ETI
ELECTRONICS TODAY INTERNATIONAL
THE ELECTRONICS, SCIENCE & TECHNOLOGY MONTHLY
DECEMBER 1988 £1.50

SPEED TRAP
Doppler Speed Gun Project

ELECTRONIC THERMOSTAT
Winter Warmer Project

EPROM TECHNOLOGY
A blow by blow explanation

PLUS News, Reviews, Theory and Practice

FREE
Your PCB to build the BURGLAR BUSTER alarm

AUDIO•COMPUTING•MUSIC•DOMESTIC

December 1988

VOLUME 17 No 12

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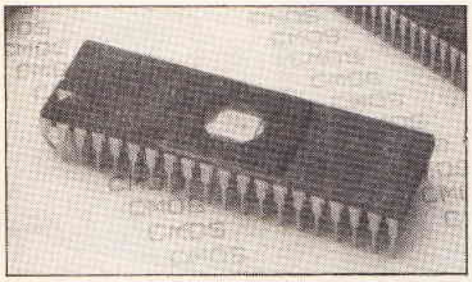

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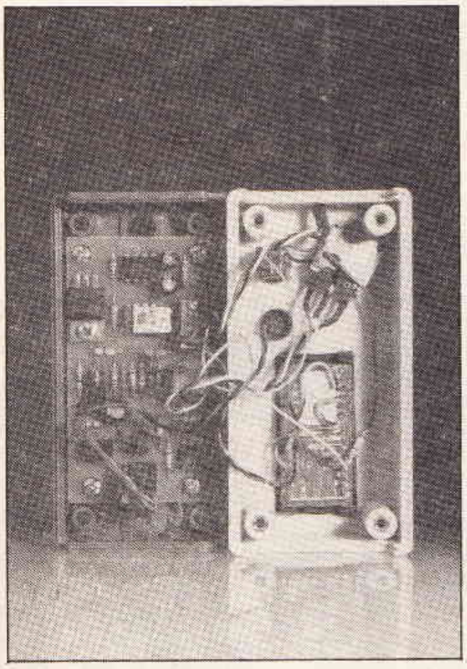

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REGULARS

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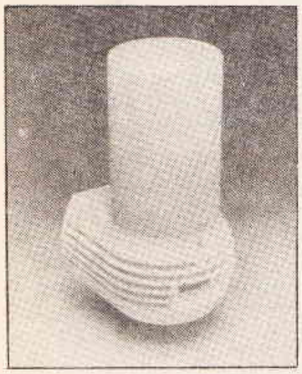
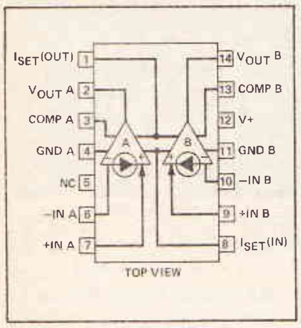
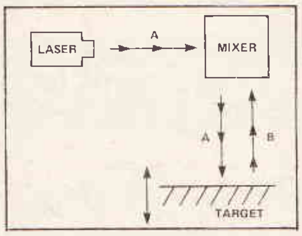
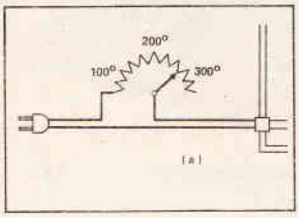
ELECTRONICS TODAY INTERNATIONAL

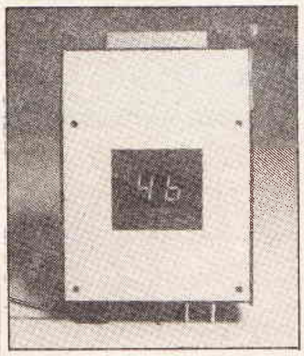
FEATURES/PROJECTS

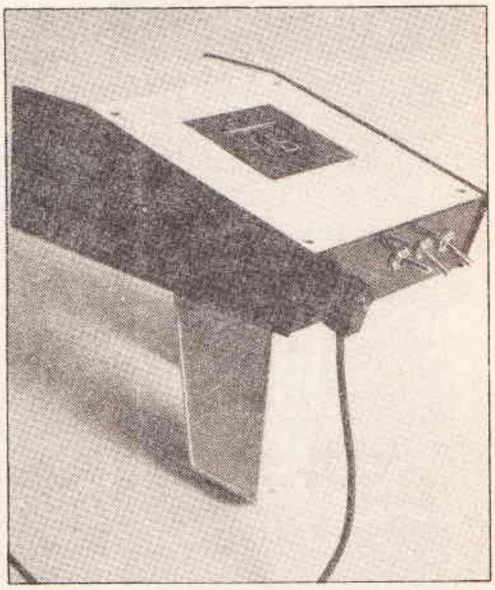












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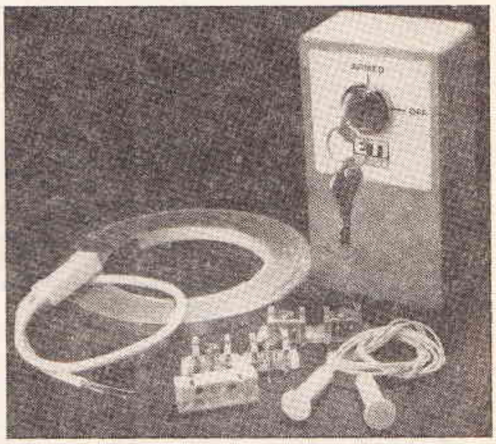

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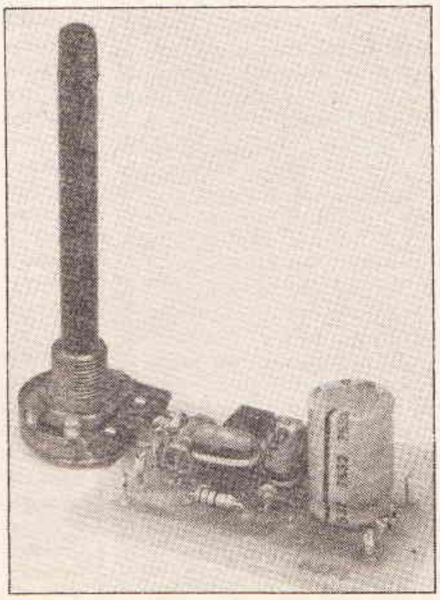

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NEWS

DIGITAL PROMS

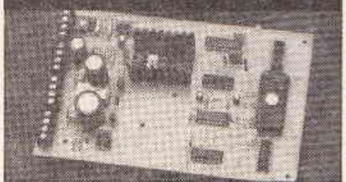
The BBC's first ever totally digital live broadcast was achieved on September 14th from the Promenade concerts at the Royal Albert Hall.

Since 1985 the last analogue link in the broadcast chain has been the continuity desk in Broadcasting House where the live broadcast is levelled and faded for mixing with the continuity announcer's microphone. Now a new digital bypass has been fitted in Broadcasting House to allow these operations to take place without decoding the signal.

The complete signal path is now as follows: Microphone signals from the Albert Hall are digitised and sent down fibre-optics to the OB van where they are mixed on a Neve DSP digital desk and returned to a smaller digital unit in the hall where the presenter's voice is added.

After conversion to BBC NICAM format, the signal is radioed to Broadcasting House and converted back to studio format. The described continuity work takes place in Radio 3's new 'Q' studio. The output, back in NICAM form again, is sent directly to the transmitters where it is decoded and broadcast in the usual fashion.

TALKBACK



A sampled playback board is available as a descrete unit from Hakuto of Waltham Cross.

The board reads from stored EPROM information (Hakuto provides a recording service) to produce speech or effects of from four to sixteen seconds in length, depending on the EPROM purchased.

The sampling rate is 8kHz (4kHz bandwidth) with 4-bit samples. It needs a power supply (a low power version will operate from battery).

The board itself costs £53.30+VAT with EPROMs at £6 for 4s, £10 for 8s and £16 for 16s. Hakuto also produces a recording and editing unit for £396.

For full details contact Hakuto, 33-35 Eleanor Cross Road, Waltham Cross, Herts EN8 7LF. Tel: (0992) 769090.

SHANGHAI ENTERPRISE

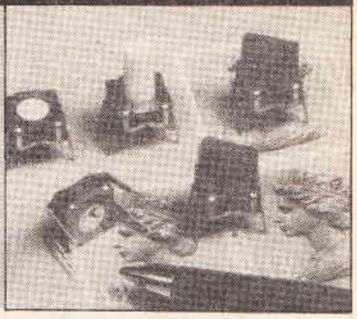
Four years of negotiations has led to a successful agreement for GEC Plessey Telecommunications to start production of private telephone exchanges in Shanghai. The talks were started by Plessey and should result in some 100000 lines a year produced by the partnership of GPT with a trio of companies in Shanghai and Singapore.

SLENDER SWITCHES

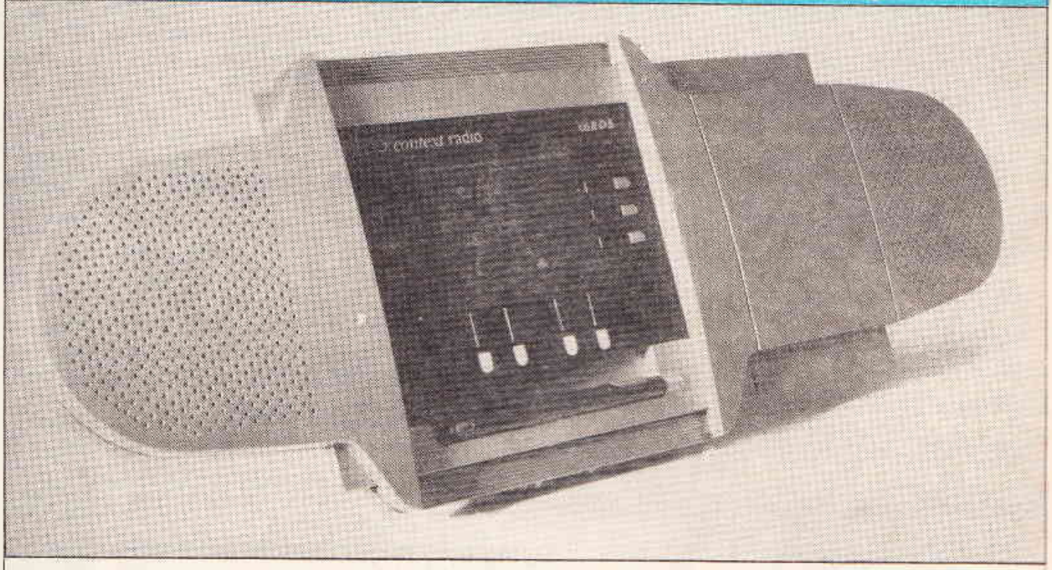
A set of versatile subminiature rotary switches are on the way from Invader of Swindon.

The RTE 10/16 series provide direct binary coding with either 10 or 16 positions available. They have an operating maximum of 30V DC and 100mA. The setting can be by shaft, button or screwdriver slot.

Contact Invader, Bridgewater Close, Hawksworth, Swindon SN2 1TZ. Tel: (0793) 613201.



RDS TAKES TO THE AIR



The Radio Data System (RDS) finally got its big launch from the BBC at a plush royal-graced presentation to preview its public unveiling at the BBC Radio Show in October.

Apart from the glitz and glam of presenters Simon Bates and Debbie Thrower, a batch of prospective RDS manufacturers were neatly arranged in an adjacent room to display their wares.

RDS adds data to FM radio broadcasts as a phase-modulated subcarrier at 57kHz — a frequency easily derived from the existing 19kHz pilot tone of FM stereo. An RDS receiver can decode this information to provide automatic tuning, programme identification and a clock signal taken straight from the Rugby MSF transmissions.

For mobile listeners, an RDS receiver can also overlay traffic reports from local radio on to the driver's chosen channel.

The system is capable of handling a great deal more information than this. Other services planned for the future include programme typing where a receiver will hunt for the type of broadcast you desire (rock, sport, news and so on) and radiotext where up to 64 characters can be transmitted by the programme producer to assist the listener (addresses or telephone numbers for instance).

The most powerful and versatile suggested service would use RDS as a full transparent data channel to download computer software, teaching notes and information sheets.

Unfortunately the BBC has created a chicken and egg problem by promising these additional services only when the hardware is on the market to receive them. Not surprisingly there is as yet no manufacturer prepared to market equipment that receives this untransmitted information.

Of the machines that *are* being produced the best design appears to be from Sharp. Its forthcoming RDS cassette radio is the only machine to have a double front-end for the tuner which enables active searching for traffic flashes. Single-ended receivers rely on redirection messages broadcast on the main networks to overlay say a Radio Kent traffic flash on to Radio 2. Naturally, the BBC national networks will only redirect to local BBC stations. Sharp's receiver will spot both BBC and independent radio travel reports.

BBC Enterprises is also planning to introduce a BBC-badged RDS radio under a similar scheme to its involvement with the BBC computer. A prototype for a domestic receiver has been made to the BBC's specifications by Kinneir Dufort, a Bristol-based industrial design group.

While the in-car manufacturers have all incorporated the RDS features into a more or less conventional design, the Kinneir Dufort 'Context' radio (see photo) is curious to say the least.

Finished in matt turquoise, the unit has a large square high resolution LCD screen surrounded by pink and yellow selection keys plus a light pen (to read those bar codes that still haven't yet appeared in the Radio and TV Times).

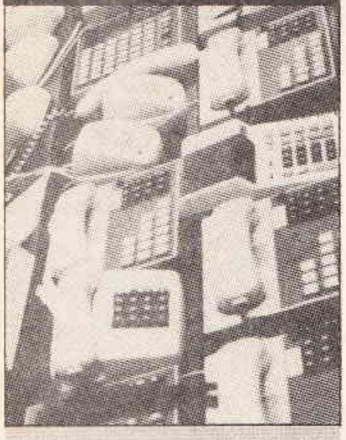
The radio also caters for several of the as yet untransmitted RDS services — there is a built-in printer and connections added for downloading to peripheral computers.

All these extras are in modular units to expand the basic radio. There is also a cassette module. Oh — and the whole thing hangs on the wall.

Despite Kinneir Dufort's enthusiasm and 'negotiations with a major manufacturer' BBC Enterprises is likely to choose a less flamboyant design for its initial domestic radio. It is instead displaying the *Context* radio in a glass case at the BBC Radio Show as 'the shape of things to come'.

Prices of most RDS radios and radio cassettes are not finalised but look to be around £400 for a high spec model. Most manufacturers reckon the RDS features add about £100 to normal retail prices.

RING AROUND THE WORLD



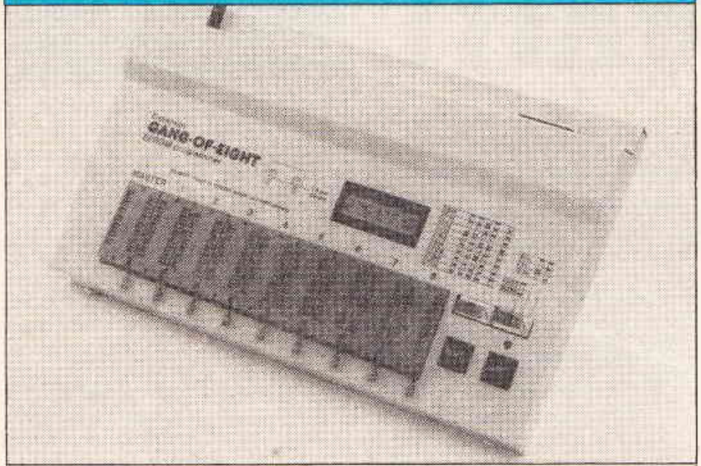
There are now over 700 million telephones on the earth, according to the *1988 International Telephone Statistics* report from Siemens.

Sweden emerges as the most telephone-rich nation in the world with 64 main stations per 100 inhabitants, with Switzerland in second place with 52. Europe as a whole averages only 22 main stations per 100 heads compared with North America's average of 50.

As the world bank recently acknowledged, expansion of communications networks is a prerequisite for economic progress and telecommunications saturation is a useful indication of third world development. Africa averages just one station per 100 heads.

The report is at present available only from Germany. Contact Siemens AG, Zentralstelle fur Information, Postfach 103, D-8000 Munchen 1, Germany. Tel: (089) 2340.

MEET THE GANG



A new version of the original 'Gang-of-Eight' production EPROM programmer has been produced by Dataman of Dorchester together with a 28-day money back guarantee.

The G8 programmer holds eight slave devices to be programmed either from a master EPROM or from an RS232 link with an IBM AT/XT or compatible PC.

It can handle EPROMs of the 27 family from 2716 to 27512 as well as 2516, 2532 and 2564 devices. Five binary switches are used to set the device type, with two more to select voltage (25V, 21V or 12V5).

An eighth switch selects between fast programming for those devices which use it and 50ms pulses for those which don't. The unit indicates each stage of programming on an 8-digit LCD.

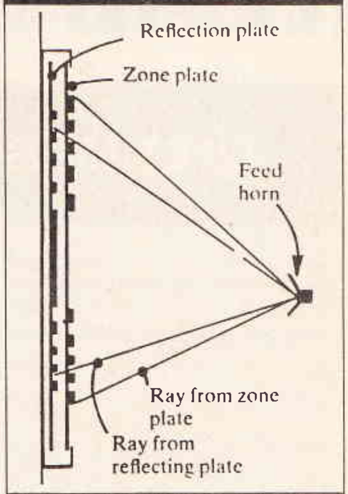
The G8 is solidly built — Securicor drove a van over an earlier model without incident — although the Post Office (master of its art) did once succeed in snapping a PCB *inside* a packaged unit!

The 2-way PC link operates at 9600 baud and supports various serial formats including binary and ASCII.

The G8 retails at £395 and comes with a 28-day money refund guarantee.

Contact Dataman, Lombard House, Cornwall Road, Dorchester DT1 1RX. Tel: (0305) 68066.

DISH OR PLATE?



In addition to the Murdoch and BSB satellite receiving systems under design and production, there is considerable scope for experimentation in the zone plate form of antenna that can be used in place of standard receiving dishes.

A zone plate is a flat thin sheet of any material carrying a set of concentric circular zones opaque to the radiation. These Fresnel zones (get your Physics book out) focus received signals at a point along the axis.

Such a sheet can be mounted on a window with the circles displaced to form ellipses which focus signals from objects above the perpendicular axis of the window.

The problems with this simple and cheap system are the losses that soon creep into the calculations. Only half the signal power across the plate is transmitted so that plate antennae must be 50% larger than a dish equivalent. Secondly the theory demands an exact half-wavelength path difference at corresponding points of adjacent rings. In practise this isn't the case and a further size increase of 60% is necessary to compensate. This gives a practical plate size around double that of a dish.

Both these losses can be reduced. The blocking loss can be almost removed completely by having the initial plate on the external side of a window with a second plate inside, positioned so that reflective zones cover the transmission areas. No signal will get inside the building at all and careful positioning brings a single focus some inches outside the window to be fed inside from an external horn (see diagram).

Mawzones manufactures 5-zone elliptical sheets and claims good results for medium and low speed data reception from existing Eutelsat transmissions. It is also developing compensated and uncompensated sheets suitable for TV reception from Astra and other satellites.

For more information contact Mawzones, 6 Hodwell, Ashwell, Baldock, Herts SG7 5QG. Tel: (046274) 2854.

LIGHT METER

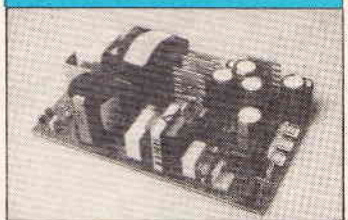
Outdoor types may be intested in a new solar charged multimeter available through Universal.

The Hioki 3242 operates from an internal NiCd cell but constantly recharges from a 50×40mm array of solar cells on the front of the meter.

Functions are limited to AC and DC volts, resistance and an audible continuity test. Display is by 3½-digit LCD and the rear of the case flips open to provide storage space for the test leads.

The Hioko 3242 costs £52.25 + VAT and may be obtained from Universal Instruments, Unit 62, GEC Site, Leicester LE8 3LH. Tel: (0533) 750123.

NO LOAD POWER



A 50W switched mode power supply that continues normal operation even at zero loading is available from Computer Products of Bedford.

The XL50-7601 power supply takes any input voltage from 85-264V AC (no adjustment needs to be made) and holds onto the secondary output regulation regardless of load. Many such supplies will produce massive voltages on secondary outputs if the primary output is unloaded. Others use a dummy load to obviate this risk but in doing so lose efficiency and produce heat. This unit does neither.

Three outputs are provided: 5V at 7A, 12V5 at 2A5 and −12V at 0A7. The price is £50+VAT.

Contact Computer Products Power Conversion, PO Box 336, Tavistock House, Bedford MK40 2XP. Tel: (0234) 273838.

HITACHI DOESN'T SEE THE LIGHT

Hitachi is attacking the age-old irritation of reflected light on TV screens.

In Japan it has already introduced a 'silky-faced' tube on its 27-inch and 29-inch colour televisions. Hitachi claims reflected light is cut by 40% without affecting the picture brightness or resolution.

As a single feature, the matt TV has a limited promotional power but coupled with the present buoyancy of the large-screen TV market and the resulting stiff competition in this area, Hitachi is hoping its aesthetic prominence will give Hitachi TVs an edge over the opposition.

READ\WRITE

LIFETIME GUARANTEE

I think that Mr Wood (Read/Write ETI October) has missed one important point about home-constructed designs versus Korean and Taiwanese imports, namely what happens when they go wrong.

If you buy an amp from Tottenham Court Road and it breaks down, you're not even allowed to replace an internal fuse without jeopardising your guarantee. Yet if you take it back to the shop they send it away for two months then give it back — often with the fault almost totally untouched.

If you've built your own amp, not only can you take it apart but you have a far better working knowledge of its internal organs, having wired the things together yourself.

If needs be you can even rip out an entire section and build a new bit, anytime something wears out you know where to track the components down.

True, the finish may not be as good, yes the components cost me more than they do Mr Morita in Japan but at least I don't burst into tears when smoke comes out of the back (which happily it doesn't do too often).

Home construction means a lifetime guarantee!

Raymond Street
Newport, Gwent

UNCERTAIN FACTS

In the September ETI particle physics article, Stephen Malone made the mistake of crediting Heisenberg with the discovery that electrons (or any matter) can behave as a particle or wave at the same time.

It was in fact old Louis de Broglie who came up with this in his PhD thesis in the 1920s. He startled the physics-speaking world by stating that $\lambda = h/p$ or simply that the wavelength of matter is inversely proportional to its momentum (a particle property). Hence the wave-particle duality was born.

Heisenberg's contribution was really one of explaining the built-in uncertainties of all of nature — an equally important feat. Besides this correction Stephen Malone's article was as good as they come — probably one of the clearest you'll find anywhere. Great stuff.

K A Malik
Blackburn, Lancs

SPEAKING OUT

Your Quarter Wave Loading loudspeaker cabinets in the August issue looked so good (and suitably sized for my meagre dwelling) that I rushed out and bought four drive units from Tandy and loads of chipboard from the local DIY megamart.

I got it all home, locked myself in the garage and started hacking the wood into small pieces according to your diagrams. When I got to the baffle board I noticed there were several dimensions missing from the diagram in the mag (page 26).

The size of the tweeter's port is also unmarked, although I have calculated this from the other measurements (assuming the top of the cabinet is a right angle).

Please help so I can build the speakers and get my car back into the garage!

Oliver Page
Maidstone, Kent

Yup, several dimensions did indeed fall off the diagram artwork at the last minute. The extra bits are in the Oops! section at the back of the mag.

You were also quite lucky to get those bass units from Tandy as there was a hiccup in their supply just around the time our design was published — this should be cured by the date of publication of this issue.

SQUASHING OR CRAMMING

In your Careers and Education special (October ETI) I was surprised to read of the electronics degree courses where the third year students suddenly find themselves with less than half the lectures they had to attend in previous years, enabling them to stay in bed or go and play squash.

As far as I recall our courses continued to within two or three weeks of the final exams — a pity really because my squash game needed at least as much work as my degree! I should have read my prospectus more thoroughly.

My thanks for a continually interesting mag.

Glen Matthews
Manchester

We didn't actually mean to imply that students were supposed to stay in bed or play squash — merely that it is not entirely unknown for this to occur! The extra hours provided in many degree third year timetables usually exist for work on a 2-term project that counts significantly in the final percentages (naturally the structure of courses varies from place to place).

STAR TURN

In an arcade in Central London is a man who produces astrological data from a multiscreened machine with a profusion of flashing lights and whirly wheels. Such a machine might make a fascinating subject for an ETI project. Have you any idea how it might work?

Pete Swan
Clapham, London

Well at the risk of enraging any astrological readers, we would suggest that it probably doesn't. However, any superstitious souls who would enjoy such a device could put together a few old ETI light sequencing projects with a home computer to randomise a horoscope in their own living room. We have no plans at present to produce such a project — it would be largely software anyway — but who can tell? Perhaps it is written in the stars . . .

BRING BACK MY BONNIE

Can I just say that despite urgent (nay, ardent) searching, no mention of Bonnie Langford has appeared in the last three issues of ETI, even though her name scarcely missed an issue in the preceding six months. Where is Doctor Who when we need him most? Mind you, those awfully nice BBC people are repeating The Good Life — does that mean ETI will return to the halcyon days of a Felicity Kendal on every other page?

Mark Wigley
Bromborough, Merseyside

Since your letter arrived in the ETI offices you will have realised that the good Doctor has returned to grace our midweek screens — but without trace of dear departed Bonnie Langford. Oh what a terrible shame.

And no, we will not be resuming our series of Felicity Kendal pics — good grief, we thought that particular episode was safely buried in the past . . .

COMPETITION

No Scrooges we! Generous to the point of benevolence, ETI and Maplin have once again teamed up to offer readers the chance to test their wits in a free-to-enter contest of intellect.

The lucky winners will receive one of Maplin's new Nite Sentry infra-red detectors (reviewed last month), a heat-triggered light to give a warm welcome as you approach your door. No more fumbling for the key in the dark of a winter snowstorm! The Nite Sentry also acts as a deterrant to surprise unwelcome visitors. It might even scare off any early carol singers!

To enter, simply complete the famous house addresses (none of which have a Nite Sentry at present although it is only a matter of time). A selection of numbers to use together with cryptic clues is on the left. Then write the complete addresses on the back of a postcard or envelope (not on the front or the postman will get terribly confused) along with your own name and address and send your entry to:

ETI Nite Sentry Competition
1 Golden Square
London W1R 3AB

The first two winners to be drawn from the Editor's Lithuanian trilby on the closing date — 9th December — will win a Maplin Nite Sentry to light up their life (and their porch).

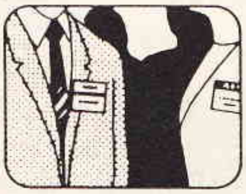
221b The cocaine fiddler
50 Barrett's home
1 Illustrious publishing house
32 One bear
100 One bear, one owl, one donkey
33 Tony's Half-hour house
11 Moneybags
84 Tome home
10 Christie's bloodbath
77 LA Drama

Charing Cross Road
Windsor Gardens
Rillington Place
Railway Cuttings
Wimpole Street
Golden Square
Sunset Strip
Baker Street
Acre Wood
Downing Street

100 EXTRA PRIZES

But that's not all. We also have 100 copies of Maplin's brand new 550-page catalogue to give away to the first 100 entries received here at ETI HQ. And to be fair to our international readership, 10 catalogues are reserved for entrants from distant lands.

DIARY



ITEX 88 — November 1st-3rd
Barbican Centre, London. IT exchange backed by DTI. Contact Cahmers Exhibitions on 01-388 9871.

Electronic Information Delivery — November 8th-9th
Tara Hotel, London. Contact Blenheim Online on 01-868 4466

Cellular And Mobile Comms — November 10th-11th
Tara Hotel, London. Contact Blenheim Online on 01-868 4466

Satellite Communications — November 10th-11th
Tara Hotel, London. Contact Blenheim Online on 01-868 4466

Electron And BBC Micro Show — November 11th-13th
New Horticultural Hall, London. Contact Database Exhibitions on (0625) 878888

Computers In The City — November 14th-17th
Barbican Centre, London. Conference with exhibition 15th-17th. Contact Blenheim Online on 01-868 4466

Image Processing — November 15th-17th
Kensington Exhibition Centre, London. Contact Network Events on (0280) 815226

Interactive 1988 (Interactive Video) — November 15th-17th
Kensington Exhibition Centre, London. Contact Network Events on (0280) 815226

Computers In The City — November 15th-17th
The Barbican Centre, London. Contact Blenheim Online on 01-868 4466

Compec — November 15th-18th
Olympia Exhibition Centre, London. Contact Cahners Exhibitions on 01-891 5051

Military Avionics — November 16th-17th
London Tara Hotel, London. Contact ERA Seminars and Exhibitions on (0372) 374151

Commodore Computer Show — November 18th-20th
Novotel, London. Contact Database Exhibitions on (0625) 878888

Electrical Safety In Hazardous Areas — November 22nd-23rd
IEE, London. Conference sponsored by IEE. Contact IEE on 01-240 1871

International System Security Conference — November 22nd-24th
Tara Hotel, London. Contact Blenheim Oline on 01-868 4466

Cellular And Mobile Comms Conference — November 29th-30th
BAFTA, London. Contact Blenheim Online on 01-868 4466

Opportunities For Commercial Exploitation Of Advanced Electronic Materials — November 29th-30th
Cumberland Hotel, London. Contact IBC on 01-236 4080

Drives, Motors, Controls and Programmable Controllers Exhibition — November 29th-31st
NEC, Birmingham. Contact Evan Steadman Communications on (0799) 26699

European Satellite Communications — December 1st-2nd
BAFTA, London. Conference. Contact Blenheim Online On 01-868 4466

Interactive '88 (Interactive System) — December 6th-8th
Metropole Exhibition Centre, Brighton. Contact PLF Communications on (0733) 60535

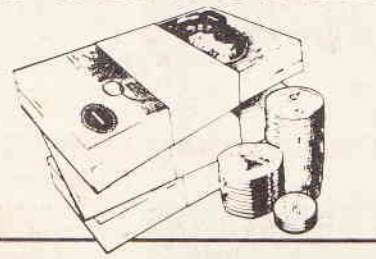
Electronic Messaging Systems — December 6th-8th
Tara Hotel, London. Conference. Contact Blenheim Online on 01-868 4466

Sound 89 — February 21st-22nd
Heathrow Penta Hotel, London. Contact Sound and Communications Industries Federation on (06286) 67633

FAME

&

FORTUNE



That's what an incredibly small number of people have achieved by contributing articles to ETI. The rest of us have had to make do with total obscurity and enough money for a couple of pints. Nevertheless it's all worthwhile and we need your contributions now!

FEATURES

If you know what you're talking about and it hasn't all been said before, we want you to add to our wide ranging and informative features. If you have a great idea for a feature or two, send in a brief resumé. If you don't have the ideas but you think you have a commanding knowledge of a suitable subject area we want to hear from you too.

PROJECTS

ETI has built its reputation on novel, worthwhile projects well designed and accurately presented. If you have recently designed and built a world-beater we want to hear from you. In the first instance send us a brief description of your masterpiece along with a circuit diagram.

Whatever you can contribute to ETI, take the plunge now. We can offer a modicum of fame and a very reasonable fortune.

Write in to:
The Editor
ETI
1 Golden Square
London W1R 3AB

Next Month in

ETI ELECTRONICS TODAY INTERNATIONAL

Hard and fast they come, fighting the vicious arctic gales that slam into their weary bones as they crash forward into icy sleet that cuts the face and numbs the mind.

The powerful stallions on which they ride crack with frost as they advance, the riders clutching the frozen manes to hold the struggling beast full into the wind, the most direct course and the only path that can guide them to their goal before the hour of the first Friday when the next new moon rises into the storm-torn sky.

Beside the straps of the worn leather saddles the riders carry their precious lading, wrapped in the finest oilskin, protecting against the ice and rime.

In a momentary parting of the waves of sleet, the shadows of helmed marauders rise up against the skyline. The riders grit their teeth and unbuckle their swords. Nothing must stop them now. No foe must stand in their path. The January issues of ETI must get through.

* * *

The January issue of ETI is packed with our unique melange of prestigious projects and artful articles to bring a ray of sun to the dullest of December days.

Following on from this month's look at EPROMs we present the ETI Stand-alone EPROM Programmer. Developed from the Universal EPROM Programmer (Marks I and II), it is a versatile unit that talks to virtually anything with an RS232 interface.

For would-be motorbike owners there's a realistic and noisy engine simulator to fix to your bicycle and a hearing booster to make sure Granny gets the full benefit.

For features we turn to the world of broadcasting with a look at the BBC's new Radio Data System.

Together with all the regulars, the January ETI should not be missed. Stick one in your stocking and give Santa a read of the best electronics magazine money can buy.

JANUARY ETI — ON SALE DECEMBER 2nd

The articles mentioned here are under preparation but circumstances (or helmed marauders) may prevent their publication.

SPECIAL OFFER — ALTAI DIGITAL MULTIMETER

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DC VOLTAGE	RESOLUTION	ACCURACY
200mV	100μV	
2V	1mV	
20V	10mV	±(0.25% of reading + 1 digit)
200V	100mV	
1000V	1V	

Input impedance: 10M on all ranges. Overload Protection: 1000V dc or peak on all ranges.

