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WAA-PHASE UNIT

A superb project for the guitarist, this unit adds a brand new range of sounds to a player's repertoire. The design can produce standard waa-waa or a unique pseudo-phase sound, has built-in mixer and balance controls, and costs a mere £15 or so to build. Design by Ray Marston. Development by Steve Ramsahadeo.

This unique project is yet another first for ETI. The unit looks like a standard foot-controlled Waa-Waa unit and is played in exactly the same way, but is, in fact, designed to produce a conventional waa-waa sound, a brand new pseudo-phase sound, or a range of sounds between these two extremes; the desired type of sound can be selected by a fully-variable 'Q' control. The unit also incorporates a built-in audio mixer, enabling the original guitar signal and the waa-phase signal to be mixed in any desired ratio, and has a balance control so that no apparent shift occurs in the guitar's mean sound level when the unit is switched in and out by a built-in bypass switch.

The completed project is housed inside a neat but robust foot-pedal unit that comes pre-drilled to accept all the control pots, switches and jack sockets that are used in the project, which is powered by a pair of PP3 batteries. We estimate the total building cost of the unit at about £15, including the price of the foot-pedal unit.

Basic Principles

A guitar produces output waveforms that are very rich in harmonics, which gives the instrument its characteristic sound. In a conventional waa-waa unit, the guitar output signal is simply passed through a foot-controlled band-pass filter before reaching the main amplifier. This filter is a low-Q type (typically with a Q of unity) and passes a broad spectrum of basic guitar sounds, but at the same time picks out and accentuates certain harmonics; when the operator sweeps the filter up and down manually using the foot pedal, the characteristic waa-waa sound is produced.

The unique feature of the ETI Waa-Phase unit is that its sweep filter has a Q that is fully variable from unity to eight. When the Q is set to unity, the circuit produces conventional waa-waa sounds. However, when the Q is set to maximum the filter picks out selected harmonics, amplifies them, and converts them to very pure tones that are quite unlike those of a normal guitar. These tones can be added to the original guitar signal via the built-in mixer. When the filter is swept manually with the foot control, the composite output of the unit can sound like that of a phase unit, or like a synthesiser, or like a vocoder, depending on the chosen settings of the variable controls. The unit thus makes a unique range of very attractive sounds available to the guitarist, at very low cost.

Construction

The foot-pedal unit used with this project (see Buylines) is supplied pre-drilled to accept all pots, switches and jack sockets that are used in the design, so construction should present very few problems.

Start by assembling the components on the PCB, as shown by the overlay, noting that Veropins are used to facilitate the interwiring to the rest of the circuit. When the board is complete, secure it in place inside the foot-pedal unit with a couple of sticky-pads, then proceed with the interwiring to the four pots, two switches, two jack sockets and the two batteries.

When interwiring, take extra care to conform to the circuit diagram. Note, for example, that the two halves of RV3 are contra-connected, so that the output of one half increases as the other decreases. Also note that the action of the foot-pedal unit is such that it sweeps only 200° or so of the available range of RV2, so position this pot carefully so that its value can be swept all the way from zero resistance to some high value.

When construction is complete, fix the two batteries in place (one in the built-in battery holder, the other secured with a sticky-pad) and give the unit a functional check. Simply connect the guitar output to the input of the unit, take the output of the unit to an amplifier, turn the unit on, switch SW1 to IN, and then vary the controls while playing the guitar.

Start by setting the mix, balance and Q controls to mid value while you get the basic feel of the unit, then vary the Q and mix controls to explore the full sound range of the device. In final use, set the Q and mix controls to give the sound that you like best, then set the balance control so that negligible apparent change in sound levels occurs when the unit is switched in and out with SW1. The unit is then ready for stage use.

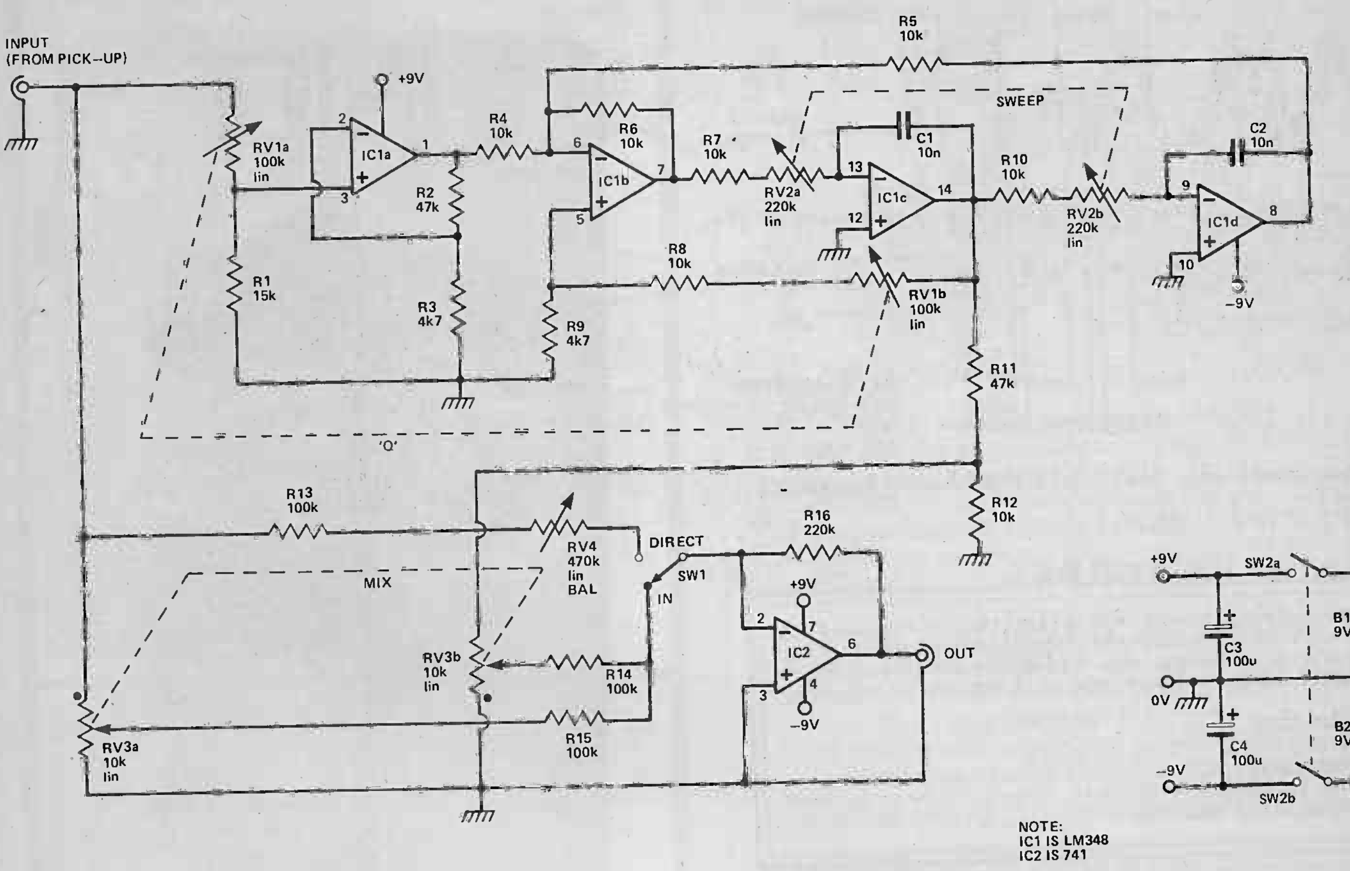


Fig. 1 Circuit diagram of the Waa-Phase unit. The dots at the ends of RV3a and RV3b indicate the left-hand terminal of the pot as seen from the rear. Make sure that this pot is wired correctly.

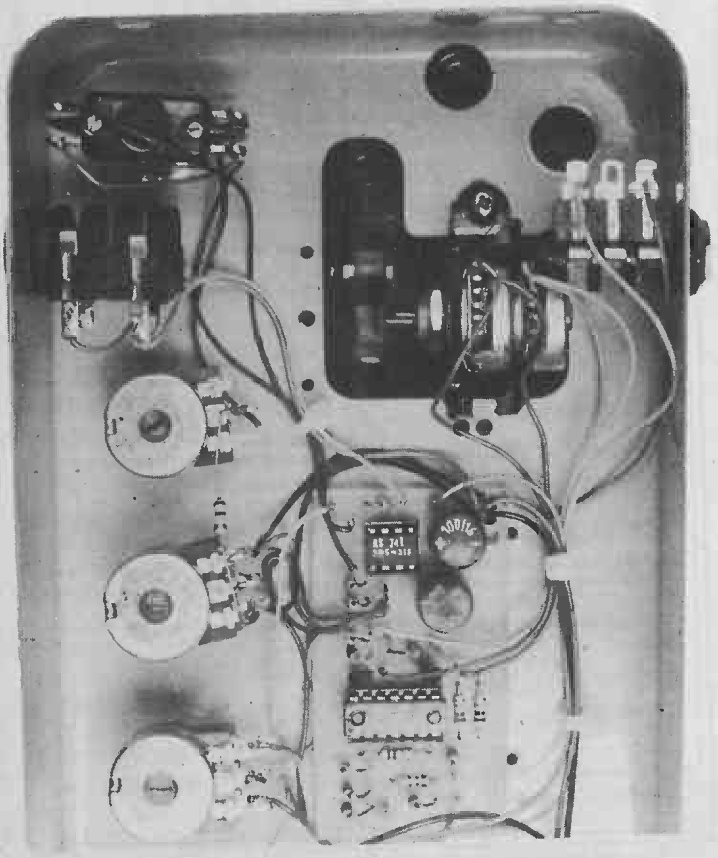
HOW IT WORKS

The unit comprises a combined preamplifier and variable-Q, variable-frequency band-pass filter designed around IC1 (a quad op-amp), plus a simple two-input audio mixer designed around IC2. The guitar output signal is passed through the band-pass filter and the resulting signal is then mixed, in any desired ratio, with the original guitar signal, producing a composite output that can be fed to an external power amplifier.

IC1a acts as the preamplifier and drives the state-variable band-pass filter that is formed by IC1b-IC1c-IC1d and the associated components. The centre frequency of this filter is varied by foot-operated two-gang rheostat RV2. The Q of the filter can be varied from unity to eight by RV1b; to maintain an effectively fixed input-to-output gain at all Q settings, the gain of the preamp stage (IC1a) is varied in opposition to the Q by RV1a, the other half of the Q-control rheostat.

The output of the filter (taken from the R11-R12 junction) is mixed (added) with the original guitar output signal by the network consisting of RV3-IC2 and associated components. Note here that the two halves of mix pot RV3 are contra-connected, enabling the final output signal to be varied from 'all guitar' to 'all waa-phase' (or any desired mixture) using the single control.

When SW1 is switched from the IN to the DIRECT mode, balance control RV4 can be adjusted to give no apparent change in the mean acoustic output levels between the two modes.



Close-up of the important bits. This photograph shows how R13 is mounted on the potentiometers. Note that the recommended case (see Buylines) comes with all the necessary holes ready-drilled. There is just sufficient room in the foot-pedal cut-out to accommodate RV2, a dual-gang pot; connecting the latter to the pedal linkage is quite straightforward.

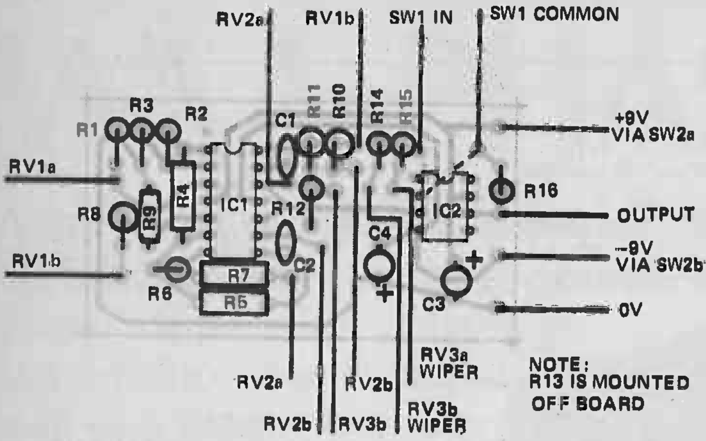
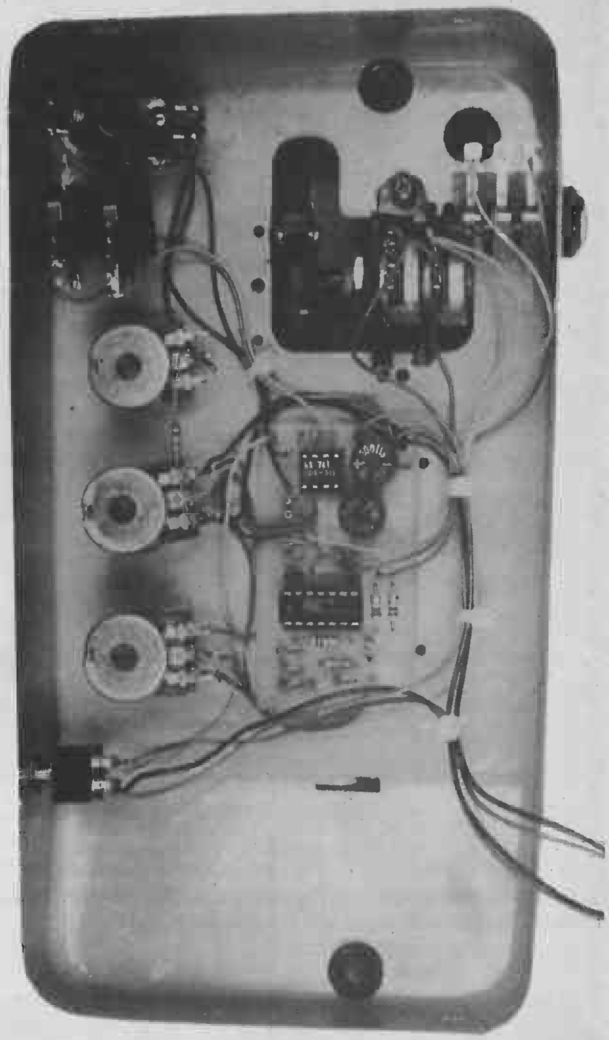


Fig. 2 Component overlay. Don't forget the insulated link between IC2 pin 2 and R16.



BUYLINES

The neat pedal that houses the Waa-Phase circuit is available from Sola Sound Ltd. The pedal gives a professional finish at just half the price of most commercial units. It comes pre-drilled to accept all the panel hardware and is priced at £7.48 including VAT. Order as WFS1.
Sola Sound Ltd,
Unit 6, Leto Works,
off Mead Road,
Edgware, Middlesex HA8 6NE
Telephone 01-952 9661/7989.

ETI

PARTS LIST

Resistors (all ¼W, 5%)	
R1	15k
R2,11	47k
R3,9	4k7
R4,5,6,7,8,10,12	10k
R13,14,15	100k
R16	220k
Potentiometers	
RV1	100k linear, dual gang
RV2	220k linear, dual gang
RV3	10k linear, dual gang
RV4	470k linear
Capacitors	
C1,2	10n ceramic
C3,4	100u 16 V electrolytic, PCB-mounting
Semiconductors	
IC1	LM348
IC2	741
Miscellaneous	
SW1	SPDT footswitch
SW2	DPDT miniature toggle

PP3 batteries (2 off), jack sockets (2 off), waa-waa pedal (see Buylines).

AUDIOPHILE

This month Ron Harris looks at (and listens to) a new tuner from those awfully nice Sony people. For moving coil buffs we have the MC30 and a couple of step-up transformers, and there's a mouth-watering sneak preview.

Before starting on what *is*, let us consider what shall be. Next month in ETI we are publishing an audio amplifier design for the home constructor. It is easily constructed and set up, has a preamp of comparable quality to ANY commercial unit and produces 150 W of good clean power into a *real* load.

Nothing too unusual there, you may say — typical ETI genius, you might add. However, there is one more little thing you ought to know before you turn the page, put the mag down, or pick up the knitting again. This amplifier is CLASS A. That's right — the one with all the heat!

Physically the System-A, as we're calling it, comes in four cases. Two mono power amps, a preamp with modular gain blocks and a PSU for the low-level modules. Future expansion plans include a two/four channel parametric equaliser for room correction, and a bridging module to allow two System-A power amps to be used per channel, with massive power gain.

As the preamp output impedance is low, long runs of screened cable to the power amps present no problem — thus the large black boxes can be hidden from the view of wives, interior designers, budgies — or anyone else who might fall over them.

The factor that makes the System-A so different is the quality of its sound output — it is truly outstanding. It lies firmly in the highest possible class and will better most amplifiers on sale today, regardless of price. If anyone out there is thinking of buying, building or stealing an amplifier of between 60 W and 120 W and costing between £100 and ∞ — wait. For the sake of your ears — wait!

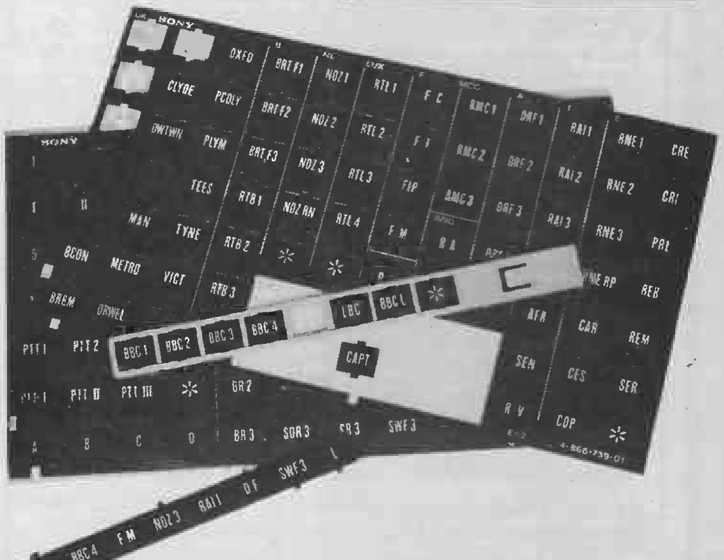
This is something *really* special and from now on will be the standard against which all else is judged. Don't miss out on this one — better to go deaf!

Sony ST-J75 Tuner

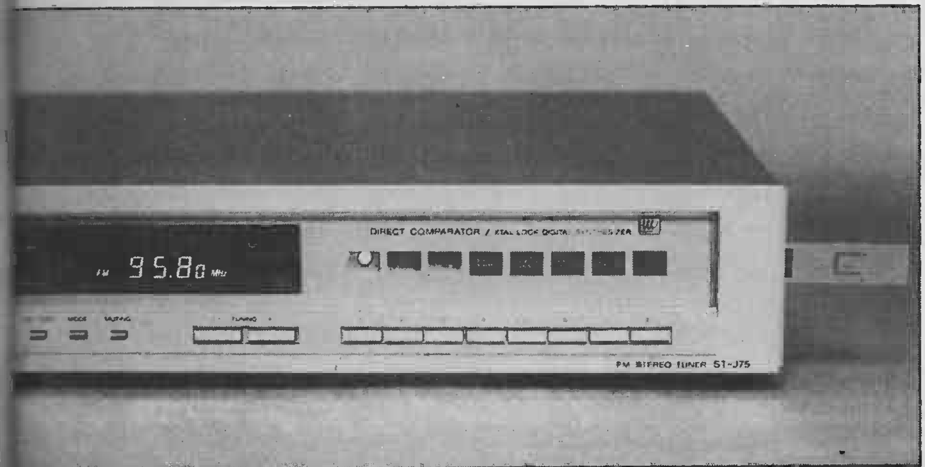
Alright, so I'm *doing* a tuner, now will you stop writing in asking what's happened to radio on these pages? The simple fact is that FM reception has changed but little in recent years. All the 'flagship' tuners comfortably exceed broadcast quality on most counts and differences between *well-designed* tuners are small compared to those encountered between other components in the hi-fi chain.

No doubt I shall now be castigated in some quarters (makes your eyes water that does, I can tell you) for that generalisation. You can annoy all of the people all of the time, but you can only please some of the people none of the time. Something like that anyway.

This new Sony model, I feel, is a significant step forward and as such deserves recognition. Technically it is a MOSFET design, using a phase locked loop (PLL) decoder and copious filtering to ensure good linearity and outstanding spurious rejection. The PLL uses a very high comparison frequency (50 kHz), eliminating the need for a prescaler in the divider circuitry. The signal-to-noise ratio benefits greatly from this, achieving a figure of 80 dB (stereo!). Other specs. can be obtained from Table 1. Note that this is an FM-only unit.



Above: the set of station labels provided with the ST-J75 tuner. Just about every radio outfit in Europe gets a mention here somewhere. Neat idea this.



Left: how those same labels are operated. The plastic slide is removed from the side of the front panel, and LEDs behind them provide the illumination. The space around the station frequency on the main display is utilised by a "program" counter which relays the information as to which part of the pre-set list the tuner has reached.

Digits Definitely

The ST-J75 is a true digital design. There is no tuning control in the conventional sense at all. Instead there are eight preset stations and up/down counter control of tuned frequency, plus muting and mode commands, so that when retuned weak stations reappear in mono with low muting level.

In addition there is a program control, which can be used in conjunction with the preset channels and an external timer to record from each of the stations in any predetermined order! This operates using the tuner's non-volatile memory to store a sequence and will 'clock along' each time the unit is re-energised by the timer unit. Clever, that.

The 'manual' tuning buttons will step the frequency by 0.05 MHz on each depression, or rapidly run up or down if held on. In addition a 'scan' facility will check all the presets in order. There are indicators for all the facility 'states', the mode switch doubling for mono or stereo. This is useful for low-level stations which are strong enough to push the tuner into stereo, but too weak to give a good signal-to-noise ratio.

A 'calibration tone' generator is included which produces a 400 Hz tone at a level roughly equal to that produced by the tuner at 40 kHz deviation. This is used for setting up a tape deck to record a program at some later time, say with a timer. After a couple of experiments it would be possible to get very good recordings this way, once the deck is calibrated to the tone level.

I made several recordings from Radio 3 this way and obtained fair results first time and superb results third time! (We won't talk about the second time — I forgot to switch the timer on!).

Test Bench

I've been getting very fed up with some hi-fi recently. There is little point in spending my Sundays crouched in front of a bank of winking instruments, like some latter-day Quasimodo, if at the end of it all the blasted equipment exceeds spec. on all counts. Where are the drop-outs and deviations of old? Wither now the smoking ruins of output stages wrecked by 2uF at 10 kHz?

No wonder reviewers are spending a great deal of time and effort devising new tests — they're hoping something will FAIL! Note the capitals. Articles are more *fun* when things go wrong. Perfection can get a little boring, after all. Still, if I must. . .

The Sony ST-J75 acquitted itself impeccably under test and exceeded its specifications on all bar two counts. Differences in measurement techniques would account for those.

Damn it.

A Capital Sound?

On then to the living room, armed with yards of co-ax and phono leads. As I mentioned earlier I experimented with the program function and found it more useful than expected; it would be ideal for recording a series of concerts, for example.

The muting levels proved sensibly set, with the more vicious setting removing all but the strongest stereo signals. Tuning is precise and simple and no problems were encountered in use. After this, going back to a mere tuning knob would be like getting out of a Rolls and riding home on a bike!

The sound quality of the tuner is revealingly good. It carries an 'openness' to it that I have not heard before. Providing the programme is up to it, of course, the ST-J75 is capable of making sweet music indeed. When replaying live concerts the ambience of the hall was nicely apparent and the sound had none of the sense of restricted range which can beset lesser units at times. If only records sounded this good, there would be no need for digital recordings! Comparing it to my present reference — a Pioneer TX 9500 II — the Sony was shown to have a smoother response with greatly improved mid-range rendition.

Concluding Lines

At a typical retail price of under £200 (just) the ST-J75 is intended for the audiophile. However, judged against the facilities and sound quality, that price cannot be called less than good value. Anyone making off-air recordings would value the Sony highly.

Overall it produced better results from FM than any other tuner I have heard to date.

Table One — Test Results ST-J75

Tuning range:	87.5 MHz — 108 MHz
Sensitivity (26 dB quieting):	1.4 uV
Signal-to-noise ratio:	80 dB (stereo); 88 dB (mono)
THD (1 kHz):	0.05% (stereo); 0.02% (mono)
IM Distortion:	0.03% (stereo); 0.02% (mono)
Frequency response:	30 Hz-15 kHz ±0.5 dB
Channel separation (1 kHz):	57 dB
Output level:	763 mV into 600R
Capture ratio:	1.2 dB
Image rejection:	100 dB
AM rejection:	68 dB
Price:	£199 (typical)

Left: gold in colour and high in price. Ortofon MC30 moving coil transducer. To boldly go where no coils have moved before?

MC30/T-30 — At Last!

After having been postponed for a month, the Ortofon MC30 makes its cantilevered way into ETIprint. The recommended step-up device for this low-output moving coil is the T-30 and I'll be taking a look at that, too.

Both these items are priced at over £200 and are strictly for the high of fi and low on money worries. However, they incorporate sufficient ingenuity as to render them highly interesting to read about (I hope).

As an interesting comparison to the T-30 I managed — at the last moment — to include a comparison with a lower priced transformer, Mayware's new T-24 II device. Unfortunately this was too last moment to get a full lab test, but I did manage to verify frequency response and gain some indication of phase shift. At £69 it makes an interesting alternative.

Ortofon Principles

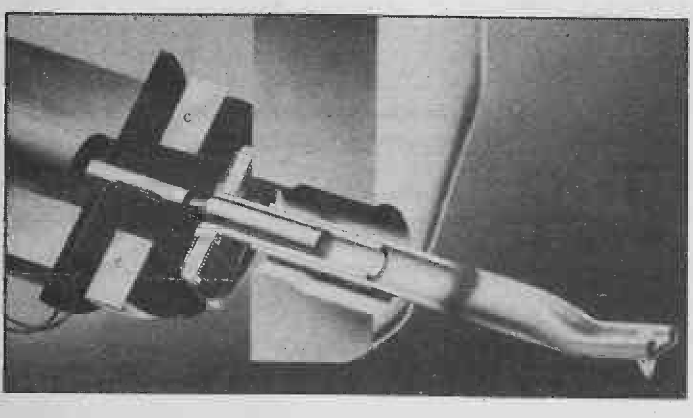
Of the many refinements contained in the MC30 design, perhaps the most interesting is the damping system. The cutaway (below) gives an idea of the complexity involved.

The system purports to optimise, across the entire audio band, the damping applied to the cantilever. At low frequencies the platinum disc will 'decouple' the two sections allowing for effectively reduced mass and improved tracking. Neat and effective — the MC30 is the best tracking moving coil cartridge I've encountered.

The cantilever is composed of an aluminium alloy which has low mass and great rigidity. The stylus is a 'fine line' design of low tip mass (0.4 mg) which helps extend the high frequency tracking capabilities.

In addition the coils themselves are wound with very small cross-section wire. Each 'layer' contains only 20 turns of wire. Each MC30 is individually tested and calibrated and the results are provided to the purchaser — as are a test record and headshell.

One drawback of the 'small coils' approach is that the MC30 has a lower output than is usual and thus requires greater gain in the step-up device used with it. This brings me nicely to the T-30, Ortofon's own required transformer.



Stepping Up To The Thirty

Transformers have fallen from grace as that with which to increase moving-coil signals — mainly due to the phase linearity problems inherent in poorly designed units. Solid state amps, such as Sony's excellent HA-55, offer a clean and extended response, albeit at a cost of some noise addition and PSU problems.

Transformers require no power supply and if the linearity problems can be overcome they offer a more elegant solution to the problem. Overcoming problems is generally expensive — and the T-30 is no exception to this! Let me say now, though, that its performance is practically beyond belief for a transformer, regardless of what it cost. Technical performance would do any amplifier proud.

Toroidal coils are employed and wound so as to reduce phase-shift overall. The gain/input impedance is switchable from 3R (32 dB gain) to 48R (20 dB gain), and a bypass position is provided for ease of comparison with moving-magnet designs. Gold-plated connectors are used throughout.

The two transformers under consideration in this months article. The Ortofon boasts that input switching and a bypass facility. The Mayware boasts a much lower price!

Technical Tests

Not twice in a month I don't. Full test results are given in the tables, and comparisons with the manufacturer's specs will reveal absolutely nothing! The T-30 has a better square wave performance than many amps I've tested and phase deviation was always within 12° (5 Hz-50 kHz) ie not worth worrying about.

The Mayware T-24 II was not given the full treatment — there wasn't time — but the tests I did came out very well indeed and boded well for the auditioning to come later.

Down To The Sound

Using a cartridge like the MC30 can be most disconcerting at first. Like all true hi-fi it adds little of itself to any material passed through it. This means that good records sound superb. It also means poor records sound rotten! Honesty is always preferable in the long run, and the MC30 scores highly on that count.

To avoid repeating superlatives I shall simply say that there is little, if anything, to criticise in the MC30 sound. It is neutral, clear and detailed. Bass response is firm and extended with no hint of boom. Treble is sharp without being hard and the mid-range beautifully defined. It is without doubt the best pick-up cartridge around, in my opinion, and will remain my point of reference for some time to come, I think.

Left: the inside story on the Ortofon wide range damping system. Note the size of the coils and the position of the platinum disc (marked "c") referred to in text. This is to decouple the system at low frequencies, being the cantilever mass.

If you are in the market for an ultra-fi cartridge don't miss the MC30 off your list. It may be fashionable to pay £500 for Oriental designs, but I fancy that £300 of that could be better employed. If the rest of your system is up to it, then this Ortofon will be money well spent.

Table Two — Test Results MC30

Compliance (vertical and horizontal):	13 x 10^{-6} cm/dyne (cu)
Output level (1 kHz, 5 cm):	0.08 mV
Stylus type:	'fine-line'
Separation (15 kHz):	22 dB
Frequency response (20 Hz-20 kHz):	±0.7 dB
Optimum tracking weight:	1.7 g
Weight:	7 g
Typical price:	£270

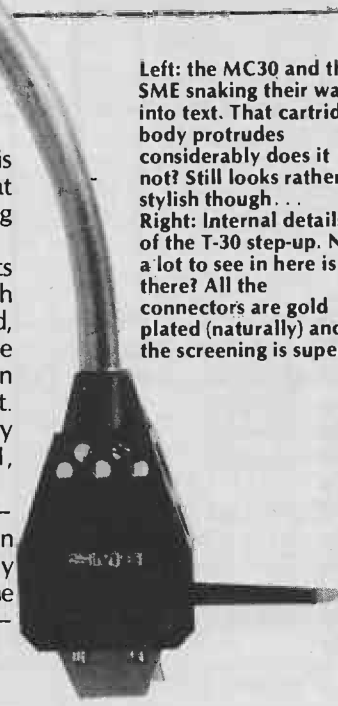
Transformer Changes

Experimenting with the two step-up devices proved interesting. Both had an improved clarity over a couple of (under £100) transistor head-amps I compared them to, with far fewer worries as to hum loops and signal-to-noise.

The T-30 has as brilliant an audible performance as it is technically perfect. It has the edge over most head-amps in that it demonstrates an improved attack and handles the leading edges of sounds much better.

The Mayware T-24 II proved to be excellent value for its £69 price tag. It clearly out-performed head-amps costing much more, especially in the mid-range. The bass is well controlled, although maybe not quite as extended as the T-30. The two were distinguishable on audition, mainly due to that difference in bass response, but not as much as the price tags would suggest. The T-24 has no switched inputs, but will match practically any cartridge. I tried with the MC30, a Coral MC81 and an Entre 1, good results being returned with all.

The two units cannot really be considered competitors — there is around £150 difference in their price! Within their own realms both are outstanding and the T-24 can be confidently recommended for those beginning to explore moving coils. The T-30 is for the more experienced — and the more pecunious — and will guarantee excellent results, albeit at a high price.



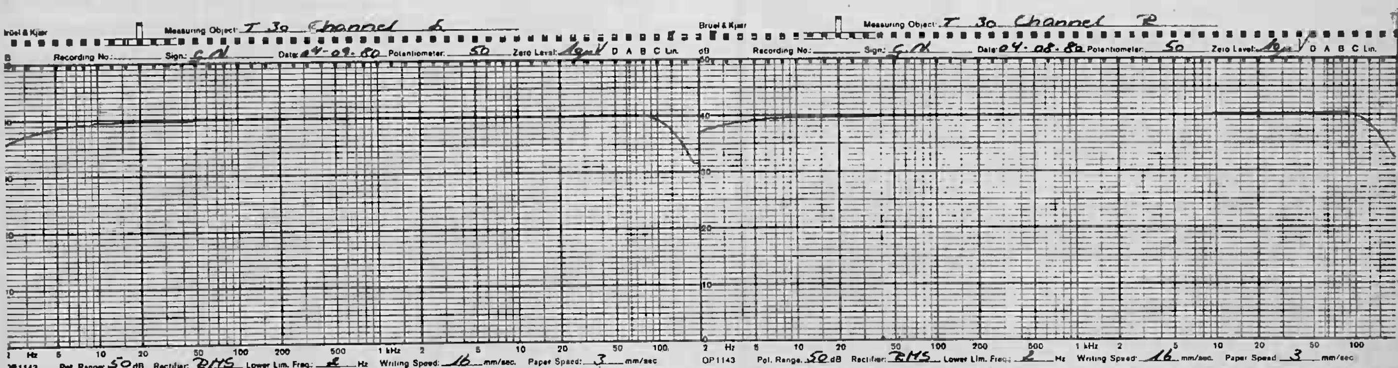
Left: the MC30 and the SME snaking their way into text. That cartridge body protrudes considerably does it not? Still looks rather stylish though...
Right: Internal details of the T-30 step-up. Not a lot to see in here is there? All the connectors are gold plated (naturally) and the screening is superb!

Table Three — Test Result T-30 and T-24 II

	T-30	T-24
Input impedance:	3-48R	—
Output impedance:	47k; 150pF	—
Frequency response:	5 Hz-100 kHz ±1 dB	20 Hz-20 kHz ±1.5 dB
Gain:	22 dB-33 dB dependent upon Z_i	—
Separation (1 kHz):	58 dB	55 dB
Phase linearity:	± 12° (5 Hz-50 kHz)	17° max
Balance:	within 1 dB	within 1 dB

Note: T-24 results are not as comprehensive due to time pressures. Within the audio band its performance was comparable to the T-30, if not quite equal in all respects.

Last months review of the Mayware MC-3L Cartridge gave the price as being around £53. It was wrong. Actual price will be £49-ish and I must confess that I have no idea where I got £53 from, now you mention it. Put it down to too much claret and I shall accept the slapped wrist as gracefully as I am able.



Above: frequency response of the T-30 transformer. It has absolutely no right to be able to perform like this — many amplifiers cannot do as well! ETI

READER'S DESIGNS

MICROCOMPUTER JOYSTICK CONTROLS

Video games have never been more popular, but many require the use of joystick controls. This A-to-D converter, submitted by I. Forster of Chelmsford, will provide such controls for any microcomputer using a 6502, and has many other applications.

This article describes a system for analogue-to-digital (A-to-D) conversion, originally intended to provide cheap and simple joystick controls for a Commodore PET computer. The system should work on any computer having a USER port, although the software necessary will probably be different to that used by the PET. The software is in 6502 machine code and can be merged with a BASIC program or used as a machine code subroutine.

Apart from joystick controls there are a number of other possibilities inherent in the principle. A few of these are described, although no practical results have been obtained with these circuits yet. The field is open for the experimenter!

