in IC1 and 2 to 1 Hz and the resulting pulse train is divided by IC3, 4, 5 and 6 to provide a four digit BCD count which is decoded to seven segment drive in IC7, 8, 9 and 10. The 4511 digit decoder-drivers would have adequate output to drive the digits direct, but the 1" displays are connected in common anode format so the transistor arrays invert and buffer the drivers to suit, whilst R23 to 50 limit the segment drive currents.

The 4510 counters are cleared to a zero count by a high level on pin 9 from SW1, and are preset to the BCD count set on pins 4, 12, 13 and 3 by a high level on pin 1 from SW2.

IC3, 4, 5 and 6 are wired for parallel clocking, and count synchronously when pin 5 of IC3 is held low by the Q output from the toggling flip-flop IC19a which is toggled by a high pin 11 from SW3 via the Schmitt trigger inverter IC20a. IC19a is wired to toggle on each pulse on the clock input pin, pin 11, by wiring the 'D' input and the Q output together. The R and S inputs of this IC are not used and are tied low to Vss.

The BCD preset inputs to IC3, 4, 5 and 6 are set by hard wiring the appropriate pins to either Vss or Vdd as required. With the wiring shown the counters are preset to 900. Operation of the preset-enable SW2 also pulls the rest pin of IC19b high, resetting the Q output low and setting the 4510 counters to count down. Thus the counters always count down from the preset count, IC19a can also be toggled by SW4 at any time independent of the state of the count.

The count shown on the displays can be latched at any time with SW5 which toggles IC21a, further operation of the same switch unlatching the display and showing the updated count. Similarly, SW6 toggles IC21b blanking the display and turning them back on as required.

SW3, 4, 5 and 6 all operate through Schmitt trigger inverters with C3, 4, 5 and 6 cutting out contact bounce and the switch outputs are tied high or low as required by R3, 6. SW1, 2 are not subject to contact bounce so are wired direct, with R1, 2 pull-up resistors, and C1, 2 slow down capacitors.

Because the count is sensitive to operation of SW1, 2, 3 and 4 some protection from inadvertent operation during a count is required and this is provided by SW7a, b. These are two separate switches mounted under one large button so that both close when the button is pressed, enabling the switches SW1, 2, 3 and 4. In this way a deliberate action is required to operate any of these switches. SW5 and 6 are not count sensitive and do not require this protection.

The BCD count is tapped off the outputs of the 4510 counters to four, four input NOR gates IC15a, b and IC16a, b, so that when the four digit count is at 0000, the outputs from these NOR gates go high to the inputs of a four input NAND gate IC17a. The resulting low on the output of this gate is inverted in a spare NAND gate IC18a, and this output sets the Q output of IC19b high so that the counters change over and commence to count upwards.

LEDs 2-6 are driven from the outputs of the respective flip-flops, buffered in the non-inverting buffers in IC22, with current limiting resistors R8-12, to indicate the state of the various functions on the front of the clock.

The carry out from IC6, pin 7, drops low when the total count reaches 9999. This low is inverted to a high by the spare Schmitt trigger, IC20f and gated by the NAND gate IC18b, which is held open by a high output on pin 1 of IC19b so that IC18b is only open when the count is upwards. The output from IC18b toggles the RS flip-flop made up by cross-coupling the two NAND gates IC18c,d. The output of this RS flip-flop drives the LED marked 'add 10000,' giving an effective 4½ digit capacity and a total count without ambiguity of 20000. The RS flip-flop is cleared in the same operation as clearing the four counter ICs from SW1 via the spare Schmitt trigger inverter IC20e.

PART 2 — a 20-pin plug and socket connects the BCD data to a second board as shown in the drawing. The BCD data for the 10^3, 10 and 1 digits is carried direct to NOR gates IC23 and 24a and b, so that at a zero count on these digits the NOR outputs all go high. The 10^2 digit BCD count goes to two separate sets of EX-OR gates IC25 and 26. Each bit of data goes to one input of an EX-OR gate and the other input of each gate is tied high or low to V_{ss} or V_{dd} in accordance with the digit required. The EX-OR gates compare each bit of the 10^2 digit from the counter with the levels set on the other inputs of the gates and when these are equal the output of the gate goes low. The gate outputs in IC25 all go low at a count of 600, and those of IC26 at a count of 300, with the wiring to the inputs as shown.

These outputs are NOR'd in IC24b and IC27a respectively, and the output from IC24b is NAND'd with the outputs from IC23 and 24a in IC28a. Thus when the count reaches 600 the output from IC28a goes low, is inverted to a high in IC29b to clock flip-flop IC30b. Similarly, when the count reaches 300, IC28b goes low and clocks flip-flop IC 30a through inverter IC29a.

The Q output from IC30a is NAND'd in IC31a, inverted in IC33a and inverted and buffered in the transistor array IC34 to drive the coil for RLY 2. Similarly, the Q output from IC30b is processed in IC 31b, 28c to drive the coil of RLY 3.

The gating inputs of IC31a and b are held high during the down count by the Q output from the flip-flop IC32a which is set high by a pulse on pin 19 of the 20-pin plug from the preset to 900 switch SW2 and is reset low by a pulse from the zero sensing logic on the main board from pin 17 of the 20-pin plug. The outputs from IC29a, b, as well as driving the relay coils, are also NOR'd with the zero count signal from the main board in IC33b and used to trigger the 555 timer, IC34 which is wired as a monostable with a period of approximately two seconds. The output from the 555 is buffered and inverted in IC34 to drive RLY 1 for the horn drive. Operation of the 'clear' switch puts pin 4 of the 555 momentarily high and ensures that the timer is always enabled after the initial power-on of the clock. The input to the 555 from IC33b is inverted in IC31c and NAND'd with the Q output of IC32a so that the horn is disabled after the zero count and no further signals may take place. When the counter was first tested in practice, it was found that, at the zero count, the flip-flop IC32a was resetting and closing the gate before the 555 was triggered, so that the horn did not sound at the zero count. C14 was added to the reset input of IC32a to delay the reset pulse until the 555 had triggered.

It was also found that operation of the latching and blanking switches at any time during the count-down sequence was toggling the flip-flops in IC30 and 32, turning the lights on and off at indeterminate moments, presumably due to spikes on the supply lines and C9, 10 were wired across the supply to cure this effect.

A high on the clear line, or a high at the zero count, both from the main board via pins 17 and 18 of the 20-pin plug, or NOR'd in IC27b and inverted in IC29c to reset the Q outputs of IC30a,b low disabling the relay drives. LEDs 7-9 are driven through current limiting resistors R13-15 from the relay drivers to repeat the state of the signals on the face of the clock. SW8 with D1 and R18 was added as an afterthought to allow the horn to be sounded at any time whatever the state of the count.

The 6-volt battery is maintained at full charge by the built-in mains charger. The charging voltage is set to 6V9 by adjustment of RV2.

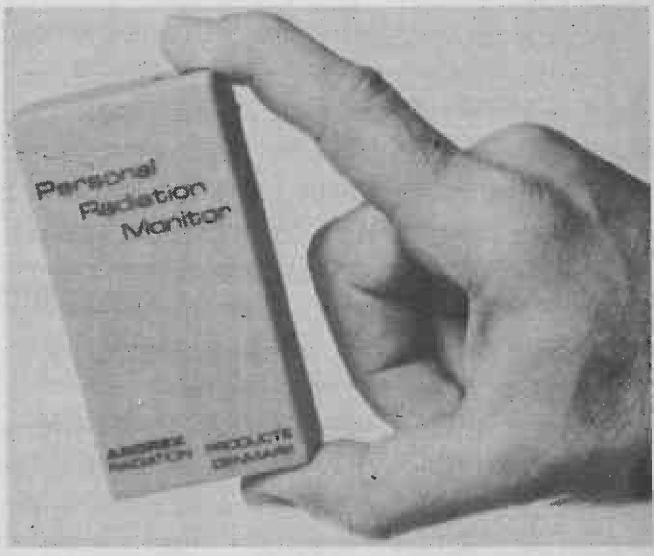
The programmable unijunction transistor BRY39 (PUT) is used as a relaxation oscillator. As the battery voltage falls the voltage on the PUT gate falls whilst the voltage on the PUT anode is held relatively constant by ZD1, and the PUT starts to oscillate when the gate voltage falls some oV6 below the anode voltage. As the battery voltage falls further, the PUT triggers at lower values of anode voltage and the rate of oscillation increases. With the values shown, RV3 is set so that the first odd flash takes place at about 5V2 on the battery, and at 4V8 the LED is flashing at 2/3 Hz. At this point there is about ten minutes of useful life left in the battery before the voltage goes to 4V5 and the crystal oscillator loses control. As the whole clock uses CMOS logic, it works perfectly satisfactorily from fully charged to 4V8 and no regulation was therefore thought necessary. The cathode gate of the PUT is not used and merely left open-circuit.

The switches are mounted on the board at a suitable height so that the buttons poke through a rectangular hole in the front panel.

The power supply regulator is mounted on a home made heat sink on the back of the case and runs very cool. The relays to drive the signals are mounted in a separate box with three 13 amp, three pin sockets on the front. The signal from the clock is taken to the relay coils from the four pin socket on the side of the case. The relay contacts are rated at 250 volts, 5A,AC and the signal lights are powered from the mains with a separate mains lead to the relay box.

The horn is an ordinary air-operated car horn, the compressor being driven from a 240/12 volt transformer and a 25 A diode bridge. Any bright lights may be used for the signals.

.... news digest......



HAM CRACKLING

If you're into amateur radio and constantly being blamed for every snap, crackle and pop of interference on neighbours' television sets, then the Radio Society of Great Britain have just done you a favour. They have published a 'Television Interference Manual,' so that you can tackle the problem without blood pressure (yours or your neighbours) rising.

Spurious-radiation and strong-signal interference are covered, as are problems in transmitter design which may cause interference. If you've spent a small fortune on your Hi-Fi and CW or SSB interference is making your life a misery, the chapter on audio breakthrough might interest your local radio ham. A useful data and reference section covers filter design.

The RSGB's Television Interference Manual by B. Priestley (80 pages) costs £1.35.

RC CHANGES

If you're thinking of building the radio control transmitter featured in our May issue, these component value changes will interest you.

R15,17 150k
C2,5,14 47n

FALL-OUT BLEEPER

After the next world war, the High Street will probably be slightly more radioactive than it is now. Pocket radiation meters might be the 'in' fashion.

With that in mind, no doubt, Andrex Radiation Products AS of Copenhagen have introduced a new version of their successful personal radiation monitor.

The new model is lighter and smaller than its predecessors, without any loss in performance.