DC CURRENT	RESOLUTION	MAX FS ACCURACY	VOLTAGE DROP
200μA	100nA	±(0.5 % rdg + 1d)	0.25V
2mA	1μA	±(0.5 % rdg + 1d)	0.25V
20mA	10μA	±(0.5 % rdg + 1d)	0.25V
200mA	100μA	±(0.75% rdg + 1d)	0.25V
2000mA	1mA	±(2 % rdg + 5d)	0.75V
10A	10mA	±(2 % rdg + 5d)	0.30V

Overload Protection: mA Input: 2A/250V fuse. 10A Input: Unfused up to 15A for 15 seconds

AC CURRENT	RESOLUTION	ACCURACY	FREQ RANGE
200mV	100μV		
2V	1mV		
20V	10mV	±(0.5% rdg + 5d)	45Hz-500Hz
200V	100mV	on all ranges	on all ranges
750V	1V	±(1% rdg + 5d)	

Conversion: Calibrated for rms of sine wave. Input Impedance: 10M shunted by 100pF on all ranges except 200mV range. Overload Protection: 1000V dc or 750 rms ac continuous, except 15 sec max above 300V on 200M range

AC CURRENT	RESOLUTION	MAX FS ACCURACY	VOLTAGE DROP
200μA	100nA	±(0.75% rdg + 5d)	0.25V rms
2mA	1μA	±(0.75% rdg + 5d)	0.25V rms
20mA	10μA	±(0.75% rdg + 5d)	0.25V rms
200mA	100μA	±(0.75% rdg + 5d)	0.25V rms
2000mA	1mA	±(2 % rdg + 5d)	0.75V rms
10A	10mA	±(2 % rdg + 5d)	0.30V rms

Overload Protection: mA Input: 2A/250V fuse. 10A Input: Unfused up to 15A for 15 seconds

RESISTANCE	RESOLUTION	ACCURACY	MAX OPEN CIRCUIT V
200Ω	100mΩ	±(0.5 % rdg + 3d)	2.8V
2KΩ	1Ω	±(0.3 % rdg + 1d)	2.8V
20Ω	10Ω	±(0.3 % rdg + 1d)	500mV
200KΩ	100Ω	±(0.3 % rdg + 3d)	500mV
2MΩ	1KΩ	±(0.75% rdg + 5d)	500mV
20MΩ	10KΩ	±(3 % rdg + 5d)	500mV

Max allowable input: 500V dc or rms

CONTINUITY TEST
Resistance range: Buzzer sounds at approximately less than 200Ω

DIODE TEST
Test voltage: 2.8 Volts. Maximum test current: 3mA.

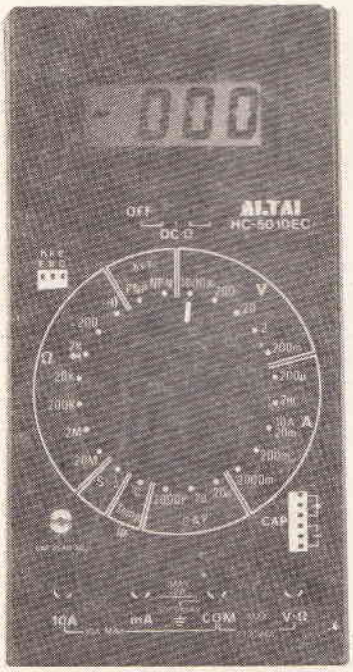
TEMPERATURE	RESOLUTION	ACCURACY
−20°C to 1370°C	1°C	±(3° + 1d) up to 150°C ±3% of rdg over 150°C

Sensor: Type K (NiCr−NiAl)

CONDUCTANCE	RESOLUTION	ACCURACY
200nS	0.1nS	±(1.5% rdg + 10d)

CAPACITANCE	RESOLUTION	ACCURACY
2000pF	1pF	±(1.5% FS + 5d)
2μF	0.001μF	±(2 % FS + 5d)
20μF	0.01μF	±(2 % FS + 5d)

hFE TEST Test condition: 10μA 2.8V. hFE gain 0-1000(npn pnp)



THE Altai HC-5010EC digital multimeter features a 0.5 inch 3½ digit lcd display with polarity, low battery and overrange indication. The meter gives 200 hours typical battery life with a 9V alkaline battery.
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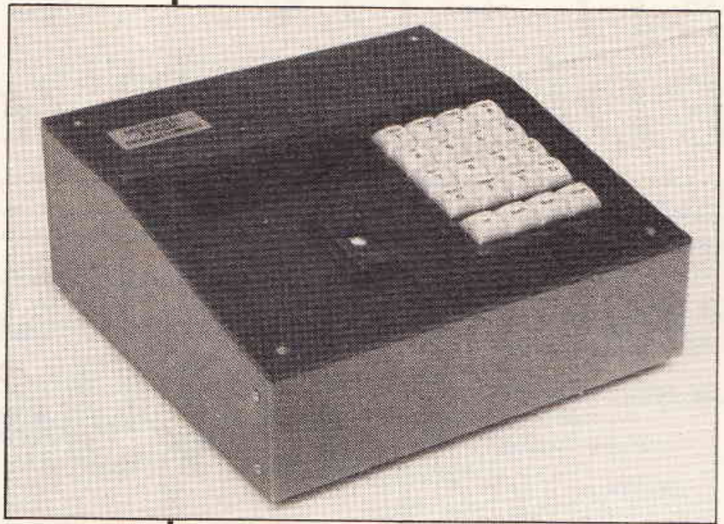
EPROM TECHNOLOGY

Mike Bedford comes to blows with the advancing world of EPROM technology

EPROMs

Over the years in ETI we have programmed them, emulated them, watched them grow and made the most of them as powerful components in numerous projects. Programming methods have improved by leaps and bounds and the number of variants of this versatile component has snowballed over the last year or so.

We're talking, of course, about the EPROM. Starting next month (weather permitting) we will be presenting the ETI Stand-alone EPROM Programmer but first let's take a look at the internal workings of EPROMs. How does UV light erase data? How do the interactive programming algorithms operate? And what is happening in the wide world of EPROM development?



Bigger Faster Stronger

My first ETI EPROM Programmer was back in 1983 when the largest device available was the 27256 with a capacity of 256Kbits. By 1985 when ETI published the MKII, the 512K 27512 and 27513 EPROMs were available. Now the 1Mbit device has been around for about a year. However this is not a single device, there are many different architectures available.

For smaller EPROMs the variants were limited and most manufacturers adopted a common numbering scheme. With the exception of Texas devices (which had a different pin out in their 25-series) and a couple of Motorola EPROMs in the 68- series virtually all manufacturers adopted the 27-series which followed a JEDEC approved pin-out and had numbers of the form 27n. The value of n could take values of 58, 16, 32, 64, 128, 256 and 512 and (with the exception of 58 which really meant 08) indicated the capacity in Kbits, the memory being organised as byte wide — ideal for 8-bit processors. The only variant to these part numbers was the addition of a suffix A to indicate that the programming voltage was lower. (For example the 2732A has a 21V programming voltage compared to 25V for the 2732).

With the appearance of the 512Kbit EPROM two architectures evolved: the 27512 which is 64K × 8 bits and the 27513 which is the first of a family of paged EPROMs organised as 4 × 16K × 8 bits. This device has a register which can be written to by the processor to select one of the 4 available pages. Such a device is of clear advantage in an 8-bit system where the address map is limited to 64K bytes.

Mega Memory

After this bit of historical background, let's take a look at the 1Mbit EPROMs, the architectural variants of which have really mushroomed. The situation is further complicated by the fact that the same device can often have different part numbers from different manufacturers.

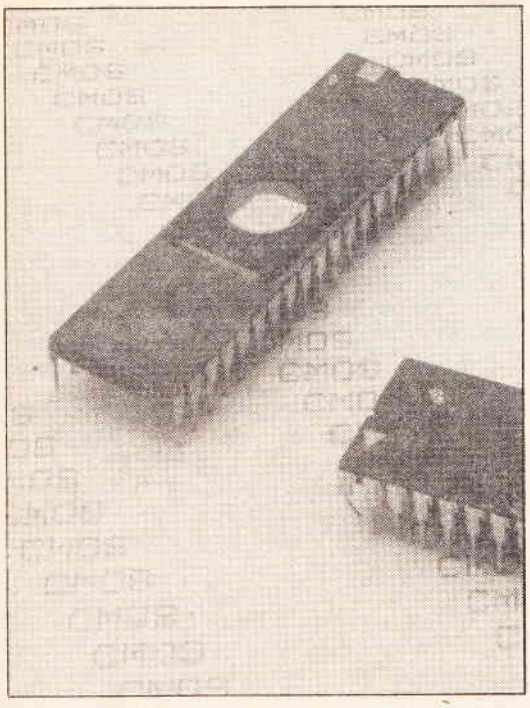
Following on from the other byte wide EPROMs the 27010 (Intel), 27C1001 (Fujitsu), 571000 (Toshiba) or 27C101 (Hitachi) offer 128Kbytes and can therefore only be used with 16 or 32-bit processors (8-bit processors can't address more than 64K linearly without paging). Toshiba also offer the 571001 which has the same architecture as those above but the pinout is compatible with the 1Mbit masked ROM rather than JEDEC standard. All these devices break through the 28-pin barrier with their need for an extra address pin and are the first EPROMs to be housed in a 32-pin DIL package. Leadless chip carrier versions are also available for surface mounting.

Following in the footsteps of the 27513 is the Intel 27011 paged EPROM which is configured as 8 × 16K × 8. Because the linear address space occupied is still only 16K bytes, the number of address bits is still 14 (the same as on the 27513) so the device is still housed in a 28-pin package. In fact Intel, the originator of the paged philosophy, has advertised its plans to continue up to 32Mbits (256 × 16K × 8) all in the same 28-pin package. This implies that hardware designed for any EPROM in this family will accept any other member, only software changes being necessary.

In order to use byte wide devices with 16-bit processors, two memory chips can effectively simulate a single 16-bit wide memory. The first EPROM designed specifically for 16-bit systems is the 27210 (Intel) or 271024 (AMD, Fujitsu, Hitachi), arranged as 64K × 16. Compared to the 27512 which has the same number of words as the byte width, a further 8 data pins are required and accordingly the package size jumps to 40 pins. To reduce the pin count the 271028 (Fujitsu) multiplexes address and data bits hence keeping the EPROM within a 28-pin package. Since many 16-bit processors also multiplex address and data busses, interfacing is not a problem.

Time After Time

Original EPROMs required a 50ms pulse to program each byte. Whereas this only meant a 100 second programming time for a 2716, the corresponding time for a 27010 would be well over an hour — even for a 2764 the time would be more than 6 minutes. For



this reason, EPROM manufacturers introduced an interactive programming algorithm for use with the 2764 and above. This works by applying 1ms pulses until the part verifies at which point a longer over-programming pulse is applied. This divided the programming time by six but required Vcc to be raised above its normal level to 6V.

Coming to the 27010, we find that even with the standard interactive algorithm the part takes about 15 minutes to program. Most 1Mbit EPROM manufacturers now recommend a much improved interactive algorithm (such as Intel Quick-pulse) in which the length of the pulses is 0.1ms and the need for an over-programming pulse is obviated. The Vcc level is increased once again to 6.25V and Vpp is also increased beyond its specified level by 0.25V. Typically the programming time for a 27010 is 15 seconds — a vast improvement.

Some manufacturers' devices which do not offer as efficient an algorithm give a different approach to programming time reduction. In these devices, internal latches allow up to 32 bits to be stored prior to starting a programming operation hence programming more than one location in parallel. Compared to byte wide devices without this facility a 4-fold speed increase is achieved.

Data Security

For many software houses and builders of micro-processor based products, it is just too easy for punters to make illegal copies of EPROMs, the contents of which could well represent many years of programming effort. Most commercial organisations have more integrity than to copy third party firmware but stealing software within the arena of home computing has almost become socially acceptable.

In its 27916 'KEYPROM' (providing "System Security in Silicon"), Intel has provided the first non-volatile memory with in-built security. Another potentially more important application is to prevent unauthorised access to multi-user computer systems — traditional security methods having been proved ineffective by the ardent hackers so often in the news. KEYPROMs are used in pairs which carry out an authentication handshaking process at initialisation prior to unlocking the contents. Once this unlocking has occurred the 27916 can be read in the normal way and looks just like a 27128.

In the multi-user system application one KEYPROM will be in the host computer and its twin in the remote terminal, whereas for firmware protection both will reside in the same piece of equipment — in each case the principal of operation is the same. Pairs of KEYPROMs are user programmed with a secret key and both devices have to be present for the data to be read. Even if a copy of KEYPROM resident firmware is made it will then only run on the computer for which it was licensed as only this machine will have a matching device as part of its system firmware.

Although the working of the 27916 is a complicated data encryption problem, the statistical security level makes interesting reading. During the authentication process the key is combined with a random number before transmission to the other device so that the secret key remains secure. The user can select 1 from 18 quintillion (18×10^{18}) possible keys. A computer program designed to pick the lock, trying one key every 8 hundredths of a second, would take 45 billion years to check every combination.

NVRAMs

Since they can only be erased by irradiation using ultra violet light, EPROMs can only be used as a true Read Only Memory and not as system non-volatile memory. The EEPROM or Electrically Erasable Programmable Read Only Memory, on the other hand, is designed with programming and erasing *within* the system in mind.

Early EEPROMs allowed the complete device to be erased electrically whereas more recent designs allow individual locations to be selectively erased. To further ease in-board programming, some EEPROMs have internal Vpp generation and programming pulse shaping and hence only require a +5V supply. Since a programming pulse measured in ms is required, recent designs also latch the address and data busses and time the pulse internally, freeing the processor once the programming operation has been initiated. Nevertheless once programming has started nothing further can be done with the EEPROM until it is completed so the software has to handle the chip in a way unlike standard memory.

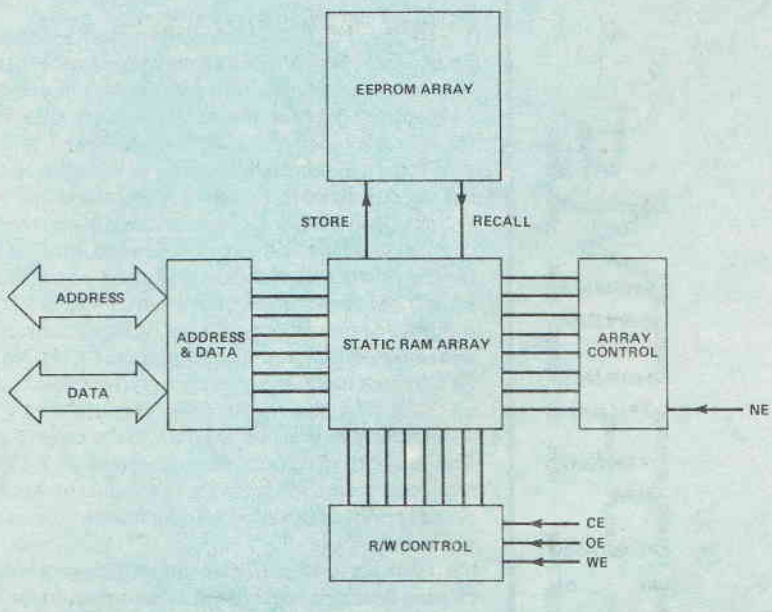


Fig. 1 NVRAM architecture

The NVRAM combines the advantages of both RAM and EEPROM having an internal organisation as shown in Figure 1. It will be noticed that the NVRAM contains a static RAM array and it is this memory which is accessed by the processor in the normal way for both read and write operations. What makes the NVRAM different, however, is that once a failing Vcc line is detected (at power down) the chip internally uses the data in the static RAM to program the EEPROM array before power is totally lost. Similarly, on power up, the reverse operation is carried out.

A control pin is also available to enable store and recall operations to be carried out under processor control. NVRAMs currently available from Intel are in the 200x series, a typical example being the 2004 with a capacity of 512×8 bits.

So much for recent developments. If space permitted we could look at the increasing trend of offering CMOS variants of all the common EPROMs, the 87- series EPROMs with inbuilt address bus latching or even serial output EPROMs. Instead let's turn to considering what makes EPROMs tick.

Inside The Eprom

Figure 2 is a diagrammatic representation of a single cell or memory bit of an EPROM. Programming is carried out by applying a high programming voltage (Vpp) to both the drain and the control gate with the

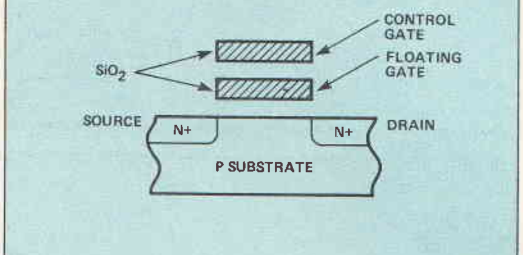


Fig. 2 An EPROM memory cell

substrate and source at ground potential. The result of this is a potential incline between source and drain producing a high electric field intensity near the drain. Some electrons are accelerated sufficiently to become 'hot electrons' which have enough energy to be attracted through the SiO_2 barrier layer towards the positively charged control gate.

Many of these electrons only make it as far as the floating gate at which point they remain stable having lost their extra energy. As the electron concentration on the floating gate increases, the negative charge has the effect of deflecting further electrons and an equilibrium is eventually achieved. At this point the cell is considered to be fully programmed.

Figure 3 is a graph of drain current against control gate voltage for both a programmed and an un-programmed cell. Reading is carried out with Vcc (+5V) present on the control gate. If the cell is un-programmed a potential of even 1V is sufficient to turn on the transistor so an un-programmed EPROM has all locations high. The presence of a negative charge on the floating gate has the effect of counteracting the application of a positive potential to the control gate. This being the case a voltage of about 7-10V is required to cause the transistor to conduct so the +5V actually present during a read operation gives a zero value.

Turning to erasure, this can only be achieved by causing the electrons trapped in the energy well of the floating gate to escape. Irradiation with ultra violet light of the correct wavelength causes the trapped electrons

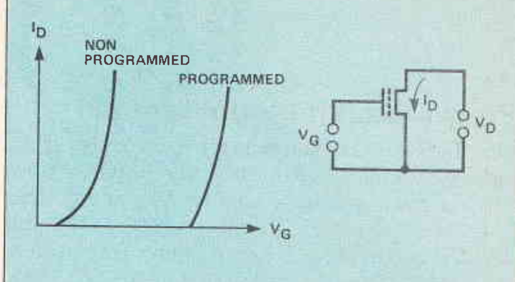


Fig. 3 Electrical characteristics of an EPROM memory cell

to turn back to hot-electrons and thereby traverse the SiO_2 energy barrier. Since the energy of electromagnetic radiation is proportional to its frequency, a maximum wavelength (corresponding to a minimum frequency) is required in order to give enough energy to the electrons. A wavelength of less than 3000 angstroms is required to cause erasure.

Since the concentration of electrons residing in the floating gate rises exponentially with time and since there is a natural variation in the characteristics of individual cells, some will reach saturation in a fraction of the time taken to program others. This being the case, the original programming method of giving all locations a 50ms pulse must be considered a 'play it safe' approach. The first type of interactive programming algorithm (such as Intel's Intelligent algorithm) recognises the difference between individual memory cells by applying short 1ms pulses until verification is achieved. Since this will cause each cell to be only just programmed an extra over programming pulse is used to make sure!

As a further safety measure, Vcc (the voltage on the control gate during verify and read) is raised to +6V compared to the +5V used for normal reading. This changes the threshold between un-programmed and programmed cells such that a border-line cell appears unprogrammed and is therefore given further pulses.

The technique, in the newer high speed interactive algorithms (such as Intel's Quick-Pulse) is very similar except that the devices are designed to withstand a slightly higher Vpp hence reducing drastically the likely time taken to program and 0.1ms pulses are therefore used. Over-programming (which accounts for a significant proportion of the programming time for the original interactive algorithms) is done away with but in order to compensate, Vcc is further increased giving a greater margin for error.

Memory Loss

Border line verification is eliminated to provide an acceptable lifetime for the programmed data. EPROMs are normally designed to provide data retention in the 5-10 year range but certain factors can reduce this. The thing which would cause an EPROM to 'forget' is electrons leaving the floating gate and it is obviously important to ensure that ultra voilet does not enter the chip accidentally. Since even sunlight and fluorescent tube lighting contain some UV, programmed EPROMs should have an opaque label placed over the window.

The other major factor affecting data retention is temperature. Since the electrons on the floating gate are not in equilibrium, dissipation of thermally activated electrons occurs. This would be eliminated if the device was stored at absolute zero but clearly this is a rather inconvenient solution! The data retention characteristics quoted by EPROM manufacturers assume room temperature — a significant decrease would result from storing EPROMs at say 200°C!

Programming Equipment

Most EPROM programmers for home constructors have been cards which interface directly onto the bus of some popular home computer. The forthcoming ETI Stand-Alone Programmer breaks from this tradition in adopting the more common industrial practice of having a separate unit interfacing to the host computer via an RS232-C link. The clear advantages are that it may be connected to virtually any computer and also that local intelligence allows straight copying to be carried out without any host intervention.

In industry, time is money — the longer it takes to programme an EPROM, the more it costs to make the piece of equipment into which it will be fitted. All interactive programming algorithms require the programmer to carry out general control functions — initiating programming pulses, carrying out verification, counting the pulses and comparing to the maximum number allowed and so on.

When the pulses are 1ms long, the extra time taken for the programmer to carry out these duties adds an insignificant amount onto the total programming time. As the pulse length is reduced to 100ms, however, the time taken by an 8-bit processor to carry out these house-keeping functions is more significant. To the home user, an increase from say 10 seconds to 20 seconds doesn't matter but in a manufacturing environment it is important to get round this problem. For this reason, many newer EPROM programmers have much higher speed 16/32-bit processors driving them.

Whereas base level programmers usually have just a single socket (or maybe one master and one programming socket), a further significant time saving measure is to use so called 'gang programmers' with a number of sockets (typically 8 or 16), all of which can take EPROMs for programming at the same time.

Ironically, the advantage of gang programmers decreases as the efficiency of the programming algorithm increases. For example, assume that we wish to program eight 2764s. With a single socket programmer, for each device it takes say 1s to insert the EPROM, 50s to program it and a further 1s to remove it from the programmer, a total of $8 \times (1+50+1) = 416$ seconds. With a gang programmer it takes 8 seconds to load up the programmer (the same 1 second per device), 50s for programming and 8s again for unloading, a total of 66 seconds. The efficiency has therefore been increased by a factor of 6.3.

With the 100μs pulse algorithm when the programming time is 1s, the time using a single socket programmer is $8 \times (1+1+1) = 24$s and the time for a gang programmer is $8+1+8=17$s. The efficiency is not even doubled.

This shows that the handling time is very significant and that this becomes a dominant factor in programming time as the actual programming itself becomes more efficient. In an attempt to reduce the cost of this activity, organisations requiring EPROM programming in very large numbers are turning to the use of automated handling equipment for loading and un-loading the programmers.

So now you know. Coming next month, the ETI Stand Alone Universal EPROM Programmer.

ETI

THE NORTON DIFFERENCE

Ray Marston presents the second half of his guide to Norton current-differencing amplifiers

Having explained the basic operation of the LM3900 quad Norton amplifier in a variety of linear amplifier circuits, we can now examine other applications of this device.

Comparators And Schmitt Circuits

The LM3900 is easily configured as a voltage comparator by simply wiring equal value resistors in series with each input to limit the current, as shown in Fig. 1. One input is a voltage reference, the other is the sample input. As shown the circuit gives a non-inverting action (the output switches high when V_{in} rises above V_{ref}) and the inverting action is achieved by simply swapping the two voltage inputs.

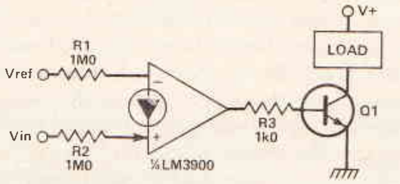


Fig. 1 Non-inverting power comparator

The Norton amp itself can supply only a few mA of output current. This can be boosted using the power stage of R3 and Q1.

Hysteresis can be added so that they act as Schmitt triggers (Fig. 2) with a high value resistor between the output and non-inverting version has the inputs swapped. The R2/R3 ratio determines the hysteresis level.

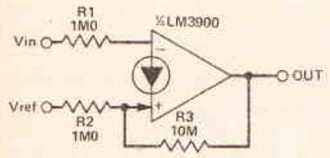


Fig. 2 Inverting Schmitt trigger

Beyond Compare

The next few circuits show some useful comparator applications. Figure 3 is an over-temperature switch. The reference is half supply voltage (set by R1 and R2) and the output of the LM3900 will go high when the temperature of negative temperature coefficient thermistor TH1 exceeds a value preset by RV1.

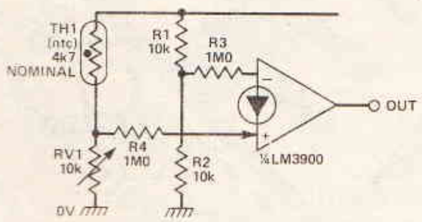


Fig. 3 Over-temperature switch

Note that this circuit will operate as an under-temperature switch by transposing TH1 and RV1. Also note that since RV1, TH1, R1 and R2 are in a Wheatstone bridge configuration, the trip point is independent of supply rail variations.

Figure 4 shows an under-temperature switch with the reference (inverting) current derived from the supply rail via R1 and the variable (non-inverting) current again derived from the RV1-TH1 junction. Since R1 is roughly double the value of R2 and generates a current proportional to the supply rail voltage, the trip point of this circuit is also independent of variations in supply rail voltage.

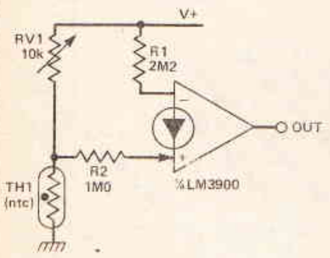


Fig. 4 Under-temperature switch

A variant of the above is shown in Figure 5, which gives a high output when the supply voltage falls below a value determined by ZD1. If ZD1 has a value of 5V6, the op-amp output switches high when the supply rail voltage falls below roughly 11V — the precise trip point can be varied by replacing R3 with a series-connected 820k resistor and a 470k pot.

In Fig. 6 a reference current is fed to the inverting pin via R4 and a greater current can be fed to the non-inverting pin via any of the R1 to R3 resistors, thus making the output switch high if any of the inputs go high. The circuit thus acts as a 3-input OR gate and could accept any desired number of OR inputs simply by using a suitable number of input resistors. The circuit becomes a NOR gate by simply transposing the input connections of the op-amp.

Raising the three resistor values to 2M7 means that the reference current will be exceeded only if all three inputs are taken high. The circuit therefore operates as a 3-input AND gate — or NAND gate if the Norton amplifier inputs are reversed.

Voltage Regulation

Figure 7 is a simple but useful variable voltage reference. The non-inverting terminal is disabled and the circuit uses the Vbe potential of the inverting terminal as a reference with a voltage gain determined by the RV1-R1 ratio. When RV1 is set to zero, the circuit gives unity gain and an output of 0.55V, when RV1 is set to the maximum value the circuit has a gain of ×50 and an output of 25V. The circuit has good regulation and can supply an output of several mA. Note, however, that the output voltage is not temperature compensated.

Figure 8 shows a fixed voltage reference circuit that generates a well regulated output slightly greater than the ZD1 voltage. R1 sets the zener current at about 1mA. The circuit without Q1 can safely supply output currents of only a few mA but this is raised to tens or hundreds of mA with the current boosting transistor in the output feedback loop of the circuit.

In Fig. 9a the op-amp is wired as a ×2 non-inverting DC amplifier (with gain determined by the R3-R4 ratio), and the input voltage is variable from 0-15V via RV1. The output voltage is thus variable over the approximate range 0.5-30V via RV1. Figure 9b shows how the available current can again be boosted to tens or hundreds of mA with the aid of an external transistor.

Current Regulation

Figure 10a acts as a fixed 1 mA current source which feeds a fixed current into a load connected between Q1 collector and ground almost irrespective of the load impedance (in the range zero to 14k). The circuit is powered from a regulated 15V supply.

Potential divider R1,R2 applies a 14V reference to R3 and the op-amp output automatically adjusts to give an identical voltage at the R4,R5 junction. This produces 1V across R5, resulting in an R5 current of 1mA.

Since this current is derived from Q1 emitter (and the emitter and collector currents of a transistor are

NORTON

almost identical) the circuit acts as a fixed 1 mA current source. The source current can be doubled, if desired, by halving the R5 value, and so on.

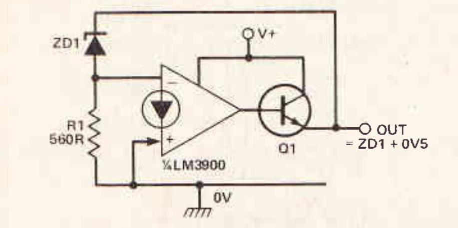


Fig. 8 Current-boosted voltage reference

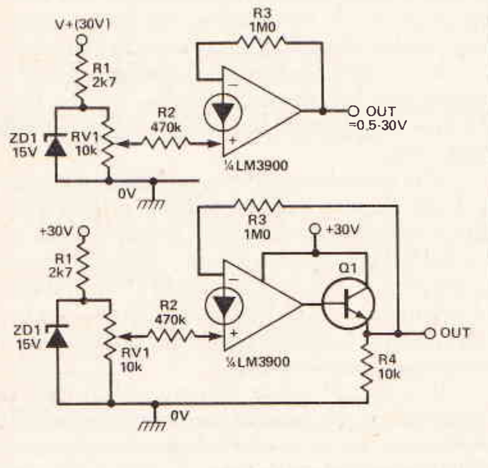


Fig. 9 (a) Variable voltage regulator.
(b) Variable voltage regulator with boosted output

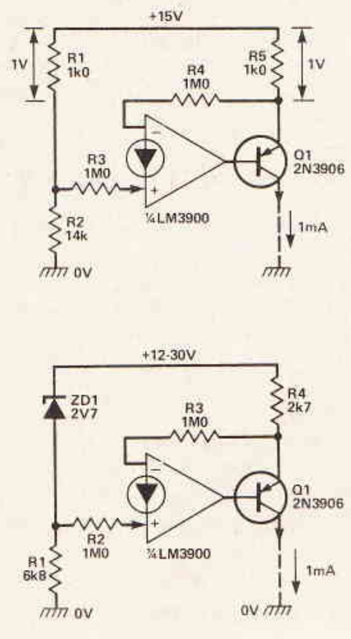


Fig. 10 (a) Fixed-current 1mA source.
(b) Alternative current source

Figure 10b is a simple variation with the source current independent of variations in supply rail voltage. The input is set to 2V7 below the supply rail value by ZD1, so 2V7 is automatically set across R4 which has a value of 2k7 and thus produces a fixed 1 mA source current from Q1.

A simple 1 mA current sink is shown in Fig. 11, in which a fixed current flows in any load connected between the positive supply rail and Q1 collector, almost irrespective of the load impedance. Here, the non-inverting terminal of the op-amp is disabled and total negative feedback is used between the output of the circuit (Q1 emitter) and the inverting terminal. The voltage across R1 thus equals the Vbe of the inverting terminal and, since this is roughly 0.55V, a fixed current of about 1 mA flows through Q1 emitter and R1 and thus into Q1 collector from any load that is connected. Note that the sink current of this circuit is not temperature compensated.

Finally, Figure 12 shows an alternative type of current sink with the op-amp fully enabled and a fixed reference of 2V7 applied to its non-inverting terminal via R2. The circuit automatically adjusts to generate 2V7 across R4 which, since it has a value of 2k7, generates a current of 1 mA in the emitter and collector of Q1. This current can be varied, if required, either by changing the value of R4 or by altering the input voltage feed to R2.

Waveform Generation

The last set of circuits for the LM3900 show some useful ways of making simple waveform generators. Figure 13a shows a 1kHz square wave generator in which C1 alternately charges and discharges via R1. When the output is high, R3 and R4 are effectively connected in parallel. C1 charges via R1 until the current flow into R2 equals that flowing into the non-inverting terminal of the op-amp; this occurs when the voltage across C1 rises to roughly ⅔V. At this point the circuit switches regeneratively, the output jumps low and C1 starts to discharge via R1 until the R2 current falls slightly below that of R3 (R4 is effectively disabled). This occurs when the C1 voltage falls to about ⅓V. At this point the circuit again switches regeneratively, and the output goes high again.

The square waves are useful only up to a few kHz — the LM3900 only has a slew rate of 0.5V/µs and the output waveform has fairly poor rise and fall times.

The circuit of Fig. 13b modifies the symmetrical square wave to give a variable mark-space (m/s) ratio output. In this case C1 alternately charges via R1,D1 and the upper half of RV1 and discharges via R1,D2 and the lower half of RV1. The m/s ratio can be varied over the approximate range 1:10 to 10:1 via RV1.

Figure 13c is a free-running pulse generator. In this case C1 alternately charges via R1 and D1 and discharges via R2, producing a m/s ratio of about 1:60.

Figure 13d shows how the basic Fig. 13a circuit can be modified to act as a gated 1 kHz astable or square wave generator by taking R3 to ground via R5, rather than directly to the positive supply rail. The circuit becomes active only when the gate terminal is pulled high (to the positive supply rail).