There are a number of improvements possible, such as using both the X and Y registers in the 6502 as counters, giving 64K resolution on an input. Hardware improvements are also very definitely possible, although beyond a certain point it would probably be much cheaper to build a dedicated device.

Joystick Controls

The circuit for use with a joystick unit is shown in Fig. 1. Two of these are necessary, one for the X axis, one for the Y. The flow diagram for operation is shown in Fig. 2. X volts is the transfer voltage of one gate in the 4081BE. This is not very predictable and better results could be obtained using a Schmitt trigger of some kind, such as the op-amp circuit shown in Fig. 3 or a CMOS Schmitt gate. If C1 is increased, keeping the charging resistor constant, the time taken to reach X volts becomes larger. If C1 is made too large the counter (in this case the X register of the 6502) will overflow and count round.

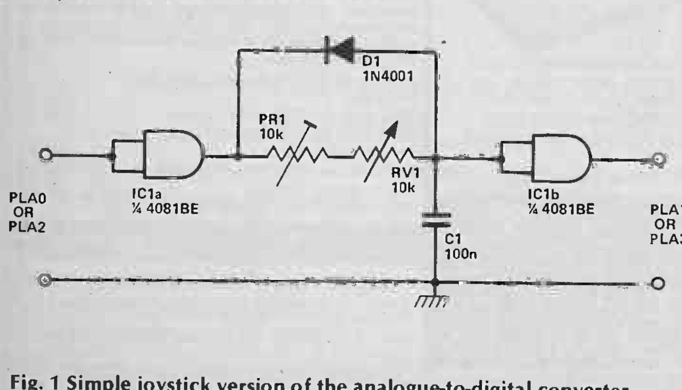


Fig. 1 Simple joystick version of the analogue-to-digital converter.

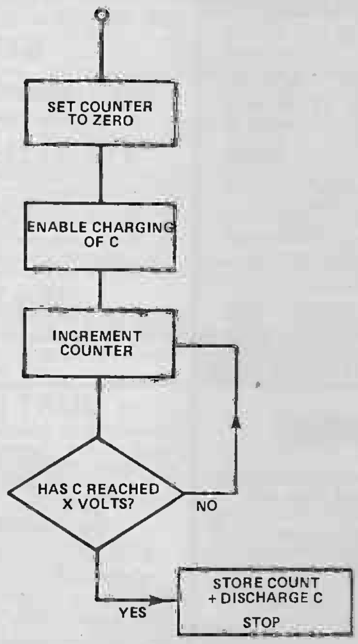


Fig. 2 Flow diagram for the ADC.

The software is disassembled Hex machine code, as shown below. It could be entered via the PET TIM monitor or as a data statement in a BASIC program. From BASIC it is called by SYS 826 and the values of the two conversions are stored in 1022(X) and 1023(Y); they can be retrieved by a PEEK instruction.

LOC'N	CODE	INSTRUCTION
033A	78	SEI
033B	A9 55	LDA ˙55
033D	8D 43 E8	STA E843
0340	A9 00	LDA ˙00
0342	8D 4F E8	STA E84F
0345	A9 01	LDA ˙01
0347	8D 4F E8	STA E84F
034A	A2 00	LDX ˙00
034C	E8	INX
034D	AD4F E8	LDA E84F
0350	C9 A3	CMP ˙A3
0352	D0 F8	BNE 034C
0354	A9 00	LDA ˙00
0356	8D 4F E8	STA E84F

```
0359  8E FE 03   STX 03FE
035C  E8         INX
035D  E0 FF      CPX *FF
035F  D0 FB      BNE 035C
0361  A9 55      LDA *55
0363  8D 43 E8   STA E843
0366  A9 00      LDA *00
0368  8D 4F E8   STA E84F
036B  A9 04      LDA *04
036D  8D 4F E8   STA E84F
0370  A2 00      LDX *00
0372  E8         INX
0373  AD4F E8    LDA E84F
0376  C9 AC      CMP *AC
0378  D0 F8      BNE 0372
037A  A9 00      LDA *00
037C  8D 4F E8   STA E84F
037F  8E FF 03   STX 03FF
0382  E8         INX
0383  E0 FF      CPX *FF
0385  D0 FB      BNE 0382
0387  58         CLI
0388  60         RTS
```

Simple Sums

The calculations involved are simple and are shown below: Fig. 1 refers.

Let X be the transfer voltage of IC1b — ie the voltage at which IC1b's output switches high. Then the time taken to get to X volts can be derived thus:-

$Q = C1.V$

where Q is charge
V is voltage

Also $Q = I.t$

where I is current
t is time

so $t = \dfrac{C1.V}{I}$

Since V = X (transfer voltage)

$t = \dfrac{C1.X}{I}$

But $I = \dfrac{V_{DD}}{R}$

where R depends on the setting of PR1 and RV1

So $t = \dfrac{C1.XR}{V_{DD}}$

C1, X, V_{DD} are constant and so t is proportional to R.

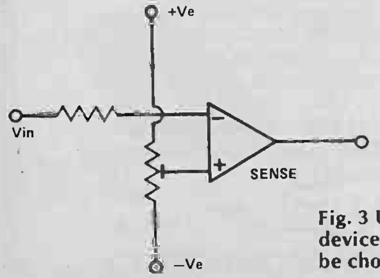
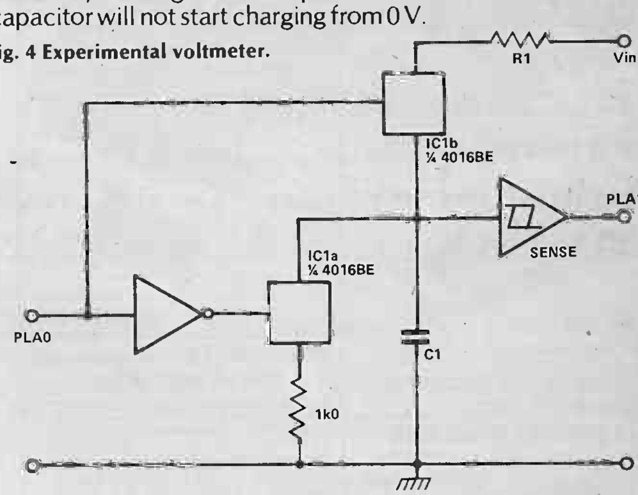


Fig. 3 Using an op-amp as the sensing device allows the transfer voltage to be chosen to suit.

Time And Again

Two other circuits are shown in Fig. 4 and Fig. 5 which use the principle of measuring the time taken to charge a capacitor. In both cases the symbol labelled 'sense' is a Schmitt trigger of some kind. The voltage across the analogue gates of the 4016BE should be less than the power supply to the chip. However, a simple op amp prescaler theoretically allows voltages up to the breakdown voltage of the resistors used to be measured. All the levels returned to the PET must be 5 V logic, so the 4016, inverter and sense output should all be 5 V logic. IC1b in Fig. 4 could be removed, although this complicates calculations because the capacitor will not start charging from 0 V.

Fig. 4 Experimental voltmeter.



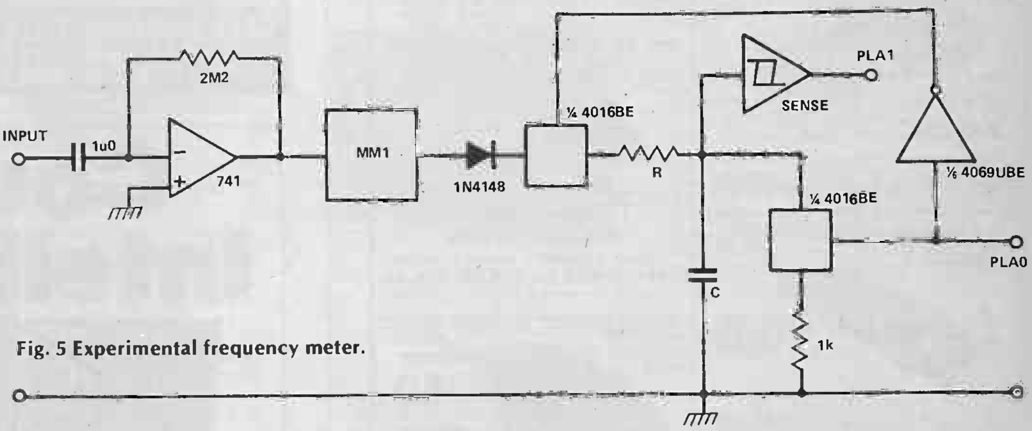


Fig. 5 Experimental frequency meter.

The circuit of Fig. 5 is designed as a frequency meter with a range of 0-100 kHz. The 741 produces a square wave of the same frequency as the input. MM1 is a positive-edge-triggered monostable with a period of 10 uS; its output is fed via a diode, analogue gate and resistor to charge the capacitor. The leakage of the capacitor could be very significant so care must be used in selecting the values of R and C as well as component types.

Current can be measured by using a virtual earth type circuit for an op-amp. With a 741 only about 10 mA can be measured since it can only sink a maximum of 20 mA. A resistive divider network or a power op amp could improve this.

Conclusion

The circuits described are fairly crude but could offer usable results to the amateur electronics experimenter. Expense is a major factor in most circuits, and most of these could be built for a few pounds. Of course, you need a computer! Beware of locking your machine into endless loops — this is harmless to the computer but very wearing on your nerves. If not already provided, setting up a way of using the NMI (non-maskable interrupt) on your processor might be advisable. Good luck! **ETI**

KIT REVIEW

If your car is tired, listless and has trouble starting, then this month's Kit Review is for you. We look at a small box that could make a big difference.

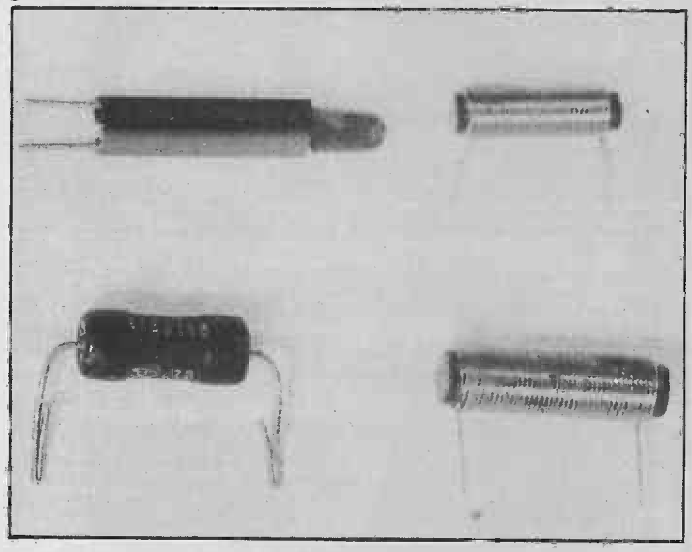
Electronic ignition systems are quite popular these days and there are a number of models to choose from, both ready-built and in kit form. This month Kit Review examines one of the latest systems, the Total Energy Discharge ignition kit from Electronize Design. This patented design has an impressive pedigree, being the result of over 10 years' experience with ignition systems, and is currently being sold under licence by a major accessory manufacturer as a ready-built unit.

Ordinary discharge systems produce a high power spark but the very short spark duration makes them incompatible with the weak air/fuel mixtures used for economy in modern cars. Inductive systems are cheaper and provide a low power, long duration spark to guarantee ignition of the fuel, but the actual firing point varies a great deal from cycle to cycle and reduces engine efficiency. Electronize claim that their Total Energy Discharge system with its very high power, medium duration spark, will ignite the weakest of mixtures with the minimum of timing delay. The unit will also cope with low battery voltage and fouled plugs, has an LED for static timing, and a built-in switch allows you to change back to the standard system in an emergency. It is only suitable for negative earth vehicles.

What You Get. . .

Well, it all sounds good but any kit stands or falls by what you actually get for your money. How does this one measure up? The kit arrives in a large plastic bag; the bigger items are loose and the smaller components are supplied in several smaller bags. Checking the components off against the parts list showed that everything was present and correct, and in this case 'everything' means just that, right down to the last nut, bolt and connector. There's even a length of solder and a tiny tube of heatsink compound for the power transistor. All you have to provide are the tools and the car.

The PCB is good quality fibreglass with tinned tracks, and the holes are all pre-drilled to the correct sizes. Everything mounts on the PCB, including the transformer, switch and power transformer, and there are lots of little touches showing that someone has actually been *thinking*. For example, there is a wirewound resistor that dissipates considerable heat and needs to be mounted clear of the PCB to allow air flow. Electronize don't just tell you that this is necessary — they've bent the resistor leads double and crimped them so that the component is automatically positioned at the right height above the board. The LED has to be 23 mm above the board and the leads aren't long enough so it's supplied with extension wires already soldered on; furthermore, you don't have to worry which lead is the cathode because colour-coded plastic sleeving has been fitted. The inductors are pre-wound with the enamelled copper wire glued to the formers, and the ends of the wire have had the enamel scraped off ready for soldering. This is the sort of attention to detail which separates the excellent kits from the merely good.



This is the way to supply kit components. The LED has colour-coded sleeving and the wirewound resistor is supplied with preformed leads so that it will mount at the correct height. The inductors are pre-wound, too.

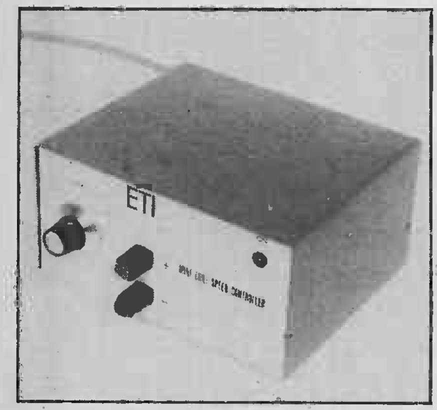
The instructions are of a similar high standard. First there is a short explanation of how to solder, which should prove adequate for most beginners, followed by the actual assembly instructions. One of my criteria for the 'perfect kit' is that the instructions should answer any question that might occur to a constructor; except for one instance mentioned later, Electronize appear to have managed this. The assembly sequence is explained almost component-by-component. Where orientation is important the reference markings are fully described; in the case of the transformer orientation is not important, and you are told so. Anything that a beginner might do wrong seems to have been anticipated and warned against.

. . . And What You Do With It

Having been suitably impressed, it was time to get out the soldering iron and get on with the construction. The markings or colour-code of every single component is given in the parts list,

Festoon yourself p.45

Solo shoot-out p.61



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FEATURES

PROJECTS

INFORMATION

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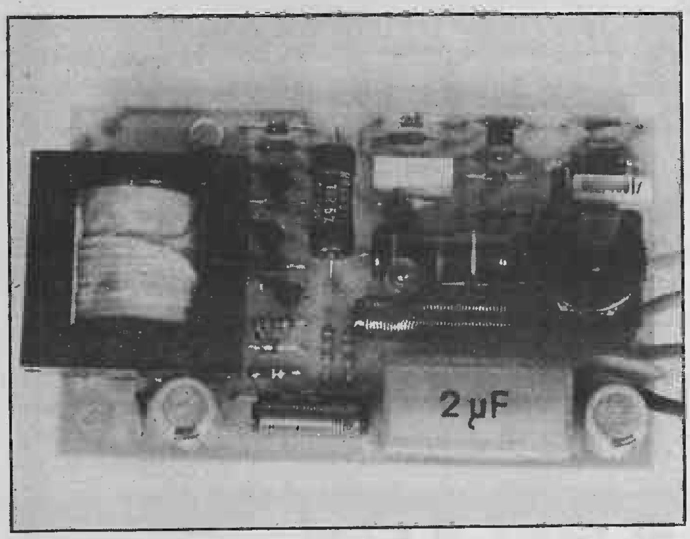
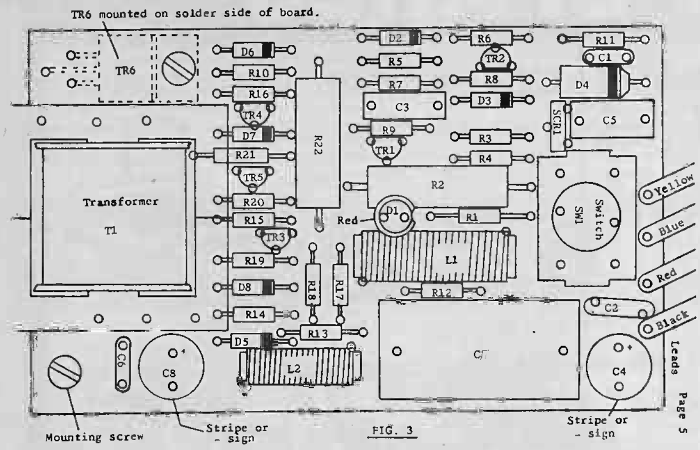


The completed board, ready to be fitted into the case.



This is a copy of the component overlay from the instruction sheet. As you can see, it's very easy to follow and shouldn't cause problems even if you're a beginner.

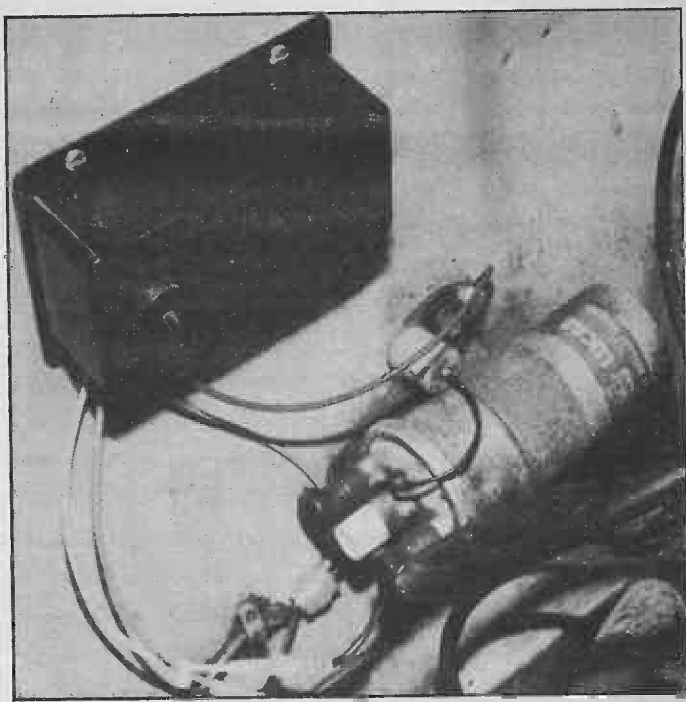
and for those items where, presumably, Electronize buy from several distributors, *all* the possible variations are listed. The overlay is very clear and easy to follow and assembly of the PCB was quite straightforward, except for a couple of points. The transformer and switch supplied in my kit were a very tight fit and I'd recommend that you test-fit these components prior to assembly in order to loosen up the holes. Second, when everything had been soldered in place there were several spare holes left on the PCB. Presumably the fact that some components may be supplied from a variety of sources means that the extra holes are to accommodate different case sizes — nevertheless, this could cause a few nagging doubts for some people and it ought to have been mentioned in the instructions. The sheer pettiness of these criticisms can probably be taken as a compliment to Electronize — but I have to find *something* to complain about or the more cynical amongst you will think the kit came wrapped in used fivers.

The completed PCB was lacquered on both sides as recommended in the instructions (engine compartments not being the kindest of environments), and fitted into the case when dry. One end of the board is secured by two bolts (one of these also holds the power transistor against the mounting plate, which doubles as a heatsink); the other end is supported once the switch is attached to the plastic case. Make sure the LED and switch are passing through their respective holes in the case as you tighten up the screws — a moment's carelessness on my part resulted in a cracking sound and great panic! No harm done, fortunately.

Kit Fitting

Not having a car of my own, I persuaded my father, trusting soul that he is, to let me fit the unit to his Ford Escort. This, too, was a simple procedure and showed once again that the designer of the kit is on the ball. The ¼" bosses around the fixing holes allow clearance for the PCB mounting hardware — but they also make it easier to fasten the flat mounting plate to curving bodywork. This is not an important point on the Escort, which has a flat area conveniently close to the ignition coil, but it could make life easier on other makes of car.

Once the case was fastened in place the electrical connections were completed — all the necessary connectors are supplied. The power supply connections are made using a 'tap-in' connector to the ignition coil supply and an earth tag to a convenient point on the chassis; the two remaining leads allow the contact-breaker side of the coil to be connected via the electronic ignition unit. That's all there is to it!



The finished unit fastened inside the engine compartment of a Ford Escort. Only four electrical connections are necessary to make the unit functional.

Judgement Day

The unit worked first time, and works well — since it was fitted the engine has started instantly on every occasion, so I'm still welcome at home. The static timing light is a useful bonus and made it easy to check that the engine is correctly adjusted.

To sum up, the kit is very impressive, with a smart finish, well-written instructions and a good performance. It is obvious that a lot of care and thought has gone into it and at £14.85 it represents excellent value for money. Highly recommended.

PETER GREEN

BUYLINES

Total Energy Discharge Electronic Ignition system £14.85 including VAT and postage and packing. Electronize Design, 2 Hillside Road, Four Oaks, Sutton Coldfield, West Midlands B74 4DQ.

ETI

LED JEWELLERY

Impress your girlfriends and test your building skills with these snazzy little flashing lights' jewellery projects. Design and development by Ray Marston.

The Star brooch, where Nature intended.

The three jewellery projects described in the following pages can be worn as brooches by women, as badges or belt buckles by men, or as either by the in-betweens. Ideal for use at parties and discos, all three projects produce highly attractive visual displays and make delightful presents.

The simplest of the projects has a four-LED display, is built on a single PCB and can be constructed in a hour or so. The second project has a 20-LED display, is built on a stacked pair of PCBs and should take several hours to build. The final project has a 25-LED two-colour display, is built on a stacked pair of PCBs and presents a real test of your constructional skills.

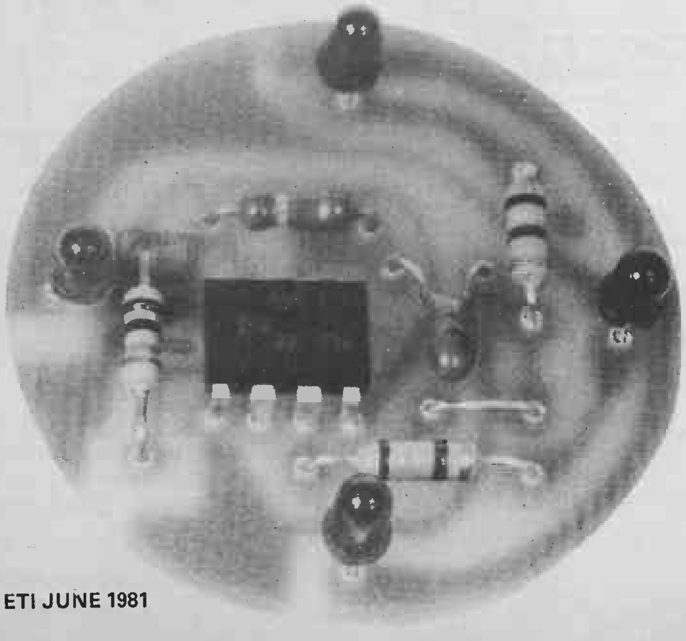
All three projects are designed to be powered by a PP3-type 9 V battery, hidden in the clothing of the user and connected to the jewellery by a pair of fine leads. The completed projects can be encapsulated in clear or tinted plastic resin and fixed in place with a clip bonded to the rear of the unit.

Cross Brooch

This simple little unit is built on a single circular PCB and has an overall diameter of 39 mm. The four-LED display is effectively arranged in the form of a crude cross and the circuit action is such that the vertical and horizontal bars turn on and off alternately, to produce an apparently moving display. The project requires a minimum of constructional skills and can be built in an hour or so.

Construction

The most difficult part of the construction of this unit relates to the manufacture of the actual PCB, which needs to be carefully filed to a round shape once the etching is complete.



When the PCB is ready, assemble the components as shown on the overlay, taking care to test the four LEDs before fitting them into place. Note that IC1 is soldered directly to the PCB, without the use of a socket. When assembly is complete, give the unit a functional check by connecting a 9 V battery (PP3 type).

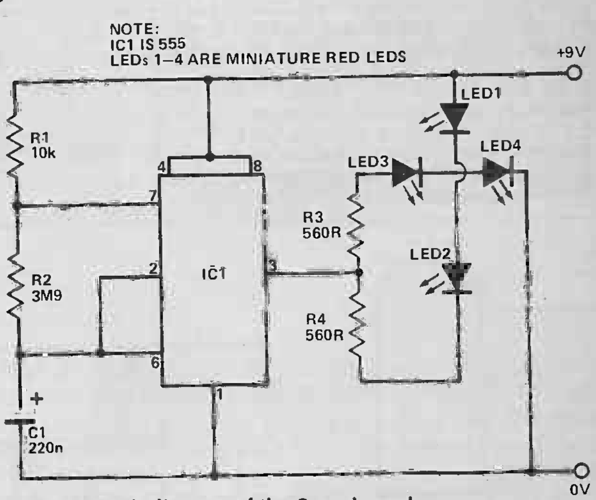


Fig. 1 Circuit diagram of the Cross brooch.

HOW IT WORKS

CROSS BROOCH

IC1 is a 555 chip, connected in the astable mode and oscillating at a rate of about 1 Hz. The output of IC1 (pin 3) is used to drive the four-LED display, which is arranged in the form of a cross. The four LEDs are effectively wired in series, with LEDs 1 and 2 and R4 in the 'upper' (vertical) half of the chain and LEDs 3 and 4 and R3 in the 'lower' (horizontal) half.

In each 555 operating cycle, when pin 3 of IC1 is low the lower half of the LED chain is shorted out and LEDs 1 and 2 illuminate via R4. When pin 3 of IC1 is high the upper half of the LED chain is shorted out and LEDs 3 and 4 illuminate via R3. The vertical and horizontal bars of the display are thus illuminated alternately.

→

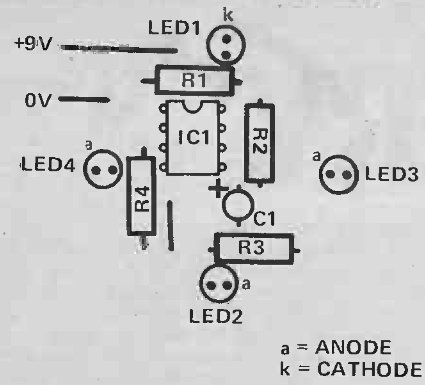


Fig. 2 Component overlay for the Cross brooch.

PARTS LIST

CROSS BROOCH	
Resistors (all ¼ W, 5%)	
R1	10k
R2	3M9
R3, 4	560R
Capacitors	
C1	220n 35 V tantalum
Semiconductors	
IC1	555
LED1-4	miniature red LEDs

Spiral Brooch

The display of this 20-LED piece of electronic jewellery takes the form of five concentric circles of LEDs, with four LEDs in each circle: the LEDs in adjacent circles are offset from one another to form four distinct spirals. The action of the display is such that the circles illuminate sequentially, from the centre outwards, until the outer circle illuminates. At this point the display blanks for one-sixth of a second and then the entire cycle repeats. The effect of all this is that the display seems to repeatedly expand and twist, with a cyclic rate of about 1 Hz.

Construction

This unit is built up of two PCBs, one being used for the display and the other for the main circuitry. When construction is complete the two boards are fixed together using four wire struts. A good deal of care is needed in the construction of this unit; a fair degree of constructional skill is required and the total building time may be several hours.

Start the construction by etching the two PCBs and then very carefully cut the two boards to size. Now drill all the necessary holes in the PCBs, using a 1 mm drill and noting that the four strut holes are located very close to the edges of each board.

Now proceed to solder the 20 LEDs on the display board, keeping the LEDs as close to the board as possible. Test each LED (using a 9 V battery and a 1k0 resistor) as soon as it is soldered into place.

Next, assemble the components on the main circuit board: Fit the wire link first, then the two resistors and two capacitors, then IC1, and finally IC2. Note that the two ICs are soldered directly to the PCB, without the use of sockets.

When construction is complete, interconnect the two boards noting that the display board connections are made to solder pads on the undersides of the PCB, and give the unit a functional check. If all is well, fix the two boards together (as close as possible) using tinned copper wire pushed through the strut holes and soldered into place. Note that the two PCBs are 'polarised' (a) by making the boards slightly non-symmetrical and (b) by the strut hole locations, to ensure correct alignment of the completed boards.

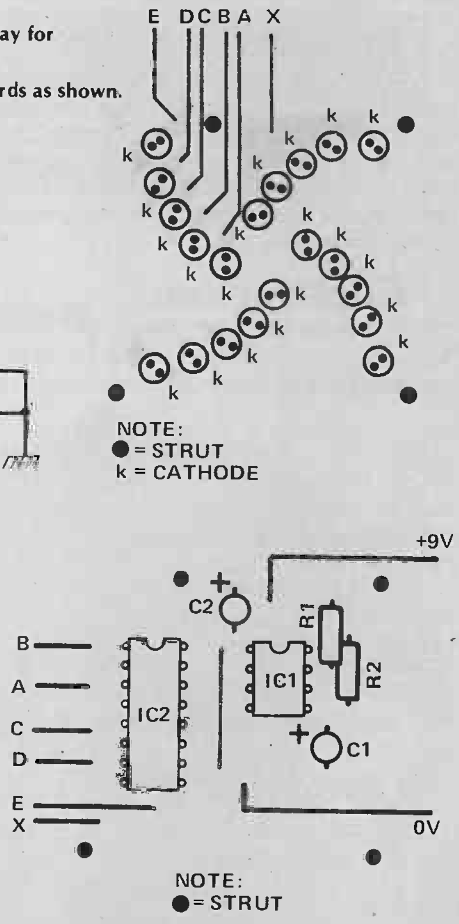


Fig. 4 Component overlay for the Spiral brooch.
This is built on two boards as shown.

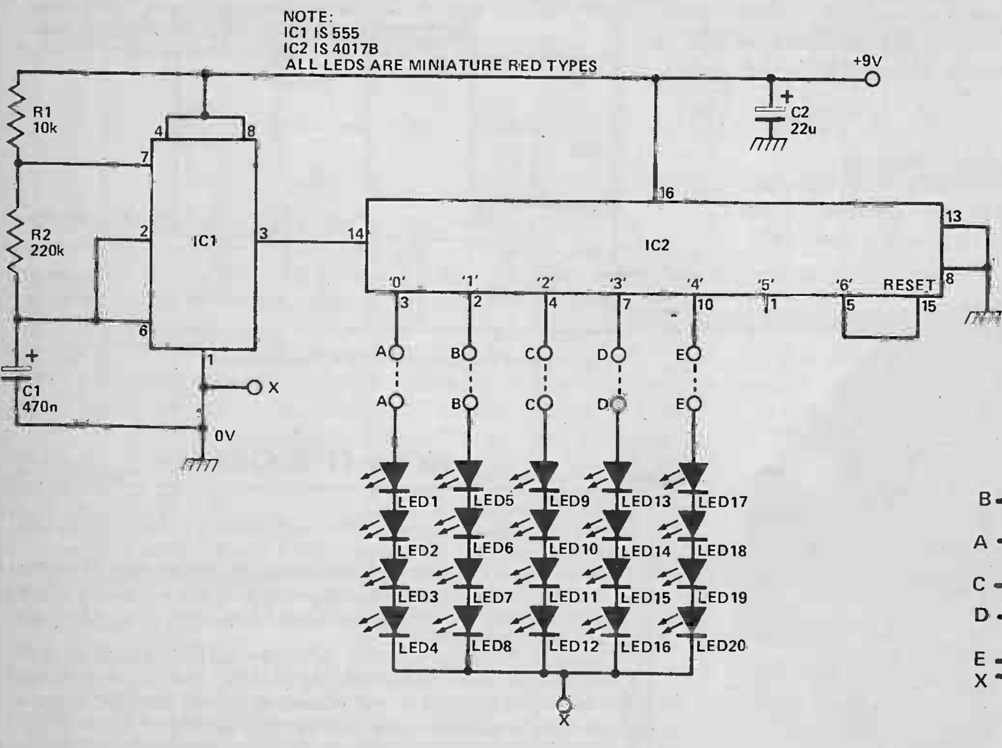


Fig. 3 Circuit diagram of the Spiral brooch.

PARTS LIST

SPIRAL BROOCH

Resistors (all ¼ W, 5%)	
R1	10k
R2	220k
Capacitors	
C1	470n 35 V tantalum
C2	22u 35 V tantalum
Semiconductors	
IC1	555
IC2	4017B
LED1-20	miniature red LEDs

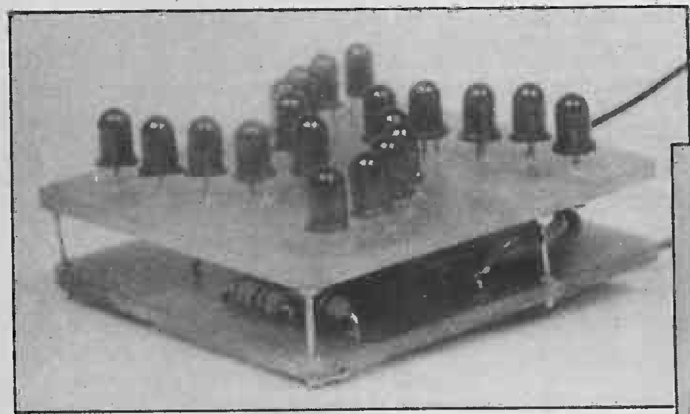
HOW IT WORKS

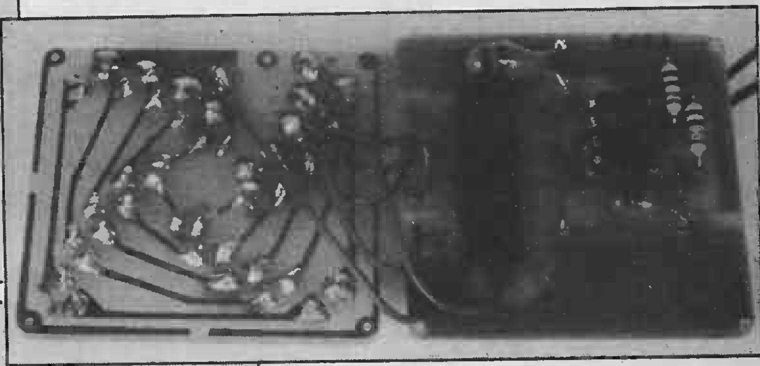
SPIRAL BROOCH

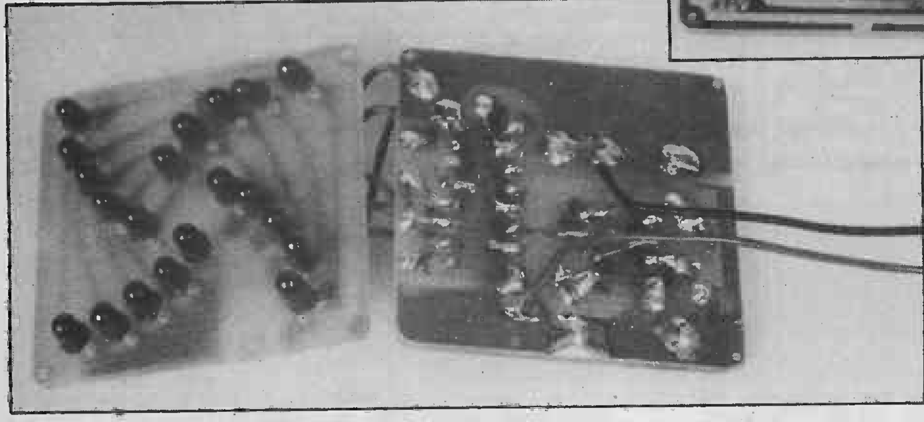
The electronic circuitry of this project is fairly simple. IC1 is a 555 chip, wired in the astable mode. This chip operates at a rate of about 6 Hz and feeds clock pulses to the input of IC2, a 4017B counter/decoder. The outputs of IC2 go high sequentially on the arrival of each new clock pulse.