The monitor remains on continuously, producing an intermittent reference bleep to confirm operation and battery condition. The more radiation there is about, the faster the little box bleeps. Sensitivity is from 1mR/h. Power is from a readily available 1.5 V battery lasting 3-6 months.

Weighing in at 80g, one of the lightest of these units on the market, it can be slipped into a pocket or clipped on to a belt. The monitor is aimed at personnel working in and around X-ray or isotope equipment or with on-site radiographic inspection gear.

The Andrex monitor will continue working even after exposure to extremely high and dangerous levels of radiation.

You can find out more about the Andrex pocket radiation monitor from its British suppliers, Andrex NDT Products (UK) Ltd, 12 Trafalgar Way, Bar Hill, Cambridge CB3 8SQ.

readers designs

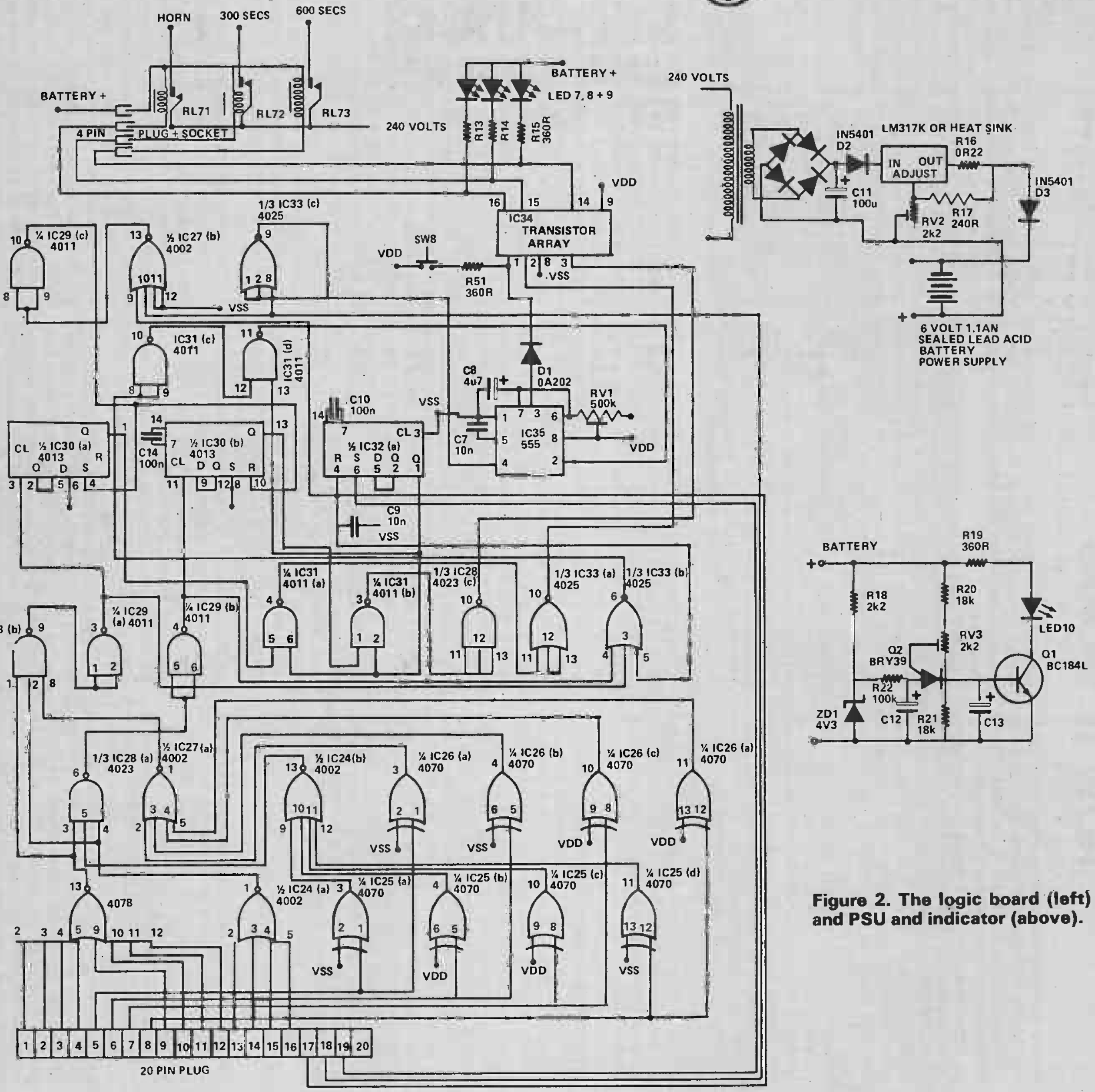


Figure 2. The logic board (left) and PSU and indicator (above).

PARTS LIST

RESISTORS ⅛W 10%

R1-6	1M
R7-15, 19, 51	369R
R16	0R22 2.5W W/W
R17	240R
R18	2k2
R20, 21	18k
R22	100k
R23-50	82R

POTENTIONMETERS

RV1	500k miniature cermet trimmer
RV2, 3	2k2 miniature cermet trimmer

CAPACITORS

C1-6, 10, 12-14	100n polyester
C7, 9	10n polyester
C8	4u7 electrolytic
C11	100u electrolytic

SEMICONDUCTOR

IC1, 2	4017
IC3-6	4510
IC7-10	4511
IC11-14, 34	RS307-109 transistor array
IC 15, 16, 24, 27	4002
IC17	4012
IC18, 29, 31	4011
IC19, 21, 30, 32	4013
IC20	40106
IC22	4050
IC23	4078
IC25, 26	4070
IC28	4023
IC35	555
Q1	BC184L
Q2	BRY39
D1	OA202
D2, 3	1N5401
ZD1	BZY884V3
LED 1-10	0.2in. red
Diode Bridge	200V 2A
Regulator	LM317K
Displays	1in. common amode red

MISCELLANEOUS

SW1-8	SPST momentary n.o.

12V, 20VA transformer, 3 off 6V 410ohm coil, 250V 5A contact relays, 6V 1.1Ah sealed lead acid battery, stripboard, plugs, sockets, etc, case to suit.

AUDIO DISPLAY

Kinaethetic kicks with scintillating new display which puts your music on show to the world. A superb ETI Project Team design.

SO MANY electronic projects rise phoenix-like from the smoke of the soldering iron and when shown to family and friends are greeted with looks of blank amazement and the inevitable question, 'I'm sure it's very clever, but what does it do?'

It is easy to understand how many projects can be confusing and uninteresting to a non-technical person. This attractive project is simple in operation and yet sophisticated in the effect it produces and will be enjoyed by anyone with an eye and an ear to spare.

Small Is Beautiful

The SCINTALITE LED audio display translates the dynamic flow of sound into a visual analogue. The circuit follows conventional lines with the input signal being amplified and filtered to extract the upper and lower frequencies. The outputs from the filters are then rectified and the peak and mean DC levels detected and made available at the 'mood' switch. Operation of this control allows the relatively fast peaks of the music or the more slowly changing levels of the overall sound to control the display.

A novel feature of the display is the ability to produce a moving dot or bar of light. The upper frequencies are displayed using both techniques and the circuit switches between them as the input level rises and falls. The lower bass range is always displayed in bar form.

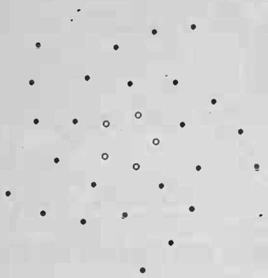
As can be seen in our photos the display is based on a pentagon and is about six inches in diameter. The upper frequencies drive five spiral arms of ten LEDs each and the bass frequencies are displayed on ten shorter straight radiating arms. There is also a circle of ten LEDs whose brilliance is controlled by the overall input signal.

Tripping The Light Fantastic

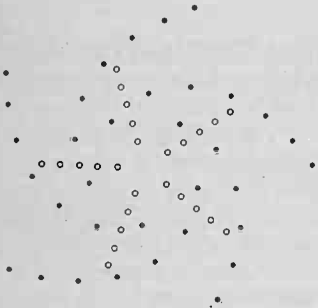
Scintalite can accept input signals from a wide variety of sources. Its sensitivity is variable from about five millivolts to five volts. Although designed primarily as an audio display, any input voltage within specified limits may be used to control the unit by replacing the input capacitor with a wire link. In this way, Scintilate could for example form the display device for a bio-feedback system. In such an application it should be noted that, except for very quickly changing signals, only the bass section will give a display and, as half-wave rectifiers are used, a negative going input signal is required owing to signal inversion in the first amplifier.

Construction and Use

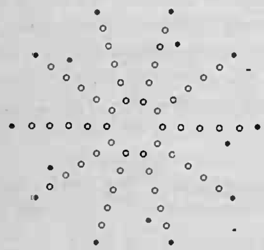
The unit is assembled on one PCB with a separate power supply. The PCB holds all the signal conditioning ▶



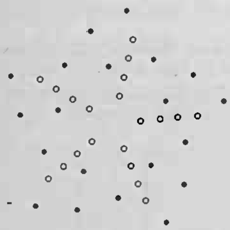
1.



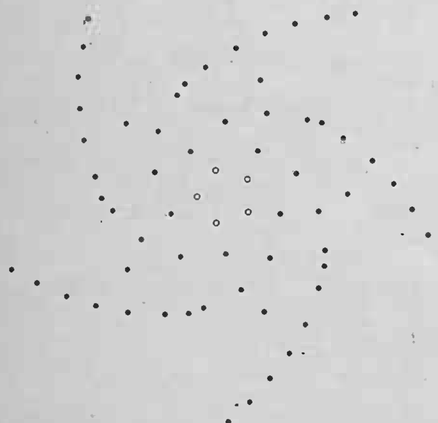
2.



3.



4.



5.