To complete our look at the LM3900, Figure 14 shows how the circuits of Figs 3 and 13d can be combined to make an audible-output over-temperature alarm, which generates a 1 kHz tone in a PB-2720 (or similar) acoustic transducer when the TH1 temperature exceeds a value pre-set via RV1.

The LM359

The LM359 is a high performance IC that houses two identical Norton op-amps plus a common 'biasing' network in a 14-pin DIL package (see Fig. 15) and can operate from a single-ended 5-22V power supply. Each of its op-amps offers a 30MHz unity-gain bandwidth, a 60V/µS slew rate, a 72dB open-loop gain and has many of its parameters fully programmable via one or two external resistors.

The LM359's op-amps differ considerably from those used in the LM3900. Fig. 16 shows the basic LM359 op-amp circuit in slightly simplified form. This consists, in essence, of a mirror-driven (via Q1 and Q2) wide-band cascode amplifier (Q3 and Q4), which

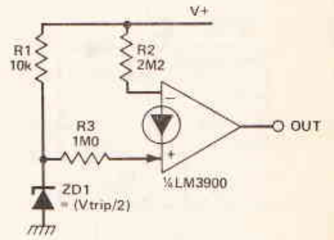


Fig. 5 Supply under-voltage detector

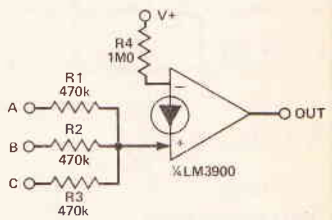


Fig. 6 3-input OR gate

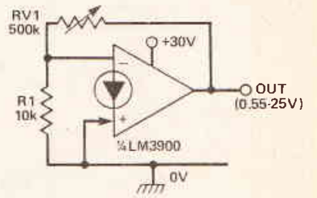


Fig. 7 Simple variable-voltage reference

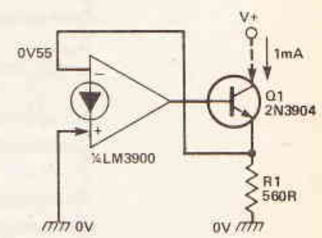


Fig. 11 Simple 1mA current sink

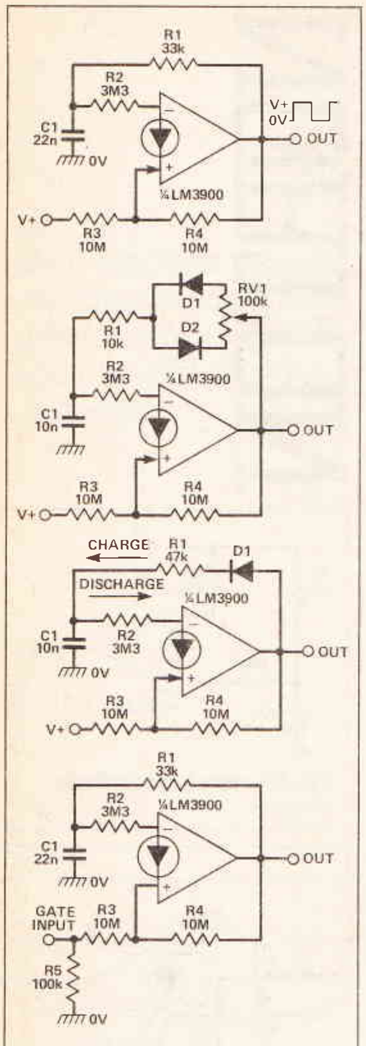


Fig. 13 (a) 1kHz square wave generator. (b) Variable M/S-ratio generator. (c) Pulse generator. (d) Gated 1kHz astable

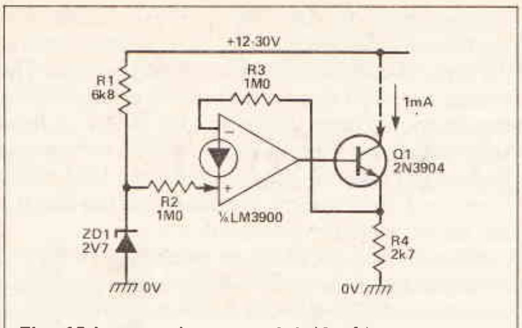


Fig. 12 Improved current sink (1mA)

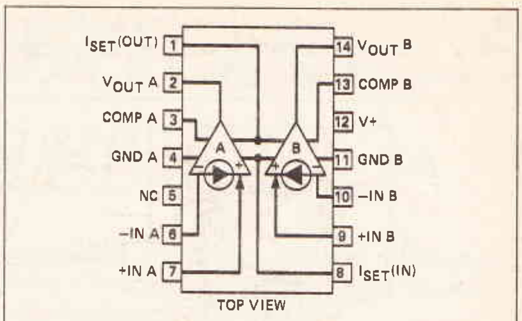


Fig. 15 LM359 outline and pin-out

does not suffer from output-to-input Miller or parasitic feedback effects (thus giving an excellent high-speed performance), plus a Darlington emitter follower output stage (Q5 and Q6).

Note that a 12p capacitor is internally wired between Q4 collector (accessible at the COMP terminal) and ground, and that the Q3,Q4 operating current can be 'programmed' via the $I_{SET(IN)}$ current of the IC's internal biasing network, thus enabling the circuit's input biasing current, slew rate, bandwidth, and supply current to be pre-set. Similarly, the operating currents of the Darlington output stage can be programmed via the $I_{SET(OUT)}$ currents of the internal biasing network, enabling the output sink current and supply current to be preset.

Figure 17 shows the basic circuit of the IC's internal biasing network which controls both op-amps. Thus the $I_{SET(IN)}$ current can be set via a suitable resistor wired between pin 8 and the positive supply, and the $I_{SET(OUT)}$ current can be set via a suitable resistor wired between pin 1 and ground B. Alternatively, if $I_{SET(IN)}$ and $I_{SET(OUT)}$ are to have equal values, the current can be set via a single resistor wired between pins 1 and 8.

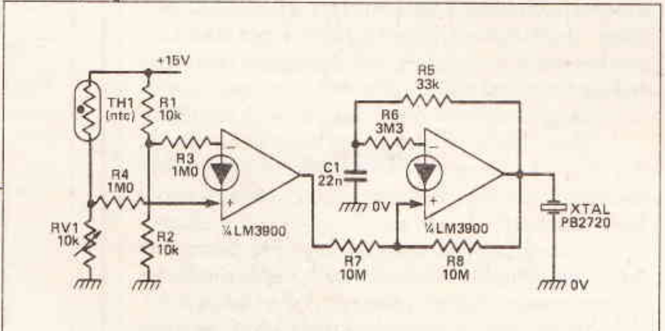


Fig. 14 Audible-output over-temperature alarm

Using The LM359

The LM359 is usually used in linear amplifier applications and in such cases the design procedure involves two simple stages — first, the design of the input biasing network and second, the selection of the programming resistor value(s).

The LM359 is biased in exactly the same way as the LM3900, using either voltage-reference biasing, supply-line biasing, or $N \times V_{be}$ biasing (as shown last month in Fig. 5).

The circuit in Fig. 18 gives inverting AC amplifier action, uses supply-line biasing, and has individual $R_{SET(IN)}$ and $R_{SET(OUT)}$ programming resistors.

The Fig. 19 circuit also acts as an inverting AC amplifier but uses $N \times V_{be}$ biasing and a single resistor for $_{IN}$ and $_{OUT}$ programming.

The circuit in Fig. 20 acts as a non-inverting AC amplifier and uses supply-line biasing and a single programming resistor.

I_{SET} Programming

The major operating parameters of the two LM359 op-amps can be programmed via the pin 1 and 8 I_{SET} currents of the IC. The gain-bandwidth product, the slew rate and the inverting input bias current can be programmed via the pin 8 $I_{SET(IN)}$ current. Figure 21 show the effects of this current on the individual parameters.

The gain-bandwidth product graph is based on a ×100 inverting amplifier fed with a 10MHz input signal but is valid for all types of amplifier. Thus, with a 10MHz input, it gives a gain of ×60 and a g-b value of 600MHz at an $I_{SET(IN)}$ current of 1mA, and a gain of ×1.1 and a g-b of 11MHz at 0.01mA. The gain-bandwidth of the circuit is thus directly proportional to the $I_{SET(IN)}$ current value.

It is also inversely proportional to that 12p capacitor (Fig. 16) which is fixed internally but can be increased by wiring an external capacitor between the COMP terminal and ground. Thus, the gain-bandwidth values can be halved by doubling the effective C_{COMP} value via an external 12p capacitor.

The slew rate of the op-amp is also directly proportional to $I_{SET(IN)}$ but inversely proportional to C_{COMP} and can thus be varied in the same way. The inverting input bias current values on the other hand, are independent of C_{COMP} and depend solely on the $I_{SET(IN)}$ values.

The output sink current (Fig. 22) is variable via the pin 1 $I_{SET(OUT)}$ current and is roughly ten times that value.

Individual resistors are used, each value is determined by:

$$R_{SET} = 500R, \text{ where } V = V_{+} - 0.6V$$

and in this case the total current consumption of the IC (of the two op-amps) is rougly equal to:

$$I_{supply} = (27 \times I_{SET(OUT)}) + (11 \times I_{SET(IN)})$$

If only a single programming resistor is used, its value is determined by:

$$R_{SET} = (V/I_{SET}) - 1kO, \text{ where } V = V_{+} - 1.2V$$

and in this case the total current consumption of the IC roughly equals $27 \times I_{SET}$. Figure 23 shows the typical consumption graph when using a 12V supply.

Wideband Amplifiers

The most important application of the LM359 is as a video or wideband amplifier.

The circuit in Fig. 24 is designed to be powered from a 12V supply and acts as a ×10 inverting amplifier that gives a bandwidth of at least 20MHz when driven via a terminated 75R line. This last requirement sets the R1 value at 75R. The input is then AC-coupled via C1, which is shunted by C2 to minimise its high-frequency impedance. R2 and R3 set the circuit's voltage gain — R2 must be small, but must not significantly shunt the R1 value — this gives R2 a sensible compromise value of 750R. To give a voltage gain of ×10, R4 must be ten times greater.

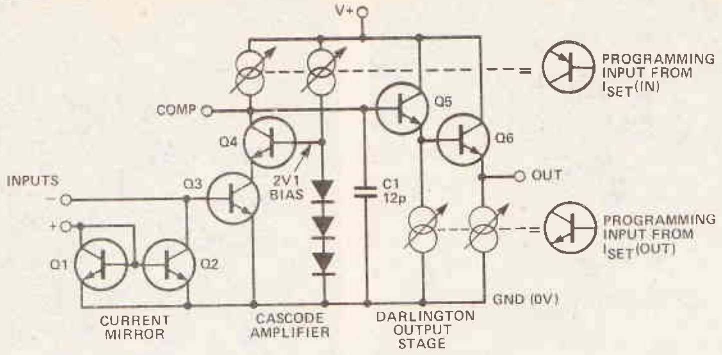


Fig. 16 Basic circuit of each LM359 op-amp

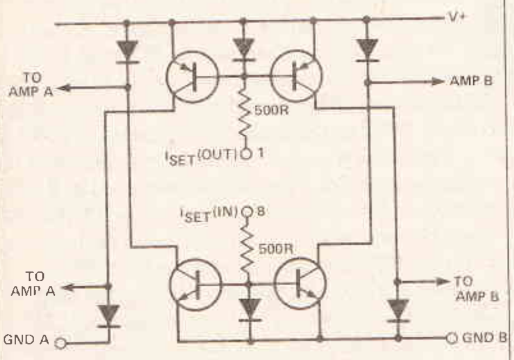
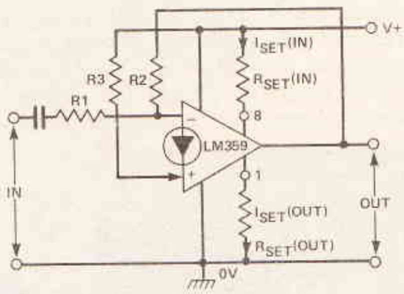


Fig. 17 LM359 internal biasing circuit



V+ = 5-22V

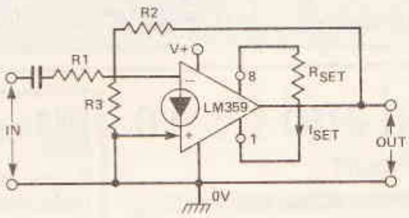
$A_V = -R2/R1$

R3 = 2 x R2

$R_{SET}(IN) = (V+ - 0V6/I_{SET}(OUT)) - 500R$

$R_{SET}(OUT) = (V+ - 0V6/I_{SET}(OUT)) - 500R$

Fig. 18 Inverting AC amplifier with supply line biasing



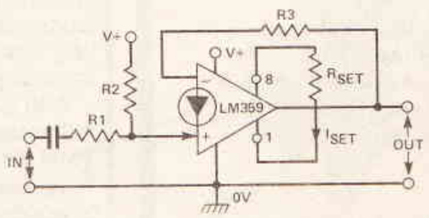
V+ = 5-22V

$A_V = -R2/R1$

$V_{OUT} = 0V55 \times R2+R3/R3$

$R_{SET} = (V+ - 1V2/I_{SET}) - 1k0$

Fig. 19 Inverting AC amplifier with NxV_{be} biasing



V+ = 5-22V

$A_V = R3/R1$

R2 = 2 x R3

$R_{SET} = (V+ - 1V2/I_{SET}) - 1k0$

Fig. 20 Non-inverting AC amplifier with supply line biasing

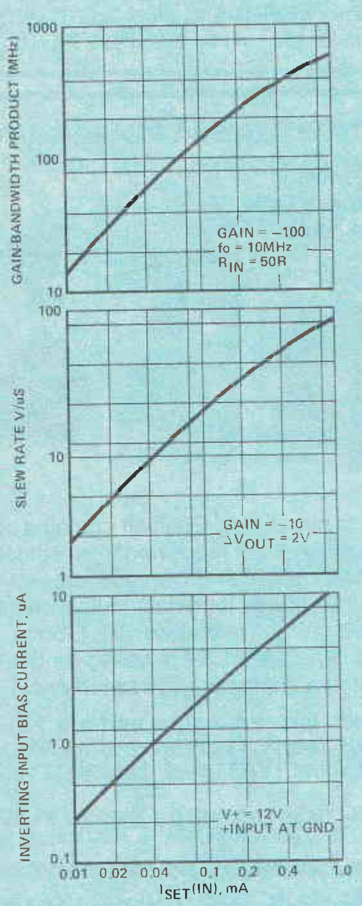


Fig. 21 (a) Gain-bandwidth product.
(b) Slew rate.
(c) Inverting input bias current

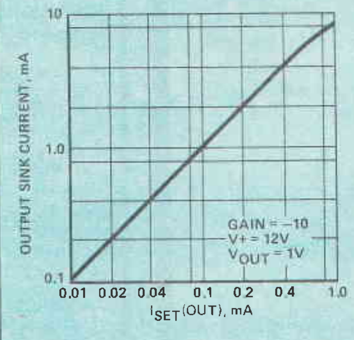


Fig. 22 Input sink current

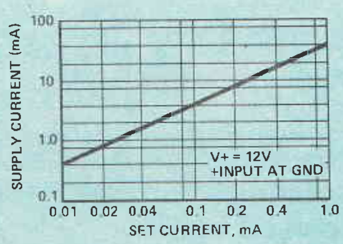


Fig. 23 Total supply current
($I_{SET(IN)} = I_{SET(OUT)}$)

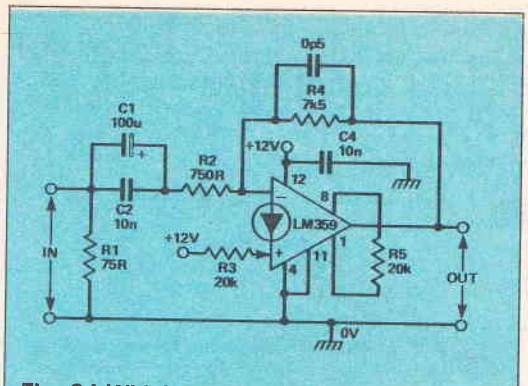


Fig. 24 Wideband ×10 inverting amplifier

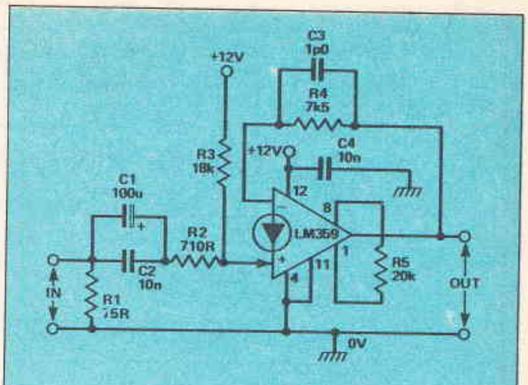


Fig. 25 Wideband ×10 non-inverting amplifier

To give maximal output signal swing the op-amp output must be DC biased to a quiescent value slightly below half-supply volts. This is achieved by making R3 a bit more than twice the R4 value; a good compromise is 20k, which sets the output at 5.1V. To give the required gain and bandwidth, the op-amp needs a minimum g-b product of 200MHz; an I_{BIAS} value of 0.5mA gives a g-b of 400MHz, which gives a good margin of safety and this can be programmed by giving R5 a value of 20k.

To ensure a good high-frequency performance, the pin 12 supply pin is RF decoupled to ground via C4. To give maximal bandwidth, C3 (two twists of insulated wire) is adjusted on test. In practice this circuit gives a 3dB bandwidth that extends from 2.5Hz to about 30MHz and is absolutely flat up to 20MHz.

Figure 25 shows a non-inverting version of the wideband amplifier. The gain is determined by the R2: R4 ratio, and the DC biasing value by the R3: R4 ratio. The 3dB bandwidth of the circuit again extends from 2.4Hz to 30MHz and is almost flat to 20MHz.

Finally, to complete this look at Norton amplifier ICs, Fig. 26 shows how both op-amps of an LM359 IC can be cascaded to make a general-purpose wideband amplifier with a nominal gain of ×1000 and a 3dB bandwidth that extends from 10Hz to 8MHz. In this case the op-amps are each wired in the inverting amplifier mode, with ×33 gain set by the R3/R1 or R6/R4 ratio. They use $N \times V_{be}$ biasing, with the 'N' ratio set by R3/R2 or R6/R5.

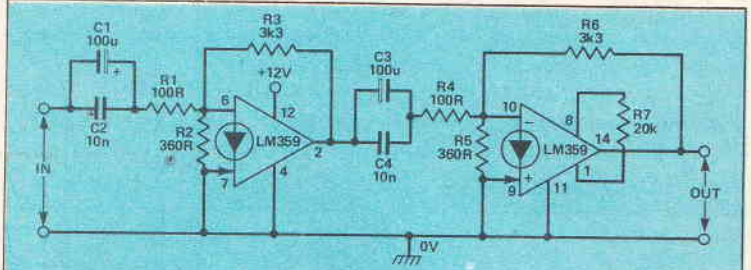


Fig. 26 High gain ×1000 general purpose wideband amplifier

Both the LM359 and LM3900 can be obtained from Cricklewood Electronics, 40 Cricklewood Broadway, London NW2 3ET. Tel: 01-450 0995.

ETI

MAKING SENSE

Mike Barwise takes a close look at the world of motion and movement

CHIP IN

Continuing our look at the broad spectrum of electronic sensing techniques we turn now to methods of detecting motion and displacement. Those examined last month (including doppler shift, echo sounding, inductive and capacitive proximity sensing) are all, however, rather crude — they are useless as feedback to real world precision devices such as machining stations and all but the simplest of handling robots. I would now like to introduce some methods of accomplishing measurement and detection of micron (1/1000mm or 1×10^{-6} metres) and sub-micron distances and displacements.

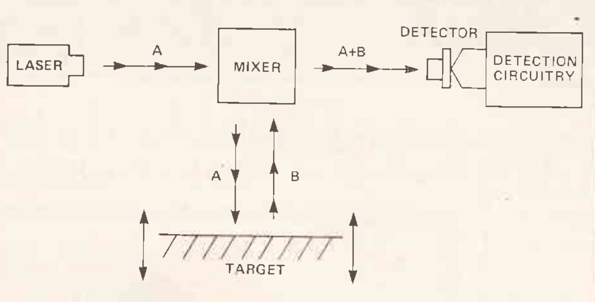


Fig. 1 The basic interferometer

The Interferometer

The basis of the interferometer is the principle of constructive and destructive interference which I mentioned when we were looking at lasers. Two beams of coherent (monochromatic) light mix to form an output beam, the intensity of which is the vector sum of their relative phase (wave definition).

So where the two beams are 180° out of phase there is no output (extinction) and where they are in phase (0°) the output is the sum of the input intensities. It matters not whether the two beams come from different sources or the same source (the latter is normally the case as it is virtually impossible to hold two sources in a constant phase relationship).

The basic interferometer therefore (Fig. 1) consists of a beam of coherent light directed at the item whose displacement is to be measured, with a means of combining the light reflected back with some of the light going out and lastly a method of detecting the intensity of the combined beam.

As the object moves along the beam axis, there will be a sinusoidal variation in the mixed beam intensity with a full cycle for each *half* wavelength displacement. As the very longest optical wavelength (long infra-red) is in the region of 900nm (0.9 microns) we can detect displacements of less than one half micron, even with this quite crude setup. Using light of shorter wavelengths will yield correspondingly increased resolution.

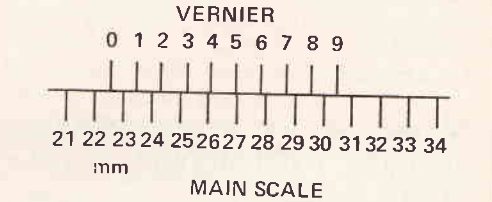


Fig. 2 Use of the Vernier scale

It should be noted here that the result is not an absolute position measurement — the cycle count only tells us how far the object has moved since we zeroed the count. There has to be a starting point reference for most useful measurement.

The Diffraction Grating

Neat though the interferometer is (and it is widely used) it is rather bulky, due to the need for free-space optical paths. A very compact alternative has been developed as a result of advances in photo-etching capability in microchip manufacture. This is the diffraction grating vernier.

What is a vernier? It is a method of measuring very small increments without the need to mark your ruler as finely as all that. It is most commonly used on engineers' callipers and such like. The principle is that if you want to measure something with a calliper to a resolution of, say, 0.1mm, it is quite impractical to engrave the whole 125mm scale of the calliper to this resolution (accuracy would suffer) and it would be very difficult to read a scale that fine anyway. So, you have a calliper engraved very accurately to a resolution of 1mm and instead of a single datum line on the slider, you have *ten*. These ten lines occupy the same space as *nine* lines on the main scale (9mm), so the distance between adjacent lines is 10% less than on the main scale.

At any setting of the calliper, there will be only one datum co-incident with a line on the main scale, and the numerical position of this datum gives you the extra resolution. The measurement to whole mm is performed at the first datum, where only whole mm are counted, and then the 'bit left over' is determined by counting along the datum scale until a datum co-incides with a division on the main scale. The count you get to is the 'bit left over'. In the example of Fig. 2 the measurement is 22.5mm.

Having grasped the principle of the vernier, let us now look at *diffraction*. If you lay two sheets of perforated metal or wire mesh together and look through the sandwich at a light source, you will see a regular pattern of bright spots which varies as the two sheets are moved with respect to each other. This is due to the distribution of co-incidence of holes in the two sheets — a very crude analogy of the diffraction grating.

For measurement systems, the grating is normally a set of parallel lines rather than a two-axis grid, and is photo-etched onto a glass plate. It is quite easy these days to produce 1 micron resolution gratings and if we use a 1 micron and a 0.9 micron grating together, the resolution of the resultant vernier is 0.1 micron (100nm) — very fine indeed.

This system requires one grating to be attached to the fixed element and the other to the moving element of the motion system. An array of detectors is required, one for each element of the vernier grating, so that the relevant co-incident line can be observed. It is very compact and precise but like the interferometer suffers from a major practical drawback — there is no method of detecting *direction* of motion. Fortunately, the solution to this problem is remarkably simple.

Quadrature Phase Detection

This is a method of determining both the quantity and direction of displacement. It works by using two identical interferometer or diffraction detectors which are physically aligned so that their output signals are 90° out of phase. The result is that in one direction of motion a reference point on the wave form (such as a rising edge) of one channel leads (and in the other direction lags) the same point of the waveform of the other channel, as in Fig. 3. The result is a measurement system which provides displacement information on either channel and direction information on a combination of both. A simple D type flip-flop can be used to resolve the direction signal from the logic-conditioned channel outputs (Fig. 4).

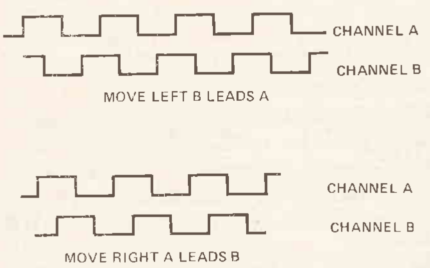


Fig. 3 Quadrature signal relationships

Several integrated solutions exist for keeping track of the outputs of these sensors, notably the Texas 74LS2000 Direction Discriminator, which contains an internal 16-bit counter that follows the bi-directional motion of a quadrature system. The number in the counter can thus be considered the absolute position of the motion system from nominal zero at all times.

The Cheap Alternatives

Having examined the super precise and priced, let us now turn our attention to the affordable. The same quadrature system is used in devices frequently known as *digital potentiometers*, though this is, like much jargon, a very misleading name. These devices consist of a disk of metal accurately perforated around its edge with a ring of slots. Two slotted opto-couplers (interrupters) are positioned so that they provide quadrature related outputs as the disk rotates. This is simply the rotational version of the linear diffraction grating on a crude scale. These units are widely used in computer graphics controls and so on. A miniature version is the active element in each axis of a micro mouse.

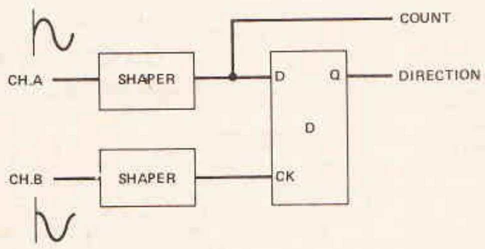


Fig. 4 A basic direction discriminator

Low Cost Linear Systems

The final set of devices worth a mention are linear potentiometers and LVDTs.

The linear potentiometer is just what its name suggests: a precision resistive track (frequently conductive plastic) and a wiper coupled to the motion system. These are remarkably convenient and accurate for short travel systems but suffer from the slight failing that they exhibit friction and therefore cannot be used in low energy systems.

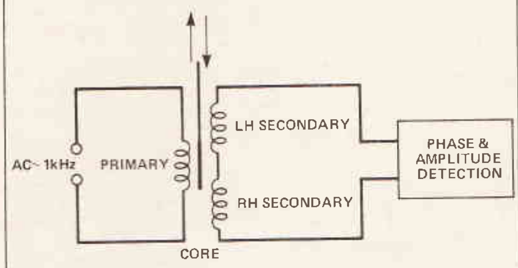


Fig. 5 Schematic of a LVDT

The solution to this is the LVDT: the Linear Variable Differential Transformer. This very cunning device consists of a transformer with a single primary winding and a pair of series-connected secondaries wound in anti-phase. The transformer core is movable.

The layout of the LVDT is shown in Fig. 5. As the core moves (attached to the motion system), the AC driven primary is differentially coupled to the two secondaries, the output being an amplitude and phase variable vector sum of the two anti-phase secondary outputs, in proportion to their coupling ratios to the primary. The output signal is quite difficult to resolve into a meaningful indication of displacement but fortunately ready-made hybrid interfaces are available. The LVDT has one very big advantage: it is a genuine non-contact sensor, as the core can be loose in the winding bobbin.

That's about it for my resumé of sensors. It has not, of course, been totally exhaustive, but has included the basics of the majority of devices you are likely to come across in all but the most sophisticated of equipment.

With the exception of the interferometer and diffraction grating systems, all the devices discussed are available in one form or another from *Electromail*, telephone (0536) 204555.

ETI

OP-AMPS

CIRCUIT THEORY

Paul Chappell continues his guide to the humble building block and digresses to design an oven

So far in this series we have carefully avoided any mention of the way an op-amp's behaviour varies with frequency. Unfortunately the topic can't be avoided for ever! The trouble is that there's no knowing where it might end as soon as you admit to yourself that an op-amp isn't simply a box which amplifies a voltage by 10^5 or so — once you allow that it does, in fact, introduce phase shifts, amplify different frequencies by varying amounts, have a limited slew rate and so on.

You have to start wondering about stability, compensation, transient response, oscillation, and all kinds of other unpleasant things. Instead of being satisfied with a simple algebraic formula to describe a circuit's behaviour, you have to get involved with complex algebra, poles and zeros, Laplace transforms, Nyquist diagrams and all the other paraphernalia of frequency response. What have you let yourself in for?

Frequency Response

Let's kick off by looking at plots of amplitude and phase against frequency for that old favourite, the 741. It's a bit of a dinosaur these days but still widely used, and the plots are typical of most general purpose, low cost op-amps so why not? The plots, from the National Semiconductors' data book, are shown in Fig.1.

From the amplitude plot you can see immediately that if you rely on the IC having a gain anything like the claimed 2×10^5 over, say, the audio band, you'll be one sorely disappointed circuit designer. Although it doesn't run out of steam entirely until about 1MHz, by 20kHz the 741's gain is only a miserable 50! (It may look a little more but remember that the horizontal and vertical axes are both scaled logarithmically).

If you are building an amplifier circuit and want to keep the amplitude response to within 1dB over the audio band, bearing in mind that the gain set by the feedback resistors must then be not much more than a tenth of the available gain from the op-amp, the maximum gain the circuit should be asked to give is about 5 or 6. That's one good reason audio designers don't rave about the 741!

Turning to the phase response, it's evident that something drastic is happening — at anything over about 200Hz, the phase at the output lags the +input by almost smack on 90° — but it's not quite so easy to see what effect this might have on a circuit built with the op-amp. In describing the operation of the circuit of Fig.2, for instance, I assumed that the IC's action was instantaneous and that at any point in time the input signal was being compared with a magnified version of itself, potted down by the two resistors. If the input is being compared with a version of itself which is, in effect, being delayed by ¼ cycle, surely this messes up the whole theory?

Even more puzzling is the fact that if you were to take a 'scope to the circuit of Fig.2, the operation would appear to be the way I originally described it in the sense that the output of the op-amp and the + and − input terminals would all have voltages in phase with each other. So where is the 90° phase shift? It's not enough to say that the negative feedback puts an end to it — the op-amp doesn't peek out of its little plastic box and say, 'Aha! There's negative feedback out there boys, hold back on the phase shift!' If there was one to start with, it will still be there when the feedback is applied. But where is it?

Before investigating the situation in more detail, I should make it quite clear that it is not some physical law of op-amp construction we're dealing with. The roll-off in gain and the shift in phase are both caused by a component deliberately introduced by the IC designer.

In the 741 (Fig.3), the component responsible for these complications is C1. So now we have another question — why would a designer intentionally spoil the amplitude and phase response of the IC? After all, if it was necessary to curtail the frequency response for some reason, instead of adding one cap to make the IC a first order filter, why couldn't a few more be added to give it a nice, sharp roll-off beginning at (say) 100kHz and reaching unity gain at 1MHz? The circuit designer would then have the benefit of the full 2×10^5 voltage gain over a wide frequency range. Intuition and common sense don't come up with any convincing answers, so we'll have to take a closer look.

Control Systems

The easy answer to the presence of the capacitor in the 741 is this: it's there to allow you to apply as much negative feedback as you like without causing instability. Without C1, if you tried connecting the IC as say a voltage follower then you'd actually end up with an oscillator. If you have the slightest doubt about this, try it with an uncompensated op-amp like the 709, or one which is not unity-gain stable like the NE5534.

That's what it does. How it does it is not such an easy question. It's all tied up with the effects that negative feedback has on a circuit. On a simple analysis, negative feedback appears to be no end of a good thing: it reduces distortion, corrects all kinds of drifts and errors and generally keeps the circuit tightly under control. Moreover the more you have of it, the better the effects seem to be.