The first five outputs of the 4017 are each used to drive a chain of four series-connected LEDs. Thus, on the arrival of the first five clock pulses in each sequence the chains of LEDs illuminate sequentially. On the arrival of the sixth pulse, no LEDs are illuminated. On the arrival of the next pulse pin 5 of IC2 goes momentarily high and resets the counter. This causes the '0' decoded output to go high, thereby initiating a new sequence of operations.

In practice, the LEDs of the display unit are arranged in the form of five concentric circles of LEDs, with four LEDs in each circle and with the LEDs in adjacent circles slightly offset from one another, to form four distinct spirals. Consequently, the display produces the expanding, twisting 'spiral' motion already described in the text.







These three photographs show the constructional details of the Spiral brooch. Two PCBs are used, with the LEDs soldered to one board and the remaining components on the other. The six interconnections are made by soldering wires directly to the copper tracks on the display board, then the boards are fastened together with short lengths of tinned copper wire. For compactness the capacitors are bent over sideways.

Star Brooch

The display in this 25-LED two-colour project is arranged in the form of a five-armed star (see circuit diagram), with four red LEDs in each arm, and with a single green LED placed between each pair of arms. The display is activated in a 10-step two-speed sequence. In the first five steps of the sequence, the five red arms of the star are sequentially switched on and off at a fairly slow rate, with the lower left arm turning on first and the lower right arm last. This action is followed by a rapid five-step sequence in which the three green 'G' LEDs turn on first, followed alternatively by red arms 'D', 'C' and 'B', with the three green 'F' LEDs turning on last. The sequence is then complete and immediately repeats, taking roughly 5 s to complete each 10-step sequence.

Construction

This unit is built up on two PCBs, one being used for the display and the other for the main circuitry. The construction of the unit needs much care and a fairly high degree of constructional skill.

Start the construction by etching the two PCBs and then carefully cut and file the boards to size. Now drill all necessary holes in the PCBs, using a 1 mm drill, noting that the unused holes shown in the photographs of our prototype display board are, in fact, erroneous.

Now proceed with the assembly of the 25 LEDs on the display board, keeping the LEDs as close to the board as possible. Once again test each LED (using a 9 V battery and 1k0 series resistor) as soon as it is soldered into place.

Next, assemble the components on the main circuit board. Fit the wire link first, then the resistors, capacitors, diodes and the three small transistors. Finally, solder IC1 and IC2 into place directly on the PCB.

When construction is complete, interconnect the two boards noting that the display board connections are made to solder pads on the underside of the PCB, and paying particular attention to the final orientation (top-to-top) of the two boards. Then give the unit a functional check. If all is well, fix the two boards together (as close as possible) using an epoxy resin adhesive, taking care to ensure that the boards are correctly aligned.

Finishing Off

Each of the completed brooches can be encapsulated in plastic resin (see Buylines), and fixed in place with a brooch clip bonded to the rear of the unit. Connections to the concealed battery can be made unobtrusively via a sub-miniature plug and socket of the type used for radio control servos.

BUYLINES

Absolutely no problems here, as all components are readily available types. It is important to note, however, that all LEDs used in these projects must be good quality (low ON voltage) types: so-called 'bargain pack' LEDs must *not* be used.

The plastic resin for encapsulating the finished PCBs is sold as Plasticraft kits, which should be available from your local arts and crafts centre.

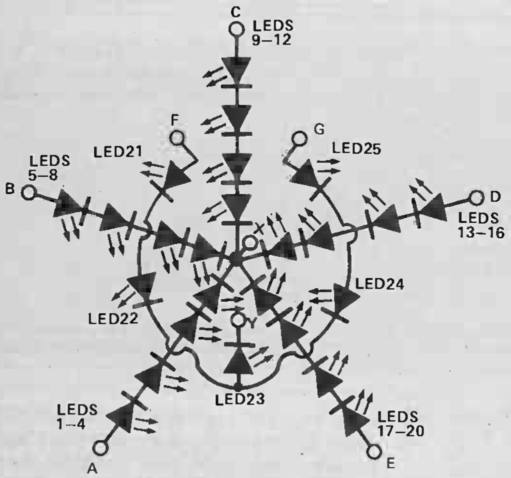
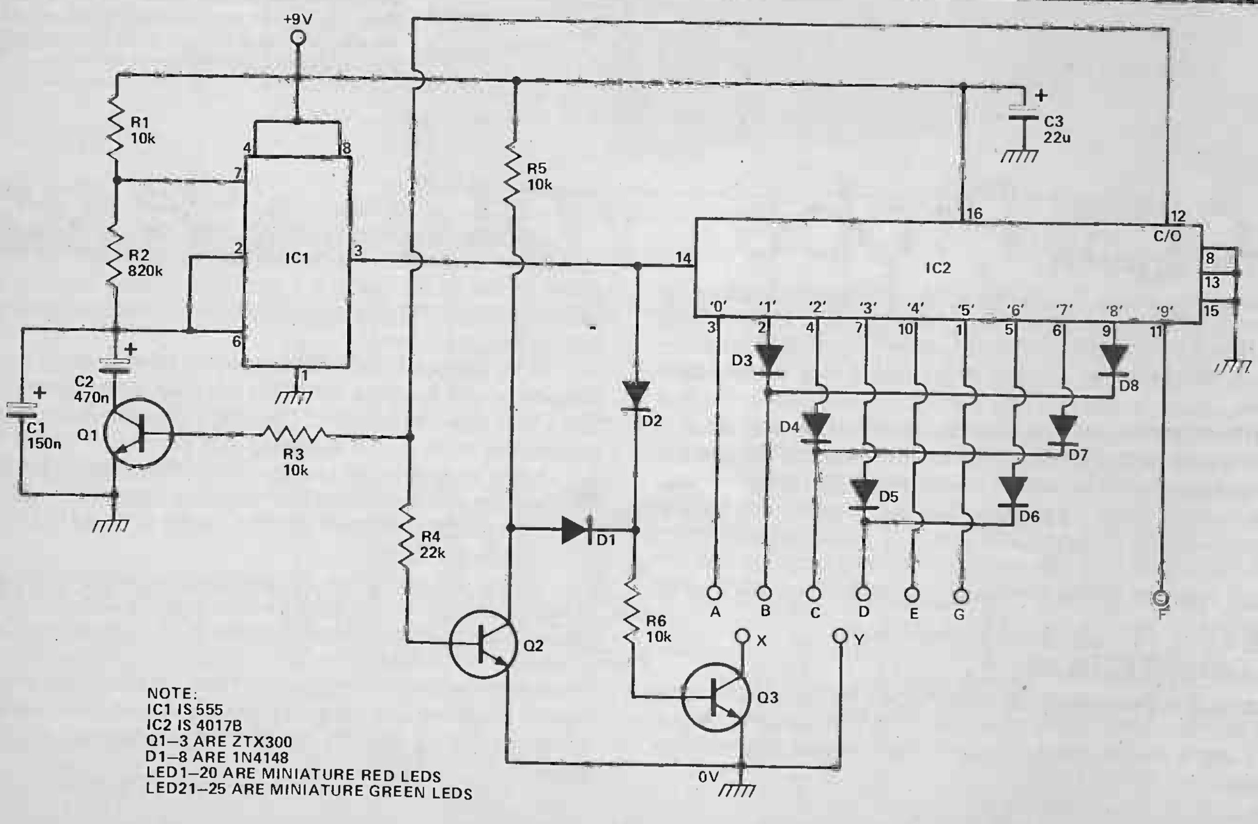


Fig. 5 Circuit diagram of the Star brooch, showing the display (above) and the drive circuitry (below).



HOW IT WORKS

STAR BROOCH

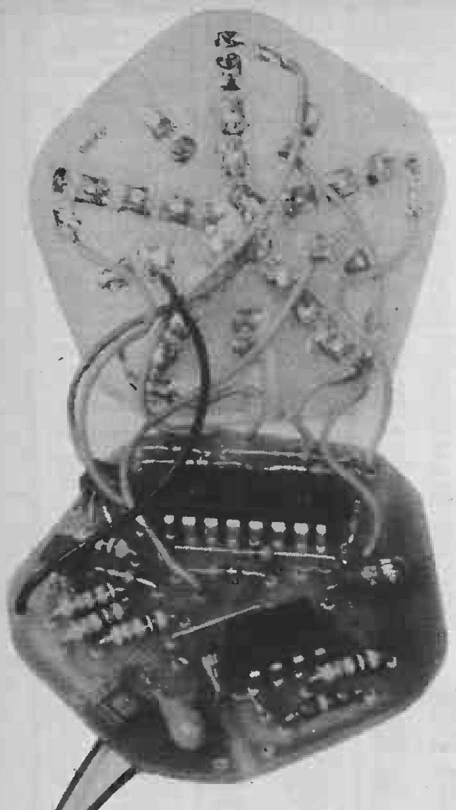
The circuitry of this piece of electronic jewellery is moderately complex. Here, IC1 is a 555 astable and feeds clock pulses to the input of IC2, a 4017B counter decoder which is wired in the divide-by-ten mode. The carry out terminal of this chip (pin 12) is high for the first five clock pulses of each 10-pulse cycle and is used, in our application, to control the speed of IC1 and the logic drive to the 25-LED display.

Thus, at the start of each operating sequence the high CO output of IC2 drives Q1 on and makes the IC1 astable operate at a slow rate, with a period determined by the combined values of C1 and C2. In the first five clock cycles outputs 'A' to 'E' of IC2 are driven high one after the other and the respective LED display arms are activated for half a clock cycle each by D2 and Q3. On the arrival of the next clock pulse the CO output of IC2 goes low, so Q1 turns off and IC1 operates at a rapid rate, with a period determined by C1 only. Simultaneously, Q3 is turned fully on via R5-D1-R6. Consequently, in the final five steps of the 10-step cycle, outputs 'G', 'D', 'C', 'B' and 'F' are rapidly sequenced on and off for one full clock cycle each. The cycle is then complete and repeats ad infinitum.

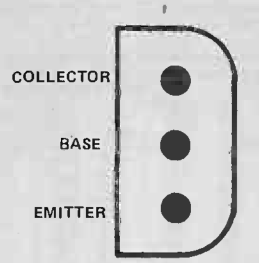
PARTS LIST

STAR BROOCH

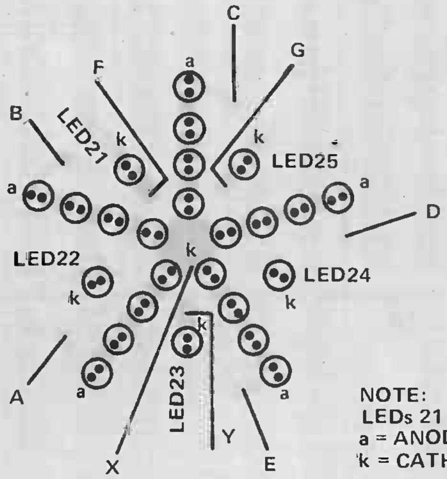
Resistors (all ¼W, 5%)	
R1,3,5,6	10k
R2	820k
R4	22k
Capacitors	
C1	150n 35 V tantalum
C2	470n 35 V tantalum
C3	22u 35V tantalum
Semiconductors	
IC1	555
IC2	4017B
Q1,2,3	ZTX300
D1-8	1N4148
LED1-20	miniature red LEDs
LED21-25	miniature green LEDs



The Star brooch with all the interwiring completed and ready for encapsulation.



ZTX300 CONNECTIONS (FROM BELOW)



NOTE:
LEDs 21 TO 25 ARE GREEN
a = ANODE
k = CATHODE

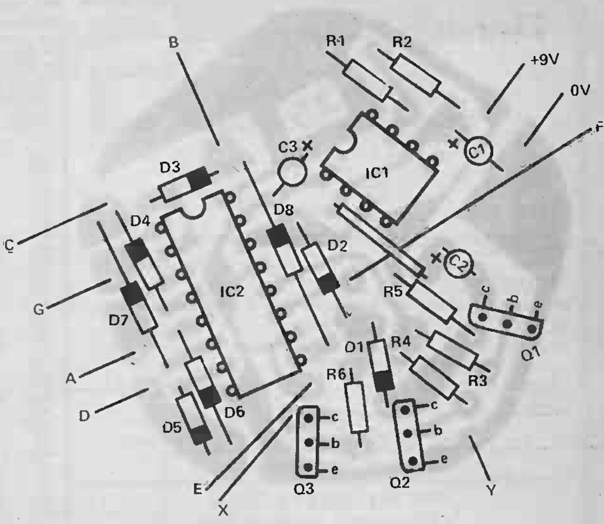
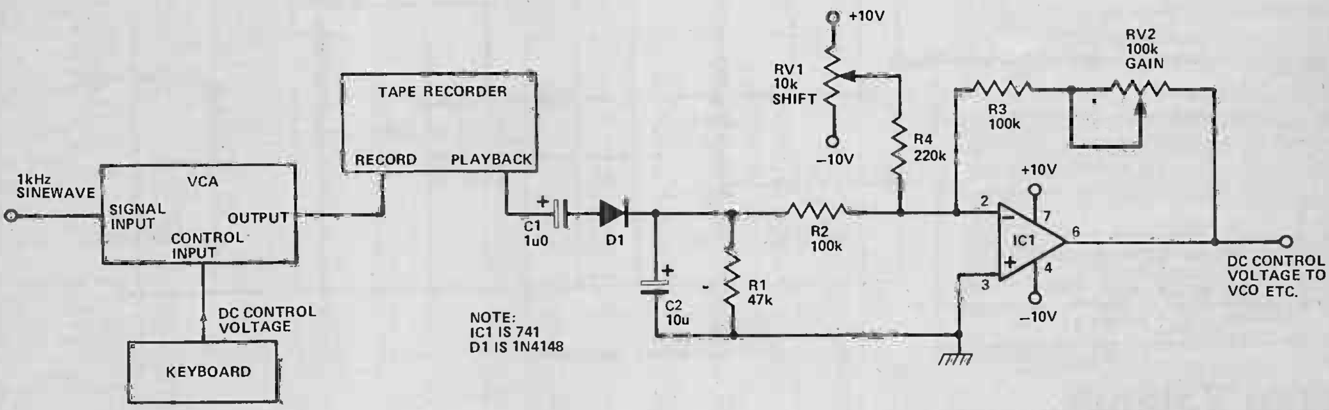


Fig. 6 Component overlay for both the boards of the Star brooch. The PCBs have an unusual shape so take extra care to orientate the polarised components correctly.

ETI

TECH TIPS SPECIAL



Magnetic Tape Sequencer

P. Hill, Chelmsford

The following circuit enables a synthesiser sequencer to be constructed using a tape recorder as the storage device for the control signals. A 1 kHz sinewave is amplitude-modulated by the DC control voltage from a keyboard, for example, using a voltage-controlled amplifier. The output of the VCA is connected to a tape recorder and recorded.

On playback, C1 couples the AM signal to an AM demodulator comprising D1, R1 and C2. The demodulated signal is a replica of the original control voltage and is passed to the buffer built around IC1, an op-amp wired in the inverting mode. The output is fed to the control input of a VCO, etc.

RV1 applies a DC shift to the output and can be used to vary the frequency range of the VCO. RV2 varies the gain and can be used to adjust the frequency/voltage law of the sequencer.

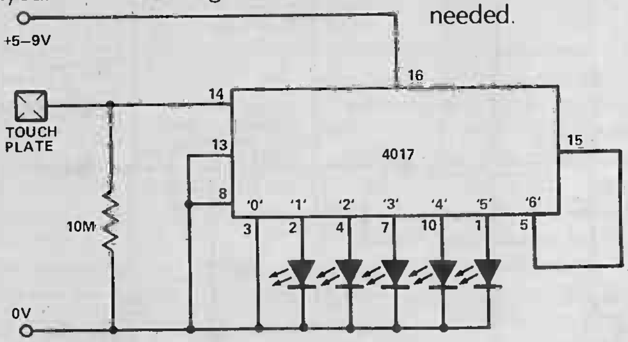
One IC Dice

P. Heap, Cambridge

This must surely be the simplest possible electronic dice; it uses one IC, one resistor and six LEDs. Operation of the circuit is as follows. Normally the resistor keeps the input to the 4017 low and one LED is illuminated. When the plate is touched, mains hum is injected into the circuit by the finger. These input pulses are counted by the 4017, making the LEDs flash too quickly to see the number displayed. When the finger is removed the 4017 stops counting and a steady display is obtained.

This principle has other applications: it could be used to clock a binary counter or applied to a gate, and used to provide a general-purpose 50 Hz clock. If the resistor is removed and the touch plate made large enough, sufficient hum is picked up to cause the circuit to count on its own.

The outputs of the 4017 could easily be decoded, using a diode matrix, to produce a proper dice display. However, this increases circuit complexity and extra driver transistors would probably be needed.



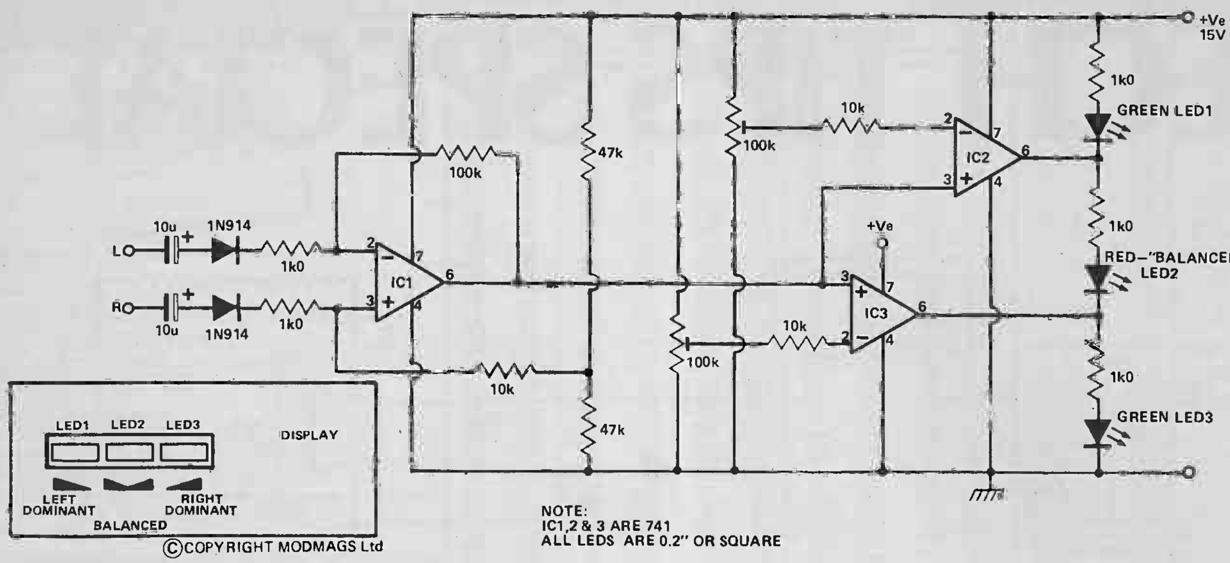
Triton Tape Modification

D.E. Buchan, Bristol

I have found that the major problem with tape load on the Triton is that the filter can exhibit different phase responses with time, so that a program loaded one day would need several attempts the next day to get a good load. After the modification the load rate was 100%. The modification involves changing the filter from a narrow band-pass filter, centred around 400 Hz, to a band-pass amplifier with a bandwidth of about 3 kHz from 400 Hz to 3.4 kHz (the telephone system bandwidth).

The changes required are as follows: C28 and C31 are changed to 47n ceramic, C29 is removed from the board, and a 47n ceramic capacitor is connected between the collector of Q3 and +5 V. R39 (4k7) may have to be changed to reduce sensitivity (eg 12k).

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.



Stereo Balance Meter

G. Durant, Selby

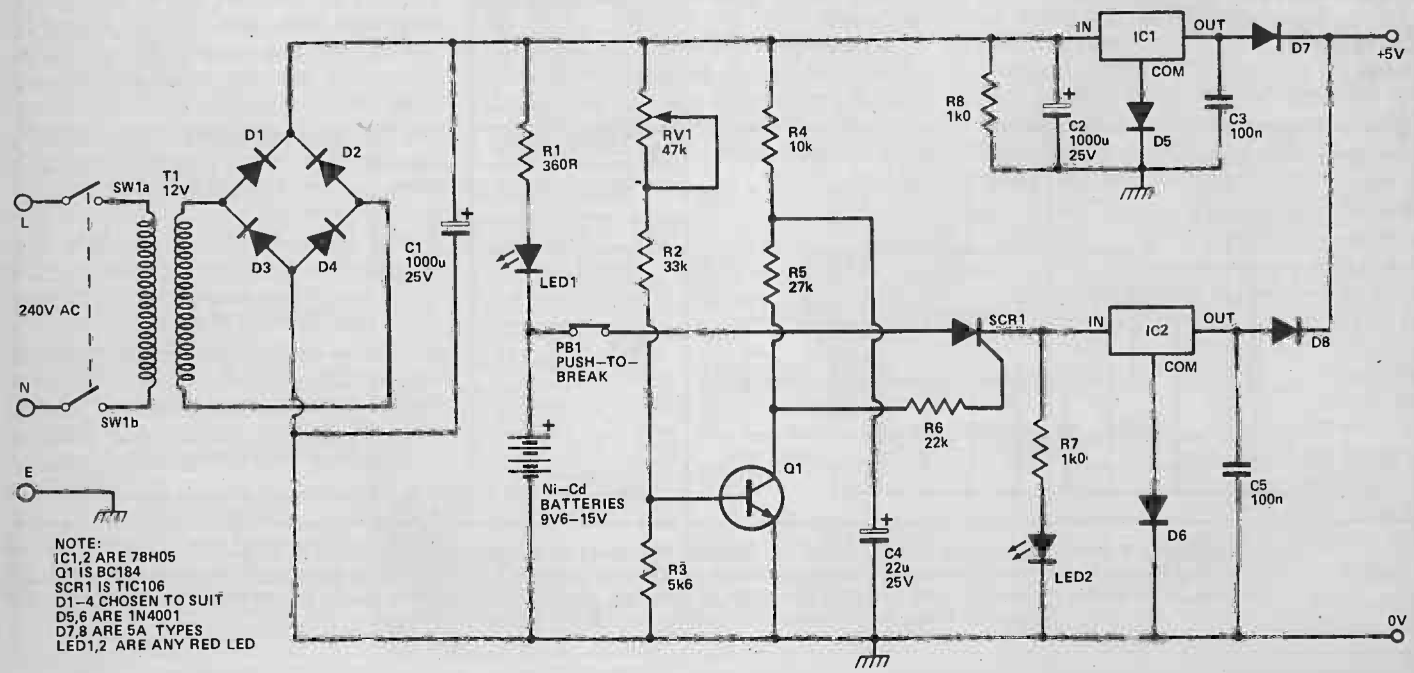
Balance on a stereo amplifier is usually set by ear, but this of course can be very difficult to judge. If an amplifier has a balance meter at all, it is usually of the centre-zero moving coil type — bulky, old-fashioned looking and expensive. This circuit is designed to overcome all of these problems.

The outputs from each channel are fed to the two inputs of IC1, this being connected as a differential amplifer. If the left and right channels are of equal levels, the output of IC1 will have its output at about halfway between the supply rails. If the left channel gets above the level of the right channel, the output of IC1 will approach the 0 V rail. If the right channel is loudest, the output becomes positive.

IC2 and 3 are also differential amplifiers, but in this case they are driven by the output of IC1. LEDs form a display at the outputs of the two ICs. Pin 2 of ICs 2 and 3 each go to a preset across the supply. In practice, the preset in conjunction with IC2 is set to hold pin 2 slightly above 0 V and the preset connected to IC3 is set to hold pin 2 just below supply voltage. These settings, however, must be set by trial and error so that the circuit works accurately.

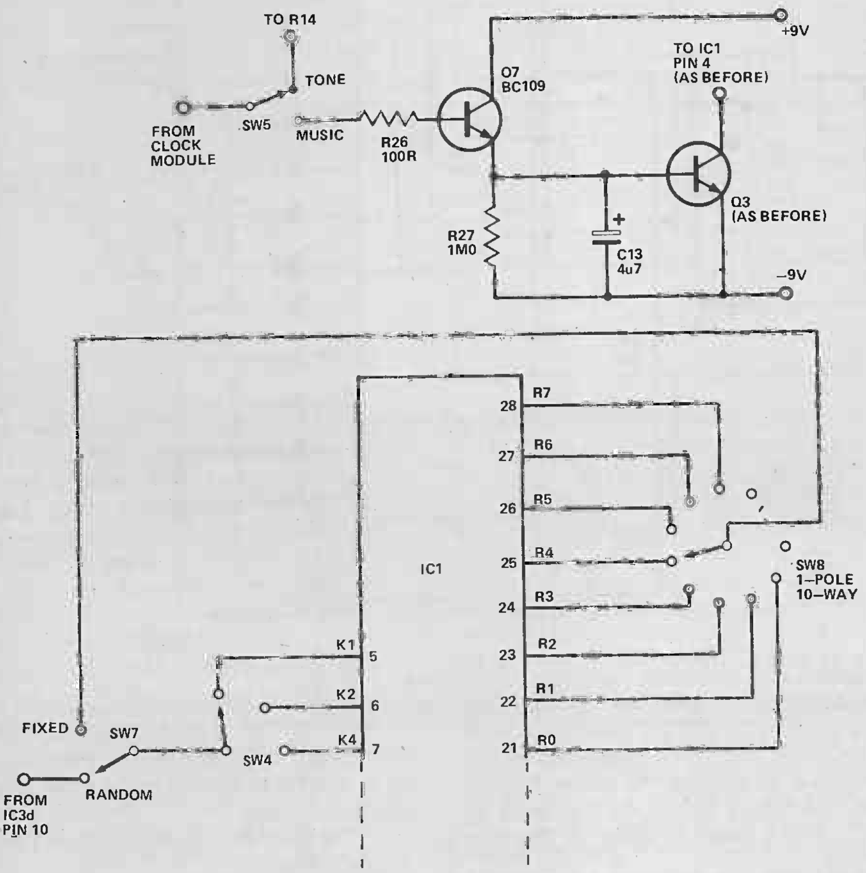
The output of IC1 is connected to the non-inverting inputs of IC2 and 3. If the output of IC1 approaches the supply rail, the outputs of ICs 2 and 3 will also go high, thus illuminating LED 3. This would happen if the right channel were dominating. If the left channel were dominant, the outputs of ICs 2 and 3 would be low, thus illuminating LED 1. If the two channels were equal in amplitude, the outputs of ICs 2 and 3 would be high and low respectively, lighting up LED 2.

The circuit can easily be added on to a ready constructed unit without using up large amounts of panel space, or used as a add-on unit for a hi-fi system. The unit draws about 20 mA, so battery operation is practical.



Alarm Clock Modifications

M. Rogers, Swansea



Here are some modifications to the ETI Musical Alarm Clock which make it even more versatile. The first enables an ordinary LCD alarm watch module to be used in the design, allowing the constructor to choose exactly which functions he requires, depending on the watch bought (eg day/date, snooze alarm, chronograph etc). The module is easily removed from the case once the back has been taken off — fine wire is soldered to the circuit board and switch plates to connect the module to the remainder of the circuit.

The first diagram shows the changes necessary to allow the musical chip to be continuously enabled by the pulsed alarm tone from the watch module. The alarm output is taken from the most positive of the small springs on the module when in the alarm condition. C13 may need to be increased if a watch unit with a long on-off bleep time is used. R12 and R13 in the original circuit are not needed and Q3 can be left on the PCB. Some constructors may feel that the decrease in display size is easily offset by the approximate halving of the cost of the clock.

The second modification allows you to select which tune is played by the chip, either in alarm or test mode. This is useful if you want a favourite tune played, or if you simply want to hear all the available tunes without waiting for them to be played randomly. There is enough room on the PCB for the pads for R_0 to R_7; if the board has already been etched then flying leads can be taken from the IC socket pins directly.

Computer PSU Back-up

E. Williams, Helston

One of the problems of running a microcomputer without auto-battery back-up is that, if the mains fails (usually after entering a long program), you lose the lot and have to re-enter it from the start. It only takes the 5 V supply to disappear for a few microseconds for the damage to be done.

After being caught once (and once was enough), I designed the supply shown here.

At switch-on the full-wave rectifier (D1-4) supplies regulator IC1, which gives 5 V after steering diode D7. D5 raises the output of IC1 to compensate for the drop across D7 (as does D6 for D8).

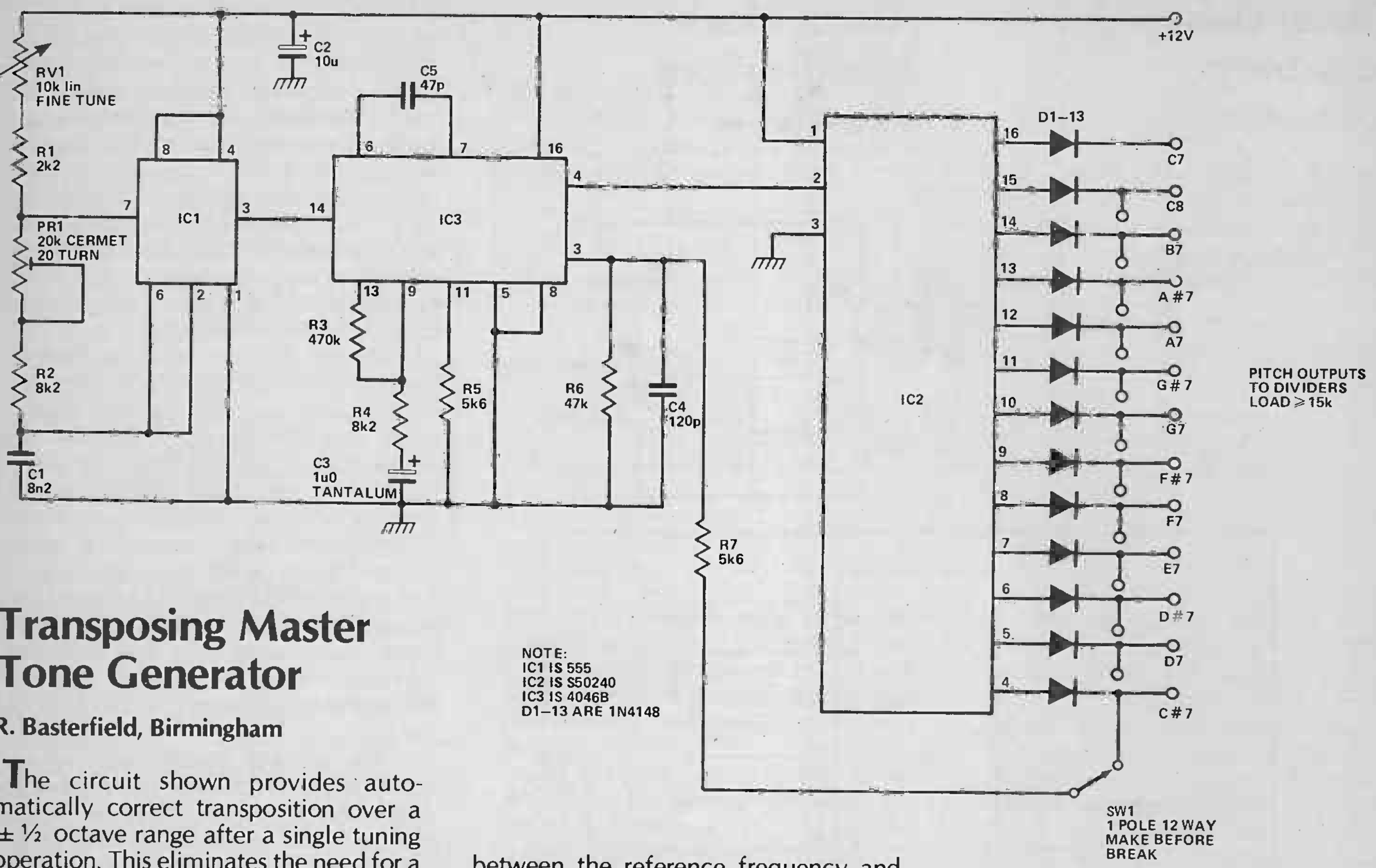
The collector of Q1 is normally held low, initially by C4 and R5 while C1 and C2 are charging to the full supply potential, and then by base bias network RV1, R2, R3. The low at Q1 collector holds SCR1 off via R6. The Ni-Cd batteries are trickle-charged by R1-LED1; LED1 lights up to indicate that the batteries are charging and becomes reverse biased when the unit is switched off to prevent battery discharge.

If the mains fails or is switched off, either by accident or on purpose, the current flowing into Q1 base via RV1 and R2 decreases to zero. Long before the supply to IC1 has become too low to maintain the 5 V rail, Q1 will have turned off and fired SCR1. This allows the batteries to supply IC2, a second regulator which takes over from IC1 before the microcomputer supply is interrupted. LED2 is turned on via R7 to give an indication that the batteries are being discharged.

If the mains should now come back on, LED1 will again light to indicate mains presence, but LED2 stays on until the reset button is pressed to switch off SCR1.

When you wish to switch the unit off, first switch off the mains and then press the reset button to turn off SCR1. In this condition there is no drain from the batteries so the unit can be left for weeks without detrimental effect. Four amp-hour Ni-Cds were used to give a 9V6 supply. Two units have been built and both have proved 100% reliable.

If a supply of less than 1 A is required, 7805 regulators can be used and D7, D8 can be replaced by 1 A devices. The transformer and rectifier diodes should be rated in accordance with the current required. RV1 should be set to middle position and then adjusted for best operation. If battery voltages greater than 9V6 are used, R7 must be increased in value and R1 decreased. The transformer, bridge rectifier, IC1 and C1-3 may be available in your original supply, in which case it will only be necessary to modify it as shown in the diagram.



Transposing Master Tone Generator

R. Basterfield, Birmingham

The circuit shown provides automatically correct transposition over a ± ½ octave range after a single tuning operation. This eliminates the need for a trained musical ear to set a bank of often expensive presets.

IC1 generates a reference frequency of 3.32 kHz. IC2 is a top octave synthesiser and IC3 is a CMOS phase-locked loop, producing a high frequency on pin 4 in proportion to the phase difference between the reference frequency and the output pitch selected by SW1. Any output selected by SW1 is always forced to produce the same frequency as the reference, so shifting the whole top octave. C4 filters RFI from the leads to SW1, which were 5" long in the prototype.

To set up, select G#(pin 11) with SW1. Set RV1 central. Adjust PR1 to give A = 440 Hz or IC1 output pin 3 to give a 300.7 us period.

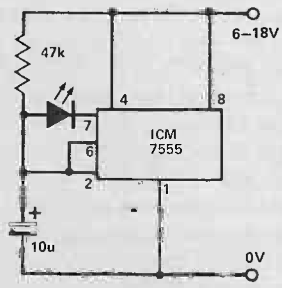
The S50240 is available from Tandy Corporation.