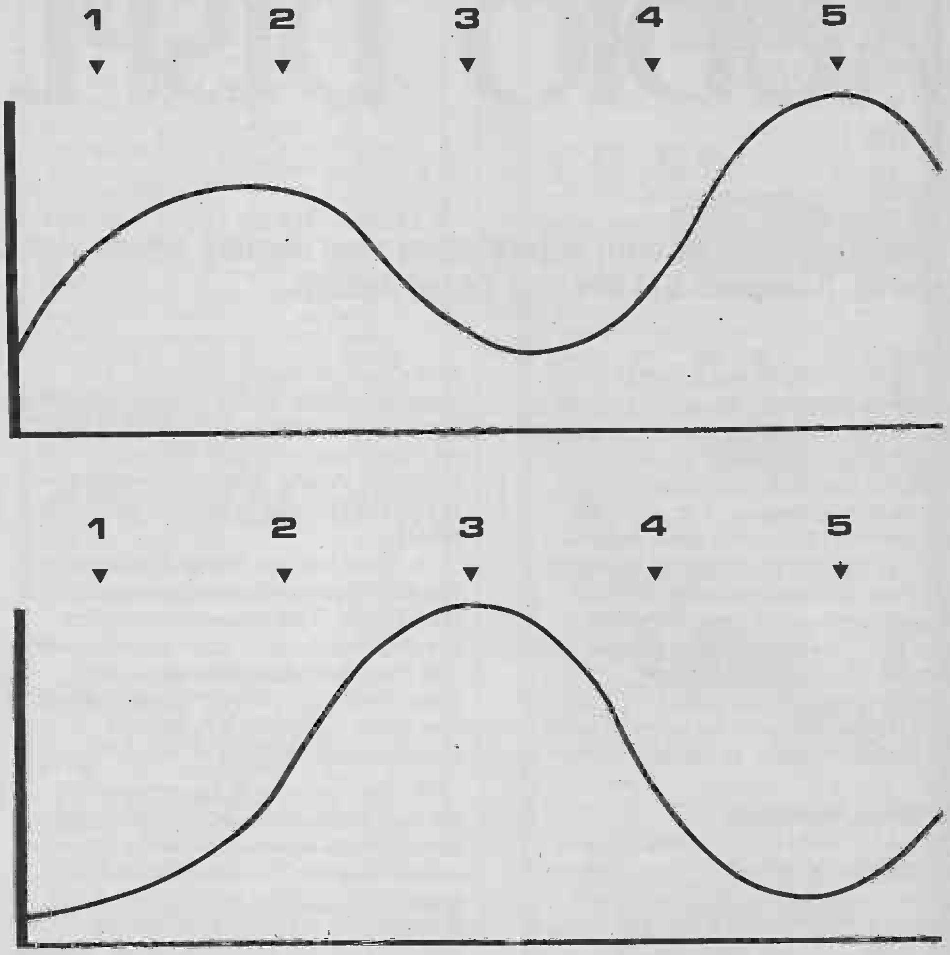


Fig. 1. Bass and treble signals are shown in the graphs, top and above respectively. At point 1, with a lot of bass and very little treble, pattern 1 of LEDs light (shown left), and so on. Thus the pattern of LEDs changes, with the changing mixture of bass and treble frequencies.

circuits, the LED driver chip and associated multiplexing circuitry and the display itself. Owing to circuit complexity, especially of the display, a double sided PCB has been designed. Use of our PCB will greatly simplify construction.

As the LEDs are wired in series, it is necessary to pre-select them or you may find that some will light very dimly or not at all. Use of a matrix board such as S-DEC or Proto board makes this job very easy and it should present few problems. In any case, the eye is very tolerant of individual differences in LED brilliance when they are assembled into a cohesive display.

The selected LEDs should be mounted on the board first. Note that some will be soldered on the top surface of the board. Then solder all the links in place and mount the IC holders, resistors and capacitors. Flying leads should be taken from the driver chip to the LED display. Check the connections carefully against the circuit diagram and overlay. Next, insert the display anode driver transistors, Q1, 2, 3, 4, as shown in the overlay. Finally insert IC's 2, 5 and the driver chip IC1. ICs 2 and 5 are CMOS chips and the usual handling precautions should be observed. Power can now be applied to the circuit and a voltage of up to five volts applied to the switch sides of resistors R12 and R25 located near the mood switches. The display should now illuminate.

If all is well, disconnect the power supply and insert the remaining components. Then re-connect the supply and apply an audio signal to the input and adjust RV1 until the display operates over its whole area.

That completes construction. A feature of our display which has a very novel appearance is the use of flock paper fixed over the PCB and tinted perspex to cover the completed unit which, used in the right setting, assures complete kinaesthesia. ETI

PARTS LIST

RESISTORS all ¼W 5%

R1, 5, 15	1m
R2, 3, 16	47k
R4	1k
R6, 13, 19, 20	15k
R7	33k
R8p 10, 21, 23	100k
R9, 22	100r
R11, 24	220k
R12, 17, 18, 25	10k
R14	10m
R26	2k2
R27	680r
R28	1k

POTENTIOMETER

RV1	1M submin preset

CAPACITORS

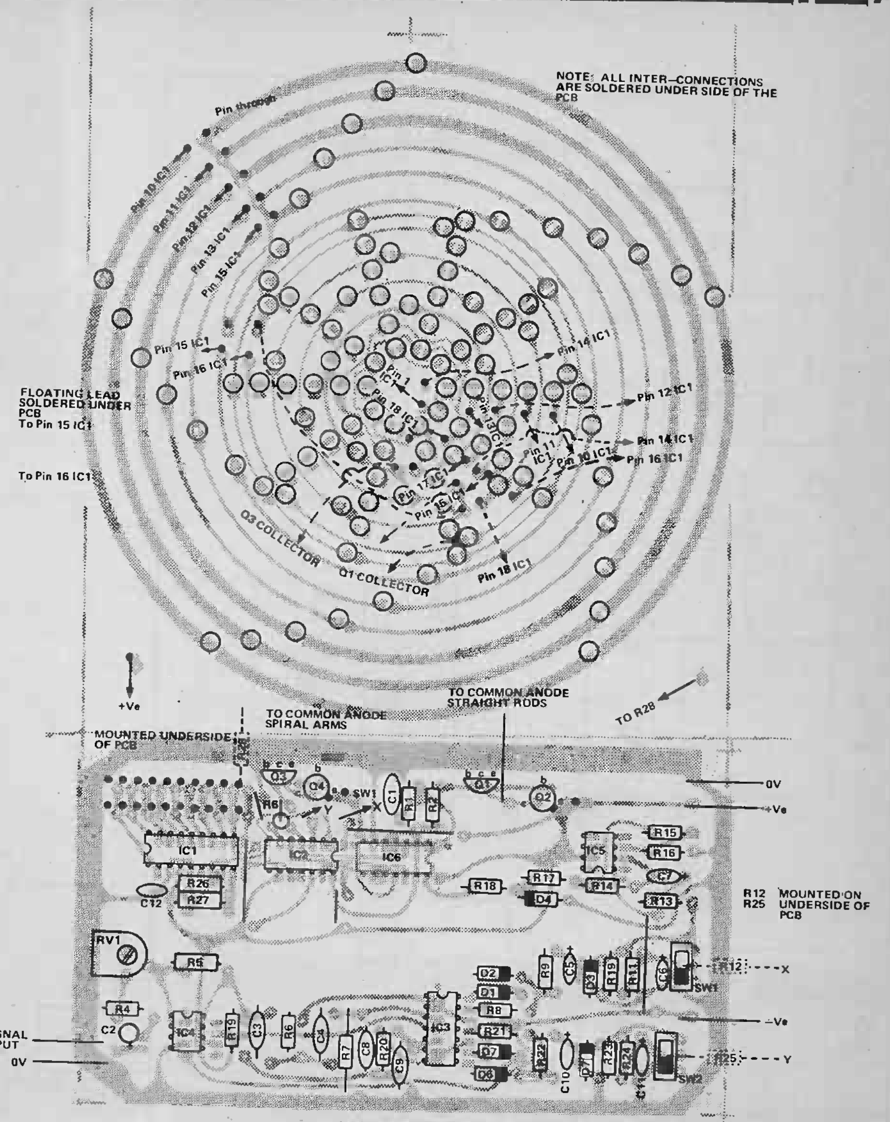
C1	10n polyester
C2	10u electrolyic
C3, 4	3n3 polystyrene
C5, 6, 10, 11, 12	10u tantalum
C7	1u tantalum
C8	100n polyester
C9	47n ployester

SEMICONDUCTORS

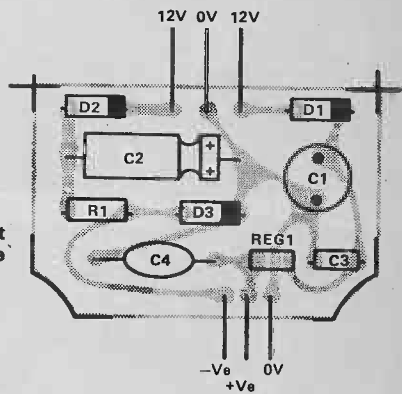
IC1	LM3914
IC2	4016B
IC3	LM324
IC4	741
IC5	CA3140
IC6	3093B
Q1, 3	BC214L
Q2, 4,	BFX 88
D1, 2, 3, 4, 5, 6, 7	1N4148
LEDs	0.125"

MISCELLANEOUS

PCB	
SW1, 2	SPDT



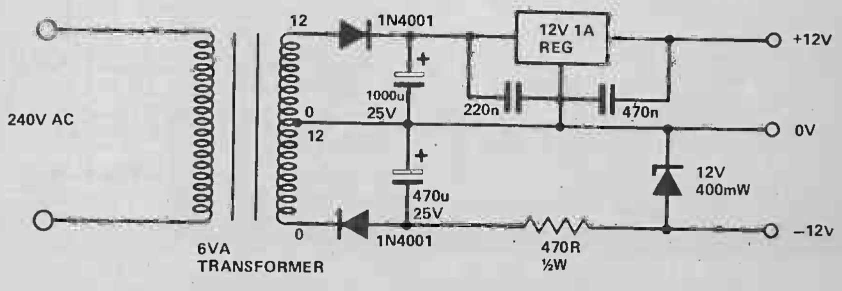
Above: Component overlay for the Scintellate Audio Display unit. Note that this PCB is in fact a double sided board, but that for clarity we have only shown one side of the foil pattern.