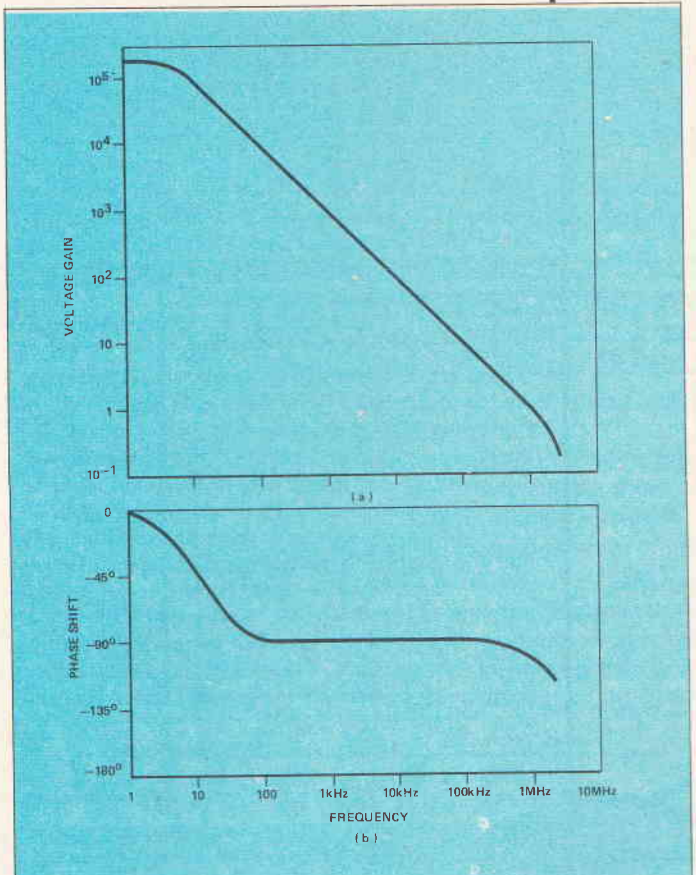


Fig. 1 The frequency response of the 741 op-amp

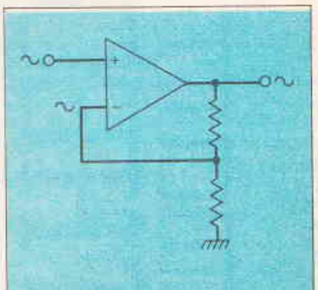


Fig. 2 A simple 741 circuit

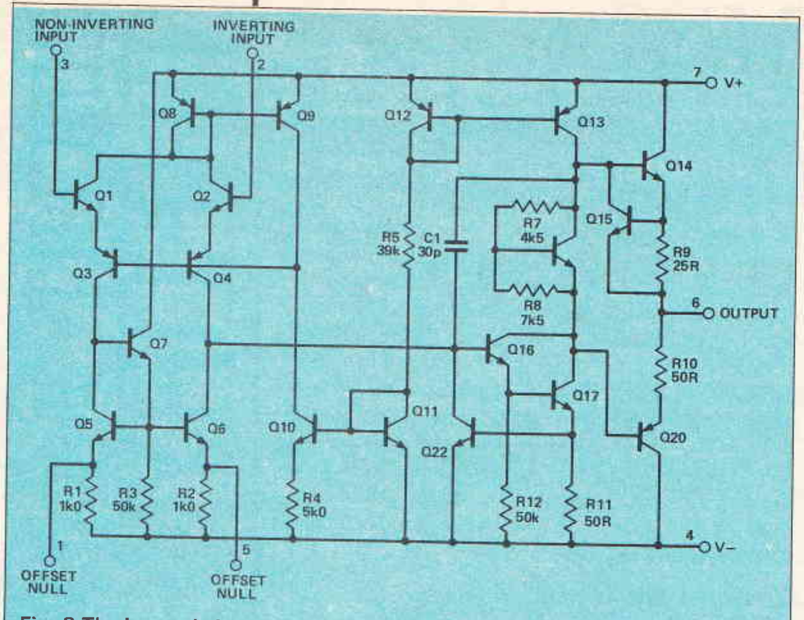


Fig. 3 The internal circuit of the 741

As is the general rule with electronics, things are never quite as simple as they first appear. Pile on more and more negative feedback without due care and the bad effects can quickly outweigh the good. But I'm telling you whodunnit before letting you in on the plot.

Instead of looking at negative feedback as it relates specifically to op-amps, I'm going to widen the scope of these articles to take in control systems — two particular examples since I don't want to stray too far into abstract theory. They may help you to see more clearly what's going on when I return to op-amps. They may not of course but since everything to do with electronics is fascinating through and through, you'll enjoy it all anyway.

Temperature Control

Suppose that you're going to make an oven of some kind — it can be the type that cooks your lunch, or if you'd like something more exotic it can be a kiln for firing pottery or even a diffusion oven for your own IC manufacturing plant! Obviously you'll want to control the temperature. How will you go about it?

One thing you could do is to experimentally make a graph of oven temperature against heater current. It might show that a current of 1A gives a temperature of 100°C, that 3A gives 200°C, that 10A gives 300°C, and so on. Your temperature control might then consist of a huge variable resistor which supplies the heater with the proper current for each temperature setting (Fig.4a).

Even if the impracticality of the huge variable resistor is overcome (with triacs and wotnot), the control would be very poor indeed. The first thing you'd find would be that the oven would take ages to stabilise at the set temperature — several hours, perhaps. The heat would have to permeate the layer of insulation you've put on for the sake of economy (and to stop the outside from being as hot as the inside!). Thermal equilibrium would only be reached when the outside has risen to a temperature such that it's losing exactly as much heat as the heater is putting in.

The inside temperature would vary considerably with the positioning of the oven — standing it in a draught would mean a very different internal temperature than you'd have if it was sheltered. As for opening the door and putting something cold inside — don't do it! The temperature would take an age to stabilise again.

What we really need is a more sophisticated controller which can keep an eye on the oven temperature and correct it if it wanders away from the set point. OK, so we add a temperature sensing element but how are we going to make use of the information it provides?

Hot Bricks

Let's gather together another set of building bricks so we know what we're dealing with. First of all we have a set-point box which puts in our request to the control system for the oven to be at a certain temperature. This gives 0-20V out according to the setting of the knob, so it might be nothing more than a DC power supply and a pot. When we've sussed out how the knob position relates to the temperature of the oven, we'll just stick on a label calibrated in °C.

Supplying current to the heater, we now have a voltage to current converter. It doesn't matter what's inside the box. For each 1V in, It supplies 1A to the heater up to a maximum of 20A.

The final building block is a temperature sensor which is, heaven be praised, perfectly linear and gives 1V per 100°C oven temperature. Now all we've got to do is to connect all the bits together to make a control system (Fig.4b).

To restore the same system as in Fig.4a, all we do is to connect the set-point box directly to the heater power box. The label on the knob would show 100°C when the set-point box is giving 1V, 200°C for 3V and 300°C for 10V, which corresponds to the heater currents we measured earlier.

OK, so now we get a plan of campaign for using the temperature sensor. To begin at the beginning — when the oven is first turned on, the temperature will be way below the set point. To get it up to temperature quickly, it would be nice if the controller could sense that it was a long way from its goal and apply loads of power. As it gets close to the set temperature, the extra power could be eased off until the heater is left with just enough current to sustain the proper temperature. This seems to suggest that we need to sense the difference between the set temperature and the oven temperature — we'll call the result of doing this the *error* signal, since it will be zero when the temperature is spot-on and will increase in magnitude as the error (the distance between the set temperature and the actual temperature) increases.

If the error signal provides extra current when the oven temperature is below set-point, this should also cope with the situation where the oven temperature drops as a result of the door being opened, or of something cold being placed inside. OK, so what if we've heated the oven to 300°C and then turn the control back to 200°C? Once again, the error signal could help to stabilise the temperature quickly by sensing the difference between the oven temperature and the set temperature, this time decreasing the heater current below the 3A that the controller of Fig.4a would give, then easing it back up to the 3A as the temperature approaches 200°C.

What about the situation where the oven is standing in a draught? Let's suppose that the set temperature is 200°C and the draught, with the control system of Fig.4a, would have reduced the temperature to 180°C. As the temperature falls, the error signal will boost the heater current, so one thing we can say for sure is that the temperature won't fall as low as 180°C. On the other hand, at 200°C there won't be any boost to the current at all, so the temperature won't be exactly right. All we can say for sure at the moment is that it will be closer to the proper temperature than before.

The idea seems fairly encouraging so far, so let's build up the new control system (Fig.4c). The set point box is a little more complicated since it is now

CIRCUIT THEORY

supplying the 1,3,10V to give the heater its steady current and the 1,2,3V that can be directly compared with the temperature sensor's output to give the error signal.

The first triangular box simply subtracts the temperature sensor output from the set-point to give the error signal; the second triangle adds this to the steady current value to give the increases and decreases which will, hopefully, improve the controller's performance.

Let's switch on and see what happens. Suppose the set-point control is at 200°C. The oven will be at room temperature so the output from the temperature sensor will be about 200mV. Subtracting this from the 2V output of the set-point box gives an error signal of 1.8V. The set-point box provides 3V to the heater power box, to which is added an extra 1.8V from the error signal, giving the heater an initial current of 4.8A. This will certainly heat it up quicker than the 3A, but wouldn't it be better if it had the full 20A?

As the temperature approaches 200°C, the error signal will decrease until at exactly 200°C the 2V output from the temperature sensor will precisely match the 2V from the set-point box, the error signal will be zero and the heater will just get its 3A to maintain the temperature.

If the oven became too hot, the output from the temperature sensor would be greater than the output from the set-point box, the error signal would be negative and the heater current would be reduced so it seems that this side of things works too. On the other hand, to reduce the heater current by 1A the temperature would have to be 100°C above set-point.

The controller works after a fashion but the error signal is not making itself felt as much as it could. Can it be amplified? If so, where should the amplifier go to make sure that the error signal is still zero when the oven is at the right temperature? All will be revealed next month.

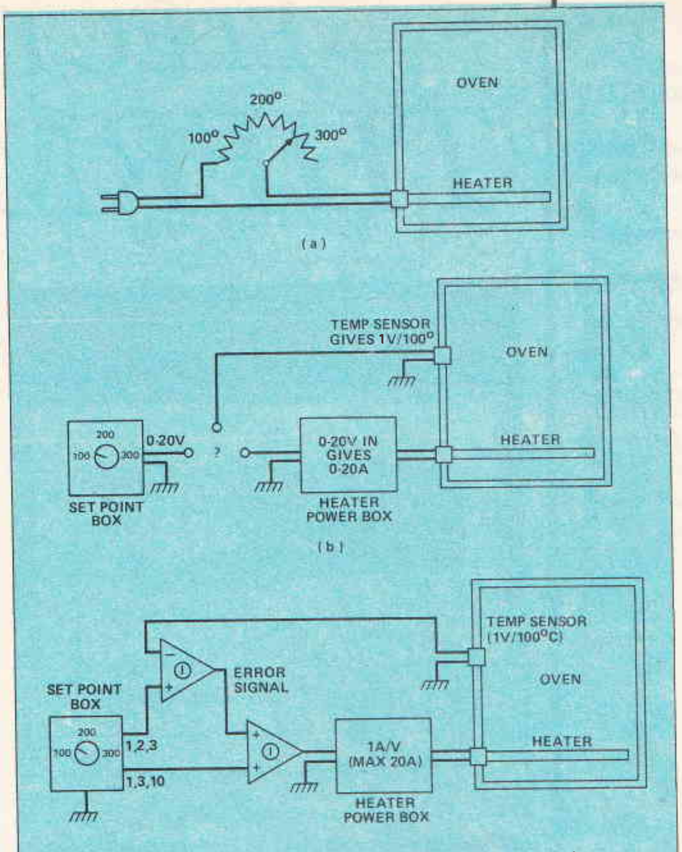


Fig. 4 Different control systems for a constant temperature oven

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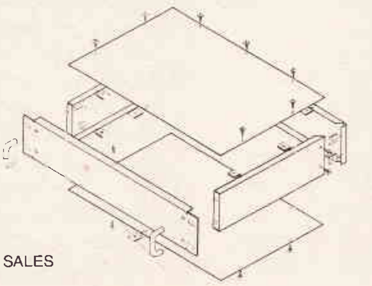
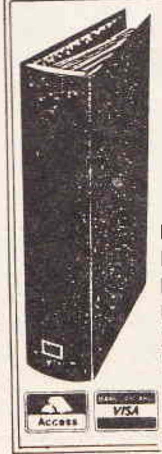
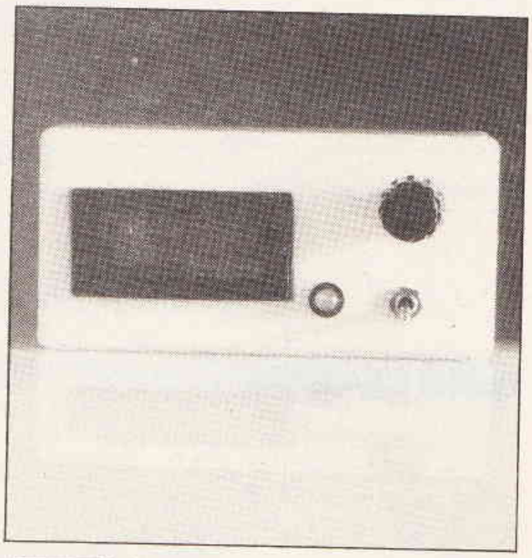




ELECTRONIC THERMOSTAT

Andrew Armstrong keeps snug and warm thanks to this electronic replacement for a central heating thermostat

PROJECT



This is a project to replace that grotty old mechanical central heating thermostat with a shiny new digital controller. The design enables this unit to be used as a direct replacement in the majority of central heating systems which use a 24V AC control system.

Figure 1 shows a typical wiring diagram for a central heating control using a conventional mechanical thermostat. From this it is clear that power to run an electronic thermostat connected directly in place of the mechanical one is not always available. When the time switch is off, the 24V supply is disconnected and when the thermostat is on (demanding more heat) there is no voltage across it.

This electronic thermostat can be used as a direct replacement for the mechanical thermostat shown in Fig. 1. This means that if the electronic thermostat should ever fail, the mechanical one can be replaced while the electronic one is repaired. The electronic thermostat runs on rechargeable batteries while it has no externally supplied power and the batteries are recharged while power is available.

The unit provides a digital readout of temperature or of thermostat set-point (selectable by a switch) all the time. It can only achieve this by using very low power consumption components, so that the rechargable battery does not run down quickly when power is unavailable.

Component Choice

Some components may be difficult to obtain. In the case of the ICs, there are no alternative types but they

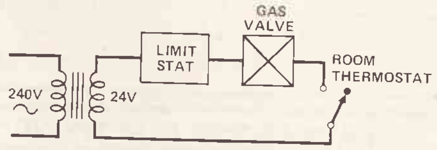


Fig. 1 The normal wiring diagram for a central heating thermostat

HOW IT WORKS

The unit controls 24V AC not as some might imagine by a triac but by using a power MOSFET and a bridge rectifier. There are two reasons for this. First of all, DC is needed to power the unit and charge its batteries and secondly no current is required to hold a power MOSFET on. A fairly substantial power MOSFET is used to handle the heavy current that may flow while relays, solenoid valves, and the like are pulling in. When the power FET Q1 is switched on, some of the current is diverted via LED 1 to show when the heating is on.

The only purpose of R3 is to cause a voltage drop so that there is some voltage to light the LED. A variety of different power MOSFETs would be suitable for Q1 — the main requirement is for the *on* resistance to be sufficiently low so that the power dissipation is not too high.

When Q1 is off and the supply is on, the NiCd battery charges via D1 and R1. The value of R1 is chosen to replace the charge used up during the periods when the timeswitch cuts off the supply. The average charging current is not as obvious as you might expect. Fig. 3 shows the charging current waveform. A close approximation to the average current, ignoring the short periods of time when the charging current is not flowing, is:

$$I_{AV} = \frac{2V_{peak}}{R\pi}$$

Substituting real figures: peak voltage=34V, battery voltage=6V, so the charging current is approximately 6.5mA. The circuit draws between 2mA and 3mA, so the current actually charging the battery is approximately 4mA. Taking account of the fact that the battery discharges when the thermostat output is on, the resistor value chosen should replace the charge used if the timeswitch is on for almost 50% of the time. The battery will neither run flat nor seriously overcharge under these conditions. If the timeswitch is to be on for a much greater or lesser percentage of the time, then the resistor value should be changed appropriately.

It is still not impossible that the battery may run low at some stage, perhaps when the timeswitch settings have been altered, or when the battery has been in use for five years and has lost some of its capacity. The control circuit does not act rationally when it has too little supply voltage and could switch Q1 half on if the supply fell to say 3.5V. This would cause high dissipation in Q1 and incinerate it smartly!

To avoid this possibility, IC1 is included. This compares the battery voltage with an internal reference voltage and switches off the load via Q2 if the battery voltage falls below 5.5V and switches it back on when the voltage exceeds 6.3V. This hysteresis (added by R5) prevents the extra voltage developed across the battery when it starts to charge from switching the circuit back on immediately before a useful amount of charge has been built up.

Tolerance of the reference voltage on the ICL7665 may alter the voltages given above enough, in a few cases, to necessitate changing the values of R4 or R6 to compensate. Only testing can show whether this is necessary or not.

Power to the rest of the unit is switched by Q2. Strictly speaking, one of the control outputs of IC1 could supply the load current of the circuit but the use of a separate MOSFET gives lower voltage drop. The current consumption of IC1 itself is very low, so it will not run the battery down significantly faster by its presence.

The temperature control part of the circuit uses an LM10 op-amp/voltage reference. The output of the voltage reference is set to 3.2V to provide a suitable voltage range to compare with the output

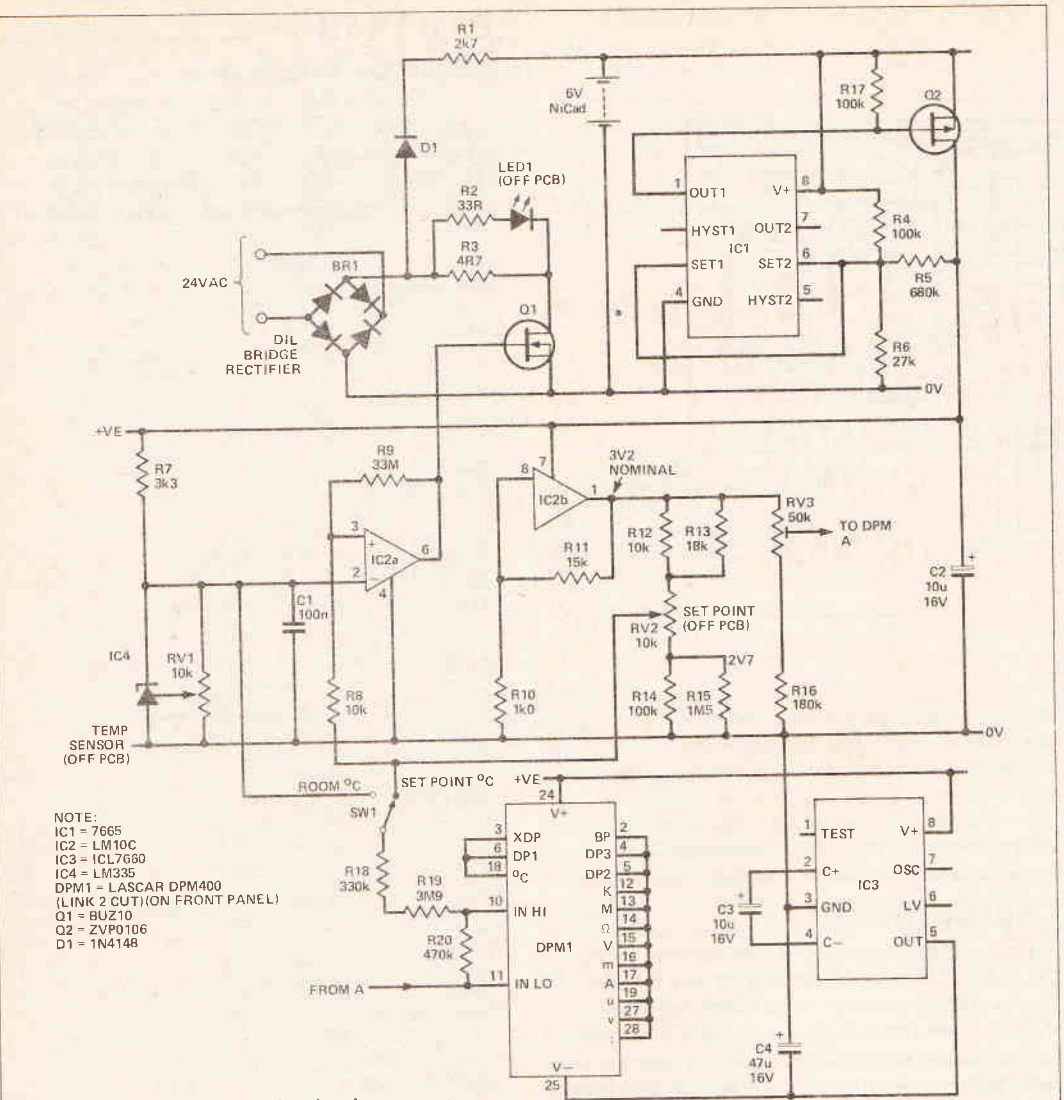


Fig. 2 The circuit diagram for the thermostat

from the temperature sensor, IC4. The output from IC4 is nominally 10mV/K. It won't work down to anywhere near 0K of course but the graph of output against temperature would pass very close to 0K if extrapolated. The sensor can have an error of ±6°C at room temperature but this is a slope error rather than an offset error, so a single adjustment will make the sensor reasonably accurate over its operating range.

The op-amp portion of IC2 is used as a comparator, comparing the voltage from the temperature sensor with the voltage set on the setting potentiometer. Enough hysteresis to ensure clean switching is provided by R9 and R8. The hysteresis amounts to about ½°C. The output of the op-amp switches Q1.

The digital panel meter needs a negative power supply as well as the positive one to work correctly in this configuration. This is provided by the ICL7660 voltage converter IC. This is specified to be approximately 98% efficient so little power is wasted.

The digital panel meter specified has a sensitivity of 200mV full scale (199.9 to be exact), which would give 1mV/°C at a resolution of 0.21°C, so the 10mV/K must be offset and potted down by 10:1 to give readings of degrees Celsius. The potting down is carried out by R18, R19, and R20, while the offset voltage is provided by RV3.

In order to read °C rather than °K, a voltage equal to the sensor output at 0°C (about 273°K) is fed to the negative input. If the temperature sensor is correctly adjusted to provide 10mV/K at any reasonable temperature, it will do so to a good approximation throughout its range and will therefore match with the nominal 0°C setting. To make the DPM read correctly, its fine adjustment pot is used to correct the reading without disturbing the correct 0°C calibration.

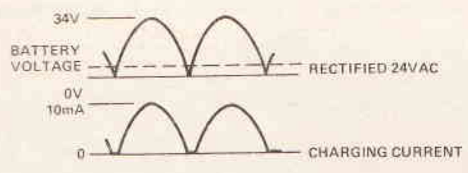


Fig. 3 The charging current for the NiCd

are all available from Electromail as well as other suppliers. The board-mounted potentiometers are multi-turn type to ease the calibration process. If you are a non-smoking, teetotal neurosurgeon you might have the steadiness of hand needed to adjust a single turn preset but otherwise use the more expensive multiturn types.

The power MOSFET Q1 is not critical. any n-channel TO220 device with an on resistance of less than 0.5R and a gate voltage of +6V will do the job. The prototype unit just happened to use an IRF630, the breadboard version used a BUZ10. Use whatever is easily available and if there is any doubt, test to make sure it doesn't get too hot in operation.

The choice of Q2 is more constrained because it seems that only Ferranti makes p-channel MOSFETS of the right type. Any of the ZVP range of MOSFETS in an E-line package will be suitable.

If it is too difficult to find a suitable MOSFET then the unit can be made to work in most cases by omitting R17 and connecting IC1 pin 2 to where the drain of Q2 would go. There could be a degradation of

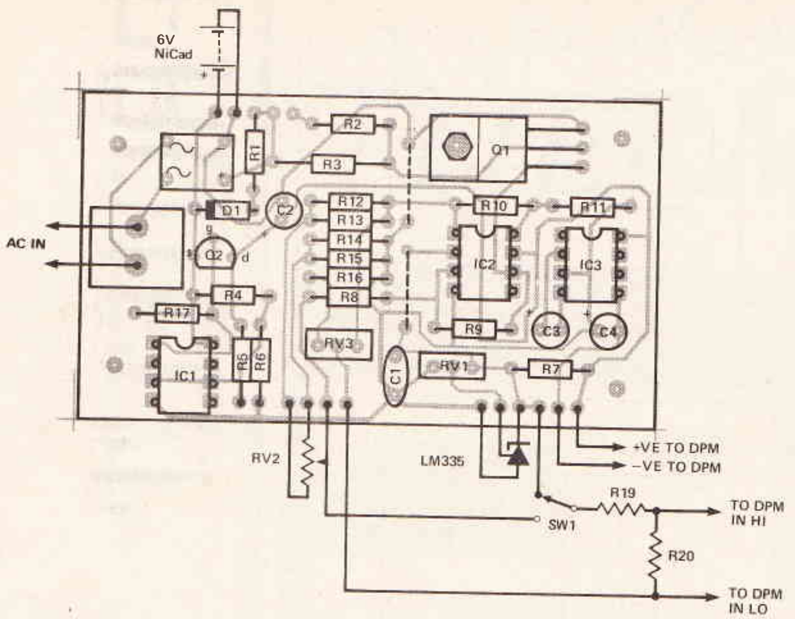


Fig. 4 The component overlay

accuracy when the battery is partially discharged in some cases, this depends on how much better than its minimum specification the hysteresis output of IC1 is.

The 6V NiCd battery is made from five button cells connected together. Electromail can supply suitable cells if they are not available elsewhere.

Construction

This project is designed to fit a standard plastic case, the BOC420 from West Hyde. This case includes M3 threaded brass inserts set closer together one end than the other. The mounting holes on the PCB are spaced to fit this arrangement. The case is *just* big enough to hold all the works, including the rechargable battery and it is small enough not to look out of place fixed to the wall in place of a mechanical thermostat. It is strongly advisable to use the printed circuit board because it would be difficult to fit a veroboard construction into a case which would look right on the wall.

PARTS LIST

RESISTORS (all ¼W 5% unless specified)

R1	2k7
R2	33R
R3	4R7 2.5W
R4, 14, 17	100k
R5	680k
R6	27k
R7	3k3
R8, 12	10k
R9	33M
R10	1k0
R11	15k 1%
R13	22k
R15	1M5
R16	180k
R18	330k
R19	3M9
R20	470k
RV1	10k multi-turn presets
RV2	10k subminiature panel mounting pot.
RV3	50k multi-turn presets

CAPACITORS

C1	100n polyester 0.2in pin spacing
C2, 3	10µ 16V radial electrolytic
C4	47µ 16V radial electrolytic

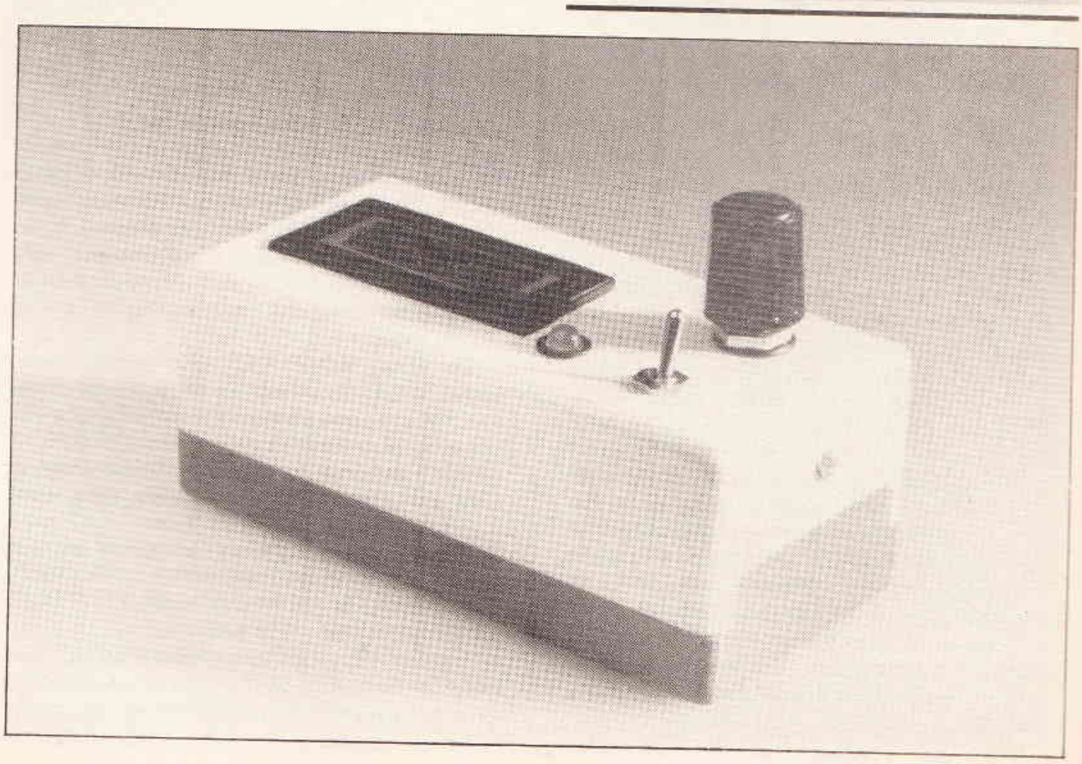
SEMICONDUCTORS

IC1	7665
IC2	LM10C
IC3	ICL7660
IC4	LM335
Q1	BUZ10 or similar
Q2	ZVP0106 or similar
BR1	DIL bridge rectifier
LED 1	Red LED
D1	IN4148

MISCELLANEOUS

B1	6V NiCd battery
DPM1	Lascar DPM400 digital panel meter module
SW1	Subminiature changeover switch

PCB. Case. Connecting wire. Nuts and bolts.



Assembly of the PCB is straightforward. Refer to the component overlay (Fig. 4). The power MOSFET is slightly vulnerable to static and should be fitted second to last. You should touch an earthed metal object before handling the MOSFET and solder it with an earthed soldering iron. It is also best to bolt the MOSFET down before soldering its pins. This avoids the risk of straining the soldered joint when the bolt is tightened.

The last item to be fitted should be the small power MOSFET. This is much more vulnerable to static because its gate capacitance is much lower than the TO220 mosfet. The pin connections of the Ferranti E-line MOSFETs are shown in Fig. 5.

When the PCB is built, parts of it can be tested. An adjustable bench power supply and a DVM are required for the testing. Connect the variable power supply to the battery connections of the PCB and adjust to check the voltages at which IC1 switches the power to the rest of the circuit on and off. A convenient point to check the voltage to the main part of the circuit is probably on IC3 pin 8 (relative to the 'battery' negative terminal). If the switching voltages are not approximately 5.5V and 6.3V for switch off and switch on respectively, then reduce R4 to lower the voltages or increase it to raise them.

Check also that the voltage converter is producing a negative supply. The voltage on IC3 pin 5 should be within 0.5V of the positive supply voltage but opposite in sign. If it is not, then check that C3 and C4 are the correct way round. This is all that can be done to test the PCB at present.

Front Panel

Holes must be drilled in the front part of the case to mount the panel mounting potentiometer, the switch, the LED, and the DPM (digital panel meter). This last is the most tedious job and will almost certainly involve a lot of filing. A hole must also be drilled in one end of the case to allow the temperature sensor to protrude.

Before the DPM is fitted to the front panel, the pins shown linked on the circuit diagram should be linked on the back of the meter, using thin tinned copper wire. R19 and R20 should also be mounted on the back of the meter. Link 2 on the back of the DPM (near the input pins) should also be cut to allow for the proper differential measurement mode.

Finally, connecting wires should be attached. Light gauge wire should be used to avoid straining the pins of the module, which are delicate.

The temperature sensor and the items on the front panel should now be wired up, as neatly as possible. The NiCd cells should be wired together to form a 6V battery. The cells should first be wired together with thin insulated wire and then be taped together so that they are safely insulated and formed into a flat battery pack which will wedge between the PCB and the components on the front panel.

Great care should be taken to ensure that the edges of the cells do not touch. The battery should be tested for fit, charged at 10mA for at least two hours and then connected to the PCB, with attention to correct polarity.

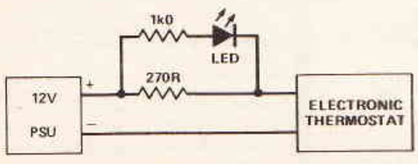


Fig. 6 A suitable testing circuit

The complete unit is now ready for test and calibration. Connect a test circuit as shown in Fig. 6. The use of this circuit should minimise damage if anything is wrong. First observe that the digital display operates, even if the readings are not accurate. Then switch on the power and check that the LED switches on and off as the temperature setting pot is adjusted either side of the measured temperature. If all is well then proceed to calibration.

Calibration

An accurate thermometer and a DVM are required for calibration. The power supply should be left switched on and the set pot should be at minimum temperature, so that the battery will be charged and will not run down while calibration is in progress.

First of all set RV3 to provide 2.73V on its slider, measured relative to 0V. Then set SW1 to read set-point and turn the pot to maximum temperature. Measure the voltage on the common pin of SW1 relative to the slider of RV3 and set the preset meter scale adjustment (a tiny preset accessible through a hole in the PCB of the module) to read the same number as the number of millivolts on SW1. For example, if the voltage on SW1 is 200mV, then the DPM should display 20.0. A very fine screwdriver should be used for this adjustment. Now return RV2 to the minimum temperature setting.

IC4 should be placed out of a draught and the thermometer should be put next to it. After a settling period of at least two minutes, the thermometer should be read and RV1 adjusted to produce the same reading on the DPM. The unit is now calibrated. It should be connected in place of the mechanical thermostat and used to control the central heating.

If the unit is connected to the 24V AC supply without the battery connected, the voltage on the circuit may exceed that which would be required to damage the ICs. A 10V zener diode should be added on the back of the board in parallel with the battery connections, with its cathode to the battery positive and its anode to the battery negative. This will protect the circuit if a battery connection breaks or the battery goes open circuit after ten years faultless operation.