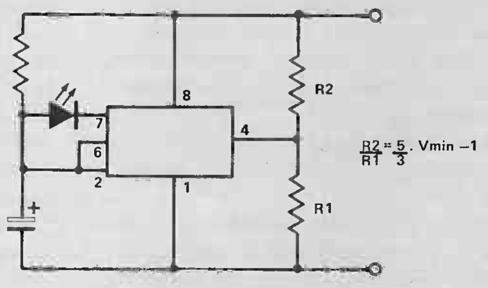
Micropower LED Flasher

D. Stewart, Wick

This circuit will brightly flash an LED, yet has a supply current of only 150 uA. In a normal 555 astable, the timing capacitor is discharged straight to ground. Here, the charge is made use of by discharging it through the LED. A suggested use is for an on-off indicator in a battery-powered circuit.

With a slight modification the circuit can be used as a good battery indicator. A potential divider is connected to pin 4 (reset) from the supply rail of the circuit whose battery is being monitored, so that when the supply drops below a predetermined voltage, then the voltage on pin 4 drops below 0V7. Thus the LED will only flash if the supply is higher than the predetermined voltage. Keep the value of the resistors high to reduce current consumption (eg 1M0 for R1).





DIGEST

Late Disc-overy

At long last, after much premature blowing of trumpets and waving of flags, the elusive Video Disc Player has finally come out of its closet. RCA used a 75-city satellite hook-up to make the announcement of its 'SelectaVision' video disc system. It went on sale nationally in the USA on March 22nd. The marketing plans for the unit are that the player will sell for $499.95 and the disc software will retail for between $14.88 and $27.98. At the time of the launch there were already 100 titles available, ranging from Shakespeare through Saturday Night Fever to Caring For Your Newborn. RCA see the video disc as the most important new consumer product since colour television. Hopefully it won't be too long before we in Britain can judge the idea for ourselves.

Computing In Sinc

Uncle Clive has very definitely done it again with his new ZX 81 Personal Computer. It has many improved features over the ZX 80. For instance, it is based on a four-chip design and is constructed in durable black ABS plastic, making it far more sturdy than its flimsy white predecessor. The masterchip is manufactured by Ferranti and is custom-built to replace 18 chips in the ZX 80. The 81 has 8K BASIC ROM and incorporates all the features of its forerunner. The advanced features are a print drive facility and the ability to operate in two software selectable modes, 'fast' and 'normal' (fast being four times normal speed). In 'normal', the ZX 81 will compute and display simultaneously giving continuous flicker-free graphics — a major deficiency on the ZX 80. The new 40-key touch-sensitive membrane keyboard gives the equivalent of 91 keys. The graphics mode enables an additional 20 graphical and 54 inverse video characters to be entered directly from the keyboard. Programs can be loaded and saved using a conventional recorder. The cassette interface facility has been improved and programs are given names so that you may use the computer to search through a tape for the required program. A comprehensive 200-page tome is provided which includes a new course in BASIC programming. The ZX 81 is available ready-assembled for £69.95, in kit form for £49.95 but with separate mains adaptor for a further £8.95. There are also some new accessories from Sinclair. The new 8K BASIC ROM for the 81 will soon be available to ZX 80 owners as a drop-in replacement chip, with a new keyboard template and operating manual. Price is £19.95. There is also a 16K byte RAM pack for both the 80 and the 81 for £49.95, which can be used for program storage or as a database. There will also be a printer launched later this year for around £50, its special feature being a facility called 'copy' which prints out *exactly* what is on the TV screen. There are also four cassettes of software immediately available at £3.95 each. The ZX 81 will be sold by mail order only.

The add-on 16K RAM pack for the ZX 81.

Surging Ahead

Suhner Electronics have announced a range of EMP protectors designed to limit surge voltages in coaxial systems. Their effectiveness is mainly due to their rapid response time of 3 ns, as opposed to a typical delay of 10 ns in other protectors. After a dangerous surge voltage such as that found in a lightning strike, the rare gas-filled protector sparks over, shorting the inner and outer conductor and allowing the surge current to flow to ground. The equipment is back in operation immediately afterwards, with full protection maintained. The series 3401 EMP protectors have the form of a coaxial feed-through adaptor for wall-mounting. A very low and stable grounding contact between wall-mounting and protector body is achieved by a V-groove washer made from soft copper. The protectors are accurately matched to 50 R line impedance and the shunt capacitance of the UC protector is carefully compensated to ensure minimum reflections when operating at the commonly used communication bands. The range of protectors is specially designed and tested for military applications, but has gained a broad-band acceptance as excellent lightning protectors for civil communications and antenna equipment. The protectors can be obtained from Suhner Electronics Ltd, Telford Road, Bicester, Oxon OX7 0LA.

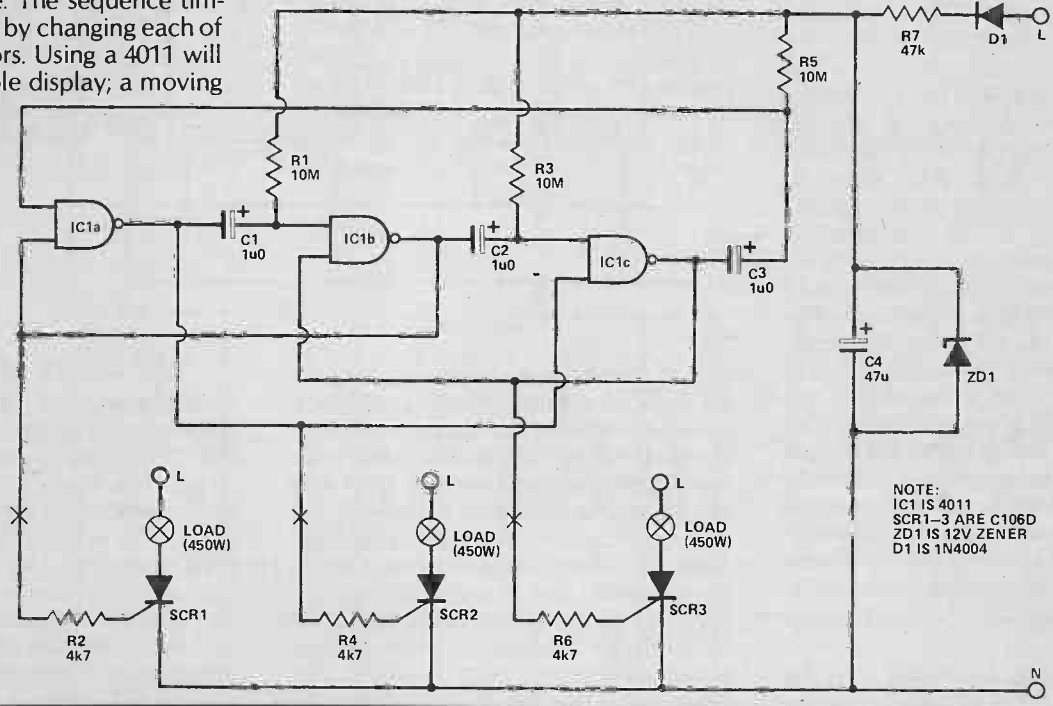
Measuring Up

Data Precision have launched a new 4½ digit multimeter called the DP255 with LCD display and a basic accuracy of .03%. It is a highly accurate, average sensing, calibrated RMS multimeter with a rechargeable Ni-Cad battery pack, which will operate for up to 100 hours between recharging. The meter measures AC and DC volts and current as well as resistance. Voltage resolution is 10uV, current resolution 10nA and resistance resolution 10.1R. All 25 ranges are selected with two front panel rotary switches, one for function and the other for range. The unit weighs less than 1.3lb, has 0.4" high digits and accepts banana plug connection. For more information contact Farnell International Instruments Ltd, Sandbeck Way, Wetherby, West Yorks LS22 4DH.

Cheap Light Sequencer

Kevin Kirk, Malta

This light sequencer is basically an extended monostable. The sequence timing can be changed by changing each of the timing capacitors. Using a 4011 will create a moving hole display; a moving light display can be obtained by replacing the 4011 with a 4001 or putting an invertor at the points marked 'x'. If an EX-NOR is placed here a single switch may be used to change from one state to the other. With the values given the sweep rate will be very slow and is used for a slow sign changer.



Digital Mark/Space

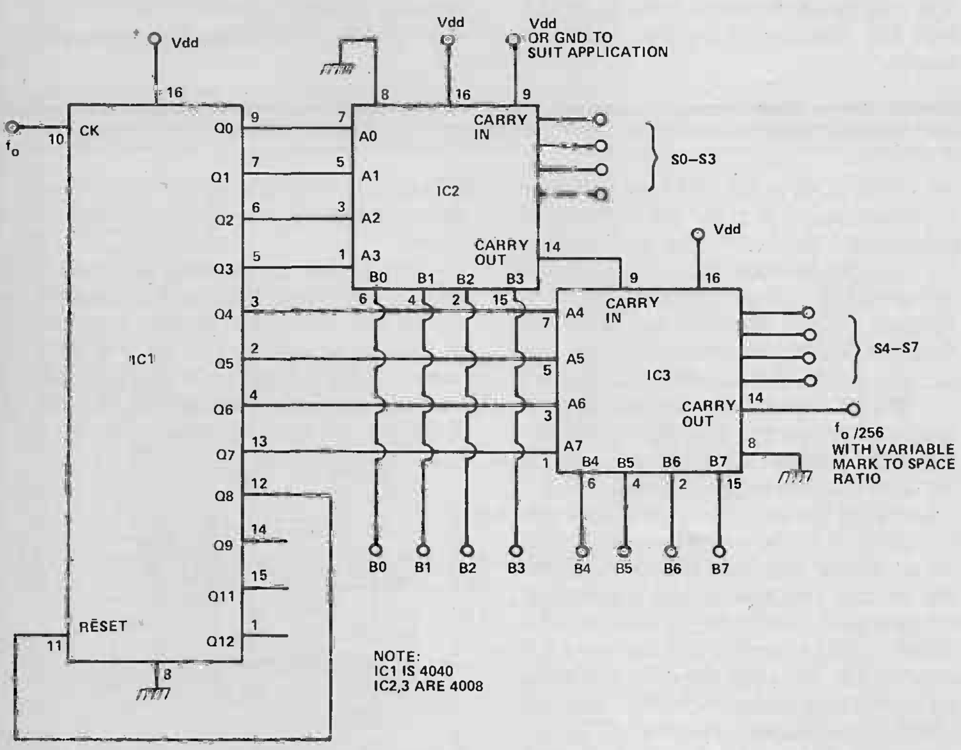
G.C. Dean, Taunton

This circuit provides a mark/space ratio at the C_{OUT} pin which depends on the binary value set up on B0 to B7. As Q0 to Q7 gradually increases in value, due to incoming clock pulses, $C_{OUT} = 0$ if Q0. . . Q7 + B0. . . B7 ≤ 11111111 and $C_{OUT} = 1$ if Q0. . . Q7 + B0. . . B7 > 11111111. The higher the value of B0. . . B7, the quicker C_{OUT} will become 1 after Q0. . . Q7 is automatically reset, and the higher the value of the mark/space ratio. The proportion of time that C_{OUT} is 1 is given by:-

$$\frac{(\text{Value of B0} \ldots \text{B7}) + C_{IN} (=0 \text{ or } 1)}{256}$$

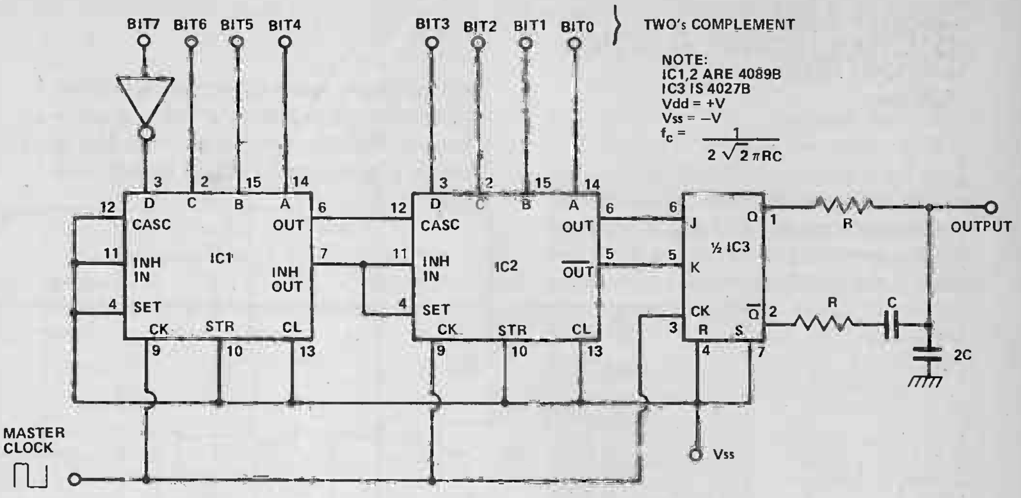
Note that for C_{OUT} to be permanently 0 C_{IN} must be 0 (and B0. . . B7 = 00000000) and that for C_{OUT} to be permanently 1 C_{IN} must be 1 (and B0. . . B7 = 11111111).

The circuit could have its clock input connected to a microprocessor clock, B0. . . B7 connected to the data bus and C_{OUT} to a moving coil meter or a red/green LED (RS 587-080). Then the meter reading will be proportional to, or the colour of the LED will depend on, the value of B0. . . B7.



D-to-A (By Stealth)

S.R. Gillbard, Liskeard



This D-to-A converter uses 4089Bs, which are four-bit binary rate multipliers. Each rate-select input controls an internally generated pulse train, with frequencies of ½, ¼, ⅛ and 1/16 the clock frequency. All pulses coincide with a low state of the clock signal. The rate output is formed by interleaving the selected pulse trains. The output of IC1 consists of N_H pulses per 16 clock cycles, where N_H is the high-order nibble of the eight-bit word (hence $N_H \leq 15$). The sixteenth (blank) clock cycle allows space for the low-order section, IC2, to insert up to 15 pulses per frame (256 clock cycles) as determined by N_L, the low-order nibble. Due to propagation delays the pulses at the IC2 'rate' output, when present, will persist for a short while after the clock's rising edge. IC3 makes use of this feature to extend each pulse so that it completely fills one clock cycle and hence merges adjacent cycles at like polarity. More important, IC3 re-synchronises the transitions between high and low levels, according each 'pulse interval' the same significance.

The resulting waveform may be considered to be a distributed pulse-width modulation in which the maximum continuous duration at the 'wrong' polarity is equal to one clock period, the error thus being dispersed throughout the conversion cycle. This should be contrasted with a strict digital implementation of PWM in which the signal would be high for number of adjacent clock cycles and low for the remainder of each frame. It will be noticed that, while both types have the same average level and would require the same bandwidth for accurate transmission, the standard form has much larger low-frequency components. This is most strikingly illustrated by the conversion of a digital zero. PWM produces a 50% square wave with a frequency equal to the frame rate; the distributive technique generates a square wave at 128 times frame rate! While other conversions provide increasingly less marked contrasts, it is only at the extreme limits of ±127 that the two systems return identical results.

This feature of the distributive technique permits the use of quite simple averaging filters with relatively high cut-off frequencies and hence fast rise times. The four-component network shown, when used with a centre frequency equal to half the frame rate, will suppress ripple to more than 80 dB below peak reconstructed sine wave.

The digital input is completely asynchronous, therefore any data feed below frame rate is acceptable. Faster data transfer will result in a slight loss of precision and low-level intermodulation between frame and feed rates. If only seven-bit conversion is required, the inverter should be driven in parallel with the high-order 'C' line, producing a half-range output.

Synthesiser Interface For Transcendent DPX

D. Pallant, London

This circuit was designed to interface a voltage controlled synthesiser such as the Transcendent 2000 to the Transcendent DPX.

The six multiplex lines, AO1 to AO6, are converted into a staircase waveform by the D-to-A converter, IC1, and are also NANDed by IC2 to give a 'keyboard scan finished' signal. The converter output is fed into two sample and hold circuits which sample the waveform (IC5,6,7) and output it to the buffer and level converter IC8. When SW1 is open the first sample and hold will remember the voltage on the D-to-A converter when the scan reaches the lowest note pressed on the keyboard. The logic in this case is performed by a latch and a NAND gate which output a pulse when the first note is pressed but, due to the latch, ignore all subsequent notes until the latch is reset by the scan finished signal. The second sample and hold is triggered by the 'scan finished' signal from IC3a, and will therefore output the voltage on the first sample and hold at the end of each scan.

If SW1 is closed the first sample and hold will remember the voltage of the last note pressed all the time. This is because it is then triggered solely by $\overline{\text{CIN}}$, which goes low as the scan reaches each key pressed. At the end of the scan the second sample and hold will then output the voltage proportional to the highest note pressed. The buffer on this circuit is widely variable and could be used for most VCOs. The volts per octave scale is set by PR1 and the tuning by RV1, both of which should be set up for the VCO to be used with the circuit. A suitable trigger pulse for the Transcendent 2000 can be obtained by inverting the key pressed (KP) signal which can be obtained from the output of IC7 (pin 9) on the dynamics board.

The circuit can be easily fastened inside the right-hand end cheek of the DPX above the dynamics board, and two ¼-inch jack sockets put on the back panel for the voltage control and trigger outputs. The logic signals required are obtained off the dynamics board as follows:

AO0	IC17, pin 8
AO1	SK1, pin 5
AO2	SK1, pin 4
AO3	SK1, pin 3
AO4	SK1, pin 2
AO5	SK1, pin 1
$\overline{\text{CIN}}$	IC6, pin 4

In almost all cases there is a through-board pin that can be used as a terminal point.

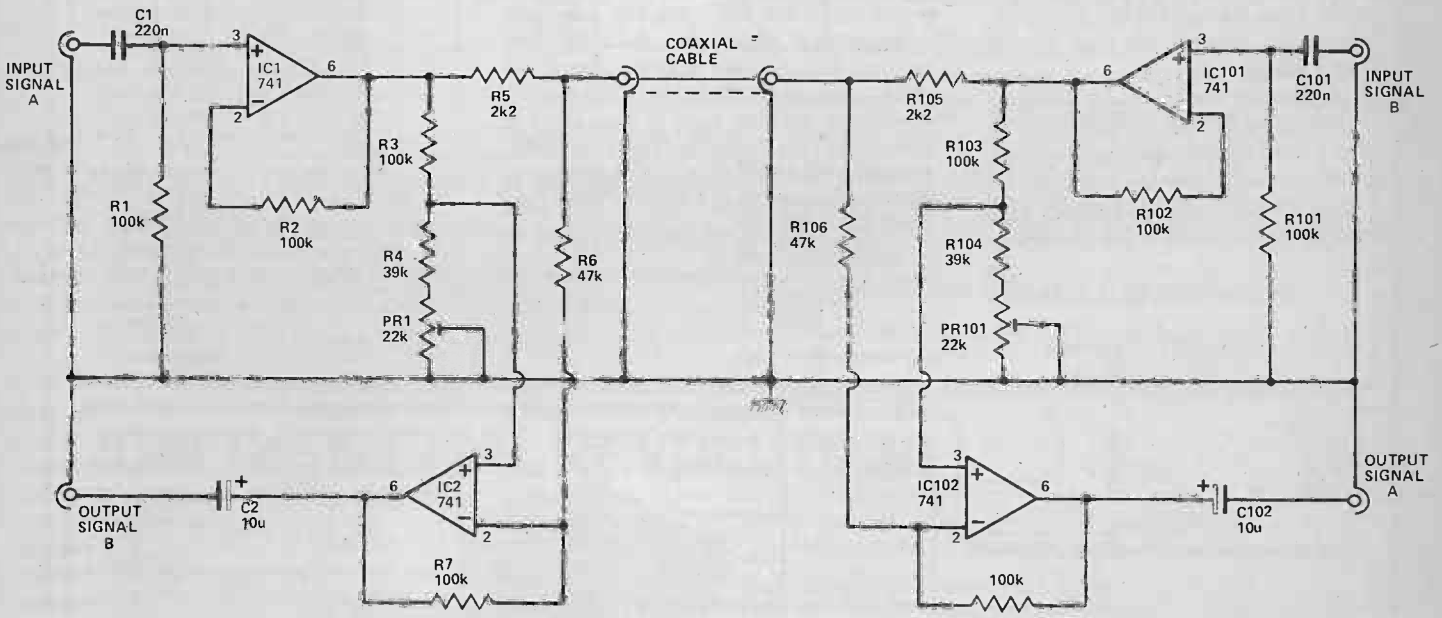
Bidirectional Audio Link

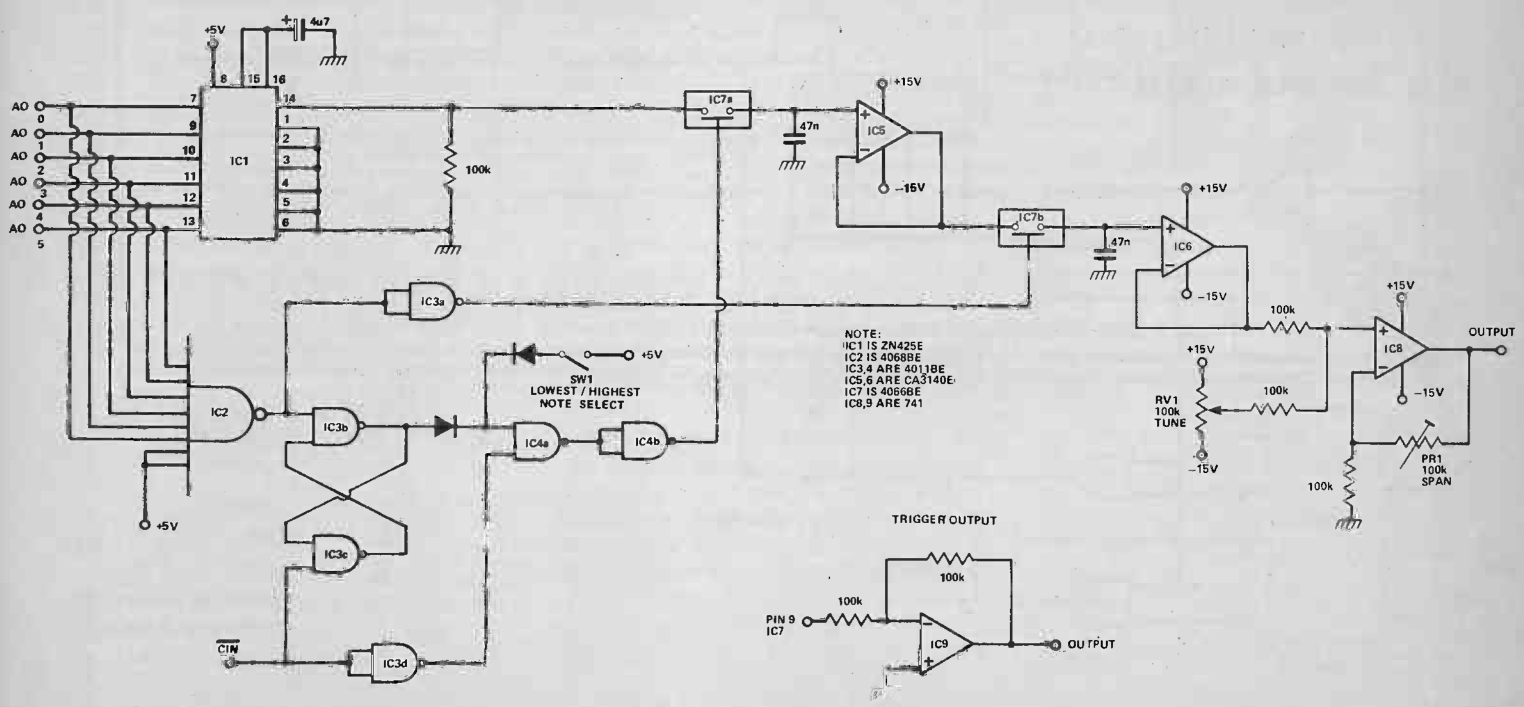
T.P. Hopkins, Stockport

This simple circuit arrangement enables audio signals to be sent along a single piece of coaxial cable in both directions simultaneously. The circuit consists of two identical parts, one in each device connected. The input signals are buffered by IC1, IC101 and fed to the cable by resistors R5, R105. IC2, IC102 subtract the signals on the cable from the output of the buffer amplifier; the difference is the signal put onto the cable at the other end. The net result is that signals inserted at one end appear only at the other end.

The audio signals should be between 100 mV and 3 V (RMS). Potentiometers PR1, PR101 set the rejection of the unwanted signal; these should be of good quality, and preferably multiturn presets. A rejection of 50-55 dB can be obtained.

The prototypes were used in an audio system where the control unit was remote from the signal source and the power amplifiers and speakers. Other possible uses include intercom and talkback systems. If this technique is tried at higher frequencies, resistors R5, R105 should be adjusted to match the characteristic impedance of the coaxial cable used. A similar system has been successfully used for digital signals.





Memory-mapped Sound Generator

W.S. Maggs, Bristol

Here is a circuit idea for using AY-3-8910 Programmable Sound Generator chips on an Apple bus.

The usual way of interfacing these chips to microprocessors (other than PIC 1650) is by using PIAs. However I wanted to remove the additional burden and wastefulness of programming PIAs by memory-mapping the PSG. This is done as follows; from the data sheet pins BC1, BC2 and BDIR control the chip operation (see Table 1).

It can be seen that if BC2 is taken to +5 V then only BC1 and BDIR control the chip. I tried various gate layouts but these failed. Finally I used a dual 4-line to 1-line data selector (74LS153), each side controlling BC1 and BDIR respectively.

To control the '153 I used the R/W̄ and A0 lines of the Apple on the A and B inputs. The inhibit input was selected by a signal from the 7442 so that the '153 was only selected if the '0' output of the 7442 was low (see Table 2).

The selection of the 7442 is an easy matter on an Apple bus because each slot has a line DEV̄ which selects one of 16 addresses. To make programming easier the reset pin of the PSG is also memory-mapped. The OR gate on output '1' of the 7442 makes sure the reset is only selected by one address.

A simple program to test the chip is given. Since the PSG requires a register address first, then the data for the register, the register address (latch address) is mapped C0X0 (where X is the slot number + 8). The data is then read or written to C0X1 with the reset on C0X2. Resetting the PSG clears all registers. In the program the data is held at 2000 Hex, with the number of registers used in 2000, followed by the data and then the registers (hi → lo). To reset the PSG a dummy store is used.

Since the load requirements of the Apple bus are fixed, the R/W̄ line is buffered to enable two PSGs to be used. The I/O ports of the PSG can either be used as extra PIAs or to address PROMs. The signal outputs of the three channels of the PSG drive a conventional audio amplifier (LM380).