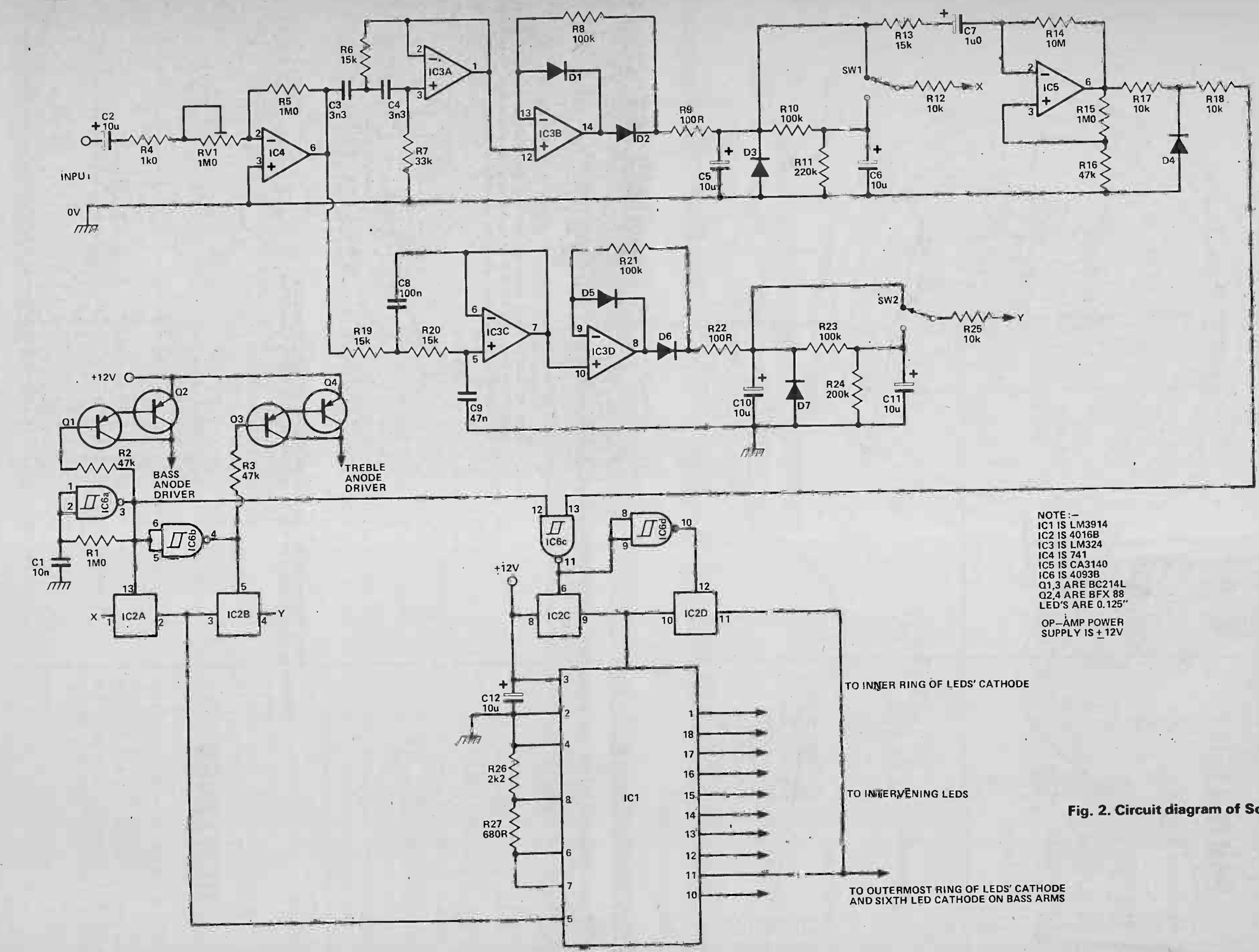


PSU is shown here. This can be any +12V supply rated at 250mA or over. Design of this is not critical, but ripple should be low.

BUYLINES

The LM3914 bargraph display driver should be available from Marshall's Watford or Maplin. All the other components should be readily available from the usual suppliers.





NOTE:–
IC1 IS LM3914
IC2 IS 4016B
IC3 IS LM324
IC4 IS 741
IC5 IS CA3140
IC6 IS 4093B
Q1,3 ARE BC214L
Q2,4 ARE BFX 88
LED'S ARE 0.125"

OP–AMP POWER SUPPLY IS ±12V

Fig. 2. Circuit diagram of Scintalite.

HOW IT WORKS

The signal is input to IC4, a conventional inverting amplifier, via C2, R4 and RV1 which sets the gain of this stage. The output, about ten volts peak to peak, drives filters IC3a and IC3c. These are second-order with a Butterworth response.

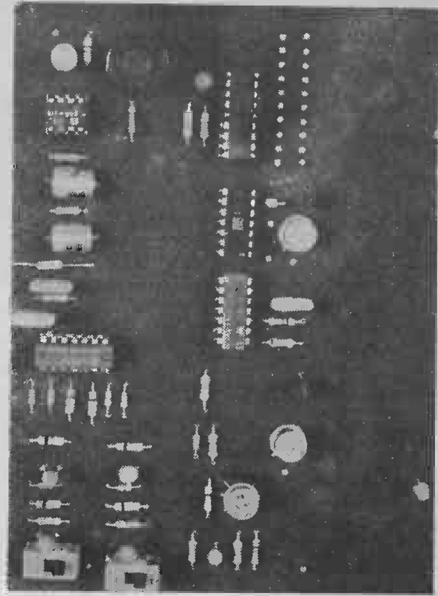
IC3a is a highpass circuit and has a turnover point around 2.5 kHz. IC3c is lowpass with a turnover point around 250 Hz. The output from the filters drives identical half-wave rectifying peak detector circuits. Two signals are available from these stages; the peak signal from the top of C5 or C10 and a low pass filtered signal from C6 or C11. The signal required is selected by operation of the mood switches SW1 and SW2.

To reduce component count and conserve power the LED displays are multiplex. IC2a and IC2b select the input signal for display driver IC1. IC6a is an oscillator running at a few kHz and around 50% duty cycle. Its output is inverted by IC6b. The antiphase signals from this network control the Darlington anode drivers Q1, 2, 3, 4 and analogue switches IC2a and IC2b. The remaining gates in these two chips are used to select dot or bar mode in the display driver chip.

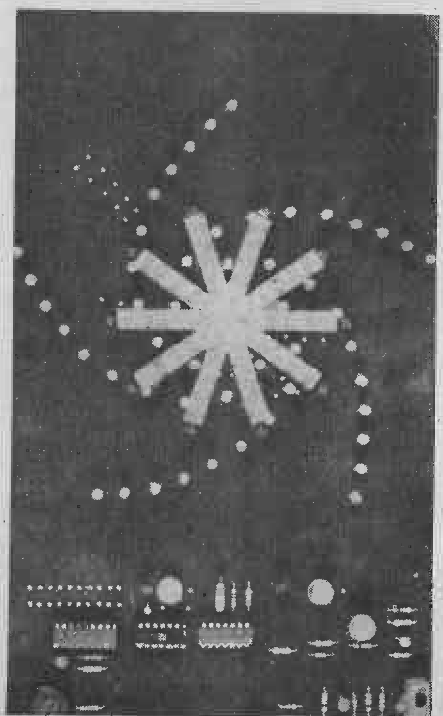
The bass display select signal at pin 12 of IC6c forces a bar display. However, the treble display operates according to the output level of IC5. This is a differentiating circuit whose output sign follows the slope of the treble peak detector output as the signal rises and falls. Some Schmitt action is provided by R15, 16.

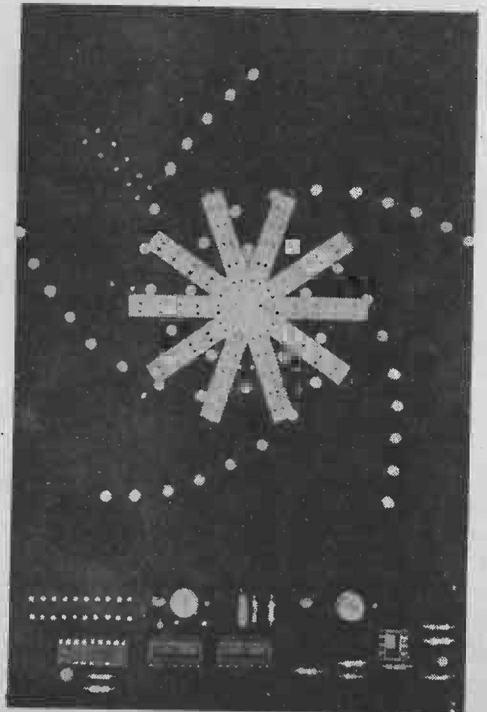
IC1 is programmed by R26 and R27 for a full scale input of about five volts and a LED current of 20 mA. We used green LEDs for the bass display and yellow for the treble. It is important to use a regulated 12V positive supply as chip dissipation could otherwise be excessive.

The same problem could arise if red LEDs are used owing to their lower forward voltage drop. The negative supply is low-power and uncritical but should anyway be kept below 15V.



(Above) The business end of the Scintalite PCB.





(Below). Two stages in the construction of Scintalite. The spiral arms are fitted (right), and then the straight lines of LEDs (left).

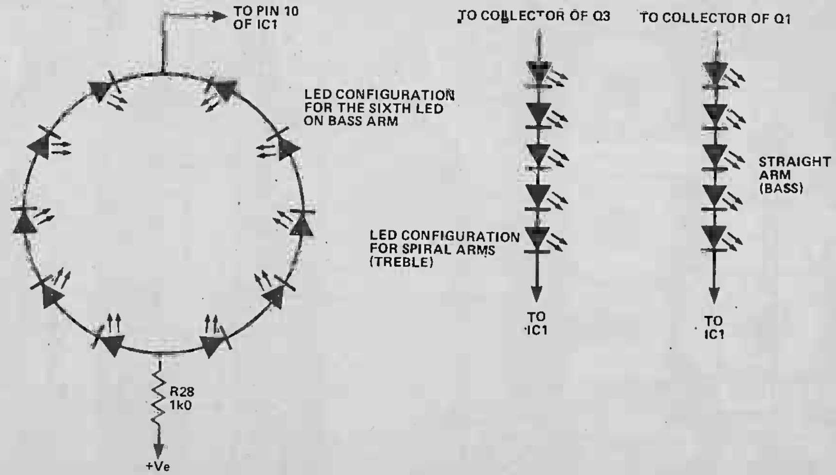
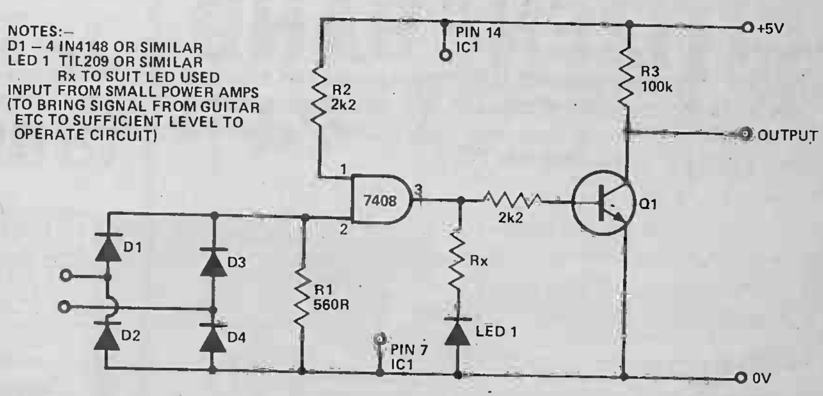


Fig. 3. LED configurations for the bass and treble lines.

Extension Trigger Device for Synthesizers

J. Trinder



The following device is intended to provide a trigger pulse for a synthesizer when using an external input source, e.g. a guitar.