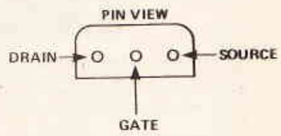
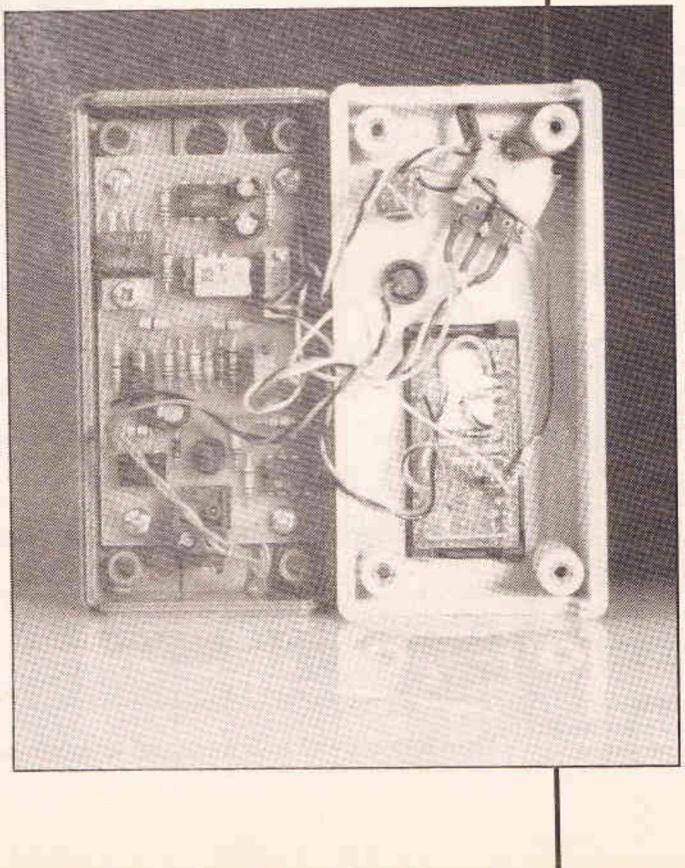


Fig. 5 The pin out of the Ferranti E-line MOSFETS



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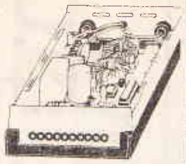

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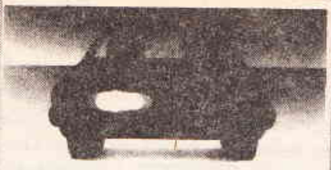

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FEATURED IN ETI JULY 1987

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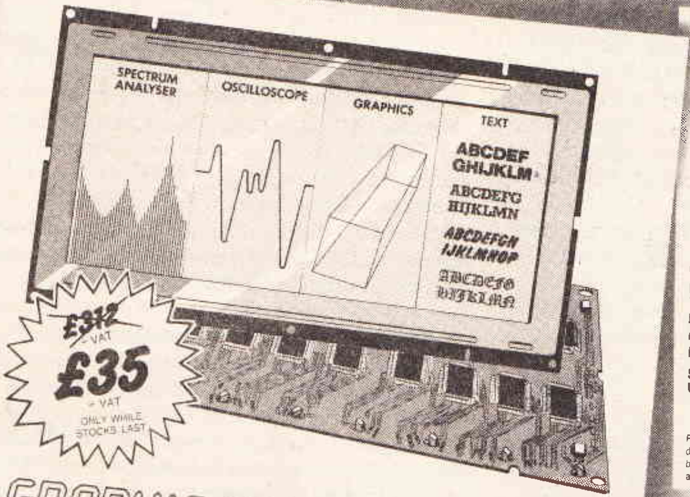

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To use the display, you will need to be fairly self-sufficient in logic design – you must know how to organise a frequency divider and serial data transfer. Apart from these basics, the data supplied with the module will tell all you need to know to get it up and running.

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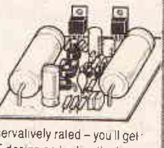

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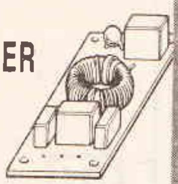

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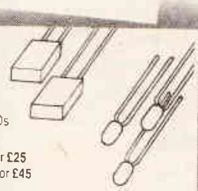

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AUGUST 1987

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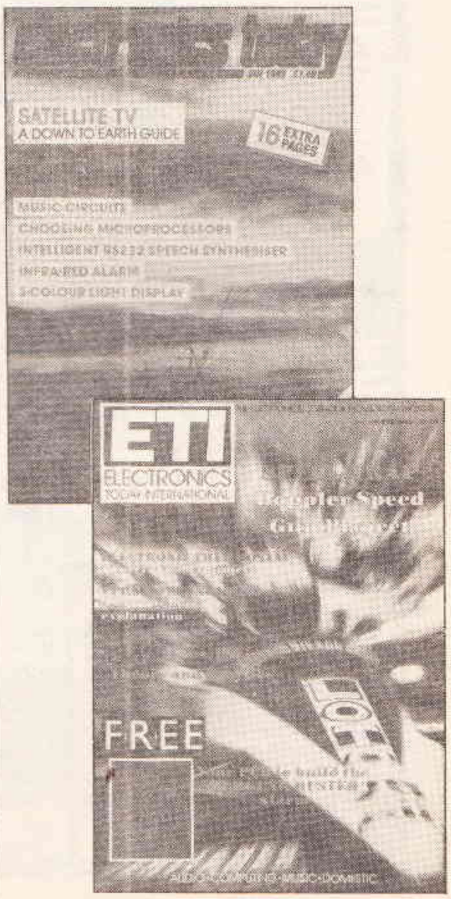

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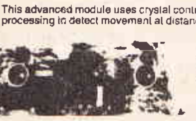

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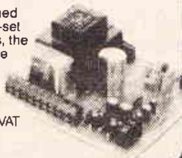

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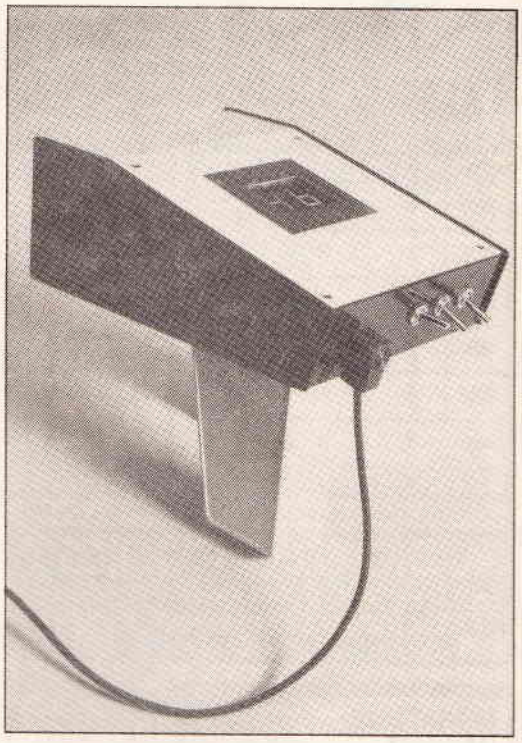
RADAR SPEED GUN

Tony Williams dabbles with Doppler to produce his traffic-tracking speed gun.

This fascinating project allows the user to tell the speed of a moving target up to fifteen metres away by measuring the Doppler effect which occurs when an object moves either towards or away from a sensor.

Designed to be hand held and fully portable, the project resembles a gun with the speed of the target shown on a 2-digit display on top. It will read to 30 or 40mph, even 60mph for a good sized target. Since it is the Doppler effect that is being detected, the target has to be moving either towards or away from the gun in order for a reading to register, not perpendicular to it (Fig. 1). The unit holds in memory the highest speed registered, since a fast moving target will quickly pass through the 15 metre range of the gun.

At this point it might be prudent to advise constructors against jumping in front of a fast moving vehicle and pointing a gunlike object at the driver. This could be very nasty. The unit works just as well on a receding vehicle, and would only give slightly inaccurate results used at a suitably oblique angle to approaching objects.



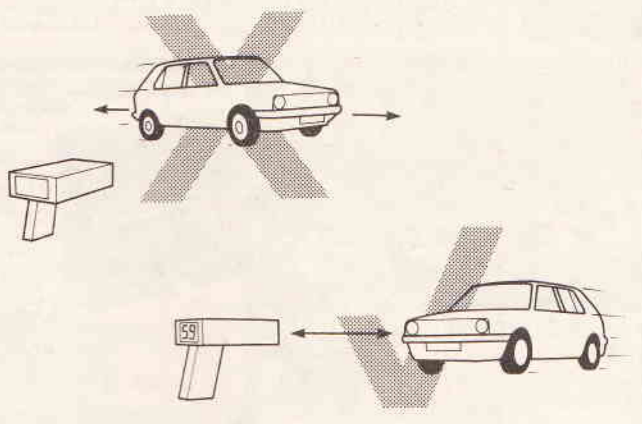


Fig. 1 Use of the radar speed gun

The Doppler Effect

The Doppler effect was first noticed by a Mr Doppler (quite a coincidence) in Austria, who published his theories in 1842. Basically he noted the change in wavelength which is observed as a signal source moves towards or away from its observer. A good example is the sound of an approaching car. As the car passes there is a sudden drop in frequency — a Doppler shift.

In physical terms, the wavelengths from the sound are being compressed as the car comes towards you, and stretched as the car goes away. Since wavelength is inversely proportional to frequency, the frequency will rise as the car approaches and drop as it recedes.

The Doppler effect is only audible because of the relatively low frequencies and long wavelengths we are considering. When the speeds approach that of light, the Doppler effect is less apparent but still present. Shifts in wavelength of light are equivalent to colour change — approaching objects are slightly blue and receding objects are slightly red. This effect was used on an astronomical scale to confirm that all other galaxies are receding from our own — they all exhibit a red shift proportional to their velocity (relative to ours of course).

But enough of the deep theory, otherwise we'll be dangerously close to tripping over that delightful treatise, the theory of relativity — and we really don't want to get into that here.

Circuit Operation

The circuit operates by emitting a low power microwave beam (around 10.7GHz at 10mW) which is reflected by the target back to the gun.

If the object is stationary then the reflected signal will be exactly in phase with the emitted signal and will cancel it out — giving no output.

However, if the target is moving then the slight change in frequency of the reflected signal (due to the Doppler effect) will not quite cancel out the original signal and — through the addition of waves — will give us an output frequency directly proportional to the speed of the target. This signal is fed to an amplifier, squared up and sent to the rest of the circuit.

The idea is that since we have a known frequency for a known speed of target, we could arrange a time interval during which 1mph would give one pulse, 10mph would give ten pulses and so on.

It is possible to calculate that a target doing 1mph will result in an output frequency of about 33Hz. The circuit divides this by eight (giving 1mph=4Hz) and counts the number of pulses that arrive within a quarter of a second. With this arrangement, one pulse is equal to 1mph, as desired.

HOW IT WORKS

The main circuit diagram is shown in Fig. 2. The Doppler unit is connected into circuit through socket SK1.

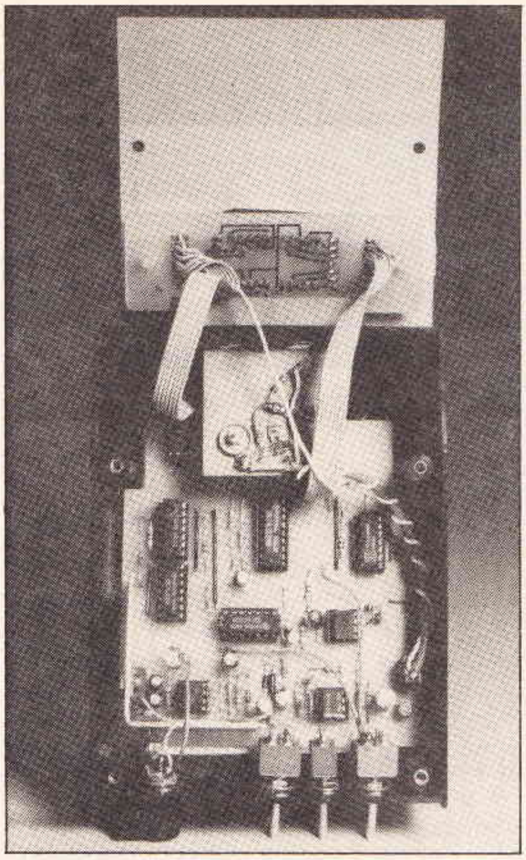
IC1 amplifiers the small current fluctuations through the diode sensor in the Doppler unit into a 9V square wave. This is buffered by Q3 and turned into a TTL compatible signal suitable for feeding into IC4 — a 4-bit binary counter configured as a divide by eight.

This (the 4Hz/mph signal) is fed into the clock input of another 4-bit binary counter (IC10a) which is configured as a BCD counter using an AND gate. Each time the count reaches 10, the AND gate resets the counter (via D5) and increments the next counter (IC6a) to give a two digit BCD counter (only the least significant digit is actually BCD).

As the counter increases, its output is compared with the value on the other pair of counters (IC10b and IC6b) by IC11. These counters hold the highest speed measured since the last system reset. If any new count reaches this value then the A>B output of IC11 (inverted by Q4) allows subsequent clock pulses to clock both sets of counters to the new maximum value.

Finally, counters IC10a and IC6a are both reset by a pulse from IC3, the CMOS 555 (this chip is CMOS because its push-pull output stage is ideally suited to driving the diode OR gate made up by D4 and D5.)

The two display decoder/drivers (ICs 7 and 8) show the value stored in the second counter and are of the type which go blank when a number greater than 9 is at the input. Consequently, if the second counter contains a 'tens' digit greater than 9, then the tens display will blank (remember that the upper display digit is not configured as a BCD counter). Therefore the display has a range of 00 to 99mph. Anything over 99mph will display with a blank 'tens' digit.



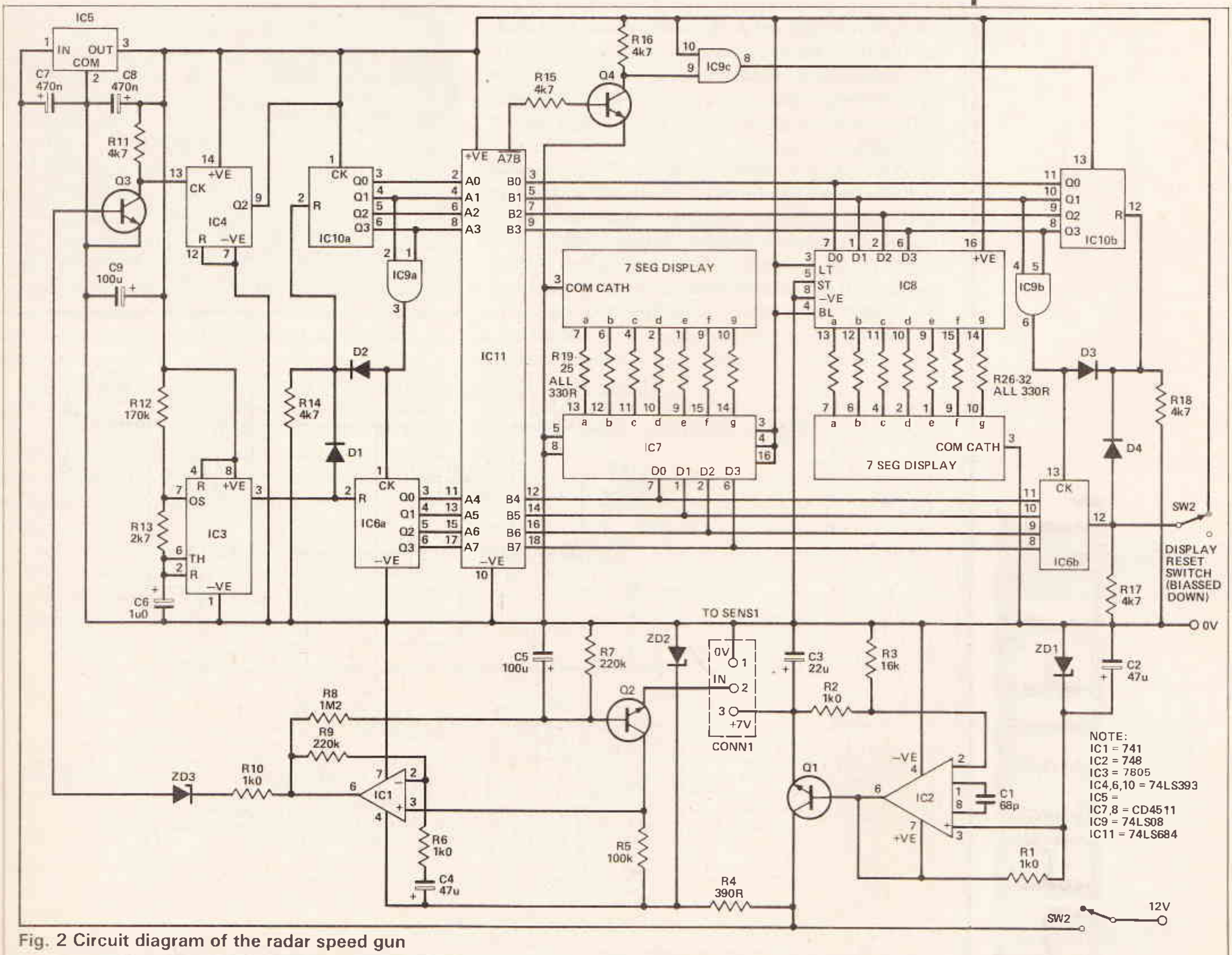
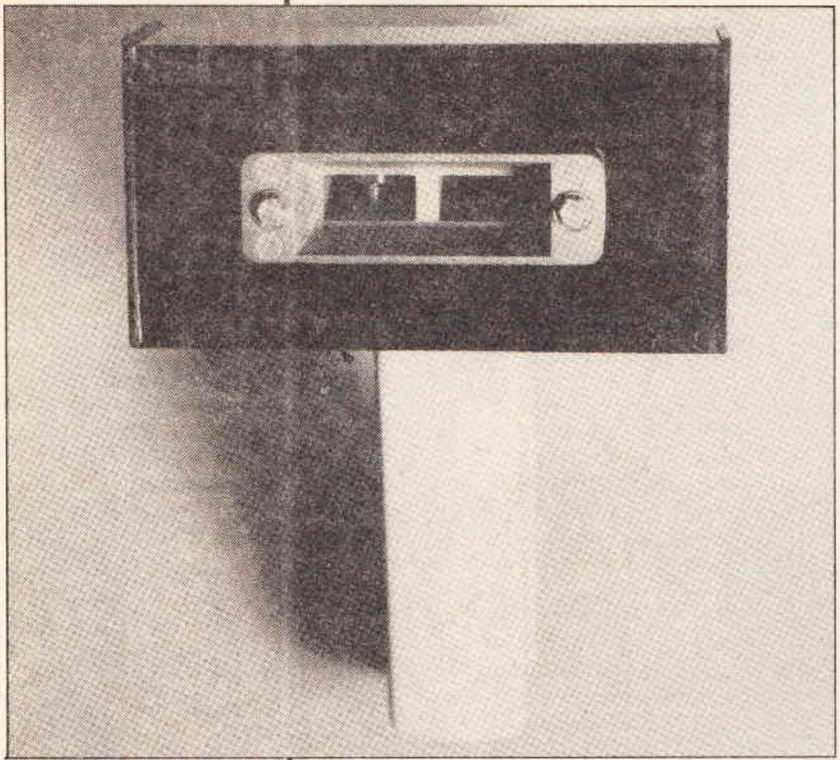


Fig. 2 Circuit diagram of the radar speed gun



If you look at the block diagram of the Radar Gun (Fig. 3), you can see that this signal (4Hz = 1mph) is fed to the input of a counter which is continually reset every 1/4s. At the end of each interval, the value at the counter's output is equal to the speed of the target in miles per hour. However, it is not there for long since the counter is then reset and begins to count again.

The value of this counter is compared with a second counter and if the value of the first is greater then the second counter is fed clock pulses via the AND gate.

This way, the reading is transferred to the second counter — and to the displays. This process continues indefinitely such that the unit always displays the highest value the first counter has ever reached. This memory can be cleared by resetting the second counter and allowing the highest subsequent reading to be loaded back into it by the first counter.

PARTS LIST

RESISTORS (all ¼W 5%)	
R1,2,6,10	1k0
R3	16k
R4	390R
R5	100k
R7,9	220k
R8	1M2
R11,14-18	4k7
R12	170k
R13	2k7
R19-32	330R
R33,34	1M0

CAPACITORS	
C1	68p disc ceramic
C2, 9	47µ radial mini electrolytic
C3	22µ radial mini electrolytic
C5	100µ radial mini electrolytic
C6	1µ0 radial mini electrolytic
C7, 8	470n radial mini electrolytic

SEMICONDUCTORS	
IC1	741
IC2	748
IC3	555 CMOS
IC4, 6, 10	74LS393
IC5	7805
IC7, 8	CD4511
IC9	74LS08
IC11	74LS684
Q1	BD135
Q2, 3, 4	BC109C
ZD1	6V8 zener diode
ZD2	8V2 zener diode
ZD3	5V6 zener diode
D1,2,3,4	1N4148

MISCELLANEOUS	
CONN1	3-way PCB connector
DISP1, 2	common cathode 7-segment LED display
SENS1	8960 Doppler unit
SW1	SPST biased toggle switch
SW2	SPST toggle switch

PCB. Cases. 3-way MNTG speedblock socket. Heatsink. Red filter. TO126 isolation kit. Cable. Nuts and bolts.

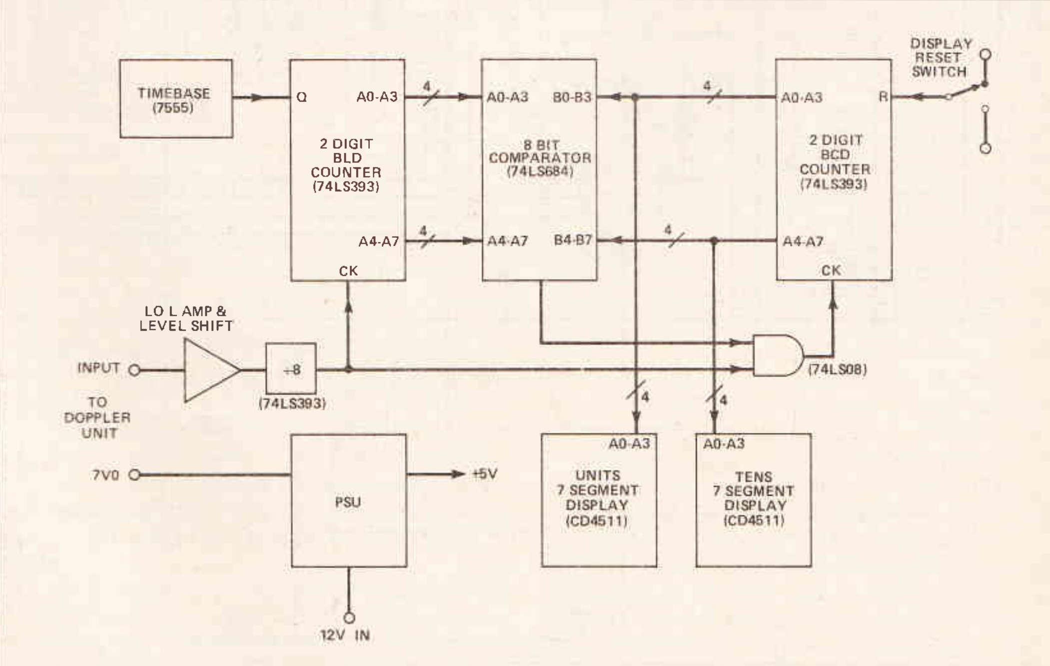


Fig. 3 Block diagram of the speed gun

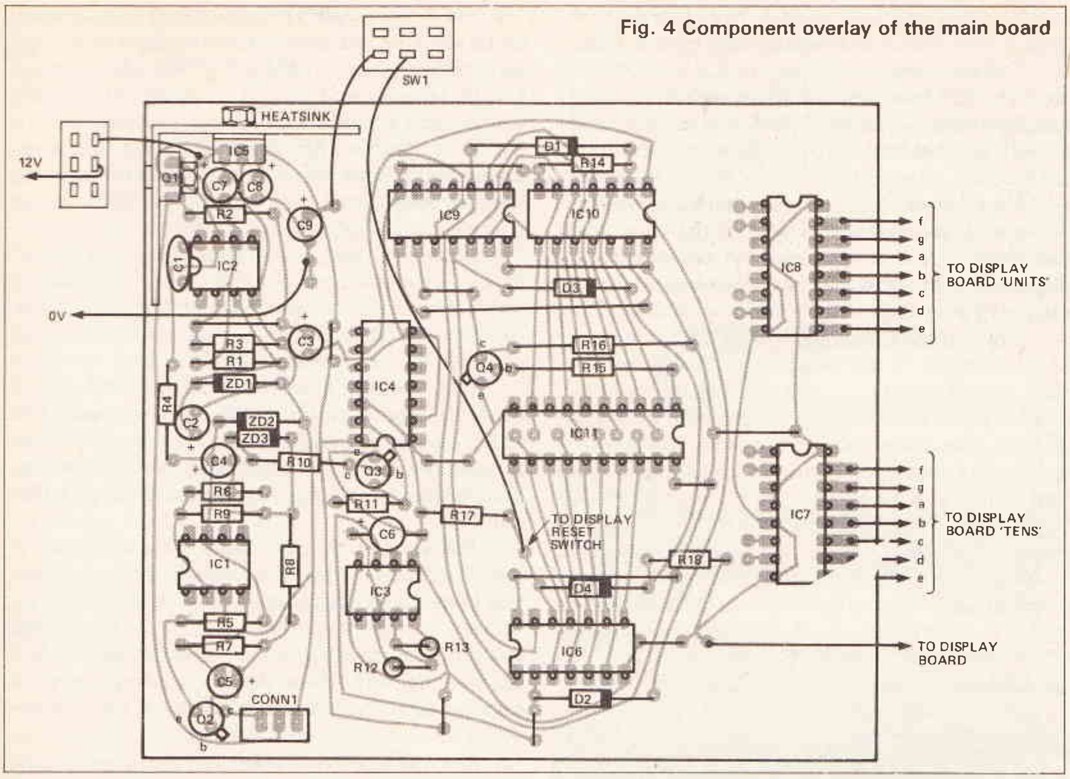


Fig. 4 Component overlay of the main board

PROJECT

Construction

The whole circuit could be built on stripboard (one of the prototypes was) but the PCBs do away with many problems that arise when trying to build a complex circuit on stripboard.

Before anything else, ensure that the Doppler unit is not going to be affected by static electricity! You could keep it in a box filled with conductive foam while constructing the rest of the project, or do what I did and solder two 1M0 resistors between ground and the +7V and output terminals on the Doppler unit. Having done this put it on a high shelf somewhere out of the way. At £40 per unit, I would hate to wake up one morning and find the dog chewing away at the wires.

Now we can get to grips with the actual construction of the project. The component overlay of the main board is shown in Fig. 4. Start with the power supply and amplifier, working down the board.

The base legs of Q2 and Q3 have to be bent over to the opposite side before they can be put into the holes on the PCB. Don't mount Q1 or IC5 on their heatsink just yet since it makes holding the circuit board awkward. Put in the IC sockets, resistors, diodes and capacitors in roughly that order and don't forget the 13 wire links.

With all the components on (not the ICs yet), you can begin to assemble the display board (Fig. 5). It is quite easy to put the displays in the wrong way around so check with the diagram before soldering them in.

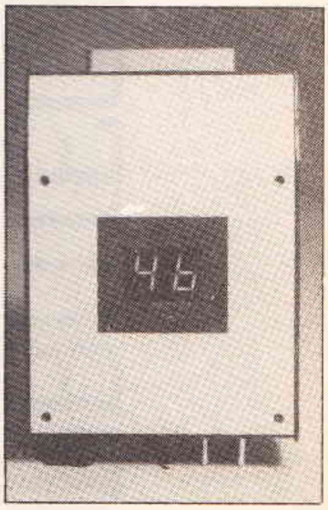
Now we come to the laborious job of soldering the fifteen wires, about six inches long, between the two boards. If you can stand the monotony, use ribbon cable — it will look less like a bird's nest!

Its a good idea to bolt the heatsink to IC5 and Q1 now, using a little heatsink compound between the two surfaces. The heatsink must be isolated from Q1 using a thin mica washer and a plastic grommet.

The power supply and amplifier sections should be tested very carefully — if these circuits aren't working properly, they could destroy the Doppler unit! Insert only IC1 and IC2 (not the Doppler unit yet!) and apply 12V to the circuit. Use a multimeter to measure the voltage between the middle and right pins of CONN1 (as shown in Fig. 4). You should get 7V. If you get more than 7.2V or less than 6.8V then the components around IC2 should be checked for orientation and so on. If you get close to 7V then it is probably due to a poor tolerance zener diode used for ZD1. Try another.

Check that IC5 is producing a stable 5V on pin 3, and that this is reaching the power pins of the other ICs.

Then it is time to check the amplifier. To do this use a multimeter — preferably digital — set to measure up to 200μA across the two outside connectors of SK1. You should read about 60μA initially, but it should start to drop and eventually stop at around 35μA (±5μA). If this isn't the case, check the components around IC1 — particularly the legs



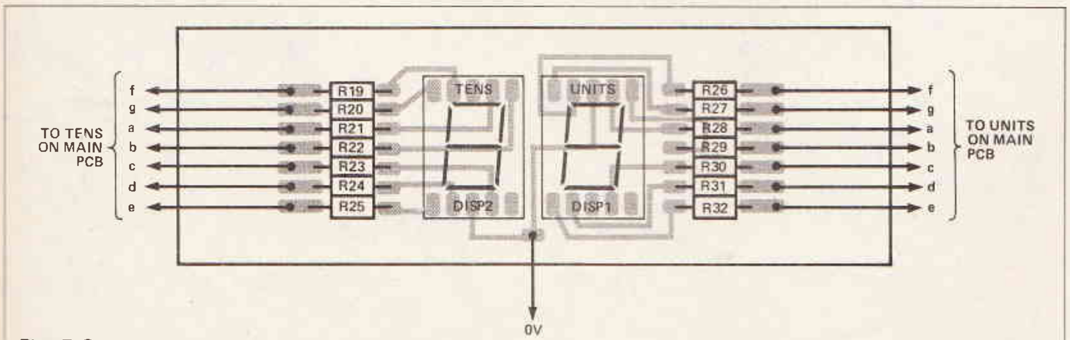


Fig. 5 Component overlay of the display board

of Q2 and the orientation of C5. Note that a current greater than 10mA will destroy the Doppler unit.

If all the checks above seem OK, check the time base. Put IC3 into its socket and check that you get roughly 4Hz signal on pin 3. To do this use an oscilloscope if you have one or an LED and resistor if you don't.

Next connect the eight wires that go underneath the board following Fig. 6. These are the wires which take the digital numbers from the counters to the display drivers — so if at a later stage you find that the display lights up incorrectly, you'll know where to look!

Now we come to that gut-wrenching moment — the connection of the Doppler unit (large tension-filled organ chord . . .). Ensure that the only ICs present are IC1,2 and 5. Connect a short length (six inches) of screened cable to the output and ground terminals of the Doppler unit and a piece of solid core wire to the 7V terminal. The core of the screened wire goes into the speedblock socket to connect with the pin of CONN1 nearest Q2 (left on Fig. 3), the solid core wire goes to the centre hole and the screen goes into the hole for the pin furthest from Q2 (right on Fig. 3). For goodness sake, get it right first time since you only have one chance! Before connecting the speedblock connector to CONN1, you may wish to repeat the earlier tests (I know I did!)

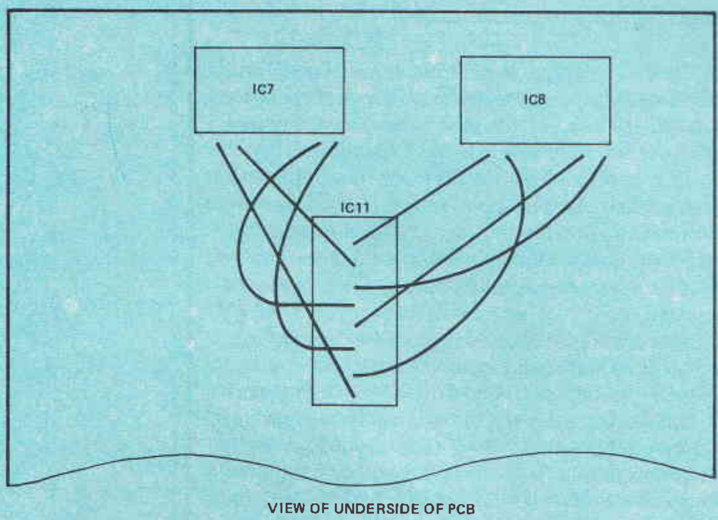


Fig. 6 Wire connections on the underside of the main PCB

Then with CONN1 connected to the Doppler unit and with 12V connected to the circuit, use either an oscilloscope or an LED with 330R resistor across pin 14 (anode) and pin 13 (cathode) of IC4. By waving your hand forwards and backwards in front of the device, the LED should flash at a rate proportional to the speed of your hand (it takes about thirty seconds for the bias current to fall to 35µA during which time the light will not flash!).