Program for frequency 440 Hz

```
1000  8D C2 C0   STA $ C0C2
      AC 00 20   LDY $ 2000
      BE 04 20   LDX $ 2004, Y
      B9 00 20   LDA $ 2000, Y
      8E C0 C0   STA $ C0C0
      8D C1 C0   STA $ C0C1
      88         DEY
      D0 F1      BNE $ 1006
      60         RTS
2000  04 0F 3E 00 FE 08 07 01 00
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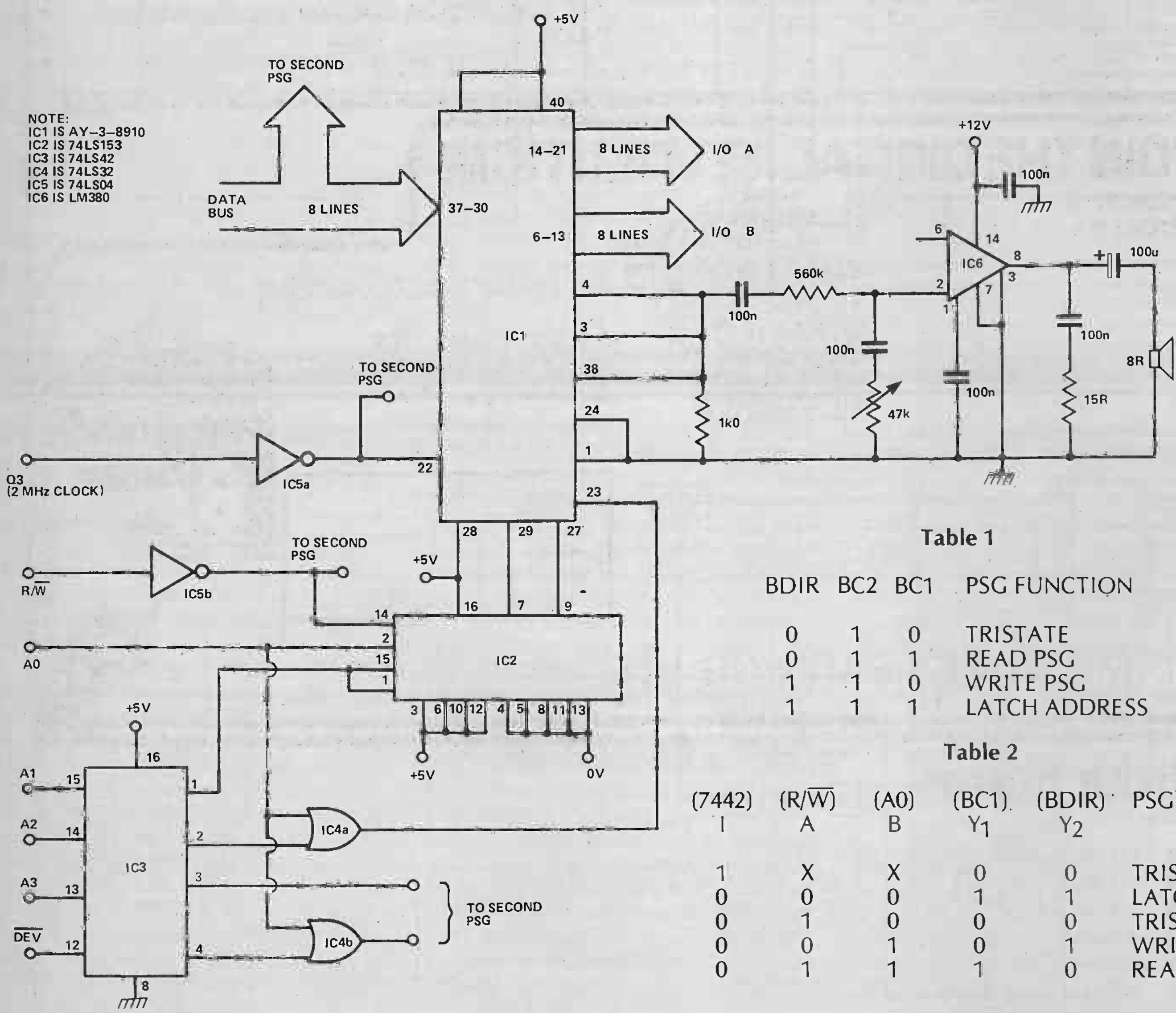


Table 1

BDIR	BC2	BC1	PSG FUNCTION
0	1	0	TRISTATE
0	1	1	READ PSG
1	1	0	WRITE PSG
1	1	1	LATCH ADDRESS

Table 2

(7442) I	(R/W̄) A	(A0) B	(BC1) Y_1	(BDIR) Y_2	PSG
1	X	X	0	0	TRISTATE
0	0	0	1	1	LATCH ADD
0	1	0	0	0	TRISTATE
0	0	1	0	1	WRITE PSG
0	1	1	1	0	READ PSG

ALIEN ATTACK

Hand-held games are becoming just as popular as the arcade versions (we can play in the comfort of our own office!) so we just had to publish our own version. Design and development by R. Eley.

Once upon a time you could only blast the hordes of little green aliens by taking a trip to your nearest pub or amusement arcade. But it wasn't long before you could indulge your violent tendencies in the privacy of your own home with TV game versions. Nowadays it's possible to avoid withdrawal symptoms wherever you may be by purchasing a hand-held version — the invaders are even turning up in calculators. Now ETI presents a simple-to-build hand-held game that, while lacking the refinements of commercial machines (such as custom-designed little 'alien' LEDs), is still a lot of fun to play with and offers a full range of sound effects.

The 'field of battle' and the score display both take the form of a line of LEDs. When the game is switched on, 'aliens' begin to drop towards you, their passage being shown by the LEDs in the display lighting one after another. When the tenth and final LED is lit, you have to fire your laser at the alien by pushing the 'fire' button. If you're successful, the score display is increased by one and another alien launches his attack. For simplicity and low cost, a simple binary counter is used to register the score.

The catch is that as you destroy the aliens, the speed at which they fall increases quite rapidly. The game has a built-in time limit of about 25-30 s, and the object is to achieve the highest score before the game ends. Your reactions have to be pretty accurate because firing the laser when the ninth LED is lit will zero your score.

Four voltage-controlled oscillators are provided, giving the familiar tromp-tromp-tromp, laser fire, falling bomb and explosion noises. An on-off switch is provided for the sound so that battery life may be extended, if desired. The unit consumes approximately 15 mA with sound or 5 mA without.

Construction

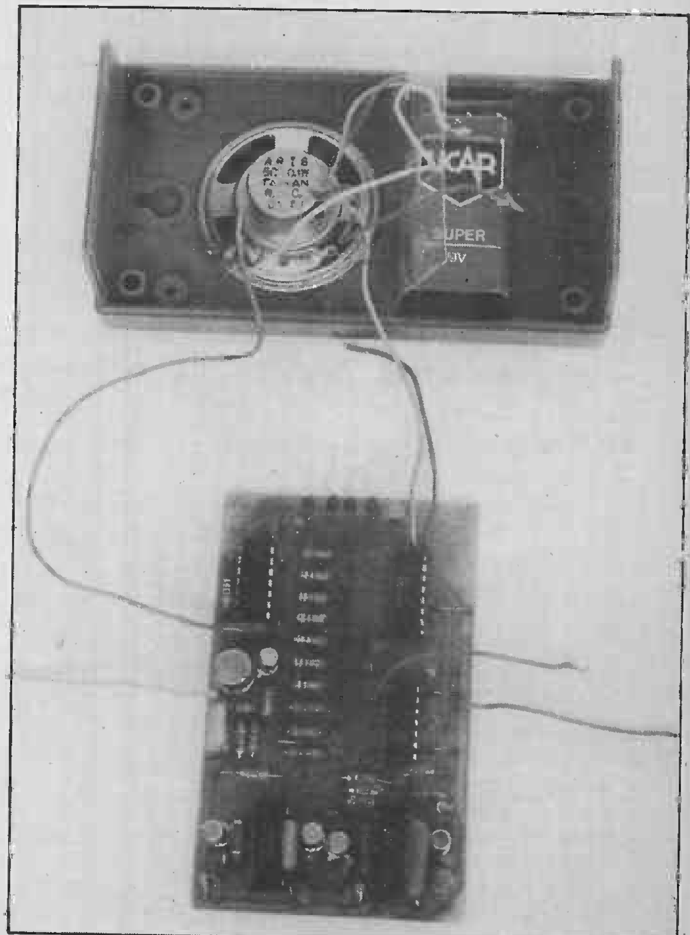
The circuit is built on a single PCB but for reasons of space this is fairly cramped and several components are mounted vertically. Tantalum capacitors are also used instead of ordinary electrolytics because of their small size. Solder all the components in place as shown on the overlay, using a soldering iron with a fine bit and lots of 'due care and attention'; the PCB tracks are very fine. Take the usual precautions when handling the CMOS ICs.

Note that R29 and C13 are not located on the PCB but are soldered into the loudspeaker lead — the photographs should make this clear.

A T-shaped hole is cut in the top of the case to reveal the LEDs and a piece of red plastic can be stuck over the aperture to improve the viewing contrast. Of course, you'll have to cut holes in it above the green LEDs or they'll disappear! The three switches are also mounted on the top of the case; the loudspeaker is fixed to the bottom after drilling a few holes to let the sound out. Thin plastic strips are glued to the sides of the case to support the PCB the correct distance from the cutout.

Now the interwiring can be completed and the case screwed together.

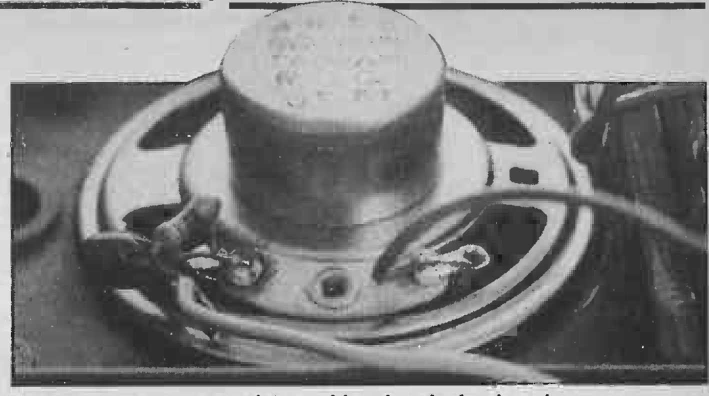
This completes the construction of the project; now you can be the envy of your fellow commuters and annoy total strangers in your efforts to beat your last score.



The completed board, wired up to the lower half of the case. The remaining wires go to the switches on the front panel.

PARTS LIST

Resistors (all ¼W, 5%)	
R1	4M7
R2-11,18	2k2
R12,24,26,27,28	100k
R13,15,20,23	1M0
R14,16	22k
R17,21	470k
R19	10k
R22	330k
R25	180k
R29	150R
Capacitors	
C1,13	10u 16 V tantalum
C2	220n polyester
C3	22u 16 V tantalum
C4	15n polyester
C5	1u0 16 V tantalum
C6	8n2 polycarbonate
C7,9,10	4u7 16 V tantalum
C8	33n polyester
C11	10n polyester
C12	47n polyester
Semiconductors	
IC1	4017B
IC2	4081B
IC3,4	4011B
IC5	4024B
Q1-4	BC108
D1-9	1N4148
LED1-9,11-14	0.125" red LED
LED10,15	0.125" green LED
Miscellaneous	
PB1	single pole push-to-make
SW1,2	SPST ultraminiature toggle
LS1	8R, 1½" diameter
PP3 battery and battery clip, Verocase.	



Here you can see R29 and C13 soldered to the loudspeaker.

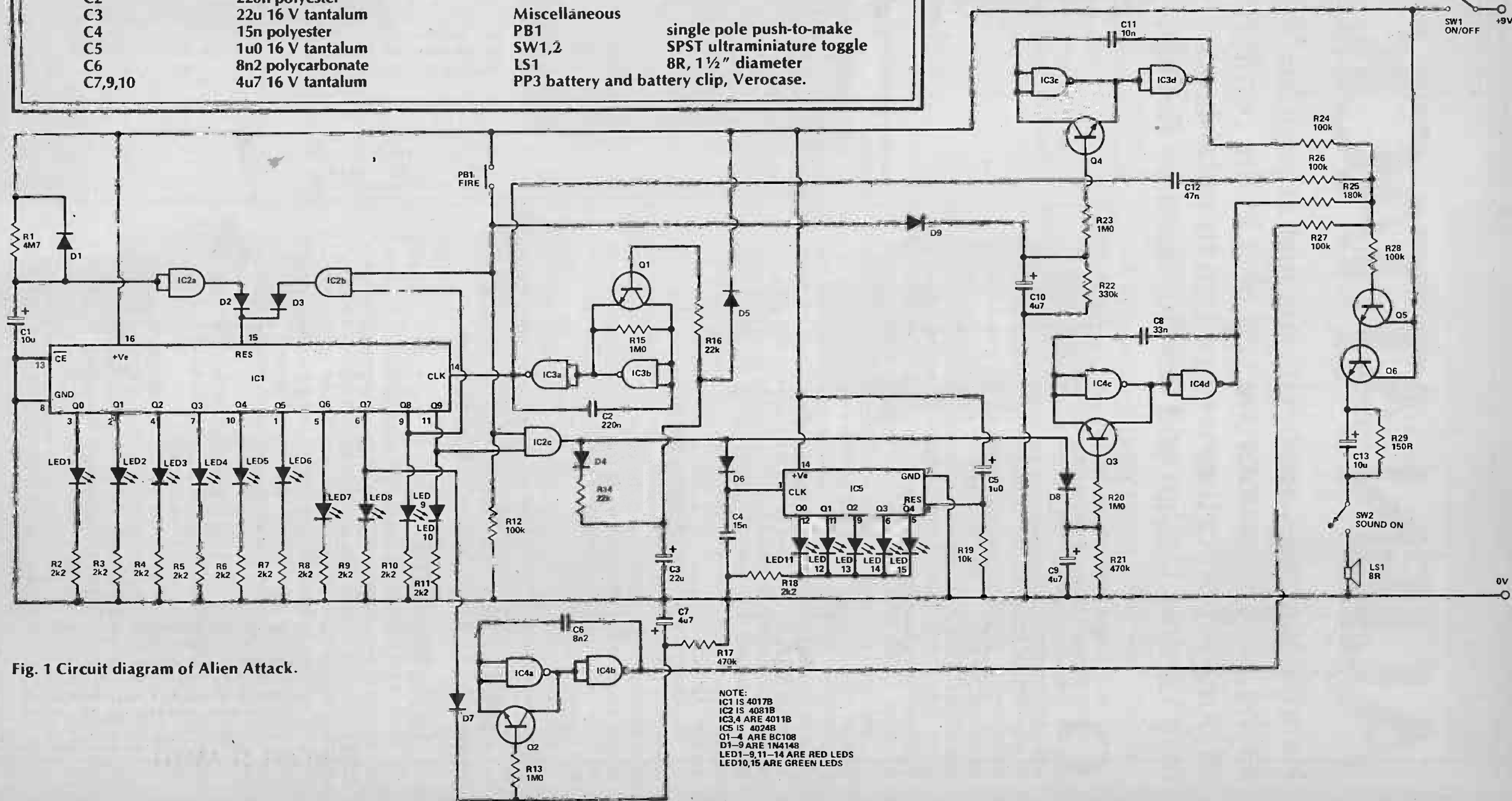


Fig. 1 Circuit diagram of Alien Attack.

HOW IT WORKS

The circuit falls into four basic sections — the decade counter IC1, which lights LEDs 1 to 10 in turn; the binary counter IC5, which provides the scoring for the game; four voltage-controlled oscillators (VCOs) which provide the sound effects; and the mixer-amplifier, which drives a small loudspeaker.

The VCOs use the common CMOS oscillator circuit, but with a difference. Instead of using a fixed resistor with a capacitor to determine the frequency, a transistor replaces the resistor and functions as a variable resistor.

Taking the VCO formed by IC4a and IC4b as an example, it can be seen that with no connection to the base of Q2, the collector-emitter resistance will be very high, preventing C6 from charging and thus disabling the oscillator. However, if a voltage is applied to Q2's base the collector-emitter resistance will fall in proportion to the applied voltage. Thus the time taken for C6 to charge will be proportional to this voltage, and so will the frequency of operation of the oscillator.

If a capacitor and resistor are connected from the base of the transistor to ground, then fully charging the capacitor will give the highest oscillator frequency. As the capacitor discharges via the resistor, the frequency will fall until the circuit again stops oscillating.

In the case of the IC3a-IC3b VCO, the lowest frequency is determined by R15.

When the circuit is switched on, C5 provides a power-on reset pulse to IC5, thus extinguishing LEDs 11 to 15. C1 will also start to charge via R1 and when the voltage on C1 eventually reaches the threshold of gate IC2a counter IC1 will be held reset, thus ending the game. With the values shown, this should take approximately 25 s.

The IC3a-IC3b VCO will clock IC1, lighting LEDs 1 to 10 in turn. When LED8 lights a pulse will be fed to the VCO formed by IC4a and IC4b, giving a falling frequency.

If the 'fire' button (PB1) is pressed, then the IC3c-IC3d VCO will be enabled. Pressing PB1 when LED10 is lit will result in IC2c enabling the VCO formed by IC4c and IC4d, and also charging C3 by an amount determined by R14. Thus the VCO driving IC1 will increase in frequency. IC5 will also be clocked, adding one to the score. C4 debounces the clock input.

If PB1 is pressed when LED9 is lit, a reset pulse is sent to IC1 by IC2b, thus preventing cheating.

The four oscillator outputs are mixed by R24-27 and C12. Q5 and Q6 act as an amplifier, driving an 8R speaker, through the filter formed by R29 and C13. This filter prevents excessive DC from reaching the speaker, as would happen if one of the VCO outputs stayed high.

Because IC2a has no hysteresis applied to the input, as the voltage on C1 reaches the gate's threshold the output will oscillate, which results in the aliens making several abortive attacks. D1 and D5 ensure that capacitors C1 and C3 are discharged at the end of each game when the circuit is switched off. This ensures that the game length and starting speed of the aliens are the same for each game.

BUYLINES

No problems here, as everything used is pretty common. The case used was a small one from Vero, reference no. 202-21029J, and the red plastic can either be a special LED display filter or any piece of cellophane you can lay your hands on (sweet wrappers?).

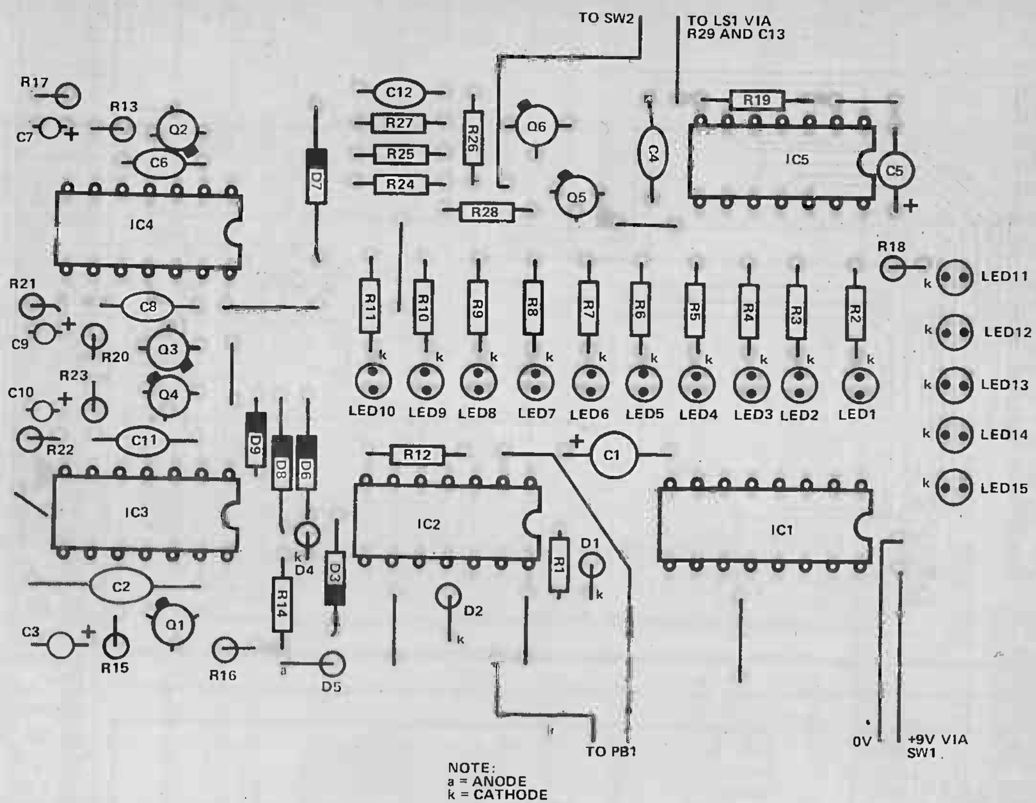
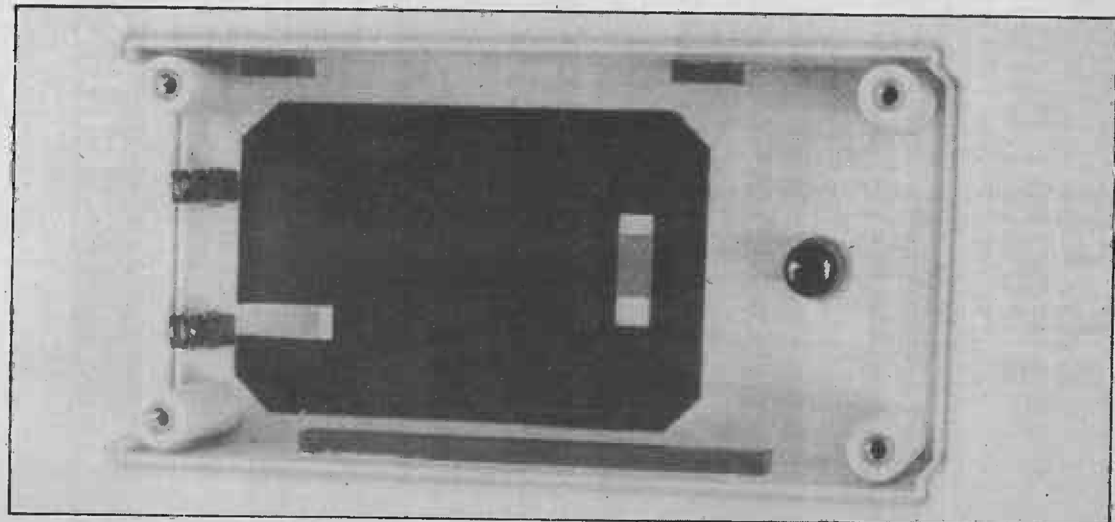
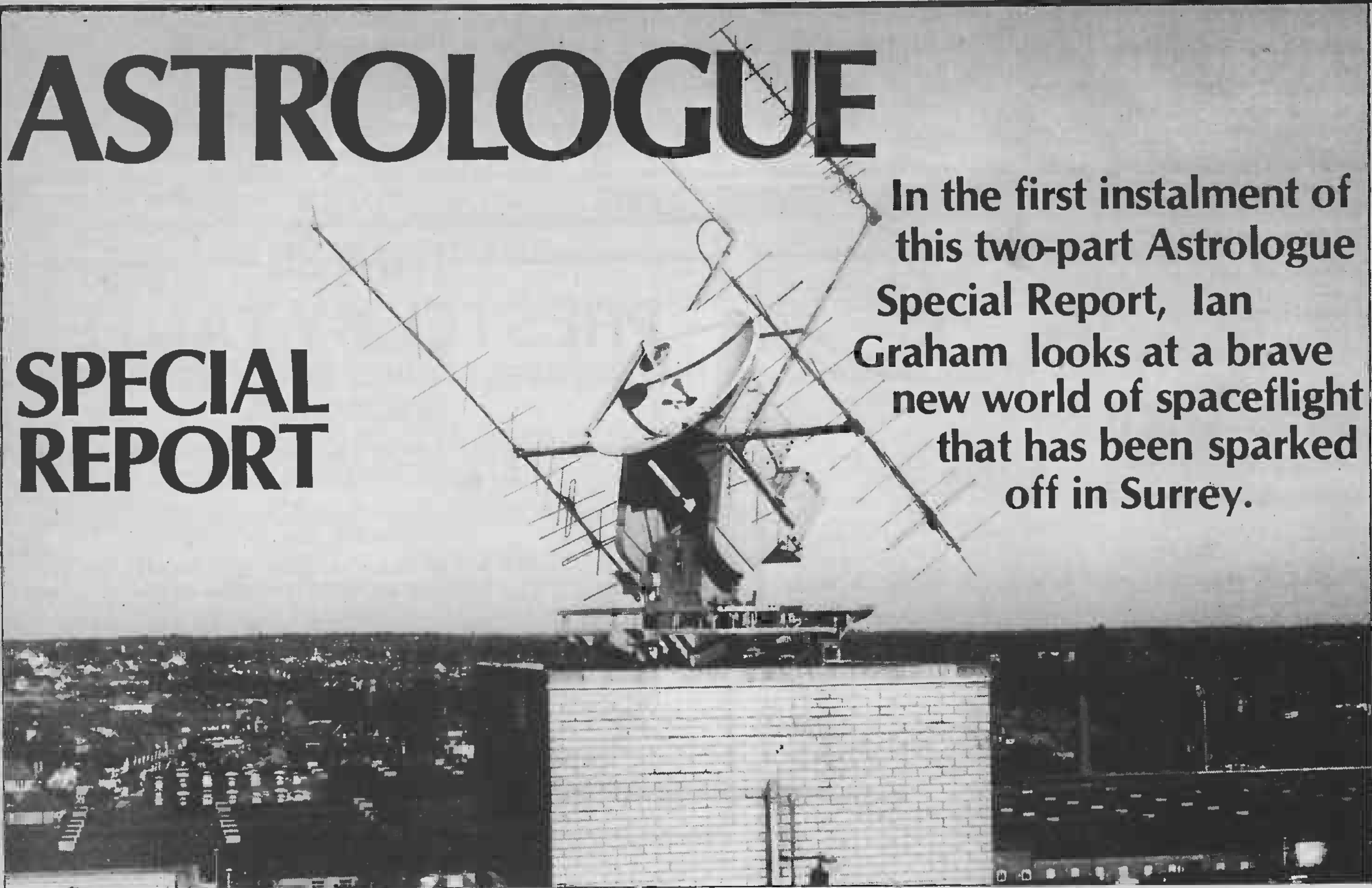


Fig. 2 Component overlay.



This photograph shows the red filter and plastic mounting strips glued into the top of the case.

ASTROLOGUE



SPECIAL REPORT

In the first instalment of this two-part Astrologue Special Report, Ian Graham looks at a brave new world of spaceflight that has been sparked off in Surrey.

You read it first in Astrologue. In the December 1980 edition I reported on Britain's first amateur satellite — UOSAT (University of Surrey Satellite). Now it's headline news as the launch day draws near. I spent a very enjoyable day as a guest of the project team at the University. Their work is so impressive and, in my opinion, has such important implications for Britain's future involvement in space that I am devoting two editions of Astrologue to UOSAT. This month there's a general view of the satellite and its objectives, and next month a rundown of the technical data.

New Look

The team, headed by Dr Martin Sweeting, has taken a refreshingly new look at the business of designing a spacecraft. They haven't automatically followed the conventional solutions to problems, largely because of cost. The last satellite of similar size was UK6, which was launched in 1978 at a cost of about £9 million excluding the launcher. The Surrey team is working on a budget of £100,000.

The honeycomb structure that forms part of the spacecraft surface would normally have cost £15,000, but the team found a firm which produces the same material for racing cars and which would do the job for £300.

The team has explored every avenue in an attempt to cut costs, but that doesn't mean that they are turning out a Heath Robinson stringbag affair of a spacecraft. Before NASA will agree to launch the craft they must be satisfied that it passes all the vibrational and thermal tests, structural specifications, etc demanded of every satellite.

Genesis

How did they get into the satellite business? Five or six years ago a small tracking station was set up to track OSCAR 7 (an American amateur radio satellite) and meteorological satellites. It was a natural progression from the work on tracking, amateur radio and ground station operation to actually building their own spacecraft. The driving force in the early days was the University's Electronic and Amateur Radio Society (EARS — ho, ho), which made the initial contact with AMSAT (Radio Amateur Satellite Corporation) and set up the first ground station.

The present ground station has cost about £10,000 over 10 years. The impressive aerial array is mounted on a Bofors gun platform rescued from an Admiralty scrapyard in Portsmouth. The whole assembly, weighing between 3 and 5 tons, can be pointed at any object in the sky and tracks satellites either manually or by computer, using a control system designed by undergraduates. The precarious, lofty perch is necessary so that signals can be received without ground interference from street lighting, traffic, and so on.

Project UOSAT

The UOSAT programme has three broad interests:

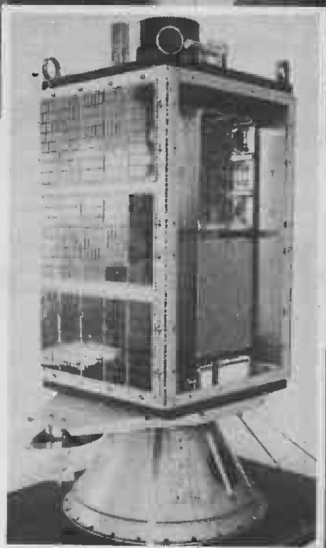
1. Examining low-cost techniques
2. Educational
3. Research.

The determination to use low-cost techniques where possible has extended beyond the practical (or practically impossible) business of designing and building the spacecraft. The aim from the beginning has been to make the satellite information available to as many people as possible, as cheaply as possible, with emphasis on the involvement of schools and colleges.

Data will, therefore, be available on a number of levels. In its simplest form, you will be able to receive spacecraft telemetry on an ordinary VHF communications receiver. This is made possible by the provision of an on-board speech synthesiser linked to selected subsystems. The spacecraft will 'speak' its status to you. If you have the necessary equipment, you can also receive the information in Morse code. Data will also be available in high-speed form for serious enthusiasts and professionals.

Left: our lead photograph shows the EARS aerial array linked to the command centre, which will be the primary command station for UOSAT. Right: the UOSAT logo. Far right: the team built their own clean room in which to construct the spacecraft. Project Manager, Dr Martin Sweeting, is on the right.

UK AMATEUR SCIENTIFIC SPACECRAFT
UNIVERSITY OF SURREY AMSAT-UK



Left: the aluminium alloy frame of the spacecra contains 16 boxes machined from solid aluminium. Each box holds two PCBs. In all UOSAT will use about 400 ICs. Below: UOSAT i position, mounted on the Delta 2310 launch vehicle during a trial mating in December 1980.

Telly Weather

More exciting to the likes of you and I, however, is the meteorological experiment. The spacecraft will photograph an area the size of Scotland as it orbits. Normally you would need several thousands of pounds worth of decoder and display/printing gear to get a weather picture out at the other end. However, the UOSAT team hope to be able to produce a handbook and kit (being designed by undergraduates) to allow weather pictures to be displayed on your living room telly. The kit is expected to cost no more than £150. Watch Astrologue for a review.

The satellite is expected to be launched in September but the team has been warned that the launch date might be brought forward to July, leaving them very little time. A series of tests will be carried out in June at British Aerospace, Stevenage. Then two days of final tests must be carried out at the Goddard Space Centre in Maryland before the launch from Vandenberg Air Base in California.

Piggy Back

UOSAT is being given a 'piggy back' launch; the main payload of the Delta 2310 launcher will be the NASA Solar Mesosphere Explorer. UOSAT will be a secondary payload, fitted beneath and to one side of the main payload. It will orbit at a height of 530 km with a period of 95 minutes and should stay up for four or five years before it re-enters the atmosphere in a fireball.

Milestone

Up to now we have assumed that building and launching a satellite is a multi-million pound/dollar operation. The UOSAT project team has proven that the cost can be reduced by at least one order of magnitude without compromising quality. The team has actively sought out sponsorship (money or test facilities) from the beginning of the programme. It is doubtful whether sponsorship would be as forthcoming for further projects of this nature, but once the principle of low-cost spaceflight is proven, it is undoubtedly a concept that could be turned into a commercial enterprise. If cost-to-orbit can be reduced from £10 million to less than £1 million, that bodes well for future British involvement in an active space programme, in which more and more people can participate.

This single project at Surrey University looks like revolutionising our approach to spaceflight. It's an important milestone in the 'space age'. UOSAT demonstrates that a small team of enthusiasts working on a very slim budget can make a valuable contribution to the use of space.

A final word — if you want any information on UOSAT, please don't try to contact the project team. They are working to a very tight schedule indeed to ready the spacecraft for its possible July launch.

Next month — a structural and technical run-down of UOSAT and its experiments.

SHORTS

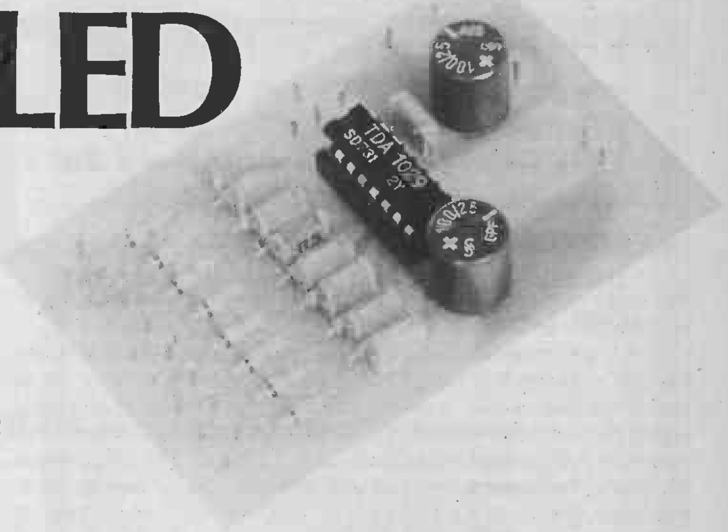
British Aerospace Dynamics Group and Plessey are to collaborate on defence communications projects. In the past, the Dynamics Group has participated in over 45 communications satellite programmes (10 as prime contractor). Plessey designed and manufactured Skynet — the first operational ship-borne satellite communications terminal — and is involved in satellite earth station manufacture.

British Aerospace will supply the spacecraft and provide overall leadership of the programme. Plessey will supply earth station equipment for monitoring and controlling the spacecraft and interfacing into terrestrial networks.

The Vatican has finally caught up with the twentieth century. At the request of Pope John Paul II, it is to review Galileo's heresy conviction of 1633. The conviction arose because Galileo contradicted contemporary beliefs (scientific and theological) when he proved that the Earth was not the centre of the Universe — it orbited the Sun like any other planet.

ETI

VOLTAGE-CONTROLLED AUDIO



DC control of hi-fi — Keith Brindley looks at some ways and means of achieving it, using Mullard's range of voltage-controlled ICs.

Back in the old days, an amplifier was an amplifier! It would have simple controls; volume, bass, treble, balance and a mode switch. The most expensive amplifier was the one which did its job (ie amplify) with the least amount of noise and distortion from linearity.

All of a sudden, manufacturers (particularly those on a faraway eastern island) got the knack of bettering their specs and the market became flooded with reasonable quality, reasonably priced systems. "Ah so, what next?" they thought, and the answer was gimmicks — little tricks which they could perform on an amplifier to make yours ever so slightly better than Mr Jones' next door, and which makes Mr Jones want to buy another one slightly better than yours.

In The Distant Future?

Two of the latest gimmicks are remote control and touch control (not just of amplifiers, but of TVs, videos and, presumably in the future, complete house electrical equipment). Now, most gimmicks — scratch filters, rumble filters, loudness controls and so on — don't add anything to the actual quality of the device; they merely colour the sound to suit the individual listener. To the hi-fi freak they are little more than useless!

However, remote or touch control can be highly desirable to the audiophile. You see, to control things at a distance or at a touch we need to be able to make all the adjustments with a mere change of voltage. In this way all the mechanical switches and potentiometers become obsolete. Even if mechanical controls are used *they do not carry the AC audio signal*, but only a DC control voltage. This means that once the signal is on the circuit board it stays there until the output. There are no signal-carrying leads to and from the pots, switches, or other controls and hence there will be less interference pickup, less interchannel crosstalk, better frequency response and fewer switching clicks and crackles — which means a dramatic improvement in amplifier quality.

Control Yourself

Recently, Mullard introduced a range of integrated circuits intended for use on DC-controllable, audio-frequency amplifiers whereby all the (usually) mechanical functions of preamplifiers are controlled by DC voltages on particular IC pins. The two ICs of interest here, the TDA 1028 and TDA 1029, are electronic switches which fulfil the functions of mode switches, filter switches, mute switches and so on. A discussion of further ICs in the range (which control volume and tone) is planned for future presentation.