The output from the guitar must first be amplified by a small power amplifier in order to bring the signal to a sufficient level to operate the device.

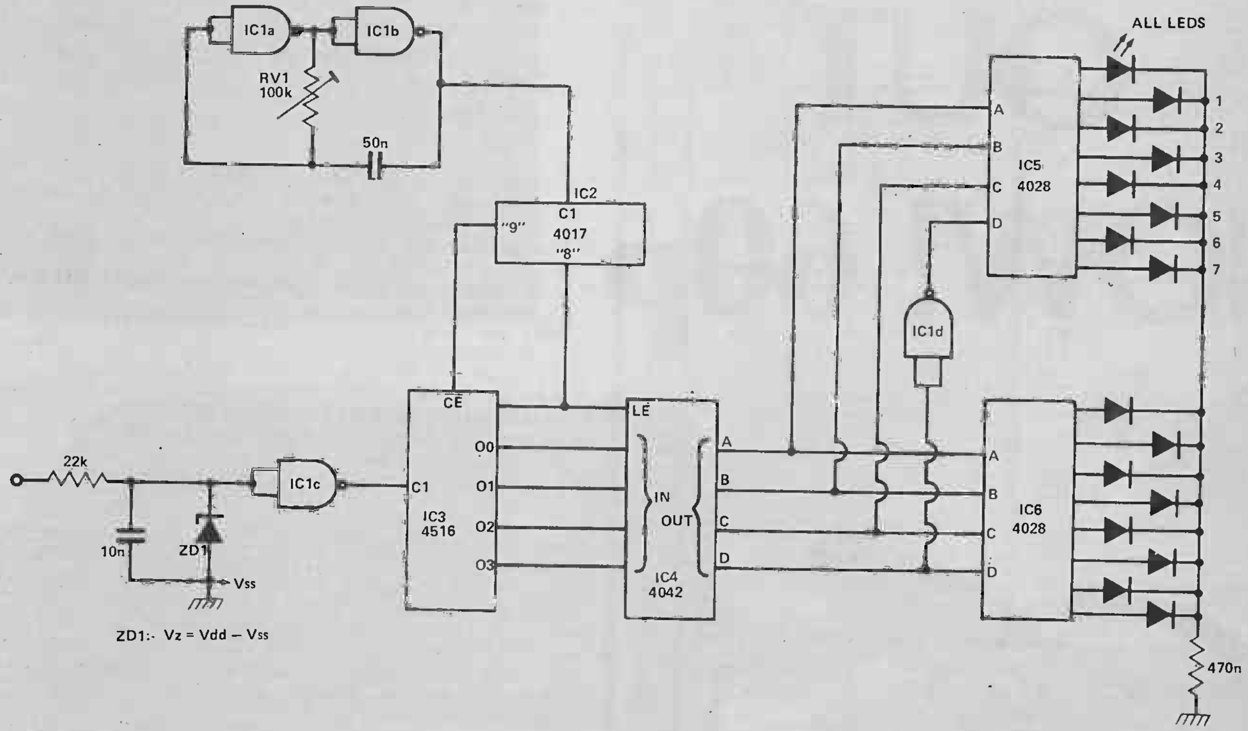
The AC input to the device is converted to DC by the bridge rectifier. When the DC level reaches a sufficient level the input of the AND gate is taken high. As the other input is already high its output becomes high.

When this happens the transistor is turned on, thus taking the output voltage to nearly zero. When the DC level at Pin 2 falls below the required level its output goes low thus turning the transistor off.

The output from the device is approx 3V5 (off) and approx 0V (on). The LED is on when the unit is triggered.

The synthesizer intended for use with the circuit has an extension trigger input which requires less than —3V on, thus the common and output connections of the external trigger device have to be reversed so that the external trigger input usually sees —3V5 (off) instead of +3V5.

The circuit can be easily modified to suit individual needs. An example of its use is to trigger a filter sweep when the input of, e.g. a guitar, reaches a certain level.



Solid State Tacho Circuit

P. Stephenson

The circuit is designed to give a non-critical display for those who like (cheap) gadgets.

IC1a/b form an oscillator which drives decade counter IC2. During eight tenths of each cycle of this section, binary counter IC3 is counted up. On count "8", the counting stops and IC4 latches the outputs. On count "9" IC3 is reset.

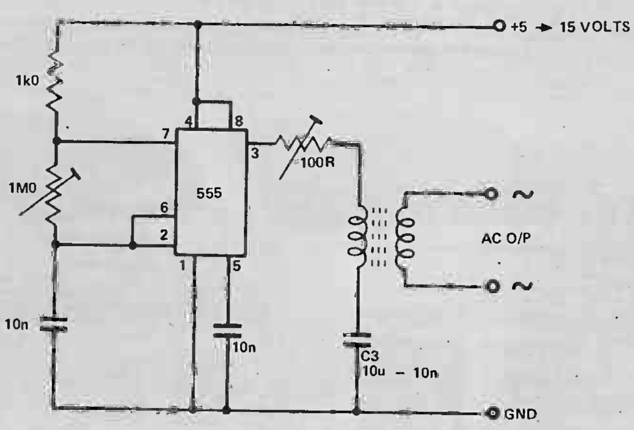
The number now on IC4 output is decoded by IC 5/6 to light up one of 16 LEDs corresponding to rpm.

Calibration is by adjusting RV1 whilst inputing a known frequency (e.g. mains frequency 50 Hz).

Tech-Tips is an ideas forum and is not aimed at the beginner. We regret we cannot answer queries on these items.
ETI is prepared to consider circuits or ideas submitted by readers for this page. All items used will be paid for. Drawings should be as clear as possible and the text should preferably be typed. Circuits must not be subject to copyright. Items for consideration should be sent to ETI TECH-TIPS, Electronics Today International, 145 Charing Cross Road, London WC2H 0EE.

Mille-power Inverter

J. S. B. Dick



Many home-grown projects require a high voltage, low current source. The simplest and safest means of providing this is by an inverter. The circuit described here is versatile, efficient and easily capable of providing power for portable Geiger counters, dosimeter chargers, high resistance meters, etc.

The 555 timer IC is used in its multivibrator mode, the frequency being adjusted to optimise the transformer characteristics. When the output of the IC is high, current flows through the limiting resistor, the primary coil to charge C3. When the output goes low, the current is reversed. With a suitable choice of frequency and C3 a good symmetric output is obtained.

Precision AC to DC Converter

T. K. Tay

The circuit is a precision AC to DC converter (amplitude). The important feature is that the system operates happily with amplitude and frequency of Vin varying (e.g. speech signal).

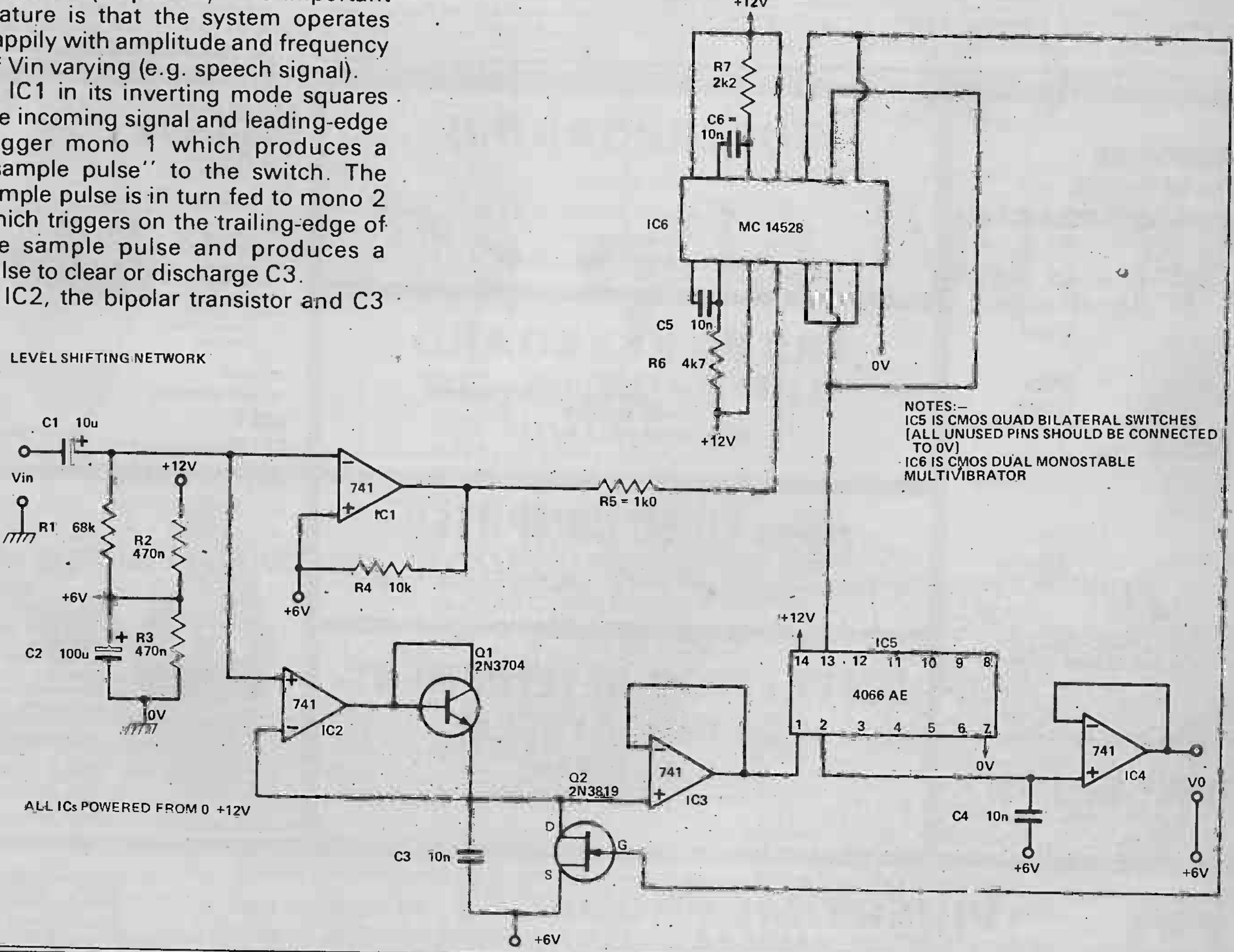
IC1 in its inverting mode squares the incoming signal and leading-edge trigger mono 1 which produces a "sample pulse" to the switch. The sample pulse is in turn fed to mono 2 which triggers on the trailing-edge of the sample pulse and produces a pulse to clear or discharge C3.