If it doesn't flash or just stays lit then don't burst into tears just yet. It could be that the zener diode ZD3 is in backwards or there is some other fault on the circuit board. Power down and check! If there is still no result then repeat the above checks.

If they are OK then try connecting the anode of the LED to pin 6 of IC1 and the cathode (via 330R resistor) to ground and power up the circuit. Wait for 30 seconds. The LED should flash this time and if so then the problem is something to do with Q3, D3, R10 and R11.

Power down the circuit and put in all the rest of the ICs and the display reset switch. Make sure that you follow the component overlay for the positioning of the ICs since they don't all point the same way! Power up the circuit and the display should show a random number. Clear this by pressing the reset button and wait 30 seconds while the bias current drops.

Waving your hand in front of the sensor should cause the display to go to 1 or 2, perhaps even 5 or 6. Taking a run at the sensor should result in even higher numbers but take care in confined workshops!

If you find that the display keeps flicking to high values when everything around you is apparently still, this is caused by instability in the amplifier and can be filtered out by putting a 270p capacitor in parallel with R9 — soldered across the back of it. This only happens when the gun is used in confined spaces and shouldn't happen at all if the gun is used outside.

Case Construction

Now we come to the part I always enjoy the most — choosing a case. As was described earlier, the prototype was built to look like a gun. The circuit needs 12V at about 300mA. Whatever way you decide to power the gun, the likelihood is that it will be quite big! I chose to use 10 × 1.2V NiCd (AA) batteries and put them in their own little box, linked to the gun via a lead with

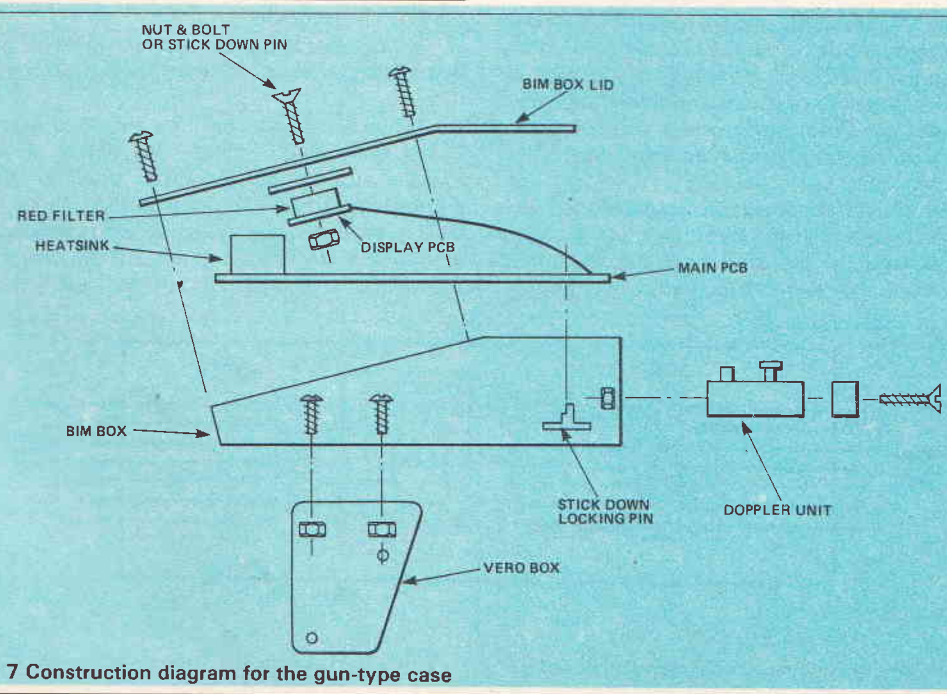


Fig. 7 Construction diagram for the gun-type case

PROJECT

a jack-plug. If you use non-rechargable AA batteries you will only require eight since they are 1.5V each. However, they will only run the gun for about 30 minutes maximum.

With regards to the case, I used two boxes bolted together rather reminiscent of the early Star Trek phasers (Fig. 7). The top box is a sloping box with the larger wall at the front holding the Doppler unit and its antenna. Since I used an external battery box, on the smaller (rear) wall of the gun, I put a battery connector (3.5mm jack-socket), the on/off switch SW2 and the display reset switch SW1. Mounted into the top of the box is the 2-digit display and inside the box is the main printed circuit board (which requires cutting before it will fit — see Fig. 8).

The handle was made from a triangular shaped box although since it contains nothing, a neatly shaped piece of wood or plastic (an old joystick perhaps) could be used. A slightly larger handle could be used to hold the batteries.

Whatever you use, it should be bolted or screwed firmly to the bottom of the top box (we don't want the top to come crashing to the floor, Doppler unit and all, do we?)

Next drill the holes for the deployment of the two switches and power socket into the back wall of the top box, and holes to correspond with however you are fixing the handle. Make sure that the holes for the switches are on the opposite side to the heatsink otherwise they may touch and cause havoc!

As the base of the top box is rather thin, I recommend using a small plate of steel to act as a stiffener, with insulation tape over the plate to prevent it shorting out the main PCB. Cut away the corners of the PCB so that it will fit into the top box, with the heatsink at the rear of the box next to the switches. If you decide to fix the circuit board down with a stick-down pillar, then drill that hole now. The dimensions for the Doppler unit's hole are shown in Fig. 8. The reason for the jagged top is that the various components on top of the unit have to fit through. The unit must be pushed through from the front and the antenna added before it is bolted in with two countersunk 1in bolts with washers.

Before you push the Doppler unit through make sure that the PCB is in place and the ribbons from it to the display PCB are free. Once assembled, the only way to remove the main PCB is to remove the Doppler unit!

The final stage in construction is to cut a hole in the metal lid of the box for the displays, roughly in the middle of the lid and just big enough for the display to fit through. I used clear red perspex as a display filter. Next cut two 4mm holes in the display board about 7mm in from each end and roughly in the middle. Push through each of them a stick down pillar and attach the display to the lid of the box.

With regards to the gun, that's just about it! If you have used an external battery box like I did then it only remains to say *don't get the polarity wrong!!*

Calibration And Use

In practice, the gun shouldn't need calibrating since the values of R12 and R13 have been calculated to give a display reading in miles per hour. However, if you should feel the need to alter this (to metres say) the resistor R12 is the component to alter.

The frequency at pin 1 of IC10 is equal to $8.9 \times V$, where V is in m/s. Consequently R12 should be chosen to that the output of IC3 goes high for 1/8.9s.

To calculate R12 from this we use the standard 555 timer equation:

$$0.7 \times (R12 + R13) \times C6$$

with R13 as 2k7 and C6 as 1M0, we can calculate R12 as 158k for a display showing m/s.

Using the gun is really quite simple. Stand by a roadside (not in the road please), switch it on and wait for the thirty seconds while the Doppler unit bias current settles down. Reset the display and point it at any oncoming cars. Try not to look too menacing, and on no account dress up as a policeman. As the car passes, the display should then show the speed of the car in miles per hour! You could even use it to see how fast you can run, by running close to parallel wall and pointing the gun forwards so that as any irregularities in the wall go past you, the gun will detect their speed.

BUYLINES

The Doppler 8960 module is available from Electromail, PO Box 33, Corby, Northants NN17 9EL. Tel: (0536) 204555.
Other components should be readily available from most sources.
The PCB is available from the ETI PCB service — see the back of this issue for details.
The cases usea in the prototype 'gun' construction were a Bimbox6005 and a small triangular Verobox.

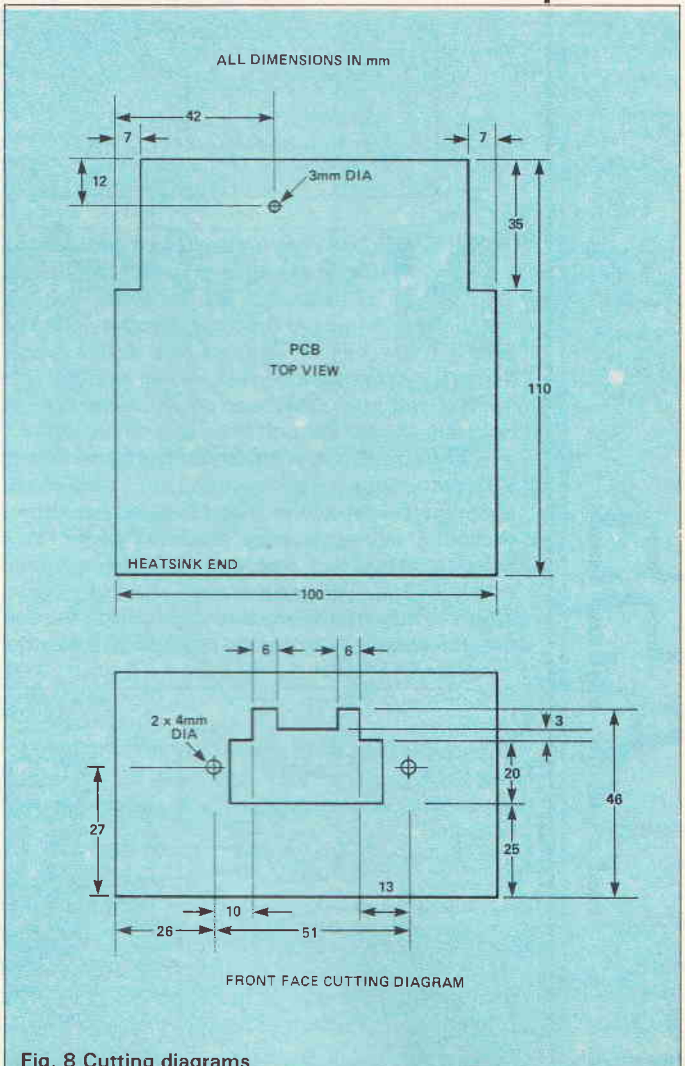


Fig. 8 Cutting diagrams

PROJECT

ETI

THE SMALL FRY MINI-AMP

Not too hi and not too fi — but small, hot and not a lot of money. Keith Brindley presents the cheap and cheerful Small Fry

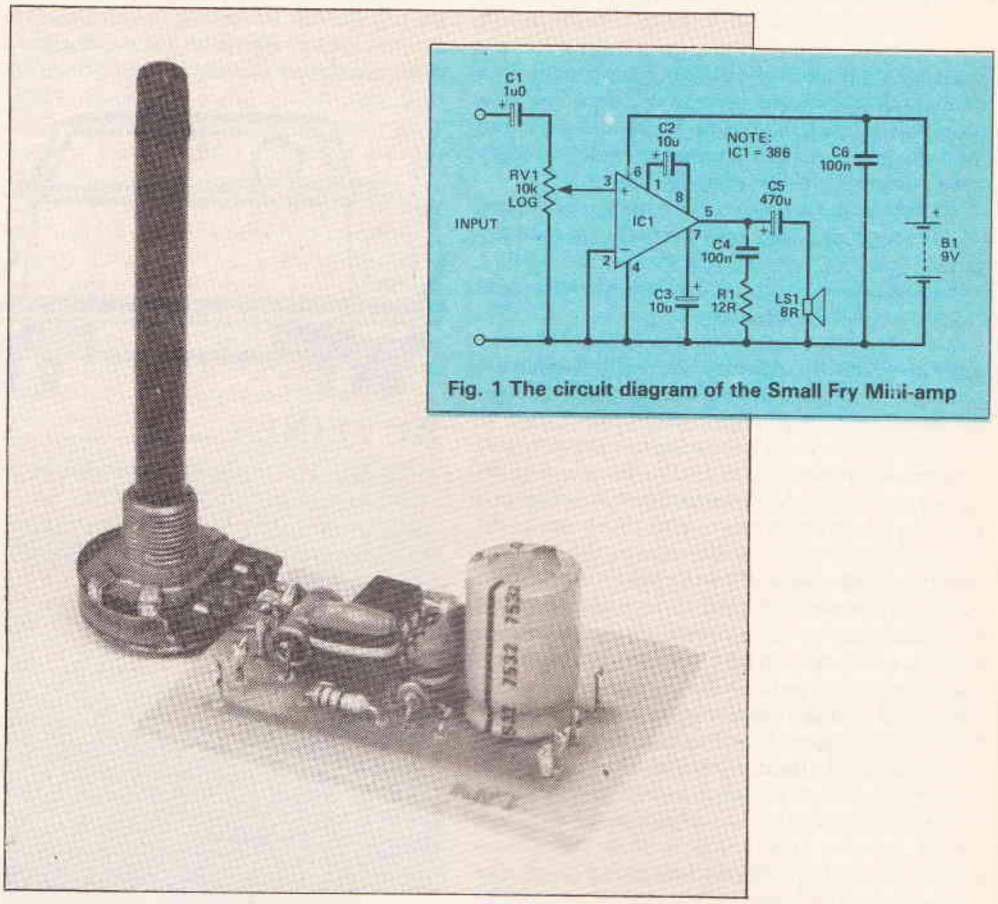


Fig. 1 The circuit diagram of the Small Fry Mini-amp

No, we certainly can't call this project the ultimate in super-powered, high-fidelity amplifiers but we can assure you it is simple-to-build and it really couldn't be cheaper. A single chip design means that as few as eight components give an amplifier with 46dB of gain, from a PP3-sized power source. A single pot controls gain through from zero to maximum.

The output power into an 8R loudspeaker with a 9V power supply is up to around half a watt which, although it won't fill the Albert Hall with eardrum-shattering volume, is more than enough for say a simple guitar practice amplifier, or a personal stereo extension amp. Power op-amps are useful as servo drivers or simple intercoms too. You think of a use and the chances are that this little beauty'll do it for you!

Construction

The circuit of the Mini-amp is given in Fig. 1. As with all our *1st Class* projects you can choose between PCB and stripboard construction. Neither method involves any hazards, the usual precautions and procedures will let you build it safely. The PCB layout, component overlay and wiring diagrams are combined in Fig. 2, while those for stripboard are shown in Fig. 3.

If PCB construction is your choice, the only point to note is to leave insertion of the integrated circuit until last. This way there is less likelihood of damage from a slap-happy soldering iron. Preferably use an IC socket (although this isn't essential) and check the chip is in the right way around. PCB pins for all input, output and power supply connections make life easy

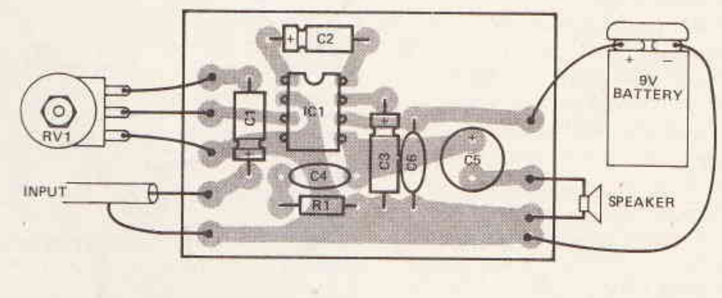


Fig. 2 The component overlay of the PCB version

1st CLASS

but again aren't essential. Watch for electrolytic capacitor polarisation — make sure you get them facing the right way.

Stripboard construction is just as easy. Before components are inserted make all track breaks, shown in the underside view of the stripboard in Fig. 3. Then follow the same rules as for PCB construction.

Screened cable *must* be used for the input connection otherwise the amplifier's high gain will ensure heaps of hum and interference — great if you like Radio One, bad if you're trying to play guitar! Mount the potentiometer as close to the board as possible, or use screened cable for these connections too. You'll see the potentiometer in the prototype amplifier is mounted directly to the PCB pins on the PCB. This is a good idea, as it keeps interference to a minimum and allows a method of fixing the board to the front panel of your choice.

Talking of housing, the vast numbers of possible uses makes suggesting a case fairly pointless. The board (PCB or stripboard) is small enough to allow housing inside the smallest of cases. If you intend

HOW IT WORKS

The circuit for the Small Fry Miniamp (Fig. 1) tells most of the story. Integrated circuit IC1 is a 386 power amplifier which functions effectively as a power operational amplifier with ground referenced input. Pinout details are provided in Fig. 4. The IC can operate from as low a voltage as 4V through to 12V. Its quiescent current drain with a power supply of 9V is only around 4mA. Internal circuit of the chip is shown in Fig. 5.

In the Small Fry the IC is connected in a fairly simple non-inverting amplifier configuration. Gain of the IC is set by the connection between pins 1 and 8. No connection between them sets the gain internally to 26dB (20 times). As shown, with a 10μ capacitor bypassing the inernal 1.35k resistor, the gain is set to its maximum of 46dB (200 times). A variable resistor in series with the capacitor allows gains in between these limits to be selected.

Pin 7 of the integrated circuit allows a supply bypass connection to be made internally, a fact which can greatly improve the circuit's power supply rejection ratio at lower frequencies. Capacitor C4 and resistor R1 form a Zobel network, which prevents instability at high frequencies due to reactance in certain types of load.

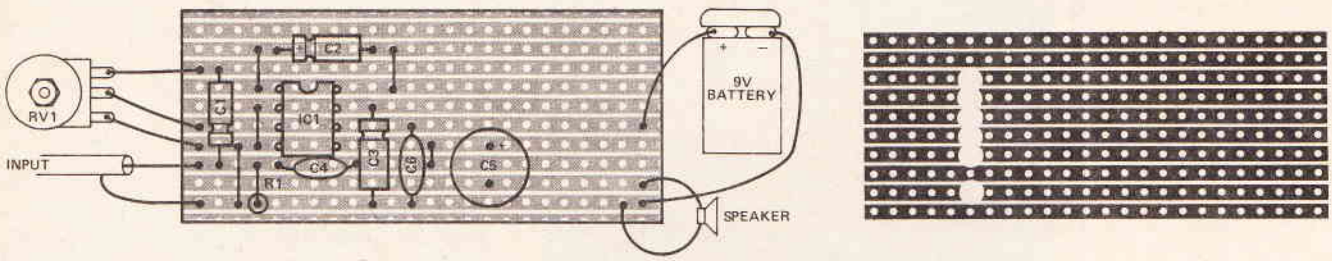


Fig. 3 The component overlay for the stripboard layout and the track cuts required

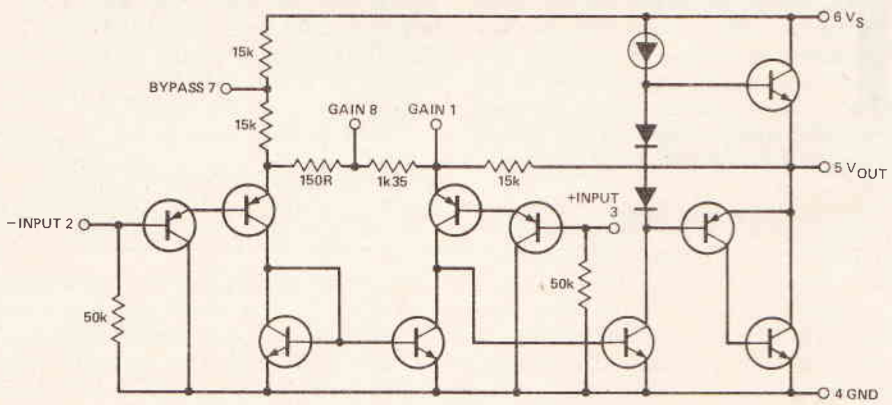


Fig. 5 The internal circuit of the 386

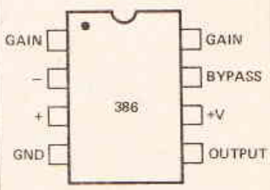


Fig. 4 Pinout details of the 386

PARTS LIST

RESISTORS (¼W 5%)

R1	12R
RV1	10k log potentiometer

CAPACITORS

C1	1μ 10V electrolytic
C2,3	10μ 10V electrolytic
C4,6	100n
C5	470μ 10V electolytic

SEMICONDUCTORS

IC1	386

MISCELLANEOUS

LS1	8R loudspeaker
B1	9V battery and clip

PCB or stripboard. PCB pins. 8-pin DIL socket.

fitting a loudspeaker into the same case, it'll be this that decides case size rather than the board.

Moving onto the loudspeaker, take care in your choice. Tiny and tinny tranny radio speakers will make your project sound similar to a tiny and tinny tranny radio and won't do your valuable time, confidence and pennies much justice either. So use as good a loudspeaker as you feel the need (and expense) for. There is an argument for not using an internal loudspeaker at all and instead using, say, one of your hi-fi system's loudspeakers. ETI

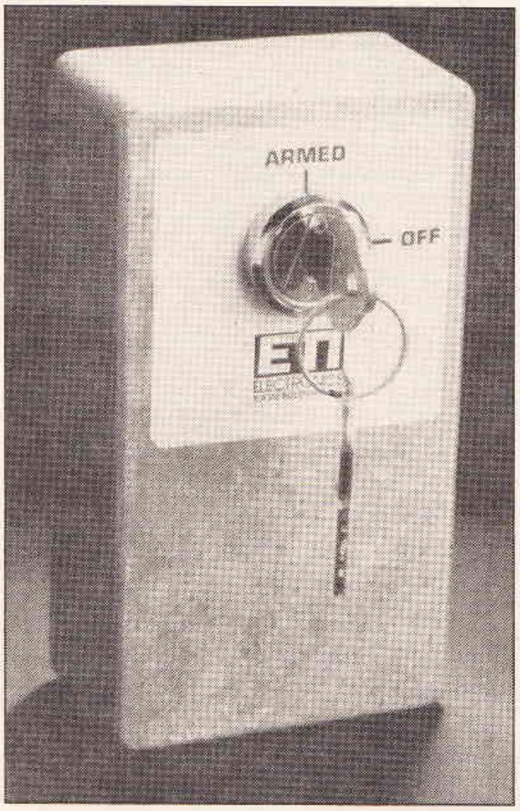
BUYLINES

None of the parts will be difficult to obtain. Apart from the integrated circuit used, the 386, there are no critical values either and any substitute around the stated value will suffice. Most mail order companies stock the 386 as a standard item (for example Maplin part VJ375).

BURGLAR BUSTER

Paul Chappell adds his free components to his free PCB to keep his home burglar-free

PROJECT



Having described the burglar alarm circuit you can build with your free components (see *Buylines* if you missed them), now it's time to get soldering into your free PCB. Figure 1 shows the component overlay for the project and Fig. 2a repeats the circuit from last month. So — what are you waiting for?

Figure 3 shows how to build the completed circuit into a suitable box — a die-cast aluminium box is a good choice — and how to connect up the power supply and relay. The PCB can be held in place with double-sided adhesive pads (most stationery shops will have them) or you can drill a hole in the board and use a nut, bolt and spacer. A single fixing bolt will be quite enough — there's nothing heavy on the board. The relay can lie on its back, glued in place, with the contacts facing upwards. The smoothing capacitor C7 can be fixed with a double-sided adhesive pad or with a capacitor clip.

The transformer shown has a split primary, which is very common, and two secondary windings, also very common. For the rectifiers D4-D7 you can either use individual 1N4000-series devices or an encapsulated bridge rectifier — whatever you've got in your spares box.

The very first switch in the anti-tamper loop is a micro-switch to protect the control box itself. If anybody removes the lid, the switch will open and sound the alarm. This is one of the many ways the alarm protects itself. The anti-tamper loop prevents any interference with the wiring. Cutting the alarm wires will sound the bell, removing the plug or cutting the power cord will activate the alarm — and it still finds time to protect all the doors and windows in your house, to check up on pressure mats and infra-red sensors, and to do all the other things a burglar alarm should. Isn't it a clever old sausage?

Entry And Exit Delay

With so many features, it's hard to imagine what could be added to the basic alarm to fill up the rest of the PCB! But there is one feature you'll find on almost all commercial alarm controllers that the circuit so far doesn't have: entry and exit delay.

With the basic alarm system, the key operated switch to turn the circuit on and off must be outside the house. When you leave, you turn on the alarm from outside. When you return, you turn it back off

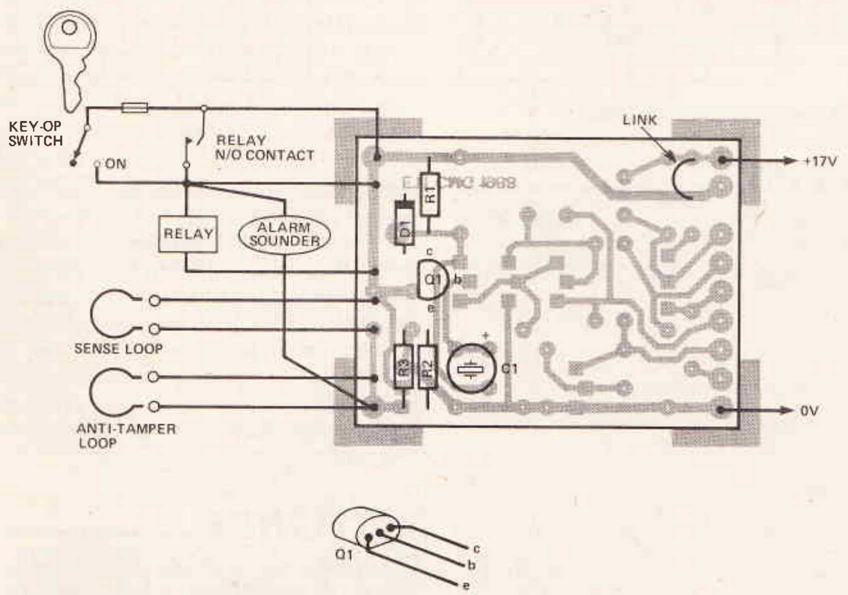


Fig. 1 Component overlay for the free Burglar Buster PCB

again before entering the house. The key-op switch, being outside the protection of the alarm system, is a point where the circuit can be attacked.

With entry and exit delay, the idea is to wire the front door in a separate loop to all the other doors and windows. When you turn on the alarm, the main loop is activated at once but the front door contact remains inactive for, say, thirty seconds. This gives you time to get out of the house and, as long as the door is closed within the delay period, the alarm won't ring. This time there's nothing outside the house to be interfered with so the alarm system is much safer.

When you return home, there's another delay to give you time to get back in but now it's not enough just to shut the front door — a burglar could manage that easily enough! The only thing that will stop the alarm from being activated is if it's turned off with the key within the thirty seconds.

The circuit that does all this for you in the ETI alarm is shown in Fig.4a. When you turn on the alarm power is applied to the board and C4, which will have no voltage across it initially, begins to charge via R6, Q5 and Q4. Transistor Q4 is held on by the charging current and in turn holds on Q3.

If the front door is closed it will prevent C2 from charging. If the front door is open C2 will charge via R1 and Q2 and after about thirty seconds the current in the main loop will no longer hold Q1 in conduction so that the alarm will sound. Closing the front door during this period will discharge C2 via D2 and the loop will derive its current from Q3 and Q4.

In the meantime C4 is still charging. After about forty seconds the current falls below the value needed to maintain Q4's b-e voltage across R5 and at the same time provide current for Q4. At this point the charging continues via R5 but Q4 now relies on Q3 for its base current. Transistor Q3 is quite happy to provide the base current as long as nobody opens the front door! As soon as this happens, Q3 and Q4 both drop out and since Q5 is no longer supplying them with any priming current they won't switch on again even if the door is closed. Now the only way to stop the alarm from ringing after C2's charge period is to use the key. Otherwise the circuit ticks on as remorselessly as a time bomb and there's not a damn thing a burglar can do about it.

The power supply and relay circuit for this version of the alarm is shown in Fig.4b. Diode D1 is now mounted on the PSU board to reduce the number of interconnections between the two PCBs. The timing circuits are reset when the key-op switch removes

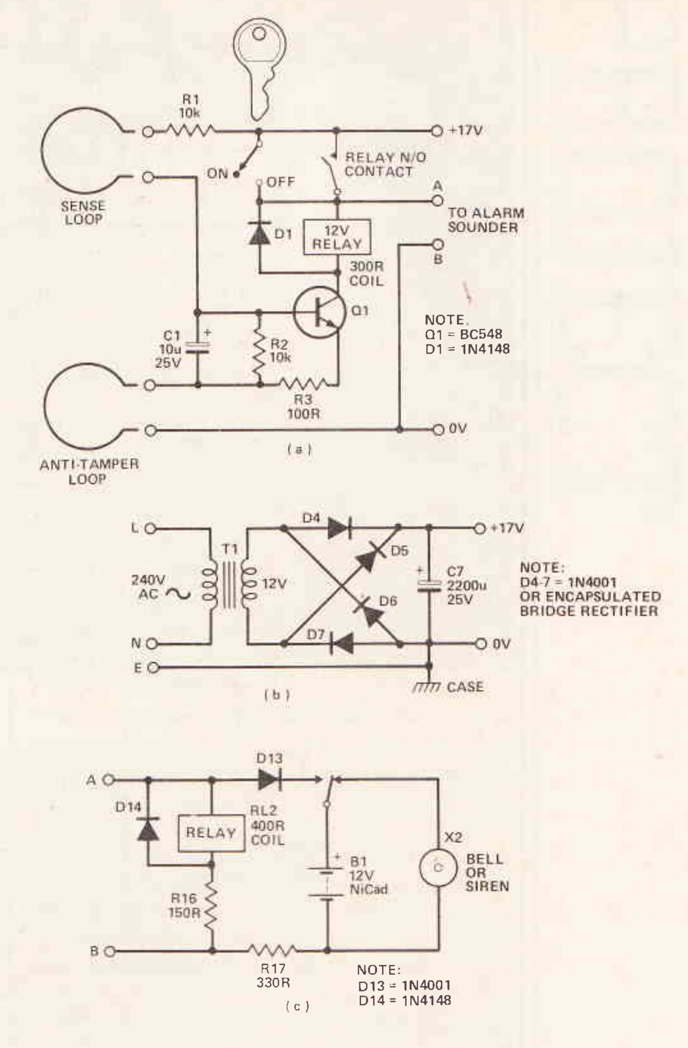


Fig. 2 The circuit diagram of the Burglar Buster (a) The main control box. (b) A suitable power supply (c) A simple alarm sounder

power from the control board. Capacitor C3 discharges through R6 and D3 (in much less than forty seconds since Q5 is no longer in action to multiply up the timing period) and C2 discharges via D2 on the control board and D9 on the PSU board. Components R7 and D10 allow Q1 to work independently of the rest of the circuit — you can change the 'off' position on the switch to a 'standby' function by leaving

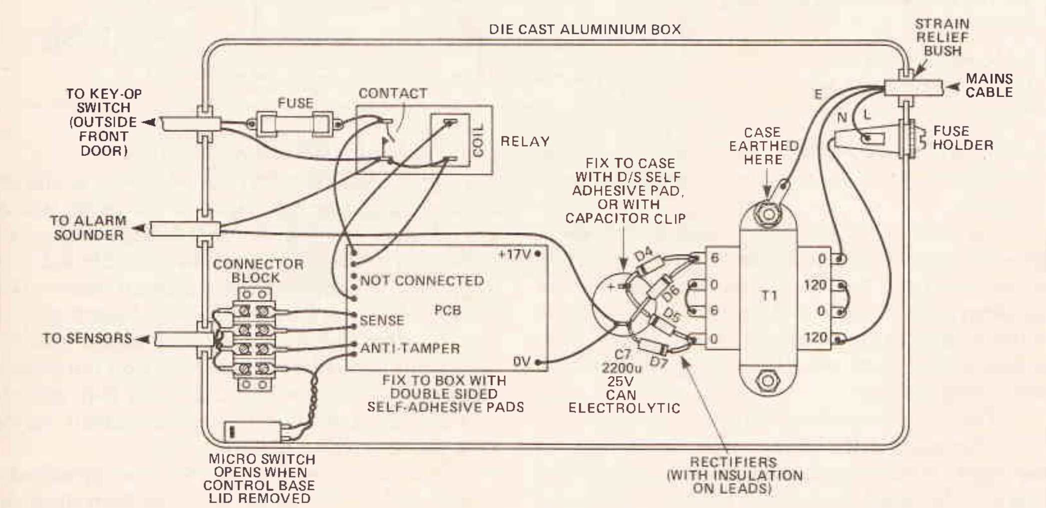
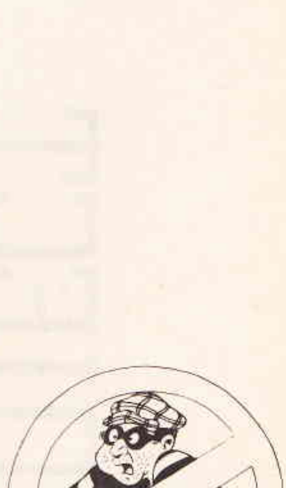


Fig. 3 Installation and off-board wiring



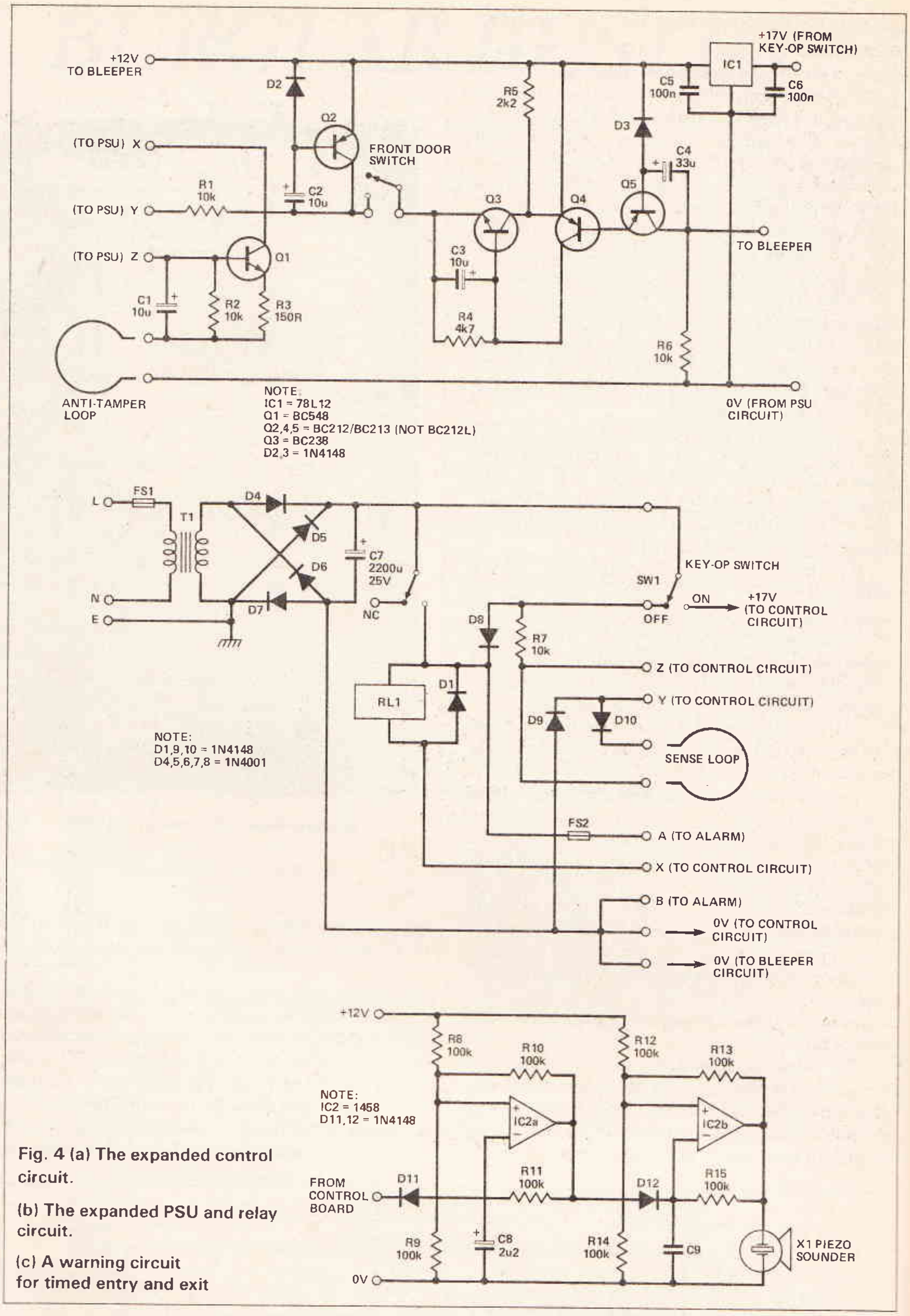


Fig. 4 (a) The expanded control circuit.