The TDA 1028 contains two double-pole, double-throw switches and the TDA 1029 one double-pole, four-way switch. Figures 1 and 2 show the simplified internal block diagrams of the ICs. If you bear in mind that these switches, although primarily intended for small-signal AC work, will also accurately switch analogue DC voltages, you will see that they are extremely versatile. The applications given later are all audio-frequency AC designs, but obvious DC suggestions lie in test or measuring equipment.

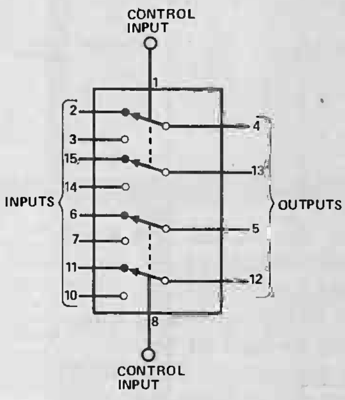


Fig. 1 Block diagram of the TDA 1028, a dual double-pole, double-throw switch.

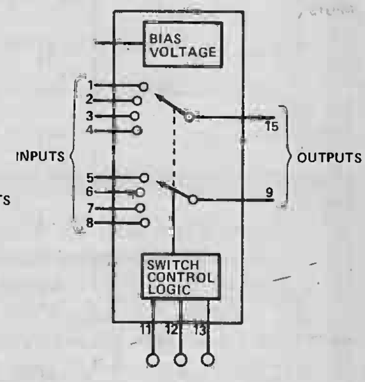


Fig. 2 Block diagram of the TDA 1029, a double-pole, four-way switch.

A Look Inside

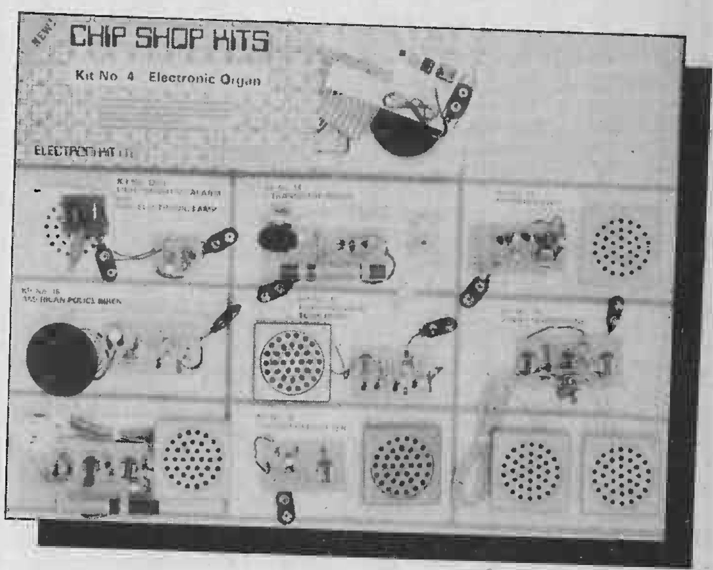
Figure 3 shows a more elaborate diagram of one of the internal signal paths. Basically, the input stage operates with a peak-to-peak input signal of something less than the supply voltage (ie typically between 3 V and 19 V). If a signal outside

Computer Games

If you, like many people, are a computer games addict, you'll be interested to hear about two products which Hanimex are launching this year. The first of these is the Interton VC4000 Microprocessor Video Computer which consists of a main video computer console and an initial software back-up of 22 varying cassettes (with a promise of 10 more by June 81). Included in the software list are favourites like 'Space Invaders' and 'Space Wars', as well as new games like 'Cockpit', an aircraft simulation game. The VC4000 is expected to retail at about £99.95 and the cassettes at £16.95 in the basic range. Certain of these contain up to 60 games each. For the more microcomputer-minded among us, Hanimex will be launching a combined Microprocessor TV Computer and Microcomputer which will retail for under £200, to become available in April or May. It has a small keyboard and fully programmable RAM incorporated in the console, together with four resident TV games plus a range of cartridges and software. Hanimex UK is at Hanimex House, Dorcan, Swindon SN3 5HW, Wilts.

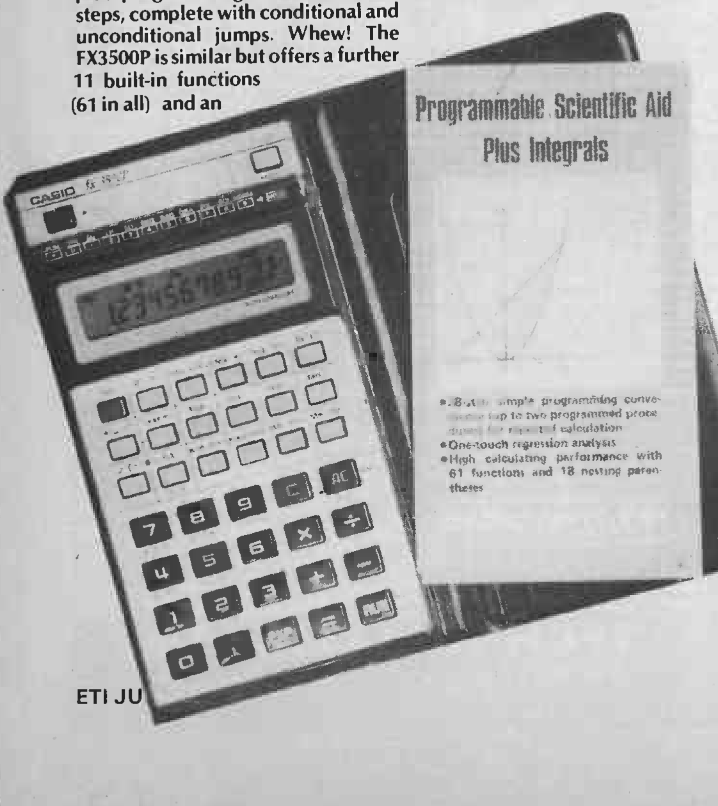
Cheap Kits

For the first time in Britain a new range of practical electronic kits retailing for under £5 will be available from high street hobby shops. They are called Chip Shop Kits and there are over 20 different versions to choose from. Included in the range are projects as diverse as a soldering iron, electronic organ, four-way transistor radio and a lie detector! Each kit contains all the components you need, and all you have to do is wield your soldering iron and add a 9 V PP3 battery. Step-by-step instructions are included with detailed educational notes about the individual circuit and advice on soldering techniques. Keep your eyes open for them in your local hobby shop, or contact Electroni-Kit Ltd, Rectory Court, Chalvington, Hailsham, East Sussex BN27 3TD.



Totting Up

Casio are, once again, introducing a new series of three LCD calculators. The FX2700P is a slimline (7 mm thick) pocket machine with 50 built-in functions: polar/rectangular, random number, 18 parenthesis (nestable up to six levels) fixing of significant digits and of decimal places, standard deviation, etc. Capacity is eight digits, plus two-digit exponent. There are seven memories plus programming to a limit of 38 steps, complete with conditional and unconditional jumps. Whew! The FX3500P is similar but offers a further 11 built-in functions (61 in all) and an extra two-digit capacity. The FX180P is closely related, featuring 55 functions (no hyperbolics) and the same standard deviation, linear regression, integration and 38-step two program facilities. It is 20 mm thick, to accommodate AA size batteries which give 8,000 hours' continuous operation. The FX2700P and FX180P both have recommended retail prices of £22.95 and the FX3500P is £25.95, but, as usual, if you shop around you can probably obtain them for less.



Music From A/D

EMI has made available a number of albums recorded using digital techniques. These include the works of Mahler, Strauss, Debussy, Bach, Wagner and Scott Joplin. Further information is obtainable from EMI Ltd, 20 Manchester Square, London W1A 1ES.

Booking Up

We've just received another four paperbacks from the prolific publisher Mr Babani. The first of these is the 'International Transistor Equivalents Guide' by Adrian Michaels. This book lists over 22,000 transistors produced by more than 100 manufacturers, and their equivalents (but then you'd guessed that from the title, hadn't you?). No characteristics are given but each entry has information on transistor type, polarity, manufacturer(s), the European, American and Japanese equivalents and typical applications. The guide is priced at £2.95.

'VMOS Projects', by R.A. Penfold, contains 96 pages of circuits using VMOS power FETs. The book opens with a discussion of the characteristics of VMOS devices, comparing them to other types of transistors, and goes on to describe audio circuits, sound generators and alarms, DC control circuits and signal control circuits — in all, a total of 33 projects. Each circuit suggestion is accompanied by a thorough explanation and a parts list. The book concludes with a table giving the pinouts of all the semiconductors used. VMOS Projects costs £1.95.

The third tome is 'Digital IC Projects', by F.G. Rayer (91 pages); this book is divided into three sections. The first gives a general guide to components and construction, including IC orientation and pinouts for Nixie tubes and seven-segment displays. The second section deals with power supplies for the projects, explaining the principles of voltage regulation and giving suitable circuits. Following this are the projects themselves, ranging from roulette and digital dice to counters, stopclocks and test gear. This book also costs £1.95.

Finally we have 'Electronic Synthesiser Projects' by M.K. Berry. In its 81 pages it covers most aspects of electronic music and gives simple circuits for the experimenter to build. The first of these is a single-chip synthesiser based on the SN76477N sound generator IC, and later chapters describe an analogue delay line, a programmable analogue sequencer, two VCOs, an envelope shaper and a power supply. The final chapter explains how the various circuits can be used together. Each project has a parts list, a suggested PCB and a component overlay. All this can be yours for only £1.75. All these books should be readily available in bookshops, but in case of difficulty you can contact Bernard Babani (Publishing) Ltd at The Grampians, Shepherds Bush Road, London W6.

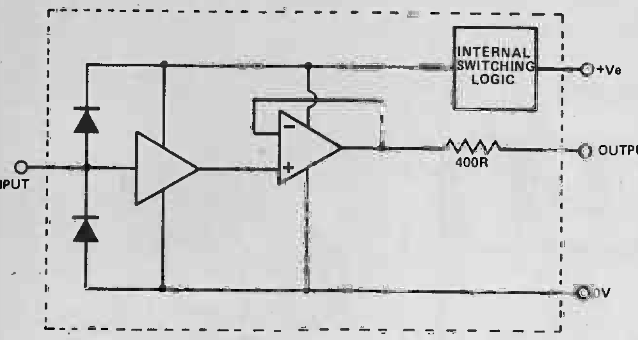


Fig. 3 Block diagram of a single internal signal path.

the supply range is applied, the diodes limit the signal, thus protecting the device.

A high impedance buffer follows the input stage and the output is connected via a 400R internal resistor which gives protection in the case of a direct short circuit. Overall gain of the signal path is close to unity and depends on the output load. For example, with a load impedance of 4k7 the gain is -1.5 dB(x0.84). Switching between one input and another is done by the internal logic, performing the simple function of connecting or disconnecting the power to the signal path in question.

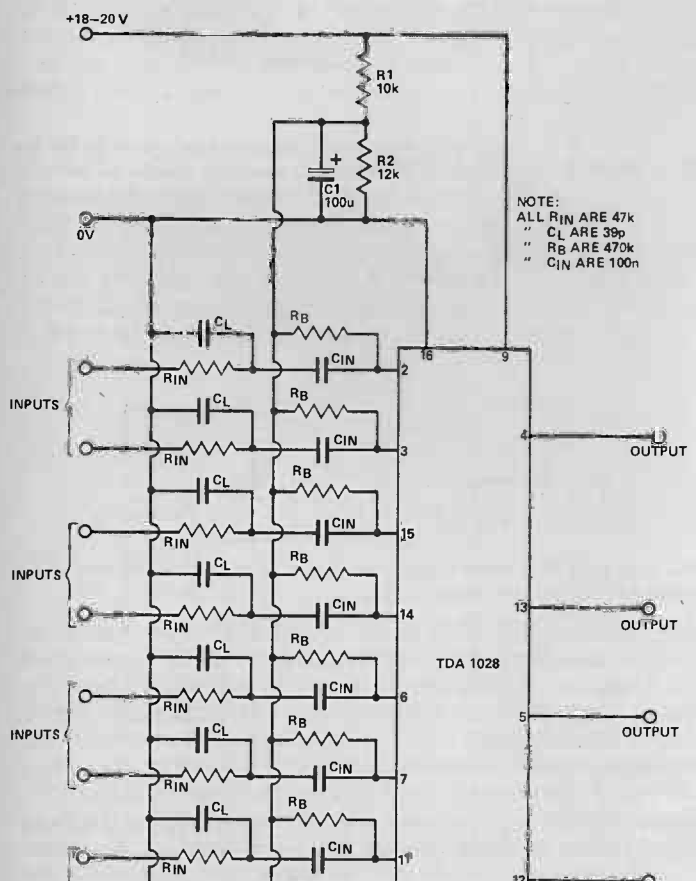


Fig. 4 Minimum component circuit for the TDA 1028.

Complications

Naturally, life is not so easy as the block diagrams suggest and certain peripheral components are needed to get the devices up and running.

(i) If the input voltage range (ie about 3 V to 19 V) is exceeded then the input current must be limited by an external resistor. The value of this resistor should be calculated so that the average input current does not exceed 20 mA. In the case of the ICs' use within a preamplifier no limiting resistors are strictly necessary.

(ii) If the switches are intended for AC work then DC blocking capacitors should be used.

(iii) A 'floating' input might cause switching noise at the output, due to rapid DC variations. To prevent this all inputs should be biased, via a resistor, to a point midway between the input voltage limits — about 11 V.

Workable circuits, with the above points considered, are found in Figs. 4 and 5. Bias for the TDA 1029 is supplied from an internal reference. This reference is unstabilised and dependent on the supply voltage. Hum and other interference will therefore affect it so a filter capacitor (C1 in Fig. 5) is required. If the TDA 1028 is used in the same circuit as the TDA 1029 then all input biases can be taken from this internal source. Alternatively, or in a separate circuit, a simple voltage divider and filter capacitor will do the job (R1,R2,C1 in Fig. 4). Bias is supplied to all inputs via 470k resistors (R_B) and all input capacitors (C_{IN}) are 100n polycarbonates. For experimental work only, all input resistors are specified as 47k, and low-pass capacitors (C_L) can be used to eliminate RF interference in the input signal leads if required. These two circuits can be built for test purposes on the

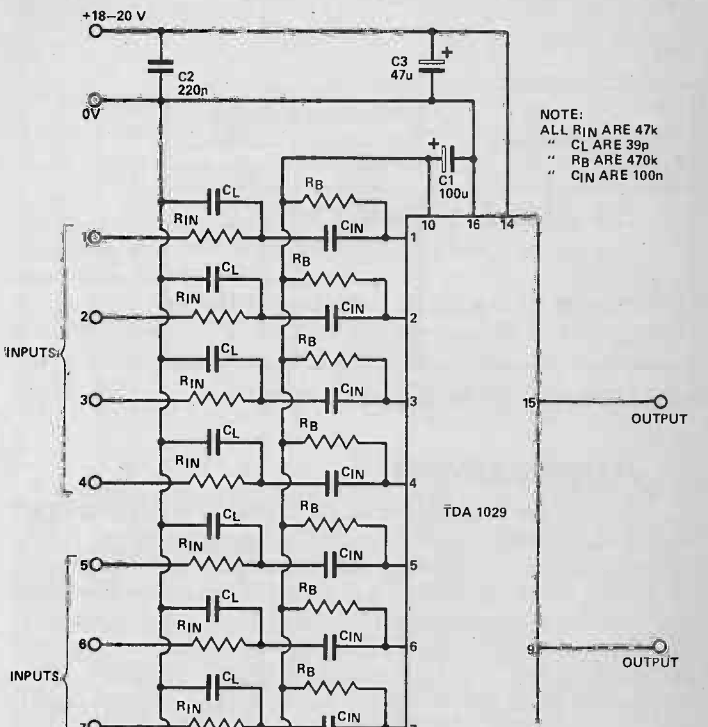
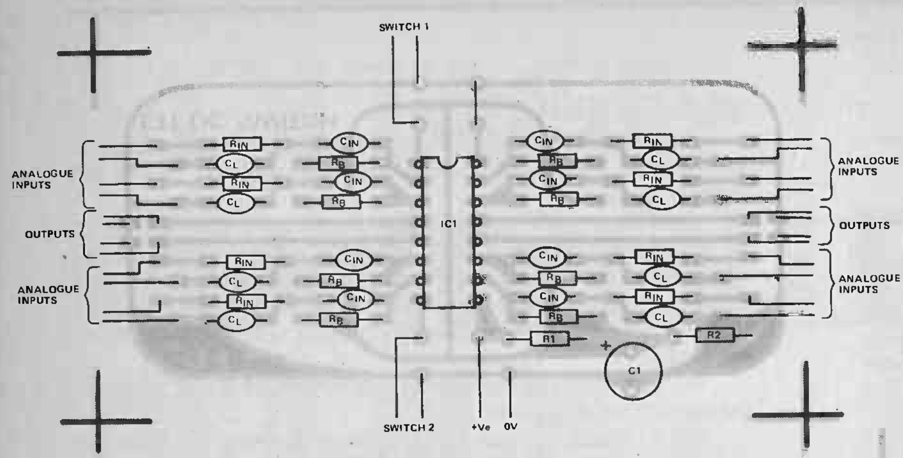


Fig. 5 The corresponding basic circuit for the TDA 1029.



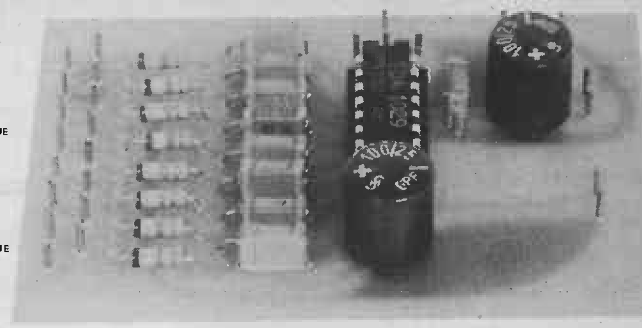


Fig. 6 Suggested layout for the experimental circuit of Fig. 4. The PCBs are on page 96.

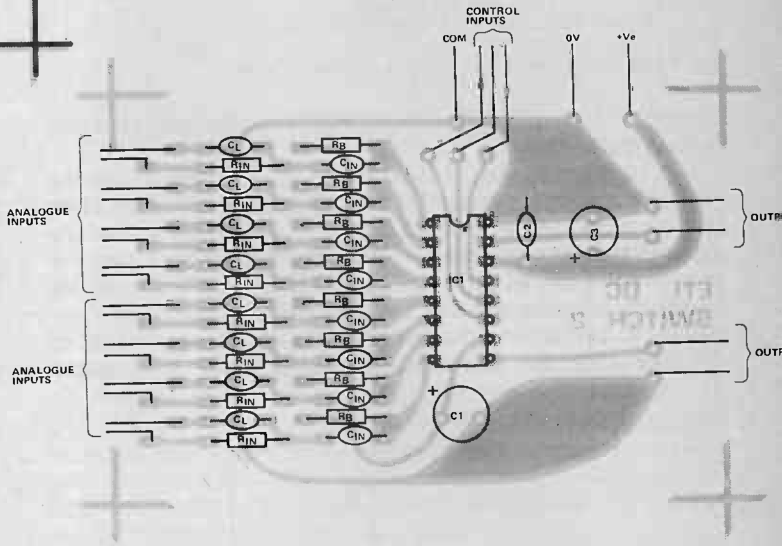


Fig. 7 Overlay for the Fig. 5 circuit.

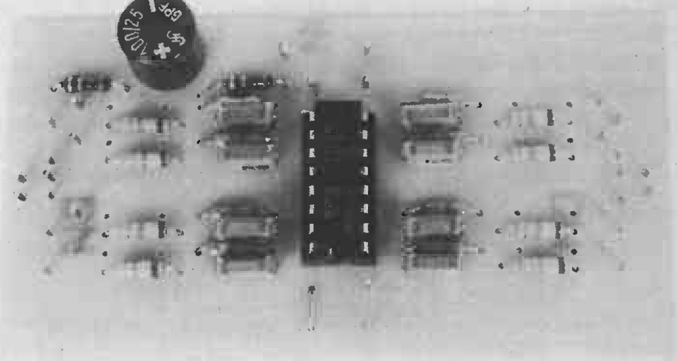
PCBs shown in the overlays in Figs. 6 and 7. Adjust the input resistors as required (47k is a suitable starting value), and for DC applications use links instead of input capacitors. Incidentally, the boards are also suitable as bases if you intend to breadboard some of the following applications.

The final things to look at before using the two chips are the control inputs: they are internally connected to a HIGH state and the simplest way to ensure the LOW state of an input is to connect it directly to 0 V. Voltage control of the inputs requires <2V1 for a low state and >3V3 for a HIGH state—the inputs are therefore compatible with CMOS or TTL logic, and remote, touch, or even computer control of the signal paths is easy.

Table 1 gives a summary of the control inputs and consequent pin interconnections for the TDA 1028. Similarly, Table 2 gives the same for the TDA 1029. The control input of pin 11 has priority over those of pins 12 and 13. Pin 12 control has priority over pin 13, but *not* pin 11's control input.

Connected pins	Control voltages	
	Pin 1	Pin 8
2 — 4, 15 — 13	H	—
3 — 4, 14 — 13	L	—
7 — 5, 10 — 12	—	H
6 — 5, 11 — 12	—	L

Table 1 TDA 1028 interconnections and control levels.



The TDA 1028 PCB. Note that the low-pass capacitors are optional and have been left off our board.

Applications

Perhaps the simplest use of the TDA 1029 is as a four-input stereo signal-source switch connecting either a stereo tuner, phono, tape deck or auxiliary input to an amplifier. Although it all sounds rather complex, Fig. 8 shows that it is not. The tuner and auxiliary input signals are fed directly, via input capacitors, into the IC, however, the tape output has a relatively high impedance source and connecting leads are therefore quite susceptible to RF interference. A suitable input network (eg R1 and C1) connected as a low-pass filter eliminates the RFI. The output of the circuit is fed back to the tape deck via coupling capacitors and 820k resistors.

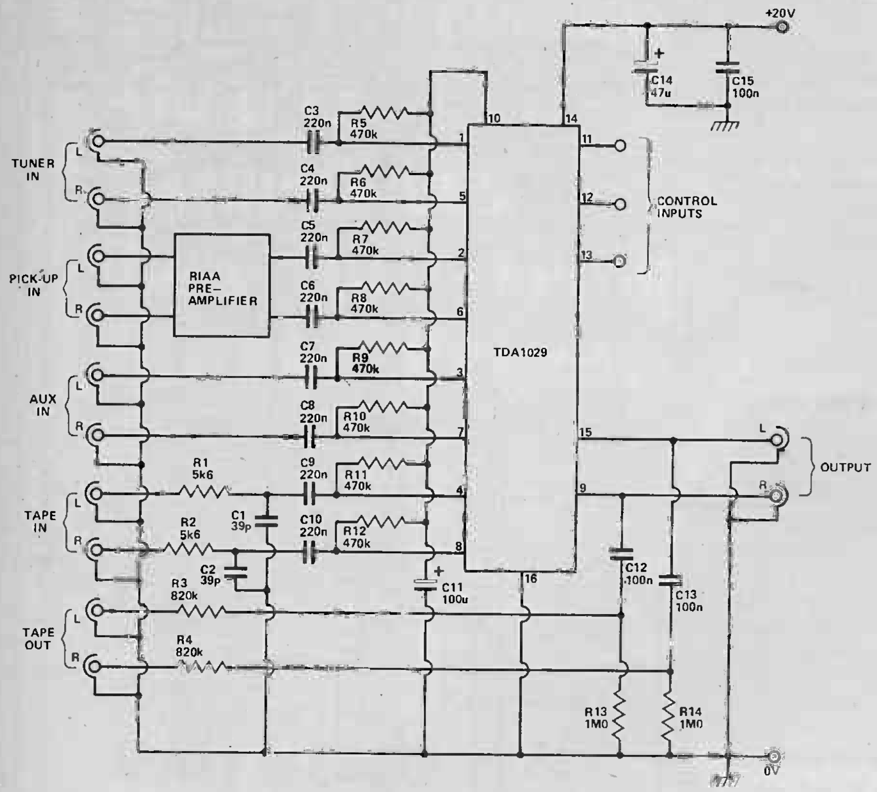
The pick-up input needs RIAA equalisation and amplification; this stage is shown as a block in the circuit. Suitable circuits for pick-up stages are common and no design for such is offered here.

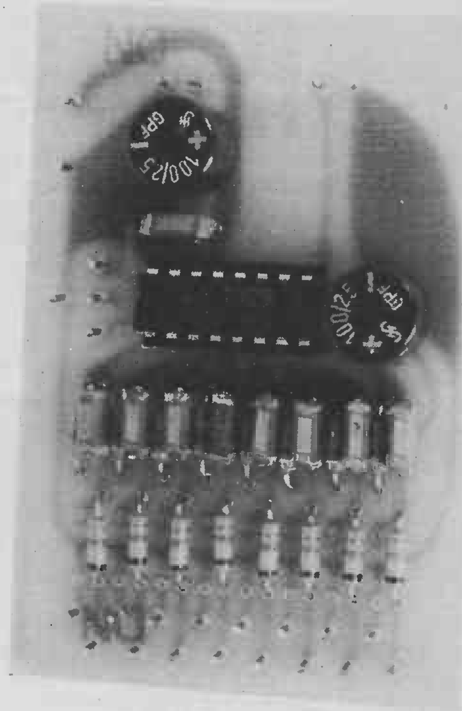
It is possible to cascade the electronically switched signal paths of these two ICs, either within the same device (eg from one half of a TDA 1028 to the other half) or from one IC to another. In either case separate signal paths are best connected via capacitors to keep switching clicks as small as possible. Figure 9 shows a typical example of a four-input stereo signal-source switch (using a TDA 1029) cascading into a monitor and stereo/mono switch (formed by a TDA 1028). A monitor switch allows comparison of recorded/played-back signals to and from a three-headed tape recorder. Thus it needs to be after the main signal-source switch but before the power amplifier, as shown.

The final two circuits given as application suggestions are switchable active filter circuits. Because each signal path is basically a unity-gain, non-inverting amplifier it is relatively easy to connect into standard filter circuits (a third-order Butterworth design being chosen) allowing electronic control of the preamplifier's frequency response.

By using each switch section of a TDA 1028 in separate filter modes (Fig. 10) a stereo high-pass/low-pass (rumble/scratch) filter can be built.

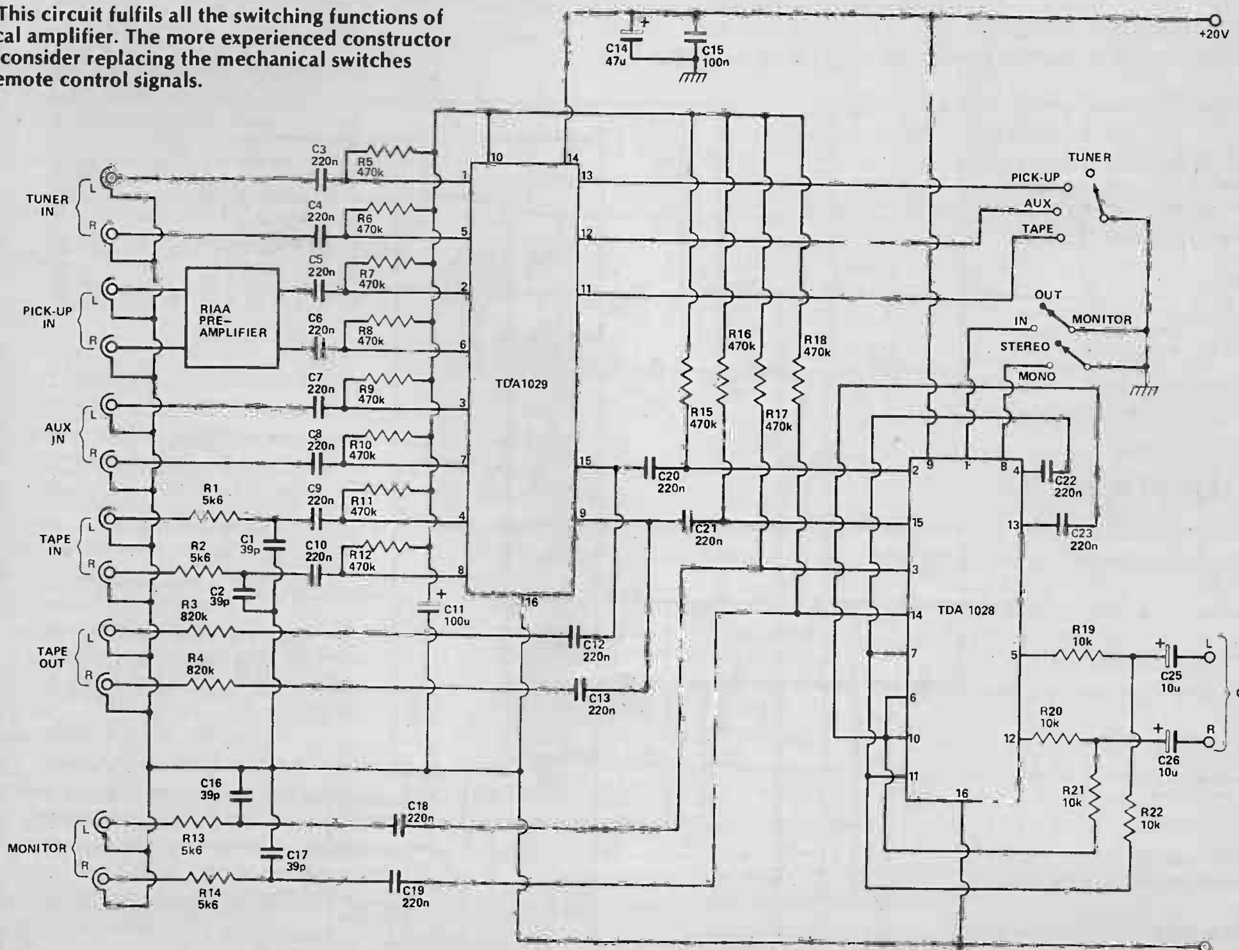
Fig. 8 Stereo signal-source switch for a hi-fi system. The control inputs could be interfaced with a remote control system.





Our prototype board for the TDA 1029. Once again, the optional low-pass capacitors have been omitted.

Fig. 9 This circuit fulfils all the switching functions of a typical amplifier. The more experienced constructor might consider replacing the mechanical switches with remote control signals.



Similarly, the TDA 1029 can be used in filter modes, taking control of four separate filters; linear, subsonic, scratch and mute in the circuit of Fig. 11. Table 2 shows that the control pins have been chosen so that the mute signal has an overriding effect on all the other control signals (as it should), and the rumble filter signal overrides that of the subsonic filter.

In conclusion, the previous applications show the TDA 1028 and TDA 1029 to be very versatile devices. The simplicity and ease with which they can be used means that they will be popular. Both chips are available from Ambit International.

Connected pins	Control voltages		
	Pin 11	Pin 12	Pin 13
1 — 15, 5 — 9	H	H	H
2 — 15, 6 — 9	H	H	L
3 — 15, 7 — 9	H	L	H
3 — 15, 7 — 9	H	L	L
4 — 15, 8 — 9	L	H	H
4 — 15, 8 — 9	L	H	L
4 — 15, 8 — 9	L	L	H
4 — 15, 8 — 9	L	L	L

Table 2 TDA 1029 interconnections and control levels.

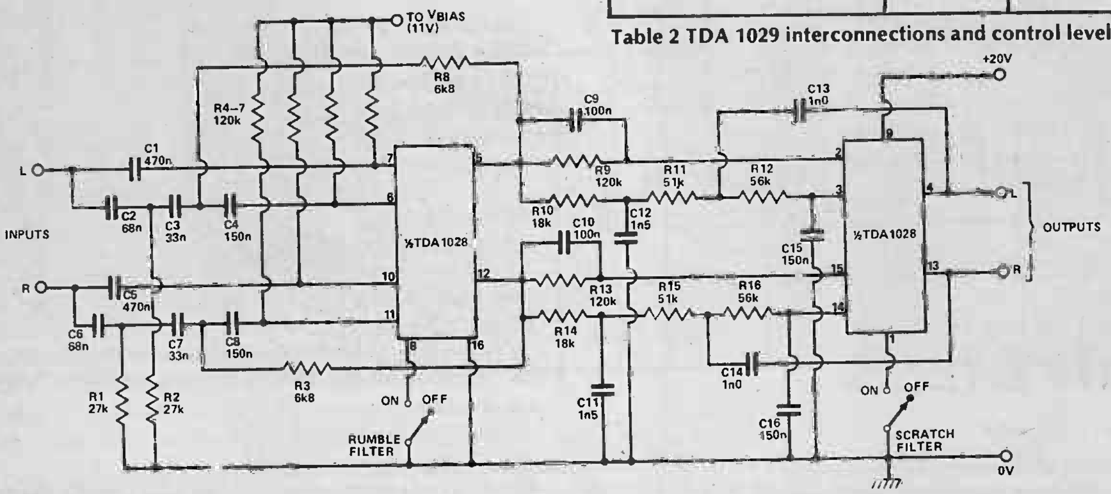


Fig. 10 This stereo rumble/scratch filter can be built using only a single TDA 1028.

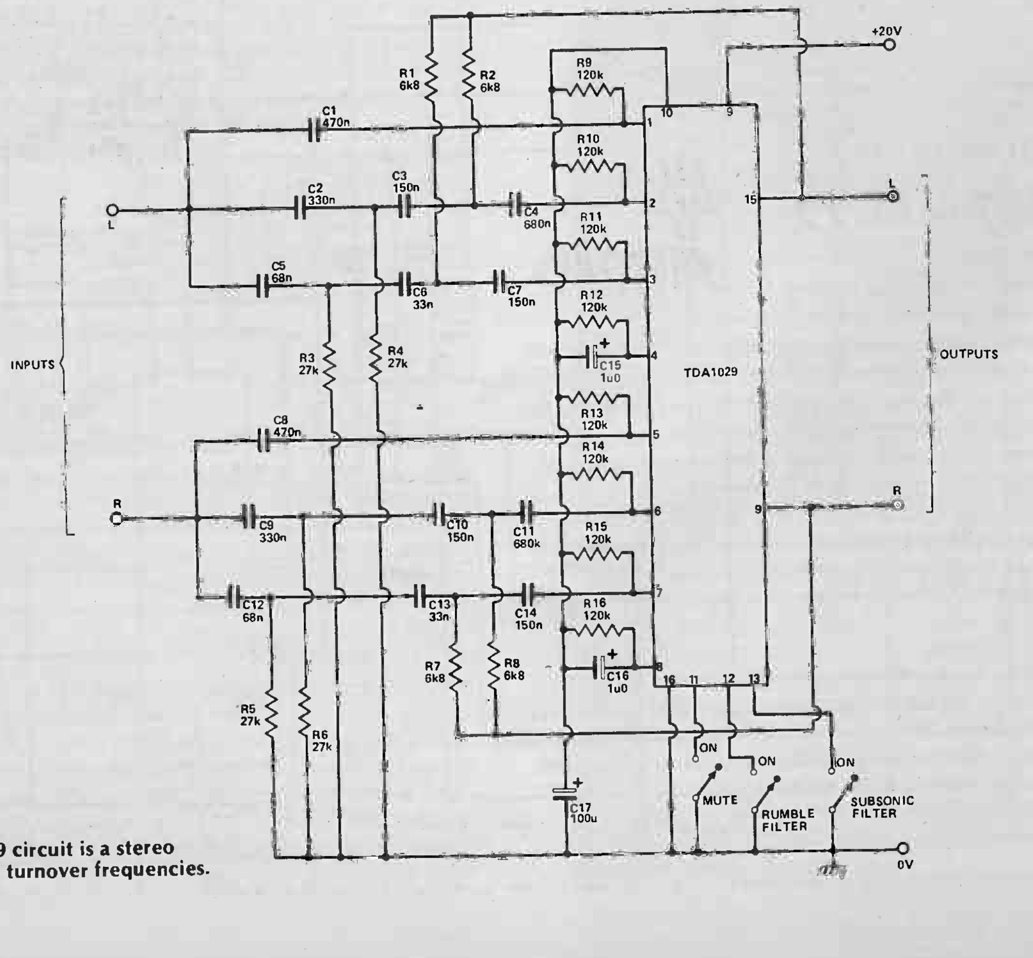


Fig. 11 This TDA 1029 circuit is a stereo filter with switchable turnover frequencies.

ANTENNA EXTENDER

If you intend to buy (or already own) a motorised antenna then you shouldn't be without this intelligent gadget which automatically controls your aerial's ups and downs. Design by Ray Marston. Development by Steve Ramsahadeo.

There is a large proportion of motorists who have had the misfortune of losing their car aerial through a car-wash, through accidental breakage or maybe to the young mischievous vandal eager to add another victim to his list.

Judging by the number of coathangers that have found their way out of the family wardrobe and into the orifice where the chrome rod once stood, one only has to wait anxiously for the coathanger industry to replace the car aerial. It is not surprising that with these catastrophic events prevailing, drivers are reluctant to replace their aerial. However, if you install a motorised antenna incorporating the ETI antenna controller, it will reduce the risk of losing your aerial.

The unit is designed to replace the manual operation of 'holding' the antenna switch in the 'on' position to activate the aerial. The ETI controller overcomes this hindrance by sensing whether the radio is 'on' or 'off' state and automatically extending or retracting the aerial.

Better Safe Than Sorry

There are also certain fail-safe features which are incorporated to comply with the manufacturer's instructions. These are:

(i) when the antenna has extended it should not be switched from up to down or vice versa without waiting for at least 3 s before the next operation.

(ii) switching the radio on and off repeatedly will have no effect while the aerial is operating.

With these features our project supersedes most commercial units already available.

Construction And Setting Up

Construction is straightforward. All components, including the relays, are mounted on a single PCB. Begin construction by inserting all low profile components, ie wire links, Veropins and sockets, followed by resistors, diodes, capacitors and transistors, observing the orientation of all polarised components. R15 is soldered underneath the PCB between the junction of PR2/PR3, and the positive end of C5.

Before you fit the PCB in its box the following setting-up procedure should be carried out:

1) Fit IC1 and link points B and C. (This link is used for setting up only.)
2) Connect a 12 V power supply to the PCB supply terminals.
3) Adjust PR1 until LED1 just turns on; mark this position.
4) Connect R_{TEST} as shown on the circuit diagram. Adjust PR1 until LED1 turns off; mark this position.
5) Disconnect R_{TEST}. PR1 should now be adjusted to the midway setting of steps 3 and 4.
6) For a final check, R_{TEST} can be reconnected and LED1 will switch on; if all is well the remaining ICs can now be fitted.

HOW IT WORKS

IC1 is configured as a voltage comparator with a fixed reference voltage at pin 3; pin 2 is arranged in the same way except that D1 is included as the sensor. If a load is present (ie the car radio is switched on), the voltage at pin 2 will fall to a value of (V_{CC} -600) mV, this being the forward voltage drop of the diode. This change of voltage is now compared to the reference at pin 3.As the voltage has decreased the output of IC2 will switch to aproximately the supply voltage.

PR1 is incorporated in the circuit to balance the tolerances of R4,5,6 and 7 so that with any extreme changes of voltage or temperature, the comparator will reliably detect a change at pin 2.

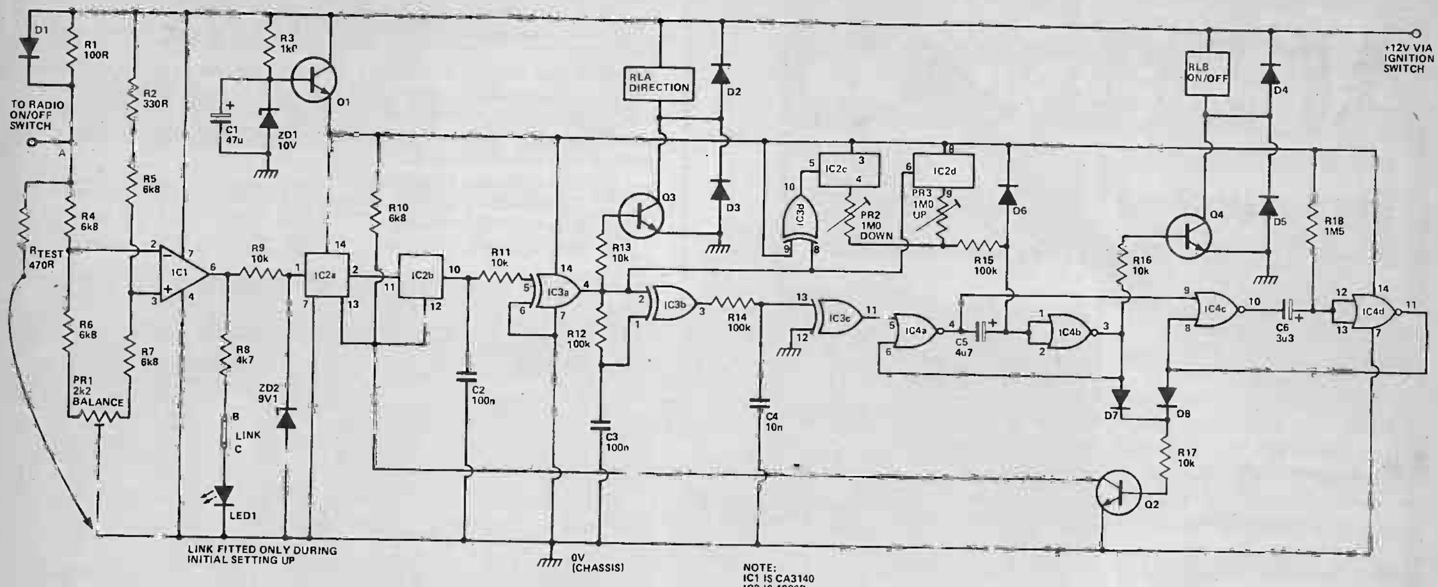
The output of IC1 is fed to IC2a and b (bilateral switches). These switches are normally closed, but with a low signal at their controls (pins 12 and 13) the switches will open, breaking the connection to the rest of the circuit and providing the necessary inhibit facility. ZD1 is added to suppress transients that might cause false triggering.

If the car radio is switched on the output of IC2b is high; this voltage is fed to the input of a non-inverting gate (IC3a). The output of this gate determines the relay direction via Q3, as well as providing the input to the edge detector IC3b. The function of this gate is to give a positive-going pulse whenever its input changes state. R14 and C4 are added for protection against spikes that occur during switching. IC3 squares the output of the edge detector, so a reasonably narrow pulse is available to trigger the first monostable (IC4a, IC4b). The output of IC4b energises RLB via Q4 for a period set by PR2 and C5 (this is not more than 5 s). RLB is now supplying power to the motor antenna with a polarity determined by RLA, so while the monostable is turned on the antenna will extend. When this period has ended, pin 4 of IC4a will assume a high state, triggering the second monostable (IC4c, IC4d). The outputs of both monostables are fed to a diode OR gate and inverted by Q2 to open the bilateral switches. This gives a total inhibit time of approximately 6 s, allowing 3 s for the antenna to extend, plus a further 3 s delay before the next operation can take place.

D6 ensures that C5 is fully discharged at the end of the monostable period, to prevent false triggering by residual charge.