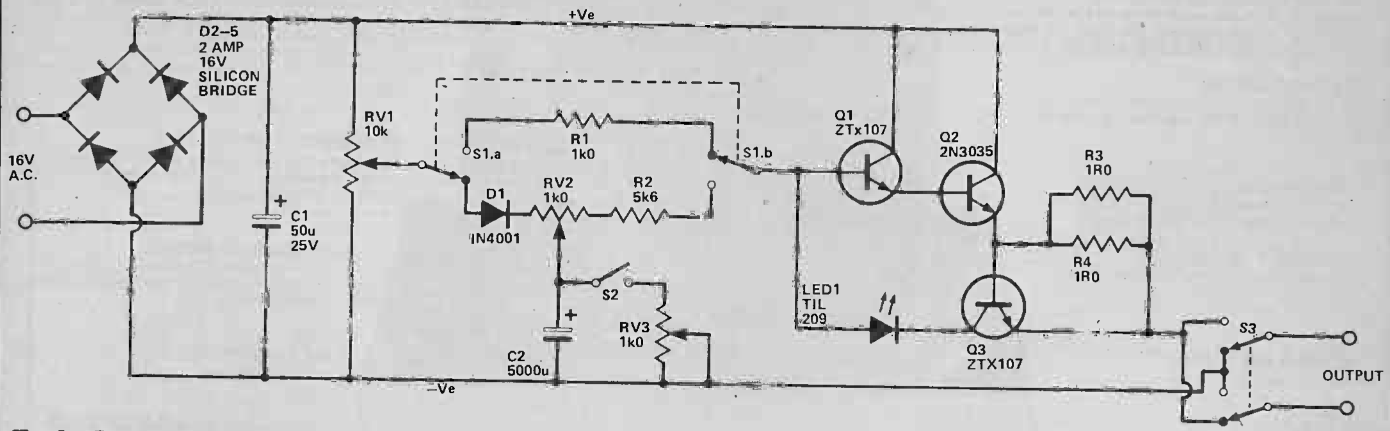
IC2, the bipolar transistor and C3 form the rectifier and first hold circuit. C4 acts as the second hold circuit.

Thus after every ½ cycle of Vin, the DC level of the first hold is being transferred to the second hold circuit by the sample pulse before the first hold is clear again.

A level shifting network is used to shift the reference level to +6V.

With the components used in the circuit, the system works very well from 25 Hz to 20 kHz.

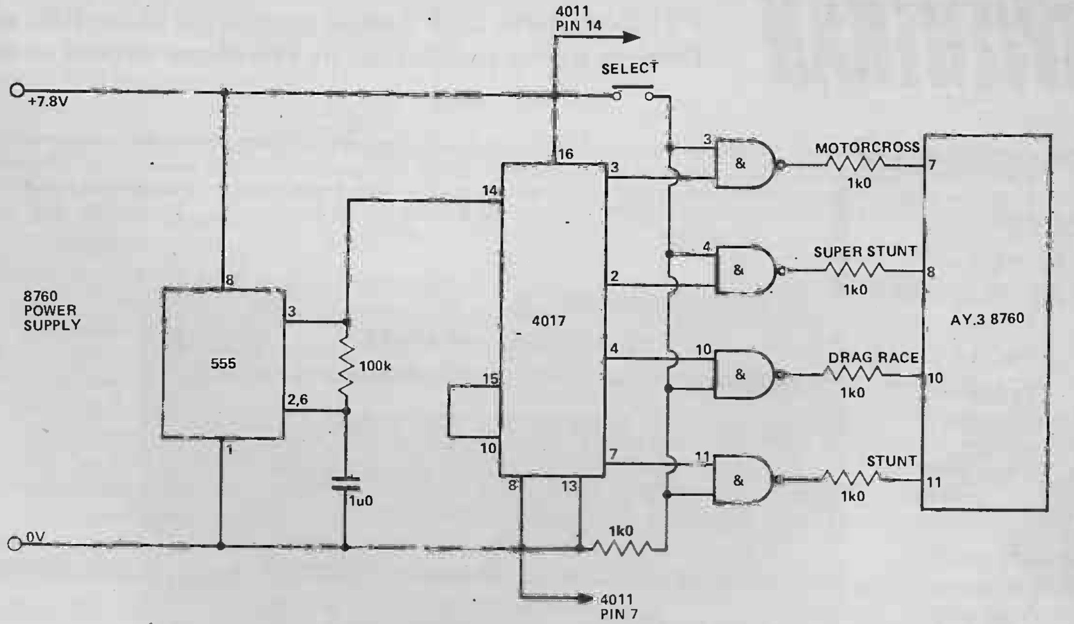




Train Controller with Inertia and Brake

M. Bright

D2-5 full wave rectifies the AC and C1 smooths the output. RV1 acts as a regulator controlling train speed. Switch S1 switches in the inertia simulator (comprising D1, RV1, R2 and C2). S2 switches in the brake, the action of which is altered by RV3. RV2 controls the amount of inertia, so that the train can take as long as ten seconds before even moving. Q1,2 act as a Darlington pair, supplying current to the output. Q3 monitors the output and provides short-circuit protection. When a short occurs, D2 lights up and the current into Q1 is reduced. Hence, the output is reduced. Two 1W resistors are used for R3,4 rather than a wirewound ½W resistor, which would cost more. S3 simply reverses the polarity and hence the train.

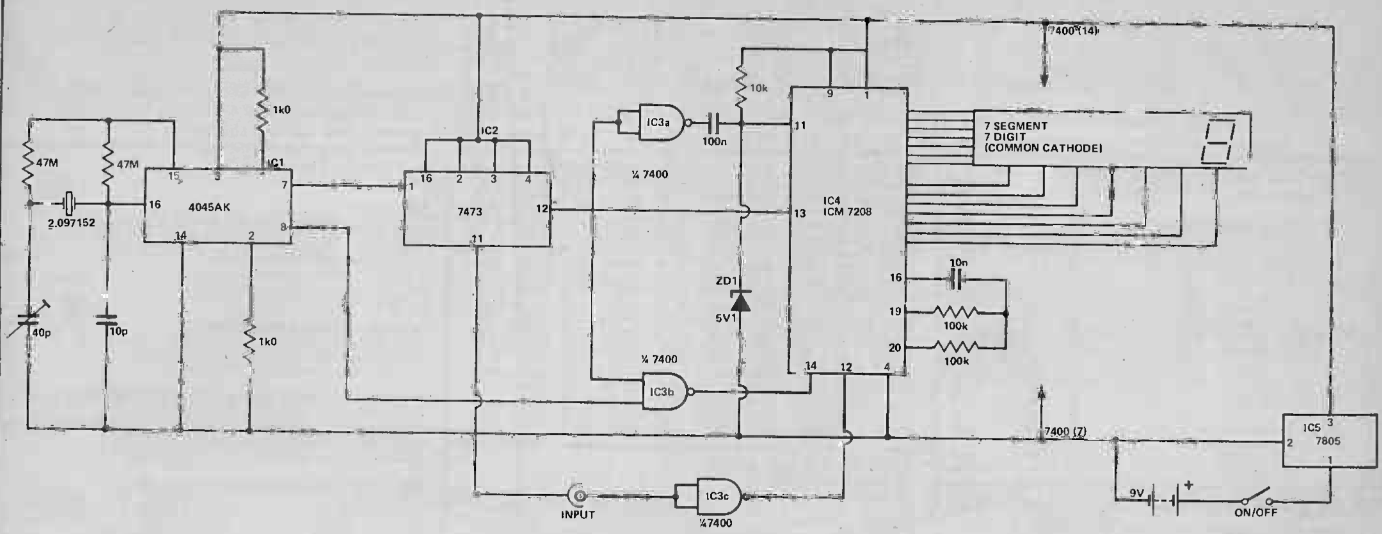


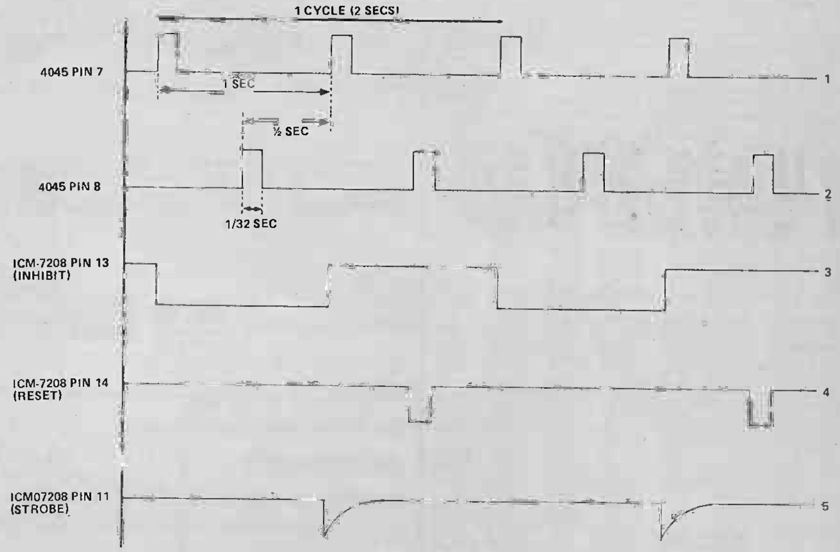
Auto Select for AY 3-8760 Stunt Cycle

S. D. Lang

Constructors of the Stunt Cycle TV game may wish to economise on switches and panel space by trying this circuit for game selection. Originally, game selection was by grounding the relevant game select pins. This requires four push switches; extravagant on switches and panel space. In this circuit, three of those switches are made redundant in a novel game selection method. The only switch required is a push switch now entitled 'game select'. Upon depression of this switch, all four games are displayed upon the screen, one a time. When the playfield of the required game is displayed, the game select switch is released and play continues.

The circuit works from the power supply of the AY 3-8760. Circuit operation is straightforward, as follows: The 555 and associated components form a pulse generator of period approx. 1 second. This pulse is applied to the input of the 4017 decade counter. Every pulse received advances the high output by one, so the high pin is 3,2,4,7 in that order. When pin 10 becomes high, the reset circuitry is operated. If the select switch is open, the output of all the NAND gates is high, so the game is played. When the select switch is closed, the selection circuitry may now operate, and the outputs of the NAND gates go low in turn, selecting the appropriate game.





A Pocket Digital Frequency Meter

S. J. Barlow

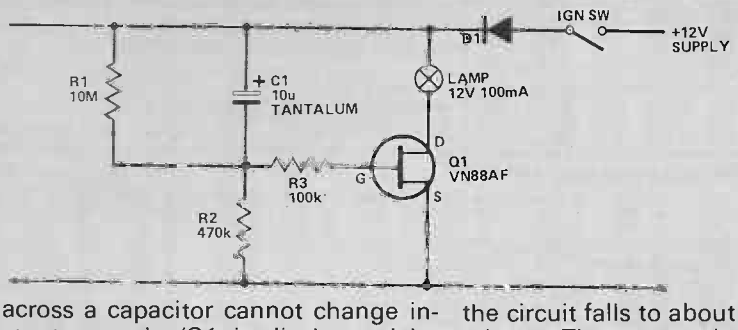
The circuit uses only five ICs and 13 passive components. It is designed to fit into the casing of a pocket calculator and makes use of the calculator's seven segment display.