(b) The expanded PSU and relay circuit.

(c) A warning circuit for timed entry and exit

PROJECT

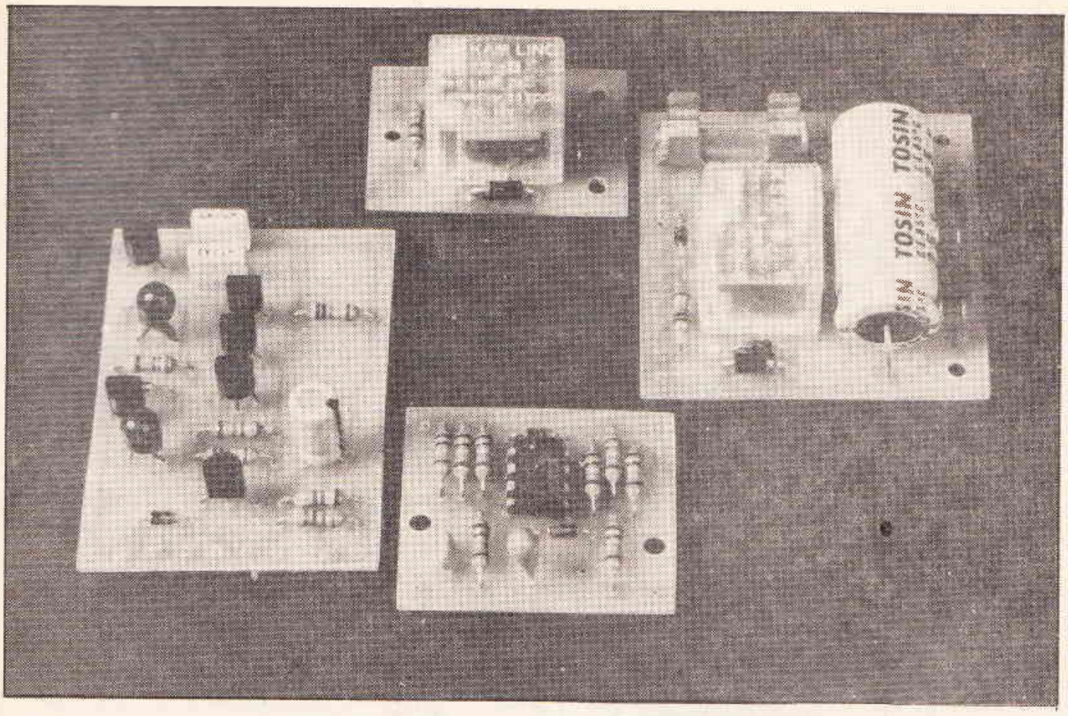
out D8 so that any interference with the anti-tamper loop will still trigger the alarm when the main loop is disabled.

Figure 4c shows a useful addition to the alarm. It's quite unnerving to turn the circuit on and know that at any moment the alarm might sound, without knowing quite when. The bleeper of Fig.4c begins to sound as soon as the alarm is turned on. When it stops sounding, you've got about ten seconds left before the alarm deafens you!

The alarm sounder itself is shown in Fig.2c. This circuit (for use with the basic or expanded versions of the alarm) is built into its own box and mounted so that it can be heard from outside the house. If you put the circuit itself outside, remember to use a weather-proof box! Spraying the circuit with a protective water-proofing compound wouldn't hurt, either.

Component overlays for all these circuits are shown in Figs 5 and 6. None of the circuit boards should give you the slightest trouble. If you are 'expanding' the basic version of the control board, note that R1 is soldered in a different position and that R16 is now 150R to suit the specified relay. Apart from that, try to bend the component leads carefully and not too close to the body (the component's body, not yours!), remember to melt the solder over the joint and not over the iron, don't cook the transistors and IC for too long and everything should be fine.

Once you've assembled all the boards you'll want to connect them all together and build them into some sort of box. Figure 7 shows the way to do it. The best place for the bleeper board is on the back of the piezo



BUYLINES

None of the components for this project should present you with any problems. The relays we used were type KS1P from Specialist Semiconductors but many other types can be used (YX96E from Maplin or 60-0310 from Rapid). Key operated switches are also available from most of the large component suppliers.

If NiCd batteries are too expensive for you, there's no reason not to use ordinary batteries — check them every six months or so to make sure there are no leaks and replace them if the alarm should ever sound for an extended period. D13 and R17 should be omitted from the alarm board if primary cells are used.

When you select a siren for the project, choose one that gives plenty of output for not too much current — there's a huge variation between different types. A good choice is a high powered piezo siren. Motor drive types tend to be thirsty for current, although the sound is less likely to be mistaken for a car alarm. You could just go for a good, old fashioned bell!!

A parts set for the project consisting of all components for the control PCB, the three extra PCBs with all parts to go on them and the piezo sounder X1, is available for £13.90 (inclusive of VAT and UK postage) or £15.90 (Eire and overseas orders) from Specialist Semiconductors, Founders House, Redbrook, Monmouth, Gwent. Parts are available separately from the same source as are sirens, window foils, sensors and anything else you might need. Send a stamped, self-addressed envelope for a list.

If you were unlucky enough to miss last month's issue, a copy of the magazine complete with free components can be had from our backnumbers department, while stocks last. See the ad and order form on page 33 for details. If you just want the components, send 30p in stamps (19p for postage and 11p for the jiffy bag) to ETI Components, Craigo Farm Ind. Est., Trelleck Road, Tintern, Gwent. Eire and overseas, please send three international reply coupons.

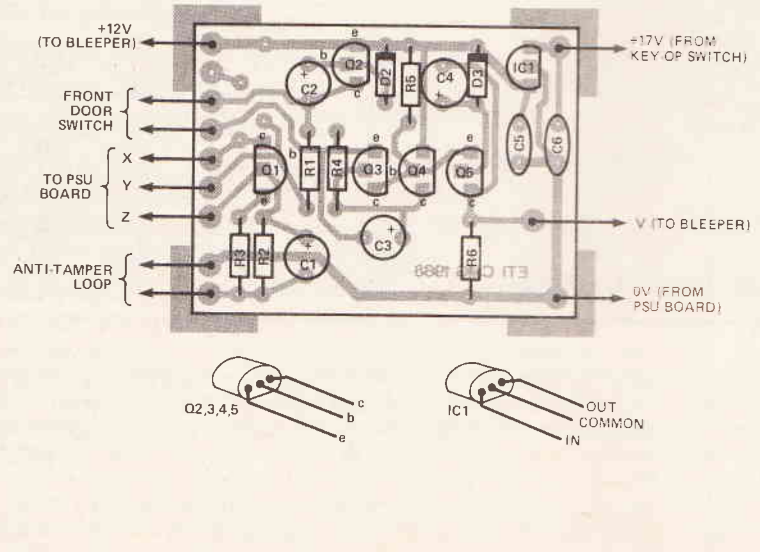


Fig. 5 Component overlay for the expanded alarm controller

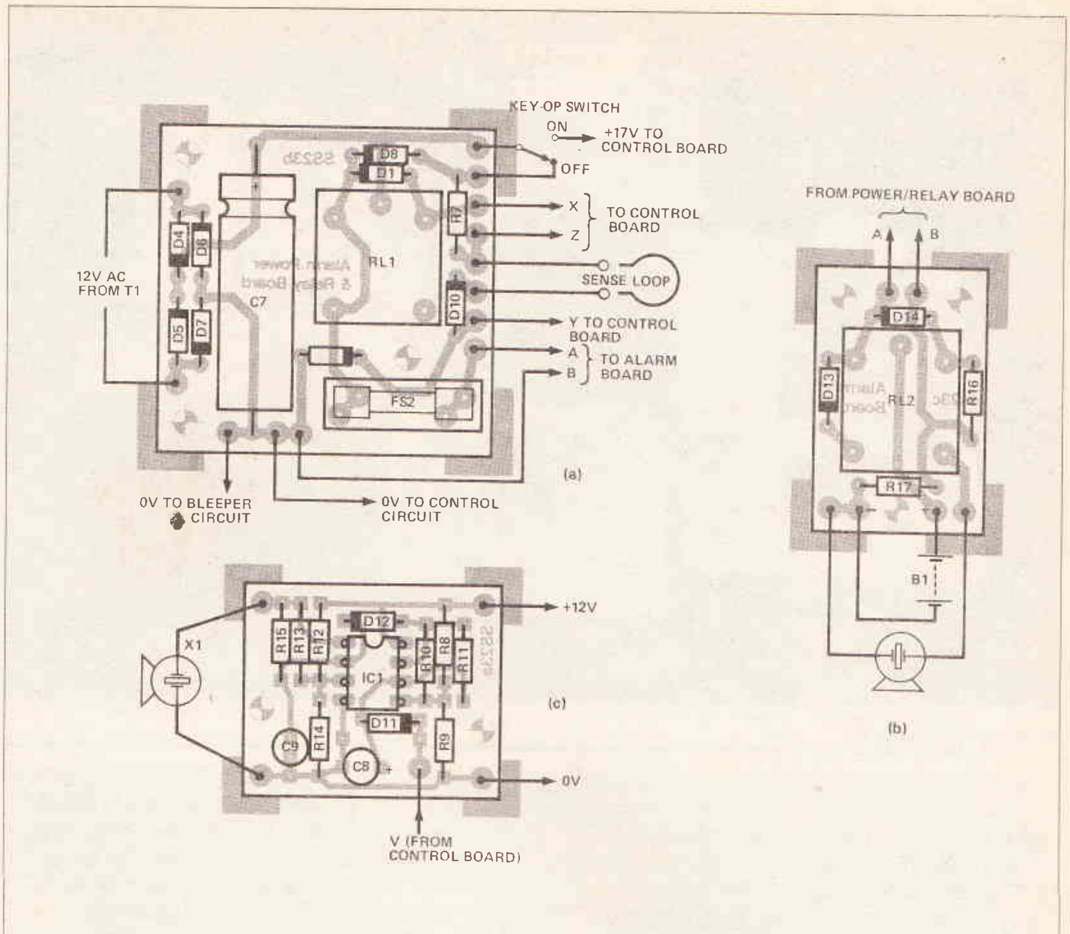


Fig. 6 Component overlays for the expanded Burglar Buster. (a) The power and relay board. (b) The bleeper board. (c) The alarm board

PARTS LIST

RESISTORS (all ¼W 5%)	
R1*, 2*, 6, 7	10k
R3*	100R (150)
R4	4k7
R5	2k2
R8-15	100k
R16	150R
R17	330R
CAPACITORS	
C1*, 2, 3	10μ elect
C4	33μ elect
C5, 6	100n
C7	2200μ elect
C8	2μ2 elect (or tant)
C9	4n7
SEMICONDUCTORS	
IC1	78L12
IC2	1458
Q1*	BC548
Q2, 4, 5	BC212 (*not* BC212L) or BC132
Q3	BC238
D1-3, 9-12, 14	1N4148
D4-8, 13	1N4001

* = components supplied free with November ETI.

MISCELLANEOUS	
RL1,2	Relays with spc/o contacts, 12V 300-400R coil
X1	Piezo sounder
X2	12V siren or bell
T1	Mains transformer, 6VA, 12V (or 0-6, 0-6) secondary
FS1	250mA anti-surge fuse
FS2	250mA quick blow fuse
SW1	key operated switch with spc/o contacts
B1	12V or 2×6V NiCd battery

Case for control unit. Case for sounder unit. Panel fuse holder. Fuse clips. Connector block. Micro switch. Strain relief bushes. Hardware for mounting transformer and PCBs. Mains cable. Connecting wire. Door switches. Window foils and other accessories to suit your installation.

sounder — use the good old self adhesive pads to hold it in place. The alarm board and the power and relay board both have relays on — adhesive pads might not be quite firm enough to hold them, so both have screw holes. Apart from that Fig.7 more or less explains itself.

Once the alarm has been assembled, the sense and anti-tamper loops are connected as described last month. Just about any commercial alarm equipment can be used with the project — window tapes, door switches, pressure mats, body heat sensors, infra-red beams and so on. For a low cost alarm system, wiring up the doors and windows will give most of the protection you could ever need, with perhaps a few pressure mats to give a surprise to anyone who might be clever enough to penetrate the external defences. The high-tech stuff can wait until ETI next publishes a project for it!

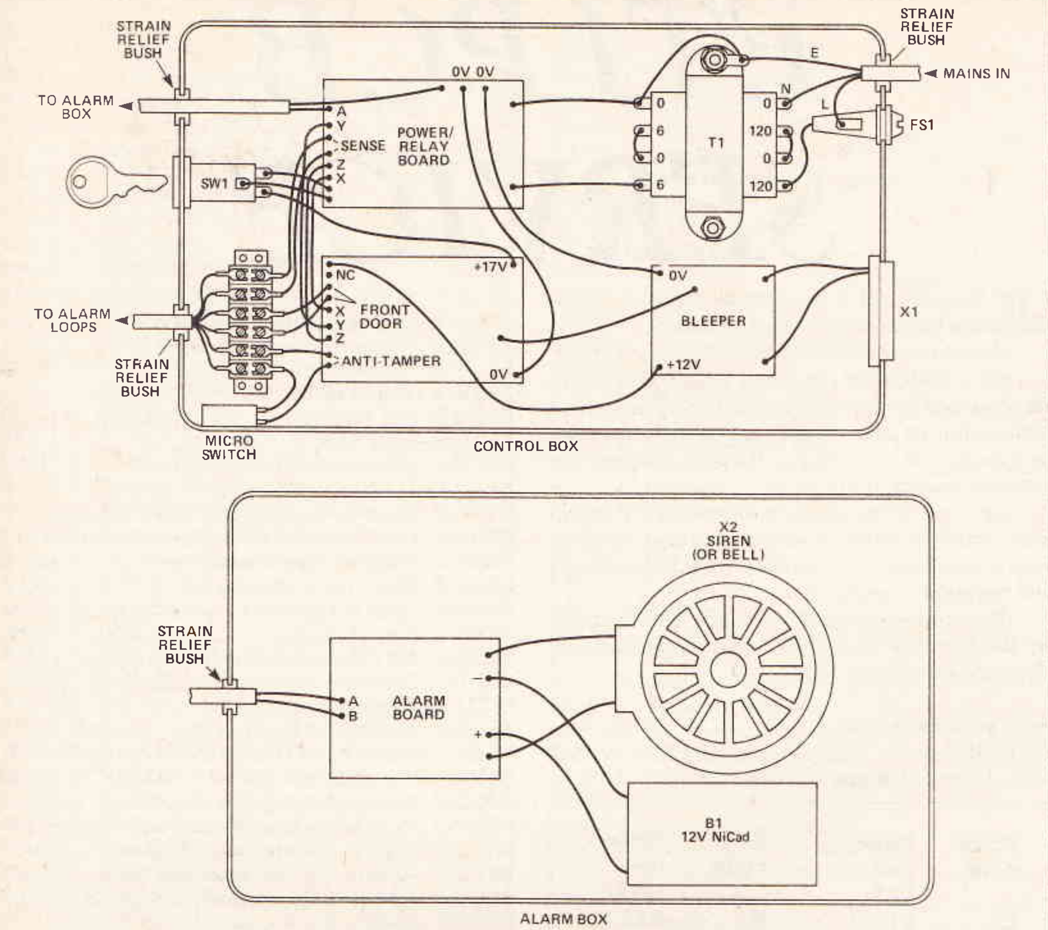


Fig. 7 Installation and off-board wiring of (a) the alarm control box and (b) the alarm sounder box

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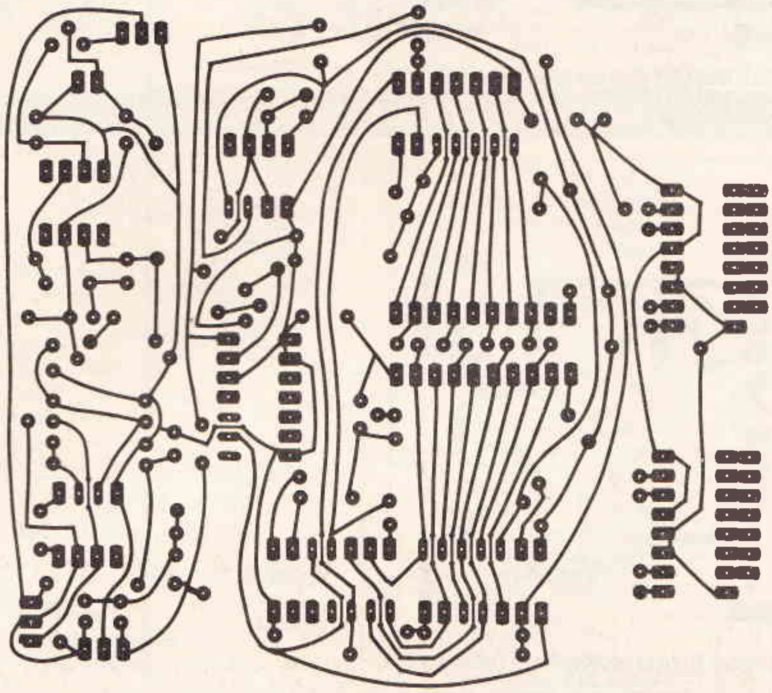
E8107-2	System A pre-amplifier Main	K
E8108-1	System A Power Amp	L
E8109-2	System A PSU	F
E8201-2	Infant Guard	C
E8202-5	MM Stage Disc Pre-amp (Tilsbrook)	G
E8206-5	Logic Lock	F
E8208-1	Playmate Practice Amp (3bds)	K
E8212-1	ELCB	F
E8301-2	Analogue to digital conv ZX81/Spectrum)	E
E8305-3	Dual Audio Power Supply, Linsley Hood	G
E8305-3	Balanced Input Preamplifier	F
E8307-2	Flash Trigger-sound or FR	F
E8308-1	Graphic Equaliser 1/3 Oct	M
E8308-2	Servo Fail-safe	C
E8309-1	NICAD Charger/Regenerator	F
E8310-3	Typewriter Interface — EX42	F
E8311-1	Mini Drum Synth	F
E8311-8	Moving Coil Pre-Pre-amp	F
E8312-3	Light Chaser EPROM Controlled (2 Bds)	K
E8402-1	Speech Board	M
E8402-2	Modular Pre-amp Disc Input Mono	F
E8402-3	Modular Pre-amp Stereo Output	F
E8402-4	Modular Pre-amp Relay, PSU	F
E8402-5	Modular Pre-amp Tone Main Mono	F
E8402-6	Modular Pre-amp Tone Filter, Stereo	F
E8402-7	Modular Pre-amp Balanced Output	F
E8402-8	Modular Pre-amp Headphone Amp	F
E8404-2	Mains Remote control Receiver	F
E8405-1	Auto Light Switch	F
E8405-2	ZX81 EPROM Programmer	N
E8405-3	Mains Remote Control Transmitter	H
E8405-4	Centronics Interface	F
E8405-6	Drum Synth	F
E8406-1	Oric EPROM Board	O
E8406-2	Spectrum Joystick	E
E8406-3	Audio Design RIAA Stage	G
E8406-4	AD Buffer/Filter/Tone	H
E8406-5	AD Headphone Amp	F
E8406-6	AD Preamp PSU	K
E8406-7	AD Power Amp	H
E8406-8	AD Power Amp PSU	J
E8406-9	AD Stereo Power Meter	F
E8406-10	AD Input Clamp	C
E8407-1	Warlock Alarm	M
E8408-2	EPROM Emulator	N
E8408-3	Infra-red Alarm Transmitter	E
E8408-4	Infra-red Alarm Receiver	F
E8409-1	EX42 Keyboard Interface	F
E8409-2	Banshee Siren Unit	F
E8410-1	Echo Unit	F
E8410-2	Digital Cassette Deck	N
E8410-3	Disco Party Strobe	H
E8411-5	Video Vandal (3 boards)	N
E8411-6	Temperature Controller	D
E8411-7	Mains Failure Alarm	D
E8411-8	Knite Light	D
E8411-9	Stage Lighting Interface	F
E8411-10	Perpetual Pendulum	E
E8412-1	Spectrum Centronics Interface	F
E8412-4	Active-8 Protection Unit	F
E8412-5	Active-8 Crossover	F
E8412-6	Active-8 LF EQ	F
E8412-7	Active-8 Equaliser	F
E8501-3	Digital Delay (2 bds)	T
E8502-1	Digital Delay Expander	N
E8502-2	Data Logger	J
E8503-1	Combo Preamplifier	F
E8503-2	THD Meter mV & oscillator boards (2 bds)	K
E8503-3	THD Meter Mains PSU	F
E8504-1	Framestore Memory	M

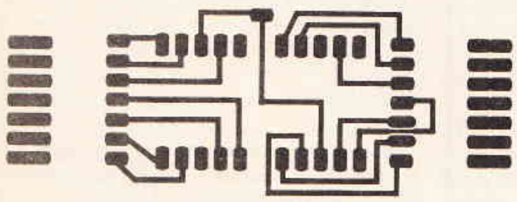
PCBs

E8504-3	Framestore Control	N
E8504-4	Buzby Meter	E
E8504-5	CCD Delay	F
E8505-5	Stereo Simulator	F
E8506-1	Audio Mixer Main	J
E8506-2	Audio Mixer PSU	F
E8506-3	Audio Mixer RIAA	D
E8506-4	Audio Mixer Tone Control	D
E8506-5	EPROM Prog MKII	O
E8507-1	Noise Gate	H
E8508-1	RCL Bridge	N
E8508-2	EX42/BBC Interface	E
E8508-3	EPROM Emulator	L
E8509-1	Spectrum EPROM card	F
E8509-2	Direct Injection Box	E
E8510-9	Sunrise Light Brightener	K
E8511-1	MTE Waveform Generator	H
E8511-2	Millifaradometer	H
E8511-3	Cymbal Synth	J
E8511-5	Chorus Effect	H
E8511-7	Enlarger Exposure Meter	F
E8511-8	Switching Regulator	E
E8511-9	Second Line of Defence	M
E8512-1	Specdrum Connector	F
E8512-2	MTE Pulse Generator	H
E8512-3	Specdrum	L
E8601-2	Walkmate	L
E8601-3	MTE Counter-timer	M
E8602-1	Digibaro	O
E8603-2	Programmable Logic Evaluation Board	H
E8603-3	Sound Sampler Analogue Board	R
E8604-1	JLLH PA PSU	H
E8604-2	Matchbox Amplifier	C
E8604-3	Matchbox Amp Bridging Version	C
E8604-4	MTE Analogue/Digital Probe	M
E8605-1	Microlight Intercom	E
E8605-2	Baud Rate Converter	M
E8605-3	Baud Rate Converter PSU Board	C
E8605-4	Portable PA	H
E8606-1	MIDI-CV Converter Board	H
E8606-2	MIDI-CV Converter PSU	D
E8606-3	Troglograph	F
E8606-4	80m Receiver	H
E8606-5	Sound Sampler	R
E8607-1	Direction	E
E8607-2	Upgradeable Amp, MC stage (Stereo)	G
E8607-3	BBC Motor Controller	F
E8608-1	Digital Panel Meter	G
E8608-2	Upgradeable Amp, MM stage (mono)	H
E8609-1	Mains Conditioner	E
E8609-2	Experimental pre-amp	F
E8609-3	Upgradeable amp, Tone board (mono)	H
E8609-4	Upgradeable amp, Output board (mono)	F
E8610-1	Audio Analyser Filter Board	L
E8610-2	Audio Analyser Display Driver	K
E8610-3	Audio Analyser Display	H
E8610-4	Audio Analyser Power Supply	F
E8611-1	Audio Switcher (2 bds)	H
E8611-2	PLL Frequency meter (4 bds)	Q
E8611-3	Upgradeable Amp PSU	J
E8611-4	Call meter, main board	O
E8611-5	Call meter, interface board	N
E8612-1	Bongo Box	J
E8612-2	Biofeedback monitor (Free PCB)	E
E8701-1	RGB Converter	F
E8701-2	Mains Controller	D
E8701-3	Flanger	H
E8701-4	Audio Selector main board	M
E8701-5	Audio Selector PSU	H
E8701-6	Tacho-Dwell	F
E8702-1	Ratemeter main board	K
E8702-2	Ratemeter ranging board	F
E8702-3	Photo Process Controller (3 bds)	O
E8702-4	LEDline display board (2 off)	K
E8702-5	LEDline PSU and controller (2 bds)	G
E8703-1	Capacitometer	F
E8703-2	Geiger Counter	L
E8703-3	Credit Card Casino	E
E8704-1	BBC micro MIDI interface	L
E8704-2	ETIFaker patch box	H
E8704-3	24Hr Sundial	E
E8705-3	MIDI Keyboard keyswitch boards (3 bds)	W
E8705-4	Batlite	C
E8705-5	Budget Power Meter	E
E8706-1	Hi-fi Power Meter	N
E8706-2	MIDI Keyboard CPU	U
E8706-3	MIDI Keyboard Front Panel	O
E8706-4	Flame Simulator	G
E8707-1	MIDI Keyboard PSU	H
E8707-2	Telephone Alarm	J
E8707-3	Nuclear Strategy Simulator	J
E8708-1	Remindalite	F
E8708-2	Rear Wiper Alarm	G
E8708-3	Rev Counter	F
E8708-4	Car Alarm	F
E8708-5	Knight Raider	J
E8709-1	Boiler Controller	G
E8709-2	Amstrad Sampler (2 bds)	P
E8709-3	Portable PA	G
E8709-4	EEG Monitor (2 bds)	L
E8710-1	Concept CPU board	N
E8710-2	Concept Power board	K
E8710-3	Concept display board	G
E8710-4	Hyper-Fuzz	F
E8710-5	Big Digits digit board	N
E8710-6	Big Digits minute board	F
E8710-7	Big Digits battery board	G
E8711-1	Quiz Controller	E
E8711-2	256K Printer Buffer	N
E8712-1	Heating Management System	O
E8712-2	SWR Meter	H
E8712-3	Dream Machine (free PCB)	D
E8801-2	Passive IR Alarm	H
E8801-3	Deluxe Mains Conditioner	G
E8801-4	RGB Dissolve	L
E8802-1	Electric Fencer	E
E8802-2	Telephone Intercom	L
E8802-3	Transistor Tester (2 bds)	L
E8802-4	Spectrum Co-processor CPU	N
E8803-1	Co-processor RAM board	N
E8803-2	Beeb-Scope (3 bds)	O
E8803-3	Jumping Jack Flash	E
E8804-1	Spectrum Co-processor Interface Board	N
E8804-2	Combo-lock	E
E8804-3	Kitchen Timer	E
E8805-1	Virtuoso 2U PSU	M
E8805-2	Virtuoso 3U PSU	N
E8805-3	Bicycle Speedometer	F
E8805-4	Dynamic Noise Reduction	E
E8806-1	Universal digital panel meter	L
E8806-2	Universal bar graph panel meter	K
E8806-3	Virtuoso power amp board	N
E8806-4	Virtuoso AOT board	G
E8806-5	Metal detector	E
E8806-6	Bicycle dynamo backup	D
E8807-1	Bar Code Lock (2 bds)	N
E8807-2	Analogue Computer Power Board	L
E8807-3	Bell Boy	F
E8807-4	Logic Probe	C
E8807-5	Updated FM stereo decoder	J
E8807-6	Breath Rate display board	F
E8808-1	Breath rate main board	H
E8808-2	Breath rate switch board	C
E8808-3	Telephone recorder	D
E8808-4	Analogue computer main board (2 bds)	M
E8809-1	Spectrum EPROM Emulator	M
E8809-2	Frequency meter (2 bds)	P
E8809-3	Travellers' Aerial Amp	E
E8810-1	Gerrada Marweh Bikebell	E
E8810-2	Peak Programme Meter (2bds)	N
E8810-3	Variat-Ion ioniser	K
E8810-4	TV-to-RGB converter	E
E8810-5	Electron RGB buffer	C
E8811-1	NiCd Charger	E
E8811-2	Chronoscope (3 bds)	P
E8811-3	Digital Transistor Tester	G
E8812-1	Doppler Speed Gun (2 bds)	K
E8812-2	Small Fry Mini Amp	D
E8812-3	Thermostat	E
E8812-4	Burglar Buster free PCB	D
E8812-5	Burglar Buster power/relay board	E
E8812-6	Burglar Buster alarm board	C
E8812-7	Burglar Buster bleeper board	C

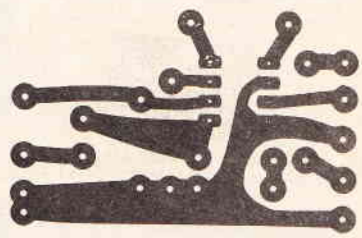
PCB FOIL PATTERNS



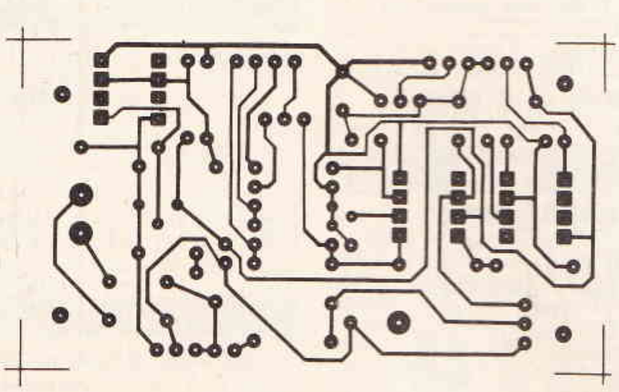
The Doppler Speed Gun foil



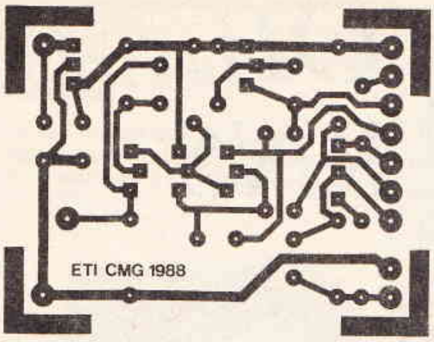
The Doppler Speed Gun display foil



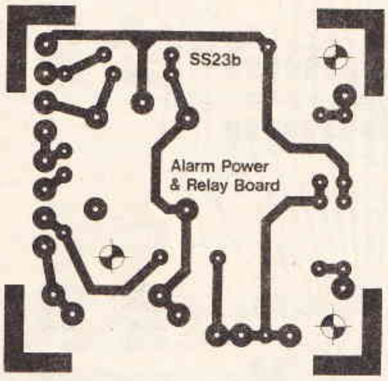
The Small Fry Mini Amp foil



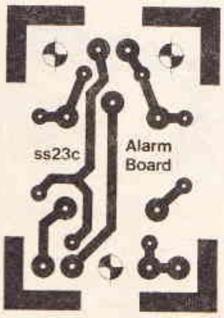
The Electronic Thermostat foil



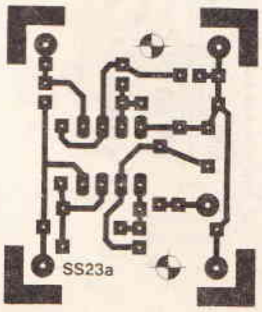
The Burglar Buster free PCB foil



The Burglar Buster power and relay board



The Burglar Buster alarm board



The Burglar Buster bleeper board

Heating Management System
(December 1987)
A 4116 is not a suitable alternative to the 6116 specified. A 4016 RAM chip will suffice. In Fig. 1 the junction of R1/D5 should connect to D1-4/C1 and not cross. The zener diodes above the temperature sensor ICs (IC16-19) should be deleted. C4 should be 220n and not 220μ. C7-10 should be 10μ. Q2-7 should be 2N3904 and not BC3904.