When the radio is switched off, the output of the comparator and IC3a will be low. As pin 8 of IC3d is at 0 V, its output will be high which closes IC2c; at the same time IC2d opens and the down sequence is activated. The monostable and RLB follow the same mode of operation as already described.

Q1 and associated components (R3, C1 and ZD1) provide a regulated supply for the CMOS devices.



We mounted our PCB on three ¼" spacers. When it comes to hooking up the unit, there should be no complications as there are only four wire connections to consider. These are made via a four-way terminal block on the side of the case. The 0 V connection is made to the internal earth terminal of the case. The completed unit can be secured in a suitable place underneath the bonnet, thus completing the earth return to the battery through the chassis.

NOTE:
IC1 IS CA3140
IC2 IS 4066B
IC3 IS 4070B
IC4 IS 4001B
Q1–4 ARE BC108
D1 IS 1N5401
D2–5 ARE 1N4001
D6–8 ARE 1N4148
ZD1 IS BZY88 10V
ZD2 IS BZY88 9V1

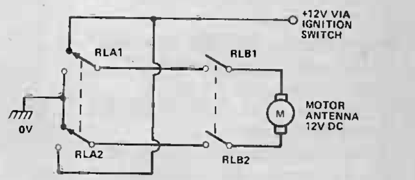


Fig. 1 Circuit diagram of the Antenna Extender.

PARTS LIST

Resistors (all ¼ W, 5%)

R1	100R
R2	330R
R3	1k0
R4,5,6,7,10	6k8
R8	4k7
R9,11,13,16,17	10k
R12,14,15	100k
R18	1M5

Potentiometers

PR1	2k2 miniature horizontal preset
PR2,3	1M0 miniature horizontal preset

Capacitors

C1	47u 16V tantalum
C2	100n polycarbonate
C3	100n ceramic
C4	10n polycarbonate
C5	4u7 35 V tantalum
C6	3u3 16 V tantalum

Semiconductors

IC1	CA3140
IC2	4066B
IC3	4070B
IC4	4001B
Q1-4	BC108
D1	1N5401
D2-5	1N4001
D6-8	1N4148
ZD1	BZY88 10V
ZD2	BZY88 9V1

Miscellaneous

RLA,B	double pole changeover, coil resistance 205R (see Buylines).

Four-way terminal block, case ref. BOA 115 (see Buylines).

Fig. 2 Component overlay. Note that R15 is soldered beneath the PCB.

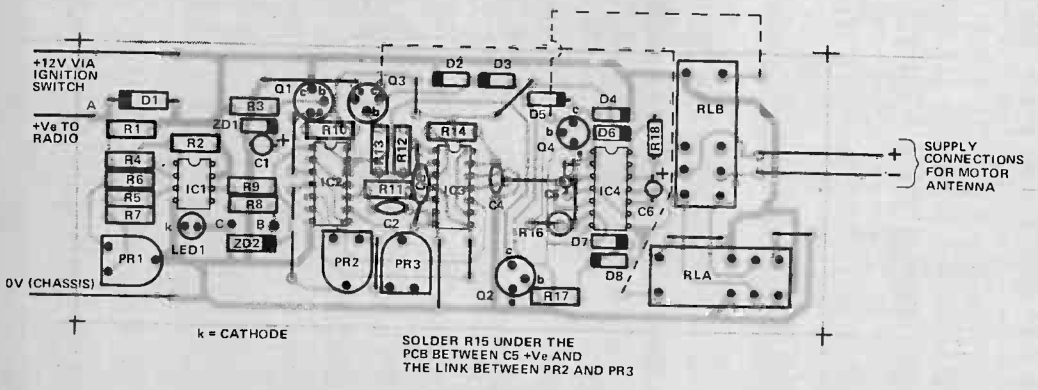
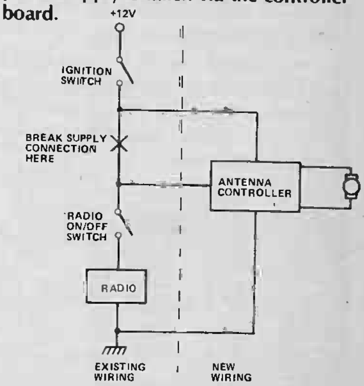
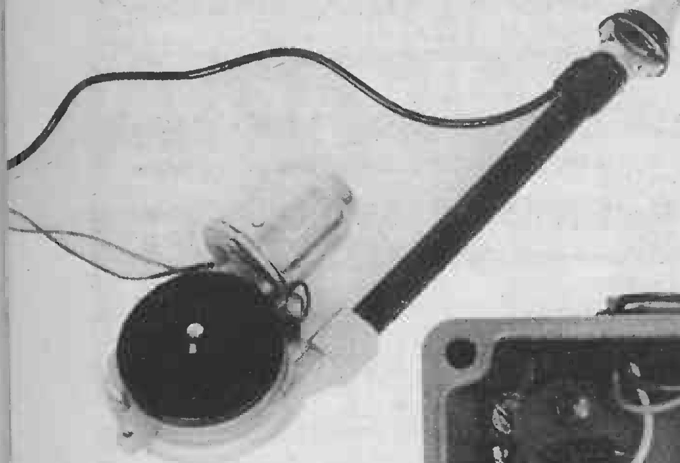


Fig. 3 How to wire up the unit. The radio power supply is taken via the controller board.

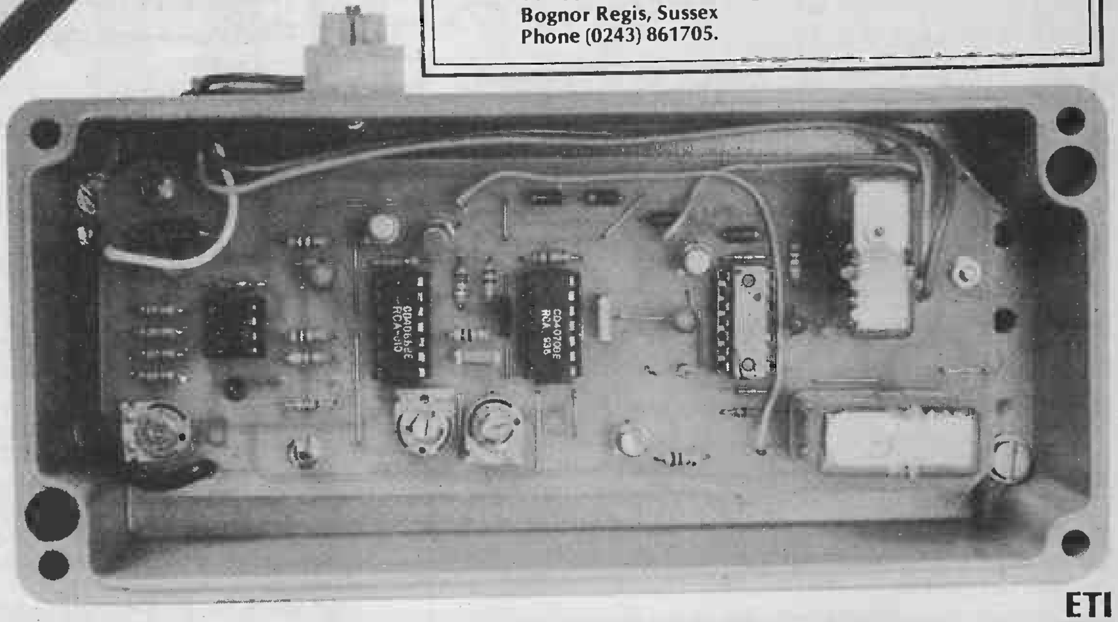




BUYLINES

Grove House Electronics offer a range of motor antennas. The one used in our prototype was a five-section 1 m model NW-510. The relays used are type RL6 from Watford Electronics, and the case is a solid weatherproof, die-cast aluminium housing marketed by West Hyde Developments.

Grove House Electronics,
14 Arcade Chambers, High St.,
Bognor Regis, Sussex
Phone (0243) 861705.



Above: the motor antenna that we used to test our prototype.

Right: the finished PCB mounted in its weatherproof case. The earth terminal for the 0 V connection can be seen in the top left-hand corner. The remaining connections are made via the terminal block on the side of the case.

ETI

DESIGNER'S NOTEBOOK

CA3140 and LF351 op-amps can be used in some special-purpose single-supply applications that are quite impossible with simple 741-type devices. Ray Marston explains.

Most op-amps can be used with either dual (split) or single-ended supplies, so long as the constraints of their input terminal limits are not exceeded. Specifically, op-amps have a parameter known as 'common-mode input voltage limit' which, in practical terms, defines how close their input terminals can be taken to the positive and negative supply rails without impairing circuit operation. Table 1 illustrates the general input constraints of the 741, CA3140 and LF351 op-amps.

Note here that the input terminals of the 741 op-amp cannot be usefully taken to within closer than a couple of volts of the positive (pin 7) or negative (pin 4) supply rails. Thus the device cannot be used as a true voltage follower in single-supply circuits, for example. The inputs of the CA3140, on the other hand, can swing all the way down to 500 mV *below* the pin 4 negative voltage, but can only swing within a couple of volts of the positive supply rail. This chip can thus be used as a true voltage follower in single-supply circuits.

Finally, the LF351 inputs can only swing down to within a couple of volts of the negative rail, but can go as high as 100 mV *above* the positive supply rail. In this way, this chip can be used in some quite unique applications in which input signals are referenced to the positive supply terminals. Let's look at some practical single-supply applications of the CA3140 and the LF351.

OP-AMP TYPE	POSITIVE INPUT LIMIT, REFERENCED TO THE PIN 7 VOLTAGE	NEGATIVE INPUT LIMIT, REFERENCED TO THE PIN 4 VOLTAGE
741	(V+) – 2V	(V–) + 2V
CA3140	(V+) – 2V	(V–) – 500mV
LF351	(V+) + 100mV	(V–) + 2V

Table 1. Common-mode input voltage limits of the 741, CA3140 and LF351 op-amps.

CA3140 Applications

The CA3140 op-amp has PMOS/FET inputs, giving the device a virtually infinite input impedance. The device uses the same pin configuration as the 741 op-amp and can be used with any supply voltage (between pins 4 and 7) from 4 to 36 V. Outstanding characteristics of the device are that its input terminals can swing as low as 500 mV below the pin 4 voltage as already mentioned, and its output can swing to within a couple of millivolts of the pin 4 voltage. A notable defect of the device is that its output can source far more current than it can sink; when used with a single-ended 5 V supply, it can source 10 mA but sink a mere 1 mA.

Figure 1 shows how the CA3140 can be used as a true voltage follower with a single-ended supply. The input can swing all the way from zero to within 2 V of the positive supply value and the circuit has a virtually infinite input impedance.

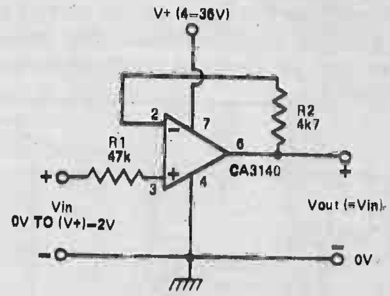


Fig. 1 Zero-referenced DC voltage follower.

Figure 2 shows how the device can be used as a x10 non-inverting DC amplifier that will accept inputs all the way down to 0 V. Again, the circuit has a virtually infinite input impedance.

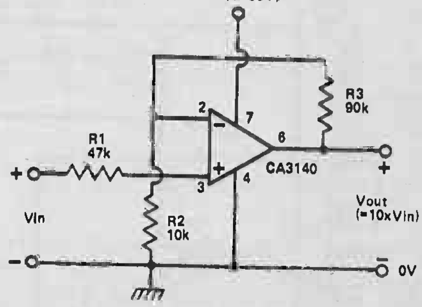


Fig. 2 Non-inverting DC amplifier with a gain of 10.

Figure 3 shows how the above circuit can be modified as a three-range (100 mV — 1 V — 10 V) DC voltmeter or multimeter adaptor with an input impedance of 11 M on all ranges. Offset control PR1 should be trimmed initially to make the meter read correctly at one-tenth of full scale. The two output diodes pro-

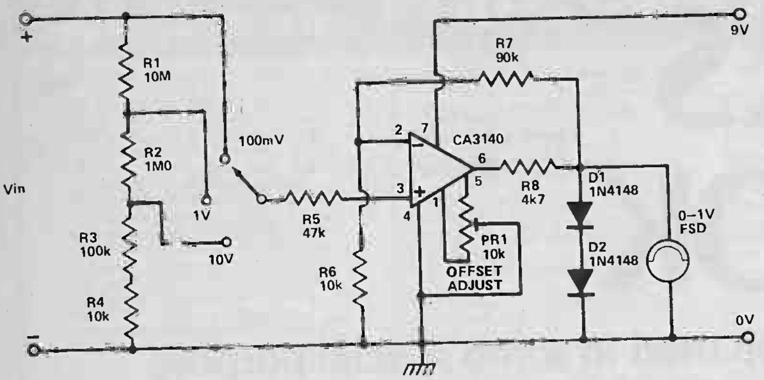


Fig. 3 Three-range DC voltmeter/meter adaptor with 11 M input impedance on all ranges.

tect the meter against damage if excessive input voltages are applied. Note in the Fig. 2 and 3 circuits that the 90k resistor can be made by wiring a 100k resistor in parallel with 1M0.

Figure 4 shows how the basic Fig. 1 circuit can be modified to give a boosted current-driving capacity (up to about 100 mA in this case). Note that the output voltage across emitter resistor R3 is identical to the circuit's input voltage. If Q1 is replaced with a Darlington power transistor, the circuit can easily be made to function as a variable-voltage DC power supply with an output that can swing all the way down to 0 V.

Figure 5 shows how the Fig. 4 circuit can be modified for use as a unity-gain DC level translator that converts a zero-referenced input into an identical positive-referenced output

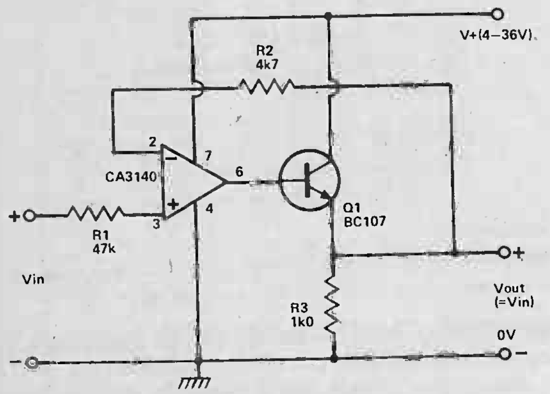


Fig. 4 Zero-referenced voltage follower with boosted output.

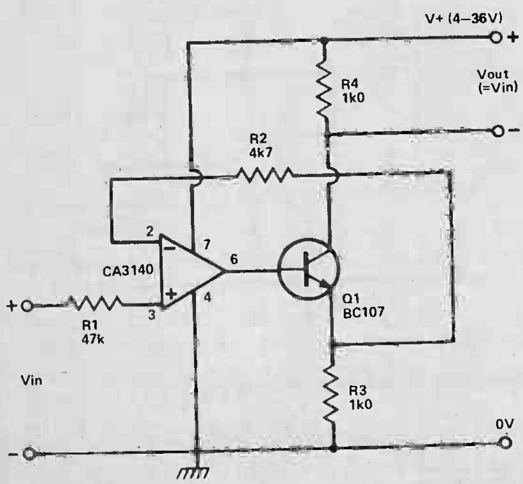


Fig. 5 This unity-gain DC level translator shifts a zero-referenced input to a positive-referenced output.

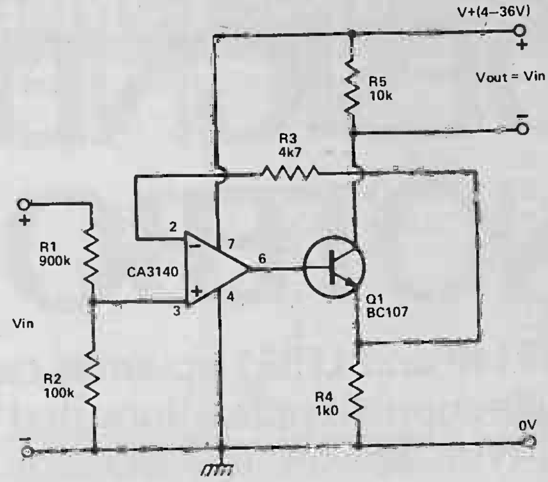


Fig. 6 Unity-gain wide-range DC level translator.

quite independent of supply-line variations. The gain of this circuit is determined by the ratios of R3 and R4, so the circuit can be given a gain of 10 (for example) by simply giving R4 a value of 10k. A minor defect of the Fig. 5 circuit is that the output cannot swing below half-supply voltage. Figure 6 shows how the circuit can be modified to enable the output to swing over roughly 85% of the supply voltage range. Here, the input voltage is simply attenuated by 20 dB by R1-R2 and the actual translator is wired in the x10 mode, to give an overall gain of unity.

Figure 7 shows the circuit of a voltage-controlled constant-current generator, with a sensitivity of 10 mA/V. Here, the CA3140 and Q1 are wired as a basic voltage follower, in which the voltage across R2 is identical to the input voltage. Consequently, since the emitter and collector currents are virtually identical, the output current is equal to $V_{IN}/R2$, virtually independent of the value of the output load resistance. The maximum available output current of this circuit is limited by the power-handling capacity of Q1.

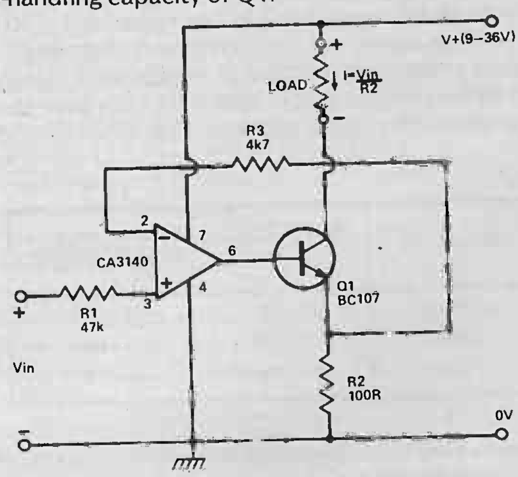


Fig. 7 Voltage-controlled constant-current generator, with a sensitivity of 10 mA/V.

Finally, Figs. 8 and 9 show how the CA3140 can be used as a precision 0-6V8 over- and under-voltage indicator. In both of these circuits the op-amp is used as a simple voltage comparator, with its output feeding to an indicator LED via an 820R limiting resistor; the reference voltage is fed to one input terminal and the sample or test voltage to the other. In the Fig. 8 over-voltage circuit the sample is fed to the non-inverting input terminal, and in the Fig. 9 under-voltage circuit the sample is fed to the inverting terminal.

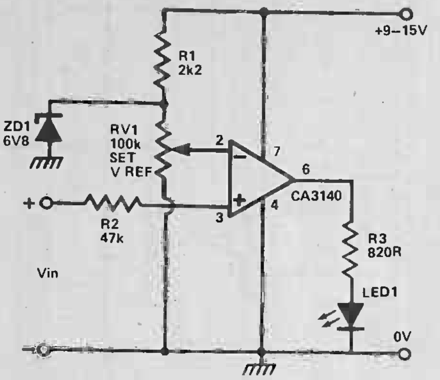


Fig. 8 Precision over-voltage indicator spanning 0 to 6V8.

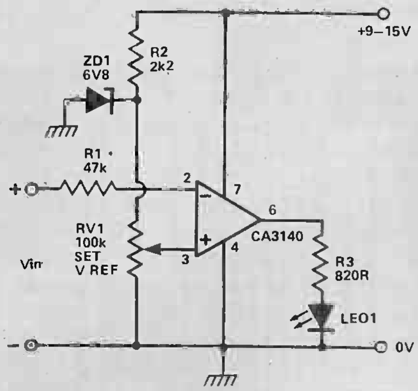


Fig. 9 Precision under-voltage indicator.

LF351 Applications

The LF351 op-amp has JFET inputs, giving the device an input impedance of about a million megohms. The device uses the same pin configurations as the 741 op-amp and can be used with any supply voltage (between pins 4 and 7) from 9 to 36 V. An outstanding feature of the device is that its input terminals can swing as high as 100 mV above the pin 7 positive supply voltage. Defects of the device are that its output can only swing within a volt or two of the positive and negative supply rails and the input can only swing within a couple of volts of the negative rail. A particularly nasty quirk of the IC is that its output inverts if one of its inputs is taken below the negative common-mode limit, or goes high if both inputs are taken below the limit. Nevertheless, the device can be used in some unique single-supply applications in which input signals are referenced to the positive supply terminals.

Figure 10 shows how the LF351 can be used as an over-current switch, in which the op-amp output switches high if the current drawn from the supply by an external load exceeds a preset value. Here, a reference voltage of 600 mV is set on the non-inverting terminal of the op-amp by D1, and a current-related voltage is applied to the inverting terminal by R_S; the op-amp output switches high if the R_S voltage exceeds the 600 mV reference level, so R_S needs a value of 0.6/I, where I is the trip current in amps. Note in the Fig. 10 circuit that the output (into a 10k load) is 1V5 when the switch is off or 1 V below the positive supply when the switch is on. This circuit can be used as a LED-output over-current indicator, if required, by replacing R2 with an LED and 820R series resistor.

Figure 11 shows how the LF351 can be used as either a positive-referenced voltage follower or as a voltage-controlled

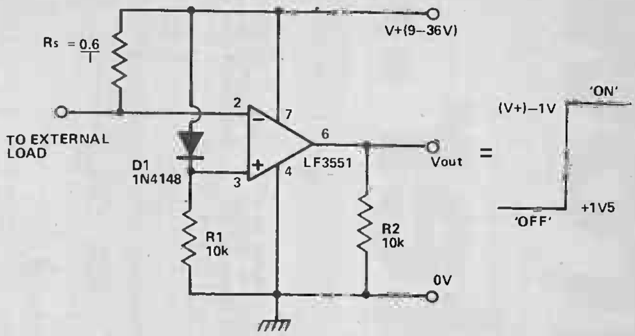


Fig. 10 This over-current switch monitors the current that an external load draws from the positive supply line.

constant-current generator. Here, the op-amp is wired as a standard follower-with-booster-output-stage (using PNP transistor Q1); zener diode ZD1 is used to enable the follower output to swing all the way down to 0 V (referenced to the positive line). The circuit can be used as a constant-current generator by breaking the Q1 collector line as shown, the output current then being equal to $V_{IN}/R2$.

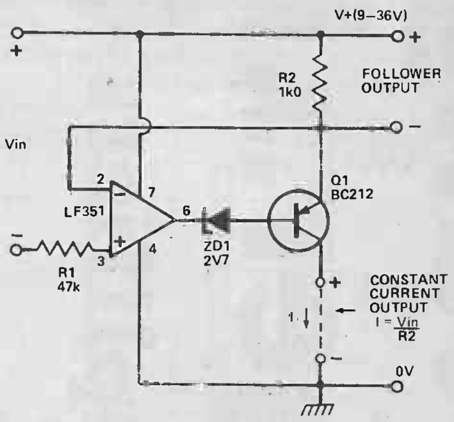


Fig. 11 This circuit can be used either as a positive-referenced voltage follower or as a voltage-controlled constant-current generator.

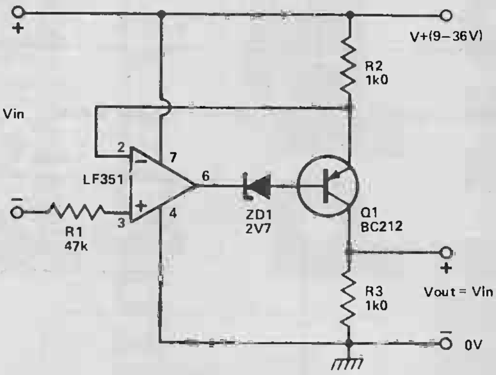


Fig. 12 This unity-gain DC level translator shifts a positive-referenced input to a zero-referenced output.

Finally, Fig. 12 shows how the LF351 can be used as a unity gain level translator that converts a positive-referenced input into a zero-referenced output. The gain of the circuit is determined by the ratios of R2 and R3, so the circuit can be given a gain of 10, for example, by simply giving R3 a value of 10k. Thus if, as an example, the translator is used in the x10 mode and has its input taken from a 1R0 (1 V/A) current-sensing resistor in the positive supply line, the circuit will give a zero-referenced output voltage of 10V/A, thereby simplifying current monitoring problems in power supply circuits. **ETI**

Stacks Of Time

At the Home Video Show in March, those awfully nice Sony people launched a new add-on accessory for their C7 video recorder. With the new generation of programmable video recorders owners have found themselves with a problem — the tapes simply aren't long enough! So Sony have come up with the Betastack which gives the owner up to 13 hours of unattended recording — a great help if you are recording while on holiday, for instance. The Betastack can be fitted to the C7 by any Sony dealer for under £150, or a new purchaser can buy it already fitted for an extra £129. For further information, contact your Sony dealer. Sony were also selling demonstration tapes at their stand showing how best to make your own video films. The tapes comprise of 30 minutes of demonstration with the rest of the tape left blank for you to record your own efforts. The tapes will still be available after the show for £6.50 so if you want to get hold of one contact the Sony Tape Group, Pyrene House, Sunbury on Thames, Middx.

RTVC Amp

In last month's Kit Review we looked at the RTVC 10 + 10 Stereo Amplifier and mentioned some errors in the instructions. As promised we are publishing their reply, which appears below.

Dear Editor,

First let us thank you for the review of our 10+10 Stereo Amplifier Kit, we much appreciate your comments on "good value for money". Thank you also for pointing out the errors in the instructions. On receipt of your copy we immediately printed a correction slip which has been included with every kit sold since.

As we are sure you are aware such errors can get through the checking procedures — we notice that your own projects are often followed by corrections and we are surprised to find you are also guilty of failing to provide adequate or correct information on mains connections. For instance in your Soldering Iron project in the May issue no mains wiring information is given, other than the circuit diagram.

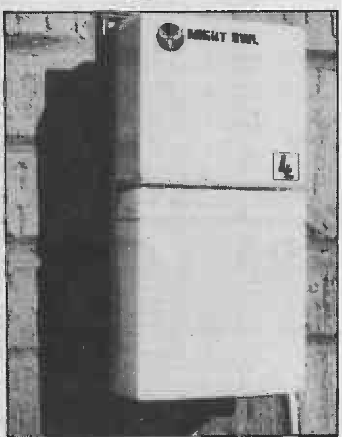
It is very easy to criticise such mistakes, which can so easily occur; however, we have now been able to correct ours (thanks to your review) and we believe we can thus maintain our tradition of supplying good quality kits which represent very good value for money.

As you have said the RTVC 10+10 "must be the cheapest stereo amplifier you can buy".

Yours faithfully,

L. Cohen

P.S. I trust that in view of your final paragraph under In Use (p.32 May issue) you will print the above reply in full.



Night Vision

With the number of burglaries on the increase, why not take advantage of the Night Owl Radar Controlled Courtesy Light and Intruder Detector from Loadpoint? The Night Owl can protect an egg-shaped area up to a forward range of 100 feet using radar. When the system detects a moving object — a person or a vehicle, for example — the internal lights are automatically turned on and will stay on until the last movement has ceased. The unit is programmed to accept only continuous movement — objects like doors, curtains and tree branches will not trigger the device. The detection range is adjustable from 6 to 100 feet and the light duration can be set from ½ to 10 minutes. If an audible alarm or extra light is required an extra set of contacts are already built into the unit. The device can be easily fitted to a 220/240 V mains supply. The unit costs £150, and further details can be obtained from Loadpoint Ltd, Chelworth Industrial Estate, Cricklade, Swindon, Wilts SN6 6HE.

Protect and Survive

This year's Ideal Home Exhibition did not simply cover the luxury aspects of life in the 1980s. Protect and Survive Monthly magazine staged its first display of nuclear war survival equipment this year. The magazine shows some of the latest equipment in the survival business, including NBC suits designed to protect the wearer against radioactive fallout dust after a nuclear explosion. Also included were survival foods, equipment and material for use in a fallout bunker, the latest in radiation meters and a display of fallout shelter ventilation equipment from Switzerland. The magazine's slogan is 'You can survive a nuclear war'. The publisher believes that Protect and Survive covers subjects which "until recently, have not been brought to the public's attention". For more information on this interesting subject contact Protect and Survive Monthly, 80 Fleet Street, London EC4Y 1EL.

Double-sided

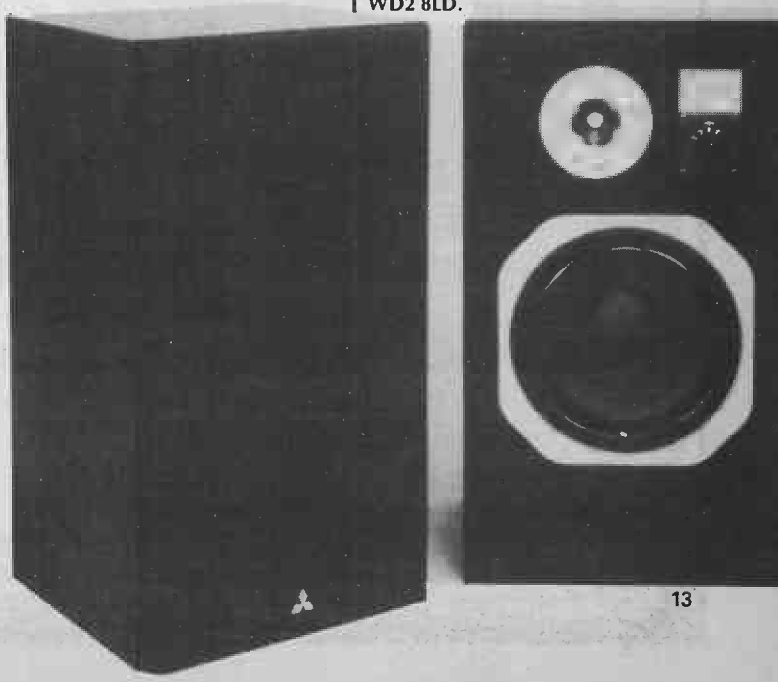
Sharp Electronics (UK) Ltd has developed a new music centre which can play both sides of a record without turning it over! The VZ3000 is a major breakthrough in convenience for music lovers: you can even repeat the process for non-stop music. The system comprises a fully automatic 2-speed belt-driven vertical 12" turntable that detects the speed and size of the record, and its two linear tracking arms with VM cartridges allow both sides to be played automatically. The unit also incorporates a LW/MW/FM stereo radio with a four-track, two-channel stereo cassette deck and speakers. It is expected to retail at £325.

Computing With Aunty

The BBC are currently planning a series of computer literacy programmes for broadcast next January. Aunty Beeb will also be launching its own microcomputer in conjunction with the series which will give the viewer the opportunity of gaining practical experience of computing in the home. The micro is a condensed version of the forthcoming Proton from Acorn Computers Ltd. It will be built to the BBC's very high specification and will be capable of being linked to teletext transmissions by using an add-on receiver. It will also have a sophisticated graphics display which will allow you to play your favourite games and also develop your own pictures. Many other features are included in the unit, which is expected to retail for around £200 with the teletext adaptor costing a further £100. More information on this exciting project will appear on these pages as soon as it is available.

Speaking Out

As a follow-up to the Mitsubishi DS 32 'European' speaker reviewed in last month's Audiophile, comes the DS 25 Mark II. It is a two-way bass reflex system handling 100 W. The 10" woofers are almost identical to those in the DS 32 and the port on the baffle panel has been specially treated to ensure additional damping of residual resonant vibrations to give a clean bass response. It is set in heat-resistant plastic to permit high input levels without insulation breakdown. The voice coil features anti-resonance apertures to reduce unwanted resonance and distortion. The resonant frequency of the 2" tweeters has been set well below the crossover frequency to ensure a speaker response free of uneven dispersion and 'beaming'. The centre cap is a titanium dome with a parabolic profile and a four-step attenuator is featured to enable the user to adjust tweeter response to suit the particular listening environment. The retail price of this pair of speakers is £153. For further details contact Mitsubishi Electric (UK) Ltd, Otterspool Way, Watford, Herts WD2 8LD.