It has a single range measuring up to 10 MHz. The display is updated with a new reading every two seconds. The preceding frequency count is held in the display during this period, thus avoiding a flashing display during the sampling interval.

The 7805 provides the 5V supply for the logic. The 4045 and the crystal form an oscillator and 21 stage binary counter producing 1/32 second pulses at 1 sec intervals as shown in waveforms 1 and 2. The 7473 flip-flop produces the one second gating pulse (waveform 3). Waveforms 2 and 3 are NANDed into pin 14 of the ICM 7208s counter chip to produce the RESET signal. Waveform 3 is also inverted before driving a differentiator with a 5V1 zener diode providing a clamp and discharge path. The differentiated waveform (5) gates the new frequency reading into the display.

Seat Belt Indicator for Vehicles

S. Winder



As a reminder to put the seat belt on, a small opaque panel with the inscription "SEAT BELT" can be fitted to the dashboard with a lamp behind, which lights up for ten seconds after the ignition has been turned on. The new VMOS power FET can be used in a very simple circuit to achieve this. The current between source and drain is dependent upon the gate/source voltage. When the ignition key is turned the +12 volt supply is initially dropped across R2, since the voltage across a capacitor cannot change instantaneously (C1 is discharged by R1 when the supply is removed). As the capacitor charges up the gate potential of Q1 drops and the lamp extinguishes. The current drawn by the circuit falls to about 50 uA after a minute. The gate resistor R3 is provided to protect the zener diode which is between gate and source of Q1, the input resistance of Q1 is too high to be affected by this resistance normally.

........news digest.......

BABANI DUO

Two new books from the Bernard Babani stable dropped through our letter box recently. The 'Beginners Guide to Digital Techniques' by G. T. Rubaroe covers everything from an introduction to the binary number system to applications such as digital computers and voltmeters.

As digital techniques spread into the hobby market, versatile and inexpensive digital ICs are becoming available to the home constructor.

This compact paperback's 62 pages pack in chapters on number systems, codes, combinational and sequential logic, analogue to digital and digital to analogue conversion and finally applications.

Next from Bernard Babani we have the 'Second Book of CMOS IC Projects' by R. A. Penfold.

The publication of this second book of CMOS projects was prompted by the success of '50 CMOS IC Projects' by R. A. Penfold, published in 1977.

The second book provides a selection of useful, mostly simple, circuits, with the minimum of overlap between the two books.

In 122 pages, four chapters deal with CMOS basics, multivibrator projects, amplifier, trigger and gate projects and special devices.

The Beginners Guide to Digital Techniques is available for 95p and the Second Book of CMOS IC Projects for £1.50, both from Bernard Babani (publishing) Ltd.

SCOPE CUTS

Telequipment have announced price reductions for two of their oscilloscopes. (Don't they have inflation in Harpenden?)

The S61, a single beam 5 MHz general purpose instrument, is down to £156.

The D32, a battery/mains dual trace portable scope with a bandwidth of 10 MHz, is now selling at £406.

Both scopes are from Tektronix UK Ltd, Beaverton House, PO Box 69, Harpenden, Herts.

HOT SPOTS

These tiny, self-adhesive tabs from Carel Components could save your bacon (or your expensive ICs).

Only ⅛in square, the Levermore 'Temp-checker' temperature indicators change from silver to black within 1% of the rated temperature. Ratings range from 40°C to 260°C in 41 increments.

These hot spot indicators come, appropriately, in a book match pack. Six packs or more are supplied in an outer wallet.

For information on Temp-checker tabs, please contact Carel Components Ltd, 40-44 The Broadway, Wimbledon, London SW19.

VAT

INCREASE

As from June 18th the VAT rate is increased for all products to 15%.

Due to printing schedules most of the advertisements in this issue will carry prices based on the old rate of VAT.

Readers should take this into account when ordering from advertisers and it is advisable, if in doubt, to contact suppliers beforehand.

ETI STRING THING

TRANSCENDENT DPX

This, the latest design from the Tim Orr stable, is a versatile digital polyphonic multi-voice keyboard instrument. Designed to have a minimum of wiring, it does not suffer from the signal breakthrough caused by the wiring jungles which some other instruments demand.

The machine features a touch sensitive (dynamic) keyboard action, and the keyboard can be 'split'. It is also polyphonic (chording) and has several voices. Included in the design is a CCD choraliser to give the machine a "several at once" facility.

BUYLINES

Powertran Electronics are supplying a complete kit of parts for this project at £365+15% VAT. Delivery by Securicor is £2.50 extra. Everything is included in the kit, down to the last nut and bolt. They even give you a plug.

The machine was designed to be a versatile keyboard instrument with a choice of several voices and characteristic waveform envelopes with a split keyboard and a dynamic option. Most string machines, organs or electric pianos usually involve a large amount of cables which can cause significant signal breakthrough and lots of wiring problems. With this in mind the machine was designed to have a bare minimum of wires, and even so, most of the resultant wiring is accomplished with manufactured 14 way ribbon cable connectors.

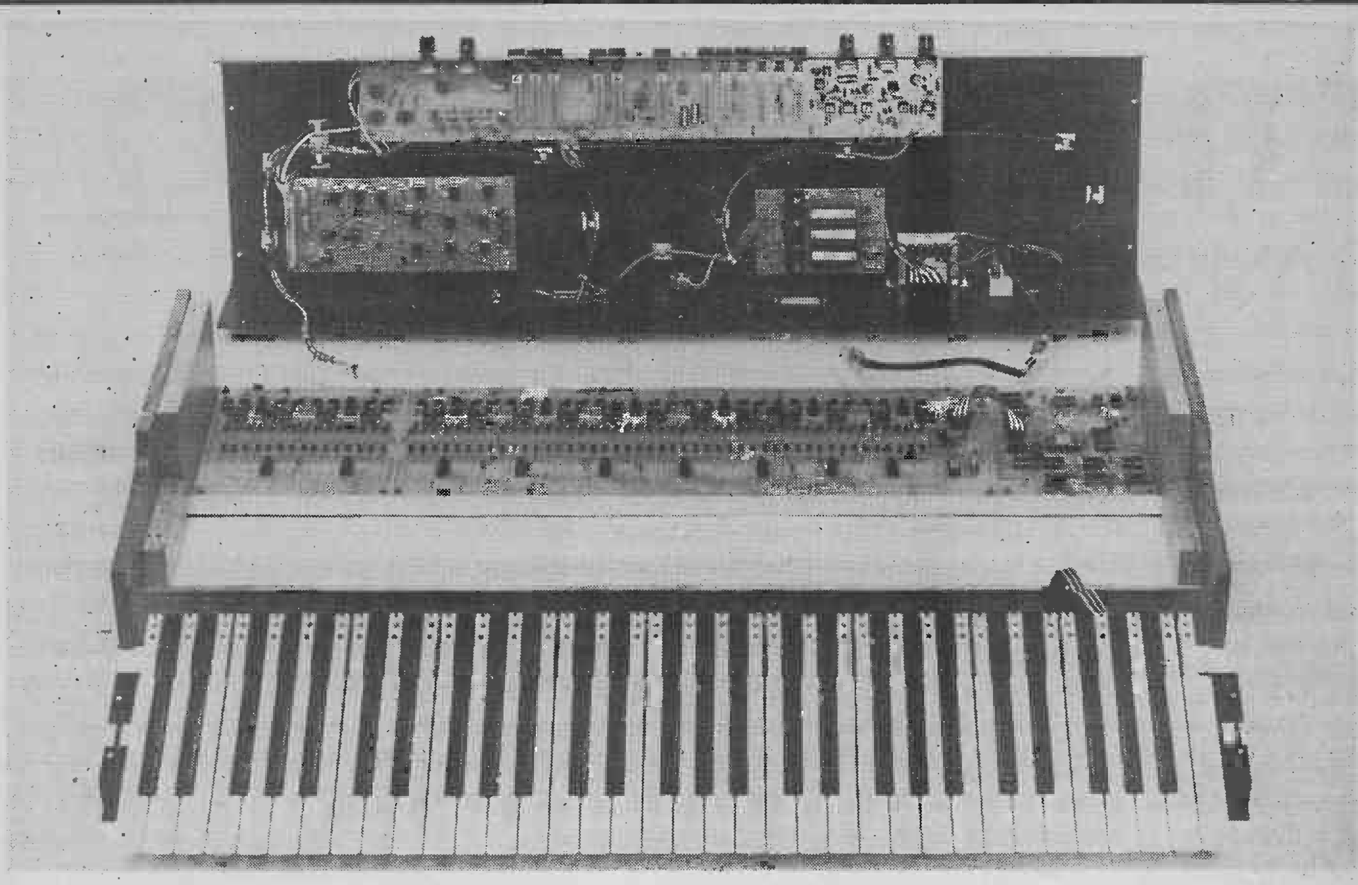
Layout

Ease of access is also very important and so the physical layout was given special attention. Merely by removing the lid and the base all the electronics become accessible. A multiplexed system was used, as this kept the wiring to a bare minimum and also enabled a relatively sophisticated dynamic and attack/sustain network to be employed. The note and envelope generation is contained on two printed circuit boards using a conventional top octave generator and divider network. The envelope generators are programmable so that they will produce either a characteristic string/brass or a piano contour. Five audio outputs, one per octave are produced from these boards which are then routed to the tone control and voicing section. The filtered sound is then processed by the ensemble section which turns the relatively dull electronic signals into interesting 'natural sounding' signals by a process of complex phasing.

Multiplexed Keyboard

Multiplexing is a method of conveying several signals down one transmission line. The signals are time division multiplexed, that is each channel of information is sequentially transmitted down the line. The sequence is repeated rapidly so that, at the receiving end, the signal can be unscrambled (demultiplexed), and reconstituted so as to resemble the originally transmitted set of signals.

The keyboard has 61 notes and so a six bit binary code, which has a possible 64 decoded states, is used to address the multiplexer. In this way it is possible to interrogate each key on the keyboard, (this is done every millisecond) and to determine whether the key is released, pressed or in the process of being depressed. This generates a lot of information which tells us which keys are being pressed and by doing some timing, how hard they have been pressed. This information can then be used to control the volume of each note in proportion to the key velocity. The harder you play the note the louder it sounds. The advantage of using a multiplexing system is that all the information passes down one wire, so the wiring is relatively simple being one wire plus an address bus rather than 61 wires. It also enables the one piece of electronics to do all the dynamic computation for all the notes. Also, as only one dynamic circuit is involved, the note to note difference in dynamic performance should be greatly reduced and it is practical to use a relatively complex dynamic law.



Playing Computers

As the key-pressed information is in a binary code it should be possible to interface the machine to a microprocessor system, such that a musical sequence can be memorised on say the lower two octaves and then replayed whilst you plan an accompaniment on the top three octaves.

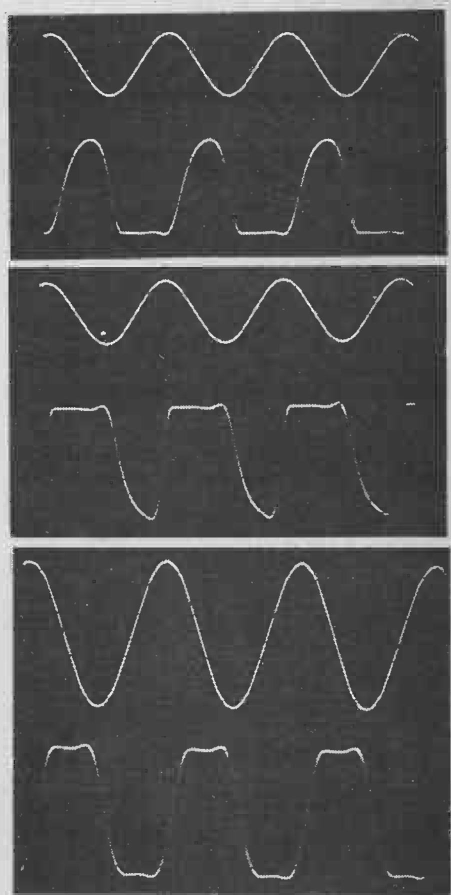
The multiplexed signal, once it has passed through whatever processes have been selected, is then demultiplexed on the master note generating board. If, say, you press middle C on the keyboard, a voltage appears at the demultiplexer output that controls the middle C note, thus causing the note to be generated.

Keyboard Multiplexer

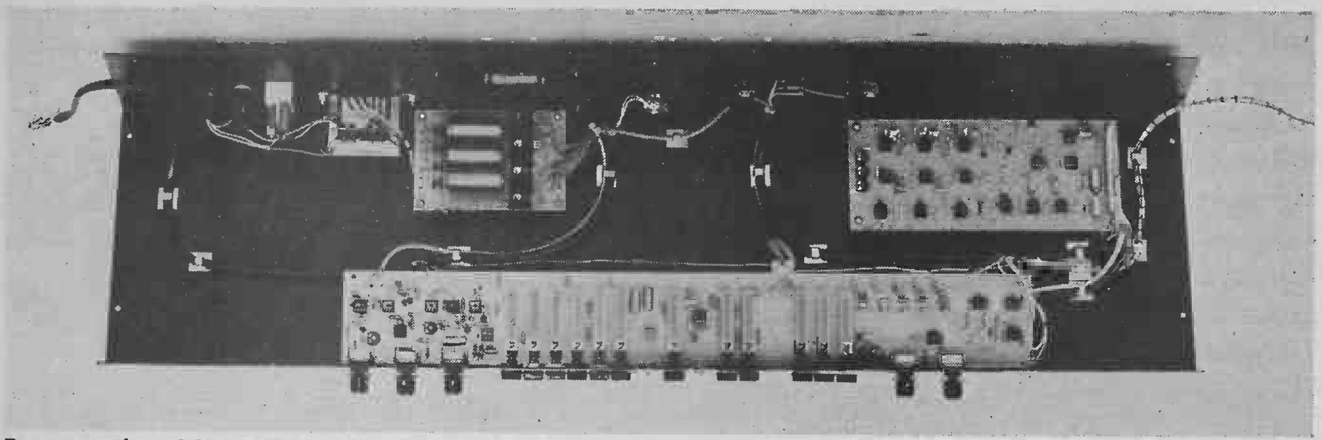
The job of the keyboard multiplexer is to look at every note on the keyboard once every millisecond and to convey this information to the dynamic and demultiplexing system. When a key is released it is connected to -5V, when it is pressed it is connected to +5V and when it is in the process of being depressed, (neither up or down), it is connected to 0V. Thus by examining the information from each key it is possible to determine what is happening on the keyboard; which notes are being played and those that are not. Also, by timing the duration of the OV period for each key, it is possible to determine the key velocity, (how hard the key was played), and to produce a signal whose volume is controlled by this. Loud notes have a timing of about 4 mS, whereas soft notes take 30 to 100 mS. The soft end of the range is very indeterminate and needs to be compressed.

Circuit Operation

A 6 bit code, generated by the dynamic network is used to address the keyboard multiplexer. This 6 bit code has a possible 2^6 (64) decoded outputs which is, therefore, sufficient to fully address the 61 notes of the keyboard. The scan time for the keyboard is approximately 1mS and so the time taken interrogating each note will be one sixty fourth of this, approximately 16 uS per note. The multiplexer is made up out of 8 x 8 way multiplexers, the address inputs of which are driven by the three least significant bits of the 6 bit code. The three most significant bits are used to drive a BCD to decimal decoder, the lowest 8 outputs of which are used to sequentially enable the multiplexers. Thus the 6 bit code sequentially interrogates each of the 61 notes and sends the keyboard information (MPI) down to the dynamic network. ▶



Adjusting bias voltage on the delay lines (chorus board). In each case the top trace is the input signal. The lower trace indicates (a) bias too negative (b) bias too positive (c) correct bias, symmetrical clipping.



Power supply, voicing control panel and chorus board

Mechanical Construction

Assemble the two keyboard printed circuit boards with the exception of the key contacts.

Stick these two printed circuit boards onto the keyboard spacer and hold in position with some nuts and bolts whilst the glue dries. There should be a 0.1" gap separating the two boards. Next thread the bus bar lengths through the holes in the contact blocks. Make sure that these bars are clean (give them a rub with a tissue), and try not to handle them as this will make them slightly greasy. Use gloves or tissues to hold them. Make certain that the gold plated wire of the contact block is in between the bus bars. Apply some glue to the bases of the contact blocks and position them onto the PCB, making sure that the bent ends of the wire pass through the holes provided. Line up the blocks and then place a weight on them whilst the glue dries. Next solder in the board to board links, solder the bent ends of the contact blocks, solder together bus bar sections and wire them to +5 and −5V as shown in Fig. 4. Position the entire keyboard assembly onto the keyboard chassis such that it overhangs the punched holes by 0.2" (Fig. 5). Mark the fixing holes through the PCB with a pencil and drill them out with a

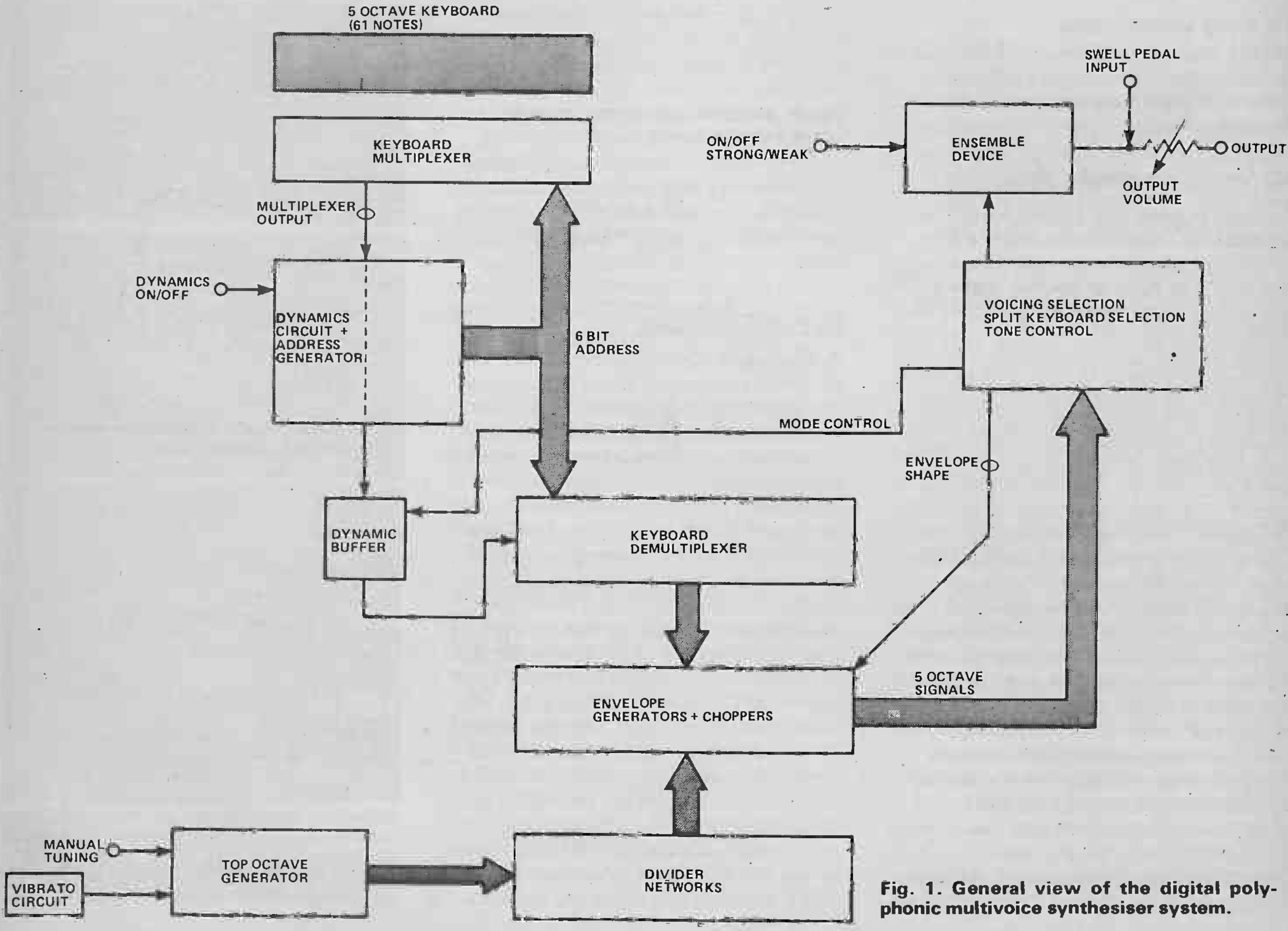


Fig. 1. General view of the digital polyphonic multivoice synthesiser system.