MINI-DRILL SPEED CONTROLLER

Control the speed of your 12 V mini-drill with this inexpensive little unit. No, it's not one of those old-fashioned PWM controllers so beloved by 'novice' designers, but is a high-quality project with built-in feedback speed-regulation and full overload protection. Design by Ray Marston. Project development by Steve Ramsahadeo.

Mini-drills are widely used by a whole range of hobby and craft enthusiasts: the electronics hobbyist and engineer find them of particular value in drilling PCBs and deburring holes in panel work, for example. Most mini-drills are designed to run from a 12 V DC supply and draw maximum currents up to about 1 A when heavily loaded or stalled.

The speed of a mini-drill can easily be changed either by varying the DC voltage supply to the drill motor, or by using a simple pulse-width modulation (PWM) technique for feeding pulsed power to the motor. The trouble with both of these simple forms of speed *control* is that they provide no form of speed *regulation*.

In practice, the speed of the drill motor falls (sometimes quite dramatically) when the drill is loaded and, simultaneously, the motor input power requirement increases in proportion to the loading level. Since both the conventional 'variable voltage' and the old-fashioned PWM control systems each effectively apply a pre-set voltage level to the motor, they are incapable of meeting the increased power requirements of the loaded motor and the drill speed inevitably falls off as the loading is increased.

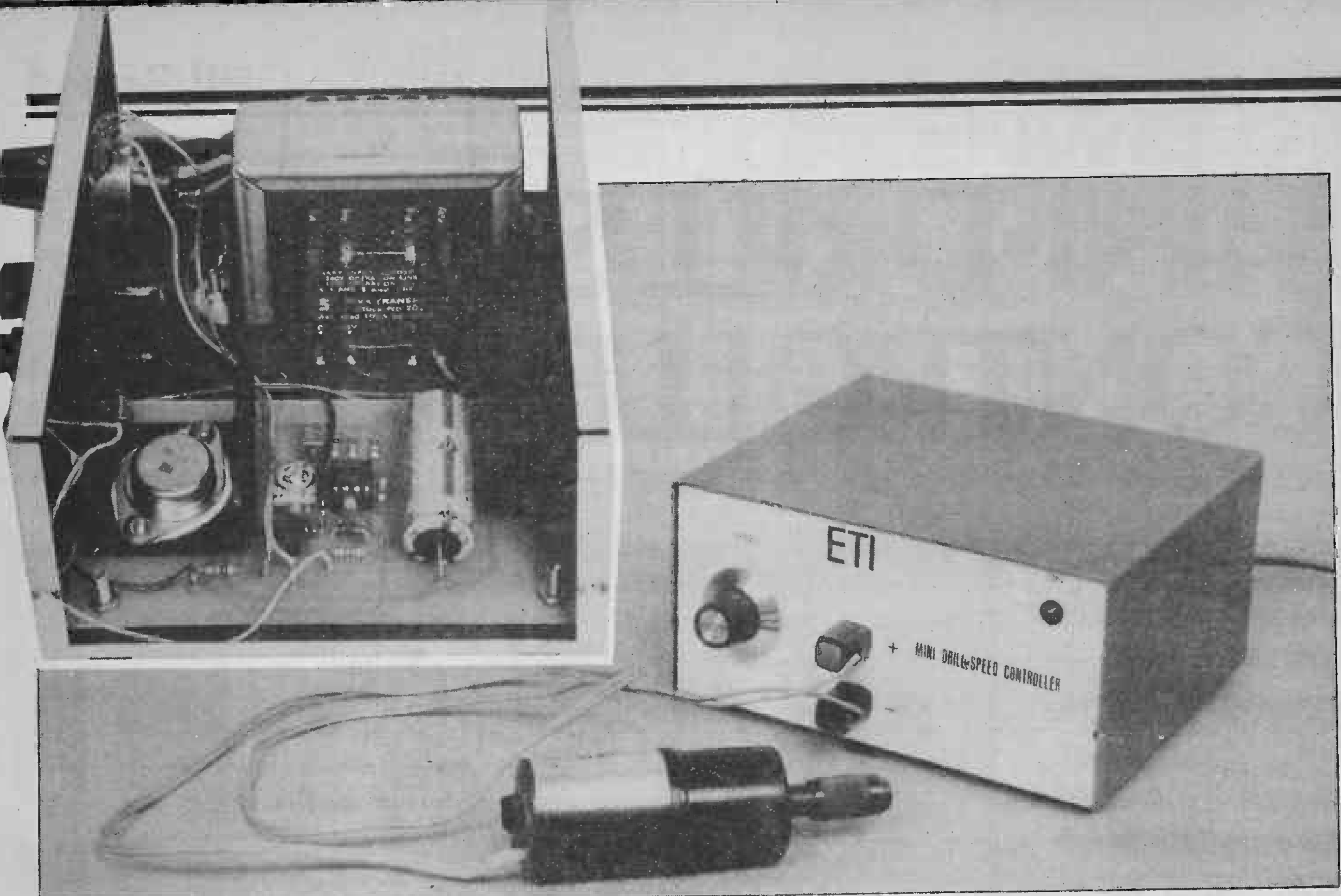
ETI's new mini-drill speed controller project overcomes these problems. It uses a 'variable voltage' form of basic speed control but also incorporates a load-sensing feedback network which automatically increases the motor power drive as loading is increased, to maintain the required drill speed under all loading conditions. The unit is mains powered, has full electronic overload protection and can be used to power any 12 V mini-drill with a current rating below 1.5 A.

Construction

Construction of this project should present very few problems, since all components other than T1, LED1 and RV1 are mounted on a single PCB. Note in the construction that IC2 (a T03-cased regulator chip) must be mounted on a small heatsink and then fixed directly to the PCB.

When the PCB construction is complete, fit the assembly in the specified case, together with transformer T1 and pot RV1, and complete the circuit interwiring. We used a pair of push-button loudspeaker terminals for the output — you can use any terminals that suit your drill. The unit can then be given a functional test.

To use the unit, simply connect it to your mini-drill, switch the unit on, and use RV1 to vary the speed of the drill. When using the unit for the first time, set the speed to roughly one-third of maximum, then lightly finger-load the drill chuck and adjust preset PR1 so that the speed remains virtually constant in both the loaded and unloaded states. The unit is then complete and ready for use.



Top: inside the case. Construction is quite straightforward. Above: our prototype unit with a PCB drill connected via the push-button loudspeaker terminals.

HOW IT WORKS

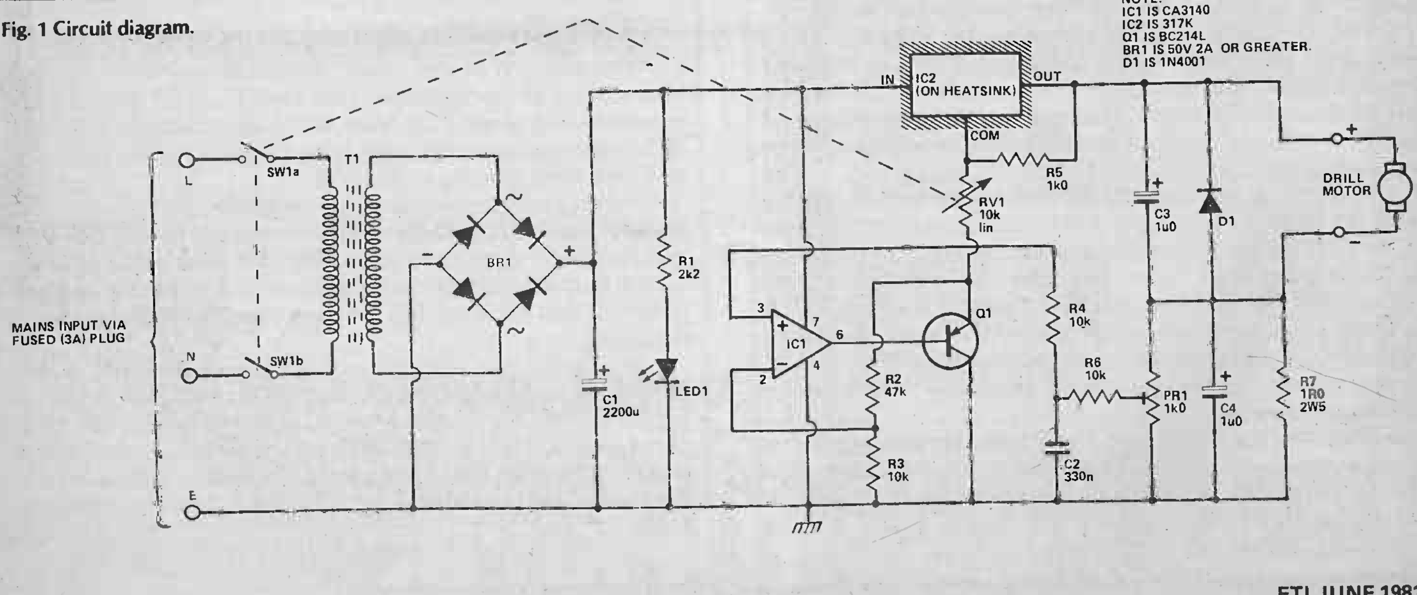
The circuit of the controller contains three basic elements, these being a power supply unit (T1-BR1-C1), a variable-voltage generator (IC2-R5-RV1), and a load-sensing feedback network (R7-PR1-IC1-Q1, etc). The basic (unloaded) speed of the drill motor is determined by the variable-voltage generator circuit; the speed regulation (loaded speed) is controlled by the load-sensing feedback network.

Circuit operation relies on the basic fact that the current consumption of the motor is directly proportional to the motor's loading factor. When the motor is lightly loaded, the current consumption is low; when the loading is high, the current consumption increases. In our circuit, the motor current consumption (and thus the loading factor) is monitored by R7. A fraction of the voltage generated across R7 is tapped off by PR1, filtered by R6-C2, and used to control the variable-voltage generator circuit (IC2) via composite non-inverting amplifier IC1-Q1.

The output of IC2 is determined by the relative ratios of R5 and RV1 and by the voltage on Q1 emitter. When Q1 emitter is at 0 V, the output of IC2 can be varied from 1.2 V to 12 V by RV1. When Q1 emitter is not at 0 V, the Q1 emitter voltage is simply added to the IC2 output voltage. In practice, the Q1 emitter voltage is directly proportional to the load current of the motor. Thus, when the motor loading is increased the resulting increase in motor current causes the Q1 emitter voltage to rise. This increases the output voltage of IC2 to a level sufficient to maintain the motor speed at a constant level. The degree of regulation is controlled by preset PR1.

IC2 is a voltage regulator chip and has built-in short-circuit output protection and thermal overload cut-off. The device thus provides the circuit with a high degree of electronic overload protection and limits short-circuit currents to about 1.5 A, thereby eliminating the need for old-fashioned output protection devices such as fuses.

Fig. 1 Circuit diagram.



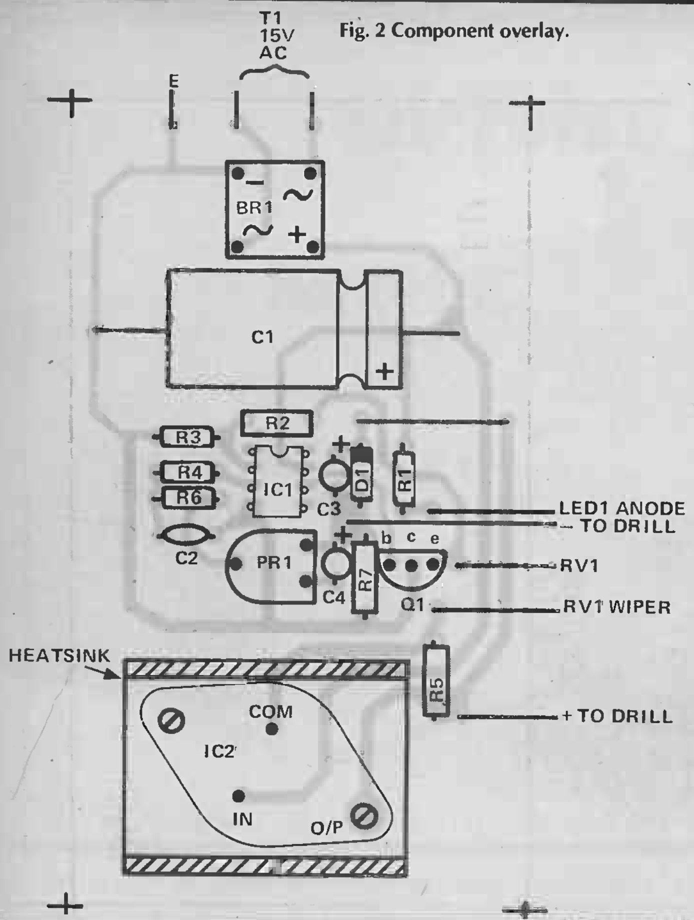


Fig. 2 Component overlay.

PARTS LIST

Resistors (all ¼W, 5% except where stated)	
R1	2k2
R2	47k
R3,4,6	10k
R5	1k0
R7	1R0, 2W5
Potentiometers	
RV1	10k linear with integral mains switch
PR1	1k0 miniature horizontal preset
Capacitors	
C1	2200u 25 V axial electrolytic
C2	330n polycarbonate
C3,4	1u0 35 V tantalum
Semiconductors	
IC1	CA3140
IC2	317K
Q1	BC214L
BR1	bridge rectifier; 50 V, 2 A or greater
D1	1N4001
LED1	0.2" red LED

Miscellaneous
Transformer (15 V, 20 VA secondary), heatsink (drilled for T03), case, output terminals, control knob.

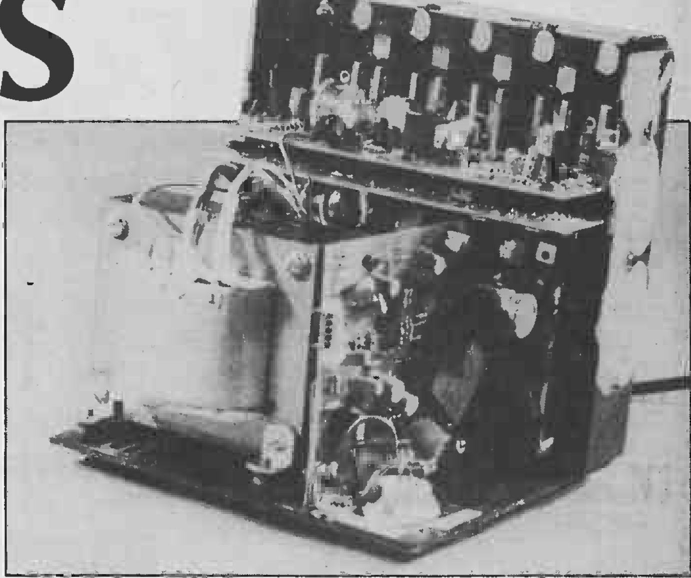
BUYLINES

The 317K voltage regulator can be obtained from Watford Electronics. All the other components are common types and should not present any problems.

The case used is available from West Hyde Developments — order as Samos 006.

ETI

MAGNETIC FIELD AMPLIFIERS



Once upon a time ETI ran an exclusive feature on magnetic field amplifiers. After nearly two years, this revolutionary design is finally in production, and it's time for another exclusive. Stan Curtis reports on the Carver Corporation's M-400.

For the past two years rumours have been rife about a radically new power amplifier conceived by Bob Carver, the designer of the original 'Phase-Linear' range of super-amps. At last this amplifier, the M-400 'magnetic field amplifier' is in production and all has been revealed. Well, not quite all. In fact, to be honest, very little has been revealed at all. To keep the competition at bay a few red-herring explanations have appeared and even ETI's preview (July '79) showed a system of far greater complexity than has finally appeared in production.

So just what is it that is so unique about this new power amplifier? To answer that question properly, let's look at the Carver M-400 in detail. As the photographs show this amplifier is housed in a small cubical box (approximately 7 x 7 x 7 inches) which also serves as the heatsink. It is something of a light-weight weighing under 9 pounds and can be held comfortably in one hand. But then so can several of the Japanese 20 W (or so) 'micro-series' power amps. The difference is that the M-400 is rated at 200 W per channel and (into 8R loads) clips at nearly 300 W per channel! Yes, it does make you stop and think and if I hadn't had one to play with for a month or two, I might not have believed it either.

To make such a powerful amplifier so small, two major problems have to be solved. The first is minimising the amplifier's dissipation (ie heat), and the second is reducing the bulk of the power supply. Let us first look at the problem of amplifier dissipation.

If, as in the case of the M-400, a total supply voltage of 160 V is used and the output stage quiescent current is set at 100 mA, then the static dissipation will be equal to 160 x 0.1, ie 16 W. For a stereo amplifier this would mean 32 W, making this particular magnetic cube *far* too hot to support in one hand! The solution is easy, as shown in Fig. 1, part of the circuit of one channel of the power amplifier. The output stage uses three pairs of complementary power transistors wired in series. Each pair is fed from a separate supply rail via blocking diodes. Low level signals are conducted to the load through transistors Q14 and Q15 which derive their power supply from the ±25 V rails. Once the output signal increases beyond +23 V peak (driving an 8R load), transistor Q16 starts to conduct, drawing its current from the +48 V rail. The blocking diode prevents this higher voltage from sinking into the +25 V supply. Similarly for a −23 V signal transistor, Q17 will start to conduct. A quick

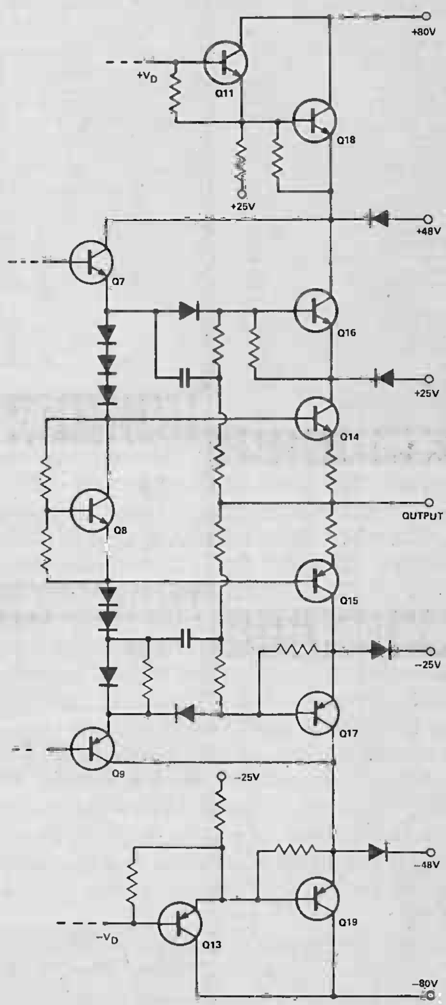


Fig. 1 Simplified circuit of the M-400 power amp output stage.

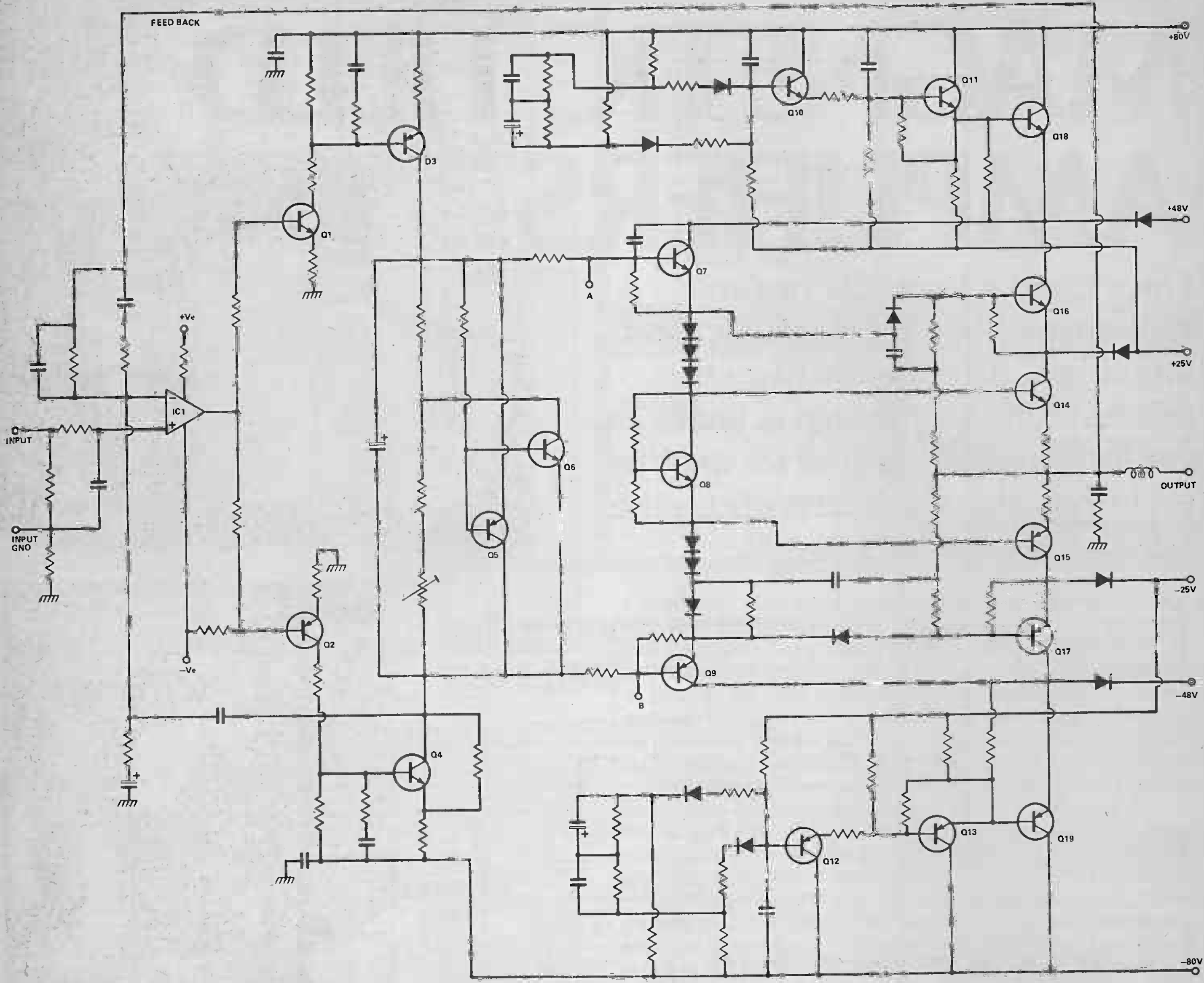


Fig. 2 Part of the circuit schematic of the Carver M-400 power amplifier.

calculation will show that the level shifting diode chain creates an overlap situation, so that Q16 (for example) starts to conduct before Q14 runs out of voltage and causes clipping. This also avoids the occurrence of any 'crossover' type of discontinuity in the output signal. Although the first two pairs of output transistors (Q14 to Q17) are driven (and hence controlled by) the signal, the final pair (Q18, Q19) are just voltage sharing and are conducting at all times. Thus the current through these two transistors is controlled by the lower transistors, but only when the output signal exceeds about ±47V4 (peak). Obviously such an output stage permits the use of lower voltage (and less expensive) power transistors, but another major benefit is the much reduced quiescent dissipation of the output stage. Now remember that horrendous figure of 32 W? Repeating the same calculation with this type of output stage gives a dissipation equal to 48.8 x 0.1 or about 10 W total; in other words, reduced by a factor of three. That means a much cooler-running magnetic cube.

This output configuration is quite interesting but hardly radical, for similar arrangements have been used in other amplifier designs before the Carver M-400. Indeed, if the various supply voltages were obtained from a stable, high-quality, but otherwise conventional power supply, the result would be very satisfactory but nothing out of the ordinary.

It is the power supply system of the M-400 that is radical, exciting and original. As everyone knows, the simplest conventional power supply consists of a power transformer, rectifiers and reservoir capacitors. These capacitors are used to store the energy in the power supply and thereby bridge the gap between the outflow of energy to the load (loudspeaker) and the inflow of rectified energy every 100 ms. Big amplifiers need to have very large reservoir capacitors with a ripple-rating that enables them to charge and discharge many Joules of energy. The laws of physics also dictate that with present day standards of metallurgical knowledge, small amplifiers have small power transformers; large amplifiers have large power transformers; and 400 W amplifiers have bloody massive transformers! Sony and JBL (amongst others) solved the problems of bulk by the use of switched-mode power supplies. The incoming AC mains supply is rectified into raw DC, which is then chopped on and off at a frequency of 50 kHz or more. This reconstituted AC voltage is stepped-down by a transformer and then rectified conventionally to generate the final DC supply. Now even a 400 W 50 kHz transformer can be wound on a comparatively small fer-

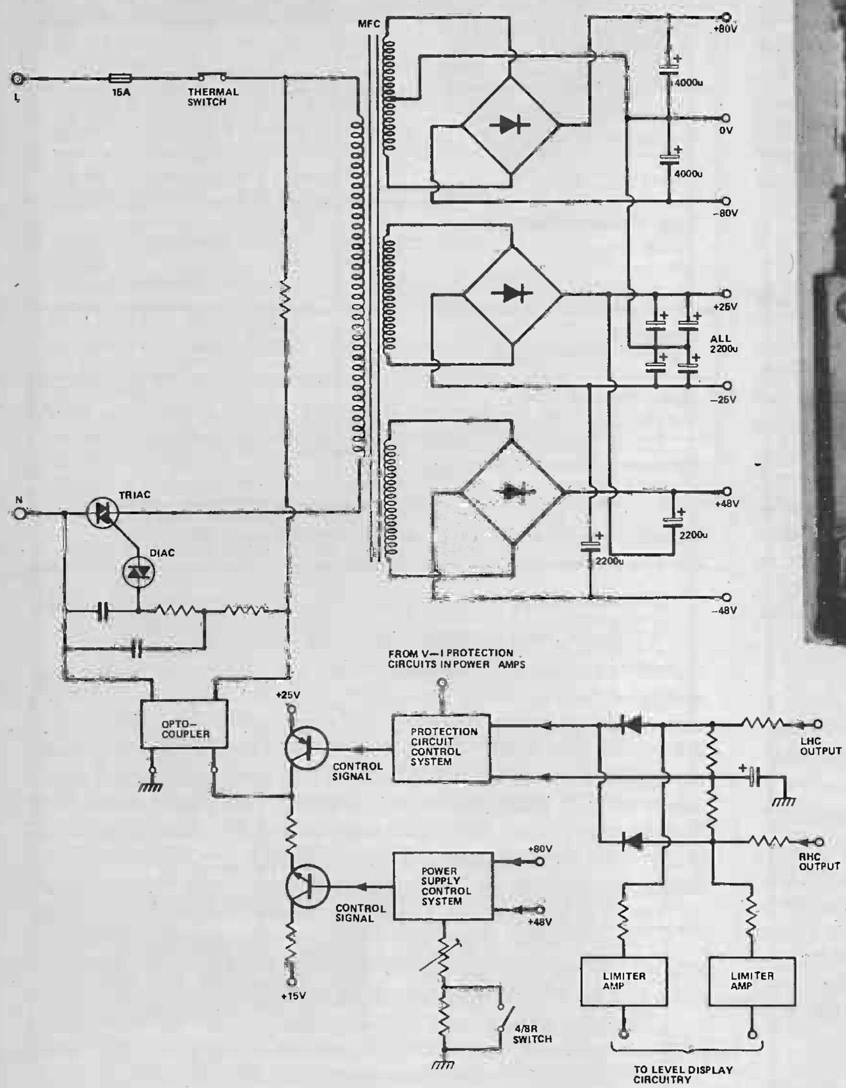
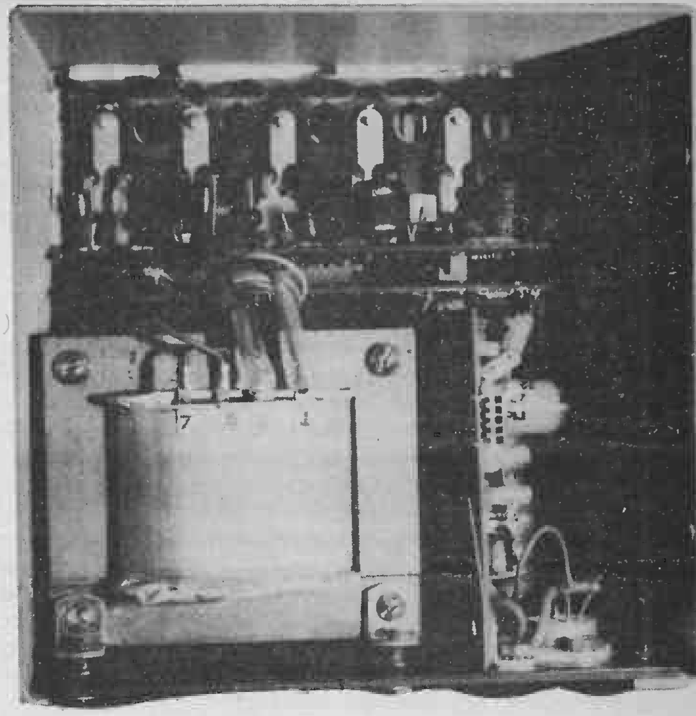
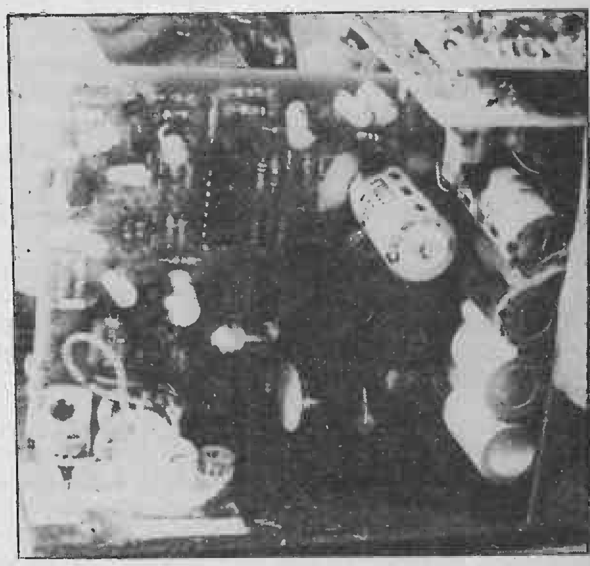


Fig. 3 Simplified circuit of the power supply used in the M-400 Magnetic Field Amplifier. As well as monitoring the outputs of the two channels, the protection circuit control system is fed from the V-I protection circuit in Fig. 4.





Top: Inside the cube. Looking like an ordinary transformer, the Magnetic Field Core can be seen at the bottom of the box.
Above: Close-up of the power supply control board. The radical design means that many of the reservoir capacitors can have values as low as 2200uF.

rite core, so the problem of bulk is solved. But in its place come the problems of cost, circuit complexity, reliability and the generation of massive amounts of spurious signal radiation. Remember that the raw DC has a voltage of around 340 V, which spells expensive power transistors in any language! Suffice it to say that switched-mode power supplies for audio amplifiers have not caught on.

Carver has adopted a new approach. The first targets for elimination were the massive power transformer and the bulky (and expensive) reservoir capacitors. A glance at the circuit of the M-400 power supply (Fig.3), and the photographs, will show that these components have not been completely eliminated but have been reduced in size and cost. The main reservoir capacitors have a value of 4000uF against the 15000uF which is typical of this class of amplifier. The transformer has been reduced to about one-fifth of its usual size. But then it isn't really a transformer because, despite appearances, the core and windings have been arranged to produce a saturable coil known as a 'magnetic field core' (MFC). This inductor is used to store energy for very short periods, thereby fulfilling one of the roles of the reservoir capacitors. Whenever the triac is turned on, a short pulse of current is fed into the MFC and builds up a

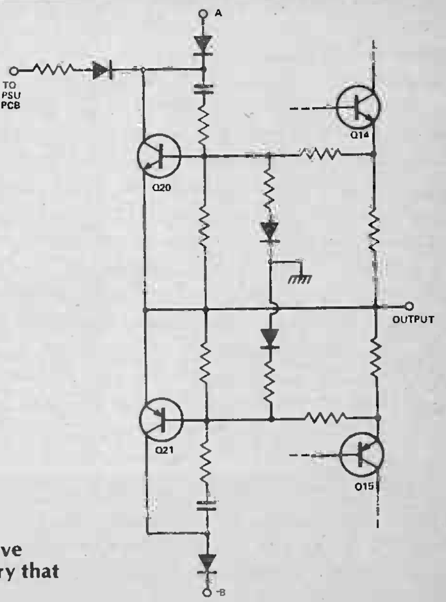


Fig. 4 (left) Output stage V-I protection circuit, just part of the impressive range of sensing circuitry that protects the amplifier.

magnetic field. At the end of the current pulse the magnetic field starts to collapse, generating a current in each winding. The 'primary' winding is effectively open-circuit because the triac is 'off' so the current is concentrated in the 'secondary' windings. This current will seek the lowest impedance path ie the discharged reservoir capacitors. So, of the three power-supply rails only those delivering current to the load will demand current from the MFC. Thus, in part, the power supply 'tracks' the demands of the audio signal.

The whole action is broadly similar in concept to the ignition-coil circuit in a car except for the voltages involved. If the triac is driven by a circuit which monitors the final DC voltages, the result would be a stable regulated supply. By using such a form of regulation in the M-400 the makers ensure that the power supply always responds to the current demand of the power amplifiers. It works well, too. My measurements showed that the supply rail voltages only varied by a few volts between no load and full loading (ie clipping into 8R loads). This novel power-supply arrangement has enabled Carver to include many extra protection circuits in the M-400. The circuit of the power amplifier shows that the normal V-I protection arrangement is used to clamp the signal level at the bases of the driver transistors. But, in addition, this protection circuit is coupled to the power supply control board. Also on this board are;

i) an output DC-offset voltage sensing circuit
ii) a clipping detector which senses the presence of high frequency components generated by sustained clipping of the output signal
iii) a voice coil integrator which monitors the long-term average power fed to the speakers
iv) a differential low-frequency circuit which monitors the two outputs. Normally the very low-frequency signals (of a music signal) are in mono, ie both channels are in phase. But suppose that you drop the pick-up onto the record; a large vertical signal will be produced. This will appear as a large out-of-phase component and trip the protection circuit.

The outputs of all these protection circuits are summed and their operation causes the triac to be turned off. The power supply has a relatively short time constant, so within that time the amplifier runs out of power and is rendered 'safe'.

As protection systems go it is pretty effective and quite fast-acting. However, I found it to be a little too sensitive and something of a nuisance in operation. I dislike protection circuits which make it necessary for you to wait a few seconds (for the capacitors to discharge) before switching it back on.

Another interesting aspect of the power supply is the way the two power amplifiers are wired out-of-phase. This arrangement permits instant conversion of the amplifier into a mono amp with a bridged output. Yet stereo operation is still quite straightforward, and is achieved by reversing the polarity of one pair of the speaker terminals. More importantly, this means that the current flow to the amplifiers is out-of-phase. For a reasonably symmetrical signal, one channel will be drawing current from the positive supply while the other draws current from the negative supply. Thus there is little likelihood of dynamic crosstalk through the supply lines, and a smoothing out of the current demands from the supply.

So how does this new super-amp perform? You'll have to wait for your resident audiophile, the editor, (all kneel) to give his opinion about its sound quality, but I can tell you how well it measures. See Table 1.

As can be seen the results are quite good except for the high-frequency distortion, which is higher than in many other large amplifiers.

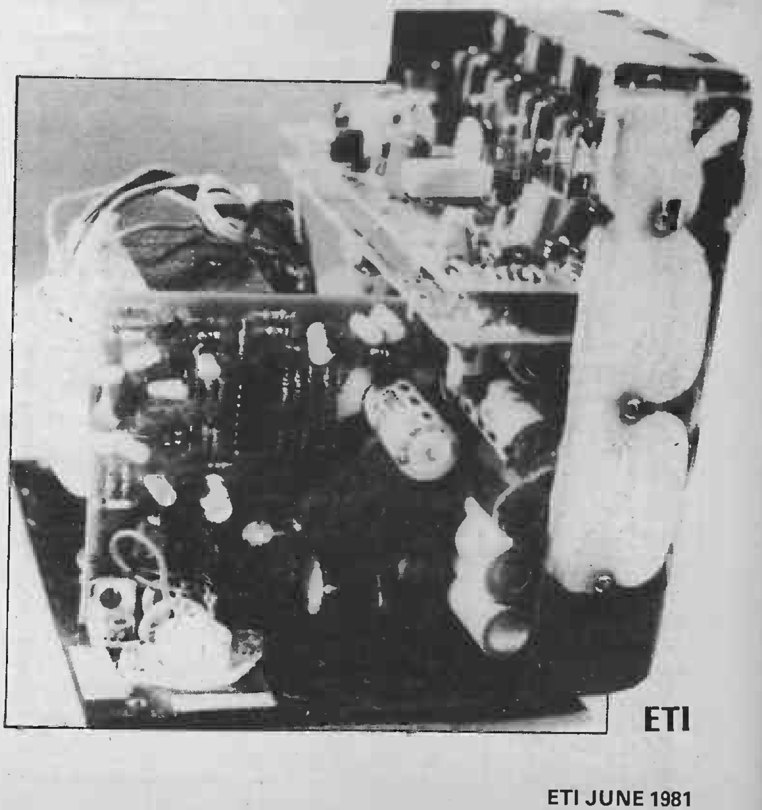
Power Output (20-20,000 Hz) 1% max. THD	300 W * 200 W (*protection limited)	8R 4R
Dynamic Power Output IHF toneburst	320 W 440 W 420 W	8R 4R 2R
Total Harmonic Distortion 200 W into 8R	0.01% 0.006% 0.07%	20 Hz 1 kHz 20 kHz
Sensitivity Input for 200 W into 8R	1.25 V	
Signal-to-Noise Ratio 'A-Weighted', 1 W into 8R	82 dB	
Frequency Response (small signal)	−1 dB −1 dB	3 Hz 53 kHz

Table 1. Performance of a typical Carver M-400 amplifier.

Of course the M-400 does have disadvantages. With all that current pushing and pulling in the coil there are some very strange noises emitted. The groans, squeaks, buzzes and the like can make you very nervous, but apparently it's quite normal and nothing to worry about. The M-400 can also develop quite an appetite for mains fuses. When it is seen that these have a value of 15 A it can make you wonder! The M-400 draws very high currents from the mains supply, but this current is out-of-phase with the voltage so at the end of the day the power (and hence the electricity bill) is comparatively low. Nevertheless, 15 A is 15 A and one can't help but wonder where it's all going.

These niggles apart, the M-400 is an interesting amplifier and all the signs are that other manufacturers will be beating a path to Carver's doorstep to discuss licence agreements.

Already I can see an immediate application in the design of high power in-car amplifiers. The words 'Magnetic Field' seem set to become an established part of audio terminology.



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