RGB Auto-Dissolve (January 1988)
In Fig. 5 there are marked two D6's. The right hand one should be D5 (they are both 1N148's anyway). In the text the reference to zener diode D5 should read ZD1.

Power Conditioner (January 1988)
There is confusion between the values of R7 and R8 in the Parts List and Fig. 1. These should be: R7-27k, R8-10k and not as given in the Parts List. In addition, ZD1 is incorrectly orientated in Fig. 3. The positive terminal should be at the southern end.

Passive Infra-Red Alarm
(January 1988)
Fig. 2(a) shows the base of Q1 connected to ground and to R14. It should be connected only to R14.

Transistor Tester (February 1988)
The foil pattern for the main board was printed reversed left-right on the foil pages. R14 is incorrectly given in Fig 1 as 330k. It should be 330R as in the Parts List.

Spectrum Co-processor (March 1988)
Mogul Electronics, given in the Buylines as suppliers of the RAM chips, have moved to: Unit 11, Vestry Estate, Sevenoaks TN14 5EU. Tel: (0732) 741841.

Dynamic Noise Reduction (May 1988)
The LM1894 is no longer available from the sources listed but it can be obtained from the author. Please address orders to Manu Mehra, 88 Gleneagle Road, Streatham, London SW16 6AF.

QL Output Port (Tech Tips May 1988)
Several problems with the diagram for this one. A5 should read AS — that is, address strobe. Pins 22 and 24 should be connected to +5V and the junction of the (only) resistor and diode connected to VPA on the QL.

QWL Loudspeakers (August 1988)
Some dimensions were missing from Fig. 7. The bass driver port centre should be 3¾in above the base of the baffle panel. The notches in the side of the tweeter cut-out are ½in wide. The top plate is missing from the cutout diagram (Fig. 6). This is 7×4⅝in.

EEG Monitor (September 1987)
The wiring for the switch SW1 in Fig. 5 shows all the wires for selecting Alpha and Beta waves swapped. A_1 should read B_1, A_2 should read B_2 and so on. The easiest remedy is to swap the front panel labelling shown in Fig. 6 so that the switch labelling reads Theta, Beta, Alpha.

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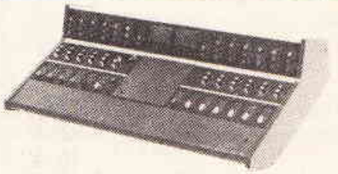

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OPEN CHANNEL

Just to give you an idea of magazine lead times. I'm writing this month's column in the midst of the national postal strike. This situation provides a good introduction to my subject — that is, fax.

Facsimile provides a means whereby representations of documents, drawings, pictures, in fact just about anything on paper can be transmitted over a telephone connection.

You could be forgiven for thinking that fax is a recent invention — after all it's only over the last couple of years that fax machines have started popping up in offices and office service bureaux.

However (here comes the history lesson) fax was invented and patented in 1843 by Alexander Bain. Naturally it wasn't until much later, around 1910, that fax was being used in commercial applications.

The reason that fax seems to have recently leaped to prominence is that few standards for communications of visual information over the line have been followed. Further, until the last few years techniques have been analogue-based, making the fax scanner and receiver pretty complicated and hence expensive. Latest generations of digital-based units are much simpler in construction and for most purposes are more than adequate. This is reflected in prices falling from the wrong side of exorbitant to less than £1000.

The postal strike has turned many people's attention to fax and the resulting sales should push prices even lower — certainly within the range of medium and large-sized organisations.

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Groups 1 and 2, for example, are high quality groups giving grey tones and (especially with Group 1) very good results. However transmission times are pretty lengthy — some six minutes per A4 page for Group 1 and half that for Group 2.

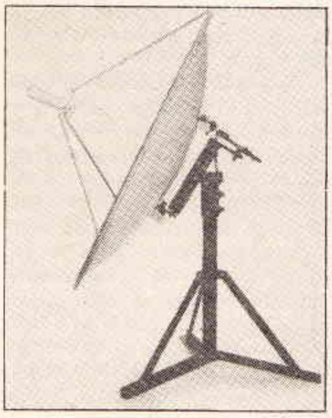
Groups 3 and 4 are digitally based and don't give grey tones but can transmit an A4 page in 15 seconds. All the modern cheap machines are of these types.

Of course you don't have to buy a fax machine. You can take your document to an office bureau and pay for it to be transmitted to your destination. And that brings me to the point of this blurb I'm writing here — this month's column has been brought to you via fax. As soon as I've finished penning I'll be on my bike to my local bureau to 'post' it to the ETI offices where the ASP fax machine will receive it.

Paying The Price

All this is costing me £1.50 (at agency prices) rather than the 19p stamp I would otherwise use. However It doesn't take too long to calculate that if I post 1316 letters a year then buying a fax will pay for itself in four years. Although a meagre freelance journalist doesn't post anywhere near this number, many organisations do.

The extra convenience that an on-site fax machine gives in speed (documents are delivered within seconds), convenience (you don't have to run to catch the post) and cheapness in running costs means that a large number of organisations own have the purchase of a fax machine as a priority course of action.



Paying The Earth!

Recent reports about salaries to be earned by TV presenters when satellite televisions systems turn on have prompted me to regret my decision many years ago when I turned down the chance to become junior assistant to the assistant office dogsbody's teaboy in a well known brand of TV company.

Let me explain. I understand that Anne Diamond (of TV-am fame) has been offered a quarter of a million pounds to move to the British Satellite Broadcasting DBS channels when they start transmission next year.

Can this really be justified? It's the users, you and me, who have to pay these salaries in the end whether by licence fee, subscription or higher priced goods in the shops after advertising costs are absorbed into retail prices. (If perchance that job is still going, could somebody let me know . . .)

Keith Brindley

KEYNOTES

The DH-100 Digital Horn is the latest MIDI implementation from the innovative laboratory of Mr and Mrs Casio in Japan.

It was originally conceived, I am told, as a children's toy to rival or perhaps update the wooden school recorder but is now being given a major launch in Britain to appeal as a novelty item to professional musicians. It was one of the big stars of this year's BMF and not surprisingly — at £100 for a MIDI controller that sends velocity and aftertouch it almost enters the realm of an impulse purchase.

The horn itself resembles a stunted tenor sax and is finished in a matt silver plastic that shines like a prop from *The Day The Earth Stood Still*. The keys look like chrome but aren't: plastic plastic everywhere. However, I tried it in a bar and in a cinema — people stared at me on both occasions so it must have something.

If you can remember recorder fingering from school (unfortunately I can remember little else) then it is simple to bring back to life all those classroom classics.

The octave key on the back works right across the scale and Casio have added two extra teardrop keys — one as a simple method of obtaining sharps without the difficult fingering, the other as a portamento switch (also transmitted by MIDI). There's no way of varying the portamento and it is rather severe, best saved for special occasions.

The on-board (on-horn?) sounds are fairly standard budget Casio fare — good clarinet, pleasing oboe, dodgy trumpet — but the control of breath sensitivity gives them a certain expressive boost.

The voice change and transpose pads are on the righthand side of the instrument which I found the perfect place for resting the inside of my hand and hitting them by mistake. This is probably a matter of practice (or competance) but considering the market for a plastic horn, I'm surprised the pads aren't a little more safely positioned.

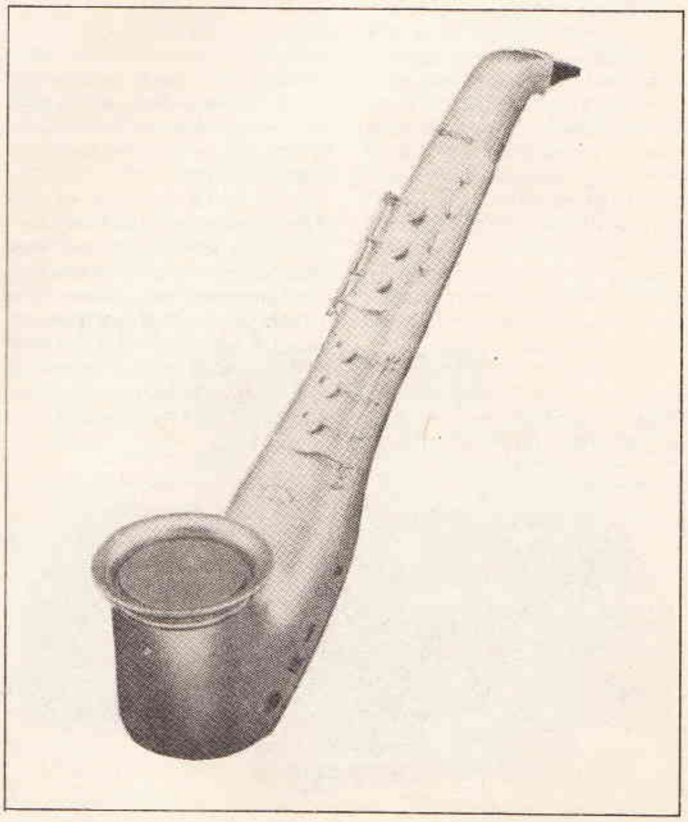
The internal speaker is in the bell of the horn and produces plenty of noise for wandering around your bedroom. The audio output is a mini-jack (why?) which is between line and headphone level and rather noisy as a result.

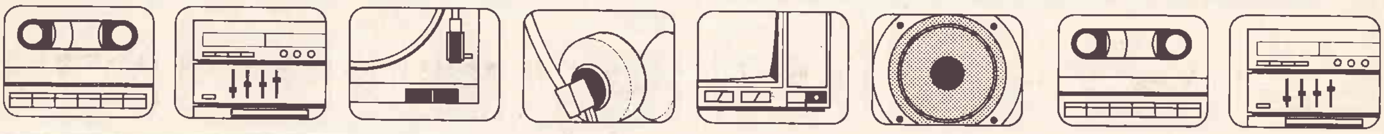
With both line-out and MIDI cables trailing from the side of the unit, the mobility of the digital horn player is considerably hampered particularly if you're used to a wireless wind or brass instrument.

But I'm forgetting that it only costs £99. At that price you have to forgive problems like there being no display to let you know if you've accidentally transposed yourself or to tell which sound has been selected.

It's a novelty but it's a useful novelty. Visit your Casio dealer and have a blow.

Colin Cat





There are many different video recorders on the market, ranging from basic models costing under £200 to professional models costing well over £1000. Top of the range domestic machines generally cost between £400 and £800.

Here we compare two such machines — the Ferguson FV14T, around £750, and the Philips VR6870, around £450. Both are top of their respective ranges but seem to be aiming for slightly different markets. The contrast between their features and performance illustrates many criteria which dictate the choice between one machine or another.

Similarities

Though the two machines offer different features, they have several points in common. Both are HQ machines which means that the video quality is improved compared with the previous generation. To be classified as HQ, a machine must offer increased white clip level on recording plus one or more of: detail enhancement, chroma processor, luminance improvement. The manual for the Ferguson machine states that it uses white clip improvement and detail enhancement. The Philips manual does not state which improvements are provided but it probably uses the same ones. This combination of enhancements is the most usual choice.

Both machines will record sound in hi-fi stereo (modulated on an FM subcarrier) as well as the standard linear mono sound used by most video recorders. They will also play commercially-recorded cassettes recorded in stereo hi-fi to their best effect — particularly effective with music videos. Of course it is only relevant if you connect the audio output of the recorder to your stereo system. Listening to the sound through an ordinary television, the improvement in sound quality on switching to hi-fi is not very significant.

Both machines have synthesised tuning with channel number display available. They both offer autosearch facilities for tuning in, which is a good idea for people who have little practice in tuning radios and televisions.

Both machines' timers can be set to record at the same time each day or week, as well as at just one preset time. Each machine will accept eight entries, which may be single recordings or daily or weekly repeats. The Philips machine sports a 31-day timer, the Ferguson only has a 14-day.

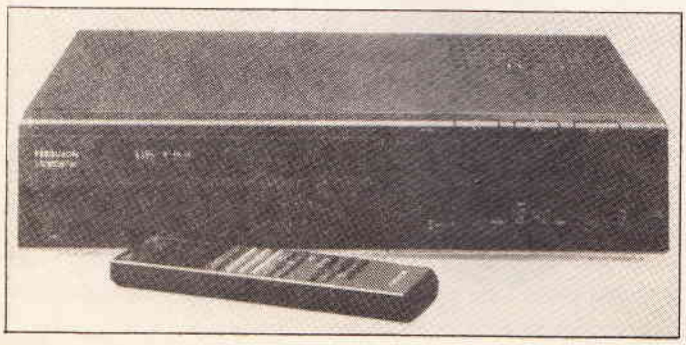
Apart from the standard manually controlled recordings in which the user switches the machine to record and it records until stopped or the tape ends, they both have an instant timer controlled record mode, in which recordings may be manually started and set to continue for any multiple of half an hour up to the tape length remaining.

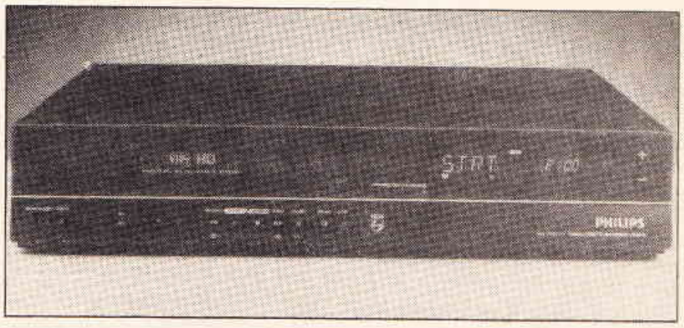
In common with every video machine I have looked at, both machines add their contribution of video noise to the signal when the tuner in the video machine is used to select the programme. Both machines add rather less coloured snow than some cheaper machines and both machines add very little if fed with a *very* good signal.

Differences

As one might expect, for its higher price, the Ferguson machine offers, a number of features which the Philips machine does not. The most obvious of these is the ability to record at half speed, stretching a four hour tape to eight hours. The video quality in this mode is slightly lower and the quality on stills or at fast search speed is much inferior. It is more than good enough for most time shift requirements and could be a boon if you wanted to capture a long event.

The SP/LP switching can be chosen separately for each timed recording so, for example, you may record all the soaps on LP to save tape and then record a feature film on SP to get better quality. Both machines can record at half-speed for sound only and in this mode they both provide up to eight hours of high-quality stereo recording on one video cassette. One hell of a party.





The Ferguson machine has a very useful function on the counter display. As well as displaying the usual arbitrary numerical count, it can be switched to display the time remaining before the end of the tape. This is accurate on both speeds and is invaluable in saving time scrolling back and forth through family tapes looking for a 'used up' slot.

I deduce that it works by measuring first of all the relative rotational speed of the two reels and secondly the rate of change of speed as the tape is transferred from one to the other. In this way, it takes account of different tape lengths.

The timer programming on each machine can be carried out from the remote controller but on the Ferguson model this function is taken to the nth degree. You can enter up to four timer settings into memory on the remote controller while sitting in your easy chair and looking at the Radio Times. As you enter the settings, your entry is displayed on a liquid crystal readout in the controller itself. Though one would not necessarily think so just to read about it, this feature makes programming the machine much easier.

When the required number of settings has been entered, they may be transferred from controller to VCR at the touch of a button. When programming the timer remotely on the Philips, the setting is shown on the VCR's own display. This display is larger than the Ferguson's to make this process easier but still becomes indiscernable within the length of many average living-rooms.

The styling of the two machines is different with the Philips machine looking more like a video recorder and the Ferguson looking minimalist and mysterious. The Philips machine has all the standard controls in view — play, fast wind, one touch record and so on. The tuning, timer, and other contols are behind a hinged panel. The only inconvenient control is the picture sharpness adjustment which is on the back panel.

The Ferguson machine had only the play, instant record and stop controls on veiw. It is clearly intended to be used from the remote controller most of the time so that the other operating controls are behind one hinged panel with the setting controls behind another.

To conceal the space age Fergie from the passing burglar, a 'display off' switch is provided. This switches off the clock, counter, and recording level meters and leaves just -:- showing on the display.

NICAM

Both the IBA and BBC are planning, officially or unofficially, to start transmitting television programmes in stereo on a national basis in the next few years. The BBC is already doing experimental stereo transmissions from Crystal Palace. The Ferguson VCR includes a NICAM decoder which could be very valuable if these plans are carried out.

It is not impossible, however, that developments such as the proposed satellite television with different stereo standards may scupper NICAM in the long term. If this does happen then an expensive feature is wasted. You pays your money and you takes your choice.

For the present, however, stereo 'television' is achieved by transmitting the stereo sound on an FM radio channel. Both machines have the facility to record a stereo signal from a radio tuner, while recording the television picture. This would allow the recording of events like last summer's Nelson Mandela Birthday Concert in glorious stereo.

Though the Ferguson machine includes a stereo decoder and is clearly intended to satisfy the enthusiast, an automatic record level facility is provided as well. The Philips machine, which appears to be aimed more for the average user, requires manual record level setting at all times. I am surprised at this omission because there are many people who seem to miss the point of record level setting and get into a muddle.

Performance

Both machines performed well. The sound quality was very good, probably better than most if not all audio cassette machines. The FM stereo sound used in this generation of machines is streets ahead of the conventional linear stereo used by earlier machines.

It seems to be a general problem with VCRs that the quality of picture is worse when viewing the signal straight from the video cassette machine's tuner (not the recorded signal but the off-air signal), unless the signal from the aerial is extremely good. Neither of these machines is an exception to the rule. I have had a chance to test both of them in an area of medium signal and an area of good signal; they both suffered from the problem in the former and not in the latter. In the medium signal area, it was sometimes worthwhile to switch to the direct television channel to get a better picture, even while taking the sound from the video cassette machine to the hi-fi system. There was little difference in this respect between the two machines.

On normal program material, both machines give a subjectively similar performance. The adjustable sharpness controls have a slightly different response and it is possible that the Philips machine gives slightly more detail but this is hard to distinguish with moving pictures.

On still frame, the performance of the Philips machine is much better than that of the Ferguson. The machine has three video heads, in order to provide what Philips call 'perfect stills' and they are indeed as near perfect as any I have seen. Nine times out of ten the still that you get upon hitting the pause button of the Philips machine is as perfect as the original recording (on the tenth it may be necessary to adjust the tracking control to remove a slight vertical jitter).

On the Ferguson machine to obtain a good still picture it is first necessary to run the machine in slow motion, while adjusting the digital tracking buttons. When the slow motion tracking is adjusted (a separate digital memory from the normal speed tracking), one must go back to the required frame and stop it there. Usually this will achieve a clean still picture. Even then the picture looks slightly more plasticy and has slightly less detail than the Philips, no matter how you adjust the picture sharpness controls.

Conclusion

These two machines, both for people who want a fairly advanced video recorder, represent some of the choices to be faced. The Ferguson would be a definite option if you are looking forward to stereo television reception and expect, or are at least prepared to gamble, that it will be fully introduced. There are less expensive VCRs fitted with NICAM but if you want stereo plus good picture performance (freeze frame and so forth) then you are usually looking at serious money.

If on the other hand the ability to decode NICAM stereo is not so important, or if you do not think that stereo for ordinary television programmes is a particular priority, then the Ferguson becomes decidedly less attractive. The Philips is a considerably cheaper machine with good freeze frame and slow speed facilities, ideal (for example) for examining musical or sporting technique closely from a video.

The NICAM decoder could justify the extra cost if you would otherwise buy a new machine to take advantage of stereo when it becomes widely available. Clearly it is more attractive to have stereo decoding in the video reocorder than the television to make it easier to use with a normal stereo hifi. Stereo televisions as such do not seem a very worthwhile prospect though no doubt they will be produced if stereo transmissions get underway.

Apart from the Philips remarkable freeze frame performance, the Ferguson machine offers considerably more for its higher price. The LP facility should be taken into consideration if your household is prone to arguments about who records what during a two week holiday. On the other hand, one could buy three basic machines for the same money and record three different programs at the same time, a sure enough way to avoid conflict. Certainly this facility is not necessary if you time shift only the odd evening or weekend viewing. And do you really want to watch eight hours of video on return from a two week holiday?

The display of tape time remaining provided by the Ferguson machine is a particularly useful feature and cannot cost much to incorporate in a machine already using a microprocessor. I am surprised that more manufacturers don't use it. Anyone who had lost the last two minutes of a programme may be tempted.

I found from experience that when looking for a new video (and I have yet to make up my mind) you can obtain any one feature to a reasonable quality at a reasonable price but once you start looking for several top-class features, the bill rises sharply. Also, you cannot rely on every feature of an advanced machine being equally satisfactory or the best in its class (as our two machines here have demonstrated) so a live test is essential before you part with money.

The key is to decide what you will be using your VCR for and how much each feature is worth to you. Then find a machine to match the mould.

Andrew Armstrong

BOOK LOOK

In a slight deviation from normal *Book Look* subjects, this month we review the newly published memoirs of John Logie Baird, inventor and demonstrator of the first television transmission system.

Sermons, Soap and Television by John Logie Baird. 174pp. Published by the Royal Television Society. £4.95.

Did Baird invent television? Did anyone invent television? The various arguments and claimants have existed for some sixty years and it seems unlikely ever to be properly clarified. Certainly the dictated memoirs of the man himself are not the place to search for a balanced account of developments.

"I write perhaps bitterly and egotistically" warns Baird and at times one has to agree with him.

However there is far more in this set of memoirs, dictated in 1941, than just the boffin's path to success. Indeed it becomes obvious that much of Baird's inventiveness is not so much technical aptitude as entrepreneurial stubborness.

In his youth in Glasgow he quickly established that a company life was not for him. His perpetual illness was a major handicap to keeping employment — although such activities as placing an iron-cased carbon rod straight across the bus bars of the power station where he worked (in an attempt to make diamonds) can't have helped either!

Out on his own he found success with the Baird Medicated Under-sock, set up a mango chutney business in the East Indies, then returned home to create Baird's Speedy Cleaner Soap which, together with his father's ministerial post, completes the book's title.

None of this would seem to pave the way for a world-shattering invention. It took a return to his electrical experiments of youth to lead him to the first working television systems. These systems used rotating discs of 3-ply wood up to eight feet in diameter, spinning at 150 rpm! Rather hazardous, as Baird writes:

"On more than one occasion lenses broke loose, striking the walls or roof like bombshells. The apparatus would then get out of balance and jump from one side of the lab to the other until it was stopped or the disc tore itself to pieces. I had some exciting moments."

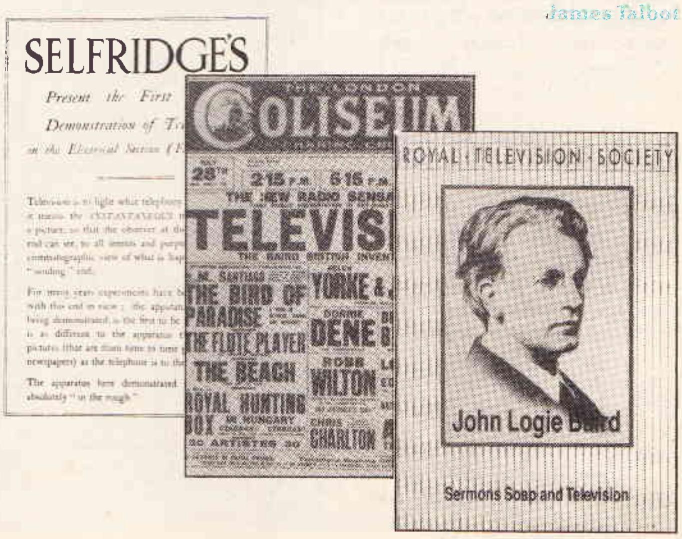
His private life holds as much fascination as these early experiments. Baird attended seances and spiritual meetings — more out of scientific curiosity than occult leanings. He intended to use his Noctovision (infra-red TV developed only months after the original) to investige what took place in the darkened rooms.

The final chapters of the book concern the problems of Baird's Television Ltd and the Marconi dominance of the small screen. In the end Baird came out with very little, despite his invention and continual innovation: first colour TV in 1928, first transatlantic broadcast in 1928, first outside broadcast (from the Derby) in 1931.

These memoirs have now been released by the Royal Television Society through the support of BBC Television — which is pretty ironic considering that the BBC of the day (and Lord Reith in particular) is one of the main villains of the piece. Perhaps it is trying to make amends.

Sermons, Soap and Television is excellent reading, a fascinating document of both the invention of television and of life at the beginning of the century. It is available only from the Royal Television Society, Tavistock House East, Tavistock Square, London WC1 9HR for £4.95 including postage and packing. Tel: 01-387 1332.

James Talbot



This column is a service to readers to provide electronic designs to order. Many a project never gets further than the drawing board because of difficulties with one small part. If you are stuck for a circuit or a technique, let the ETI expert help you out. Send your requirements, with as much detail as possible, to ETI Blueprint, 1 Golden Square, W1R 3AB.

This months *Blueprint* has been requested by two readers. They both want a power supply to provide the programming voltage for an EPROM programmer.

Marc Crosbie of Dublin wants to provide voltages of 5V, 12.5V, 21V, and 25V using 'the minimum number of expensive transformers and voltage regulators.'

Anthony Uk of Switzerland wants to control the programming voltage from a binary control signal according to the following truth table:

Inputs	Output
0 0	ground
0 1	+21V
1 0	+26V
1 1	+12V5

He says in addition that the unit is to be powered from his computer, which has only a +5V supply, but that he wants ±5V and +12V supplies constantly available in order to power triple rail EPROMS such as the 2708. Erk! I gave my last triple rail EPROM a decent burial years ago. Still, here is a circuit which will do what you want.

The main part of the circuit is shown in Fig. 1. It consists of a simple self oscillating flyback converter to increase the 5V input to approximately 28V, followed by a programmable voltage regulator switched to provide the various programming voltages used by different EPROMS. The logic control circuit is shown in Fig. 2.

A tertiary winding on the flyback transformer generates a negative voltage in approximate proportion to the +30V, approximately 8V. In practice this voltage is not very accurate because not all the magnetic flux linking this winding links the other windings and vice versa. Thus the voltage depends on the relative loading on the two rails.

The 30V supply is generated as a fixed voltage and then regulated down precisely because the need to generate a constant 5V negative supply. If no constant voltage were needed, the output of the flyback converter could be regulated to the exact programming voltage required (though extra filtering might be needed).

A switched voltage flyback converter is shown in Fig. 3. Different component values may be selected by experimentation. This still runs from +5V because a +5V supply is always needed to run EPROMS, even if triple rail ones are not to be programmed. A 5V supply can be supplied from a simple circuit using a 7805 regulator.

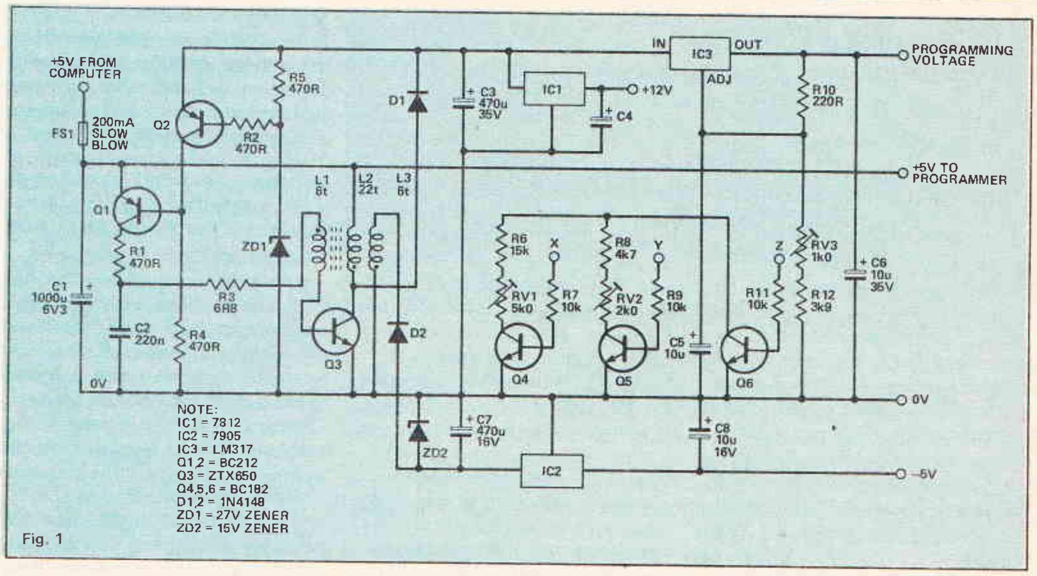


Fig. 1

Leakage Reactance

Several points need attention in the construction of the flyback converter. First of all heavy peak currents flow so the decoupling capacitor C1 must be connected to L2 and Q3 with short tracks. So spiky is the current flow that a filter inductor may need to be added between computer and power supply to prevent interference getting back to the computer's power supply and crashing it.

To minimise the effects of leakage reactance, the inductors should be wound in the closest possible contact. A good way to achieve this is to wind 11 turns of L2, followed by all of L1 and L3, followed by the remaining 11 turns of L2. When winding the transformer, take note of the dot convention where the dot denotes the clockwise (or anticlockwise) end of each winding. If the phase of one of the windings is reversed it will not work.

Whole numbers of turns are shown in the circuit diagram but it may be convenient to connect windings to diametrically opposite pins of the former, so that the finished coil is symmetrical and may be installed either way round. In this case, ½ turn may be added to all windings without problem.

The ZTX650 transistor shown for Q3 is almost the only type suitable for the job. Its important characteristic is very low saturation voltage at over 1A with moderate base drive. If the ZTX 650 is not available, a BD131 on a small heatsink may be used. The efficiency of the ZTX650 is so high that, though it is an E line transistor, it does not get hot or need a heatsink.

D2 and D3 are 1N4148 diodes for high speed. 1N4001s, for example, would prevent efficient operation because they switch so slowly.

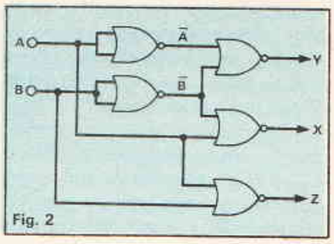


Fig. 2

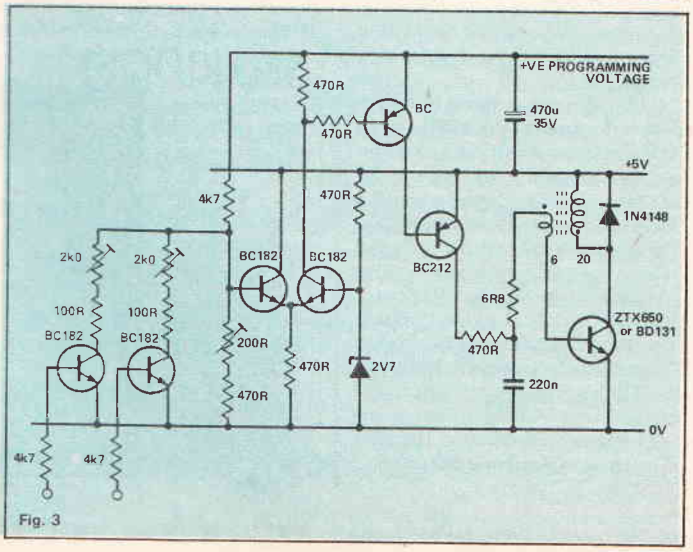


Fig. 3

Switched Voltage

To regulate the 28V down to the levels required for PROM programming, an LM317 variable regulator is used. This type of voltage regulator acts to maintain a constant voltage of 1.25V between the adjust and output terminals. This feeds a constant current through R10 and hence generates a voltage drop proportional to resistance between adjust and ground. The resistance which is always in circuit, RV3 in series with R12, is adjusted to give the required 25V output and extra parallel resistances are switched in to reduce this to 21V or 12.5V as required. Q6 is included to reduce the output to 1.25V which should be close enough to 0V for most purposes. If it is not close enough, then a relay should be connected so to switch the programming voltage output to ground instead of to the output voltage.

The logic control circuit shown in Fig. 2 is suitable to drive Q4, Q5, and Q6 to provide the control required by Anthony Uk, but if computer control of voltage is not required then the transistors may be replaced with a selector switch, and the circuit of Fig. 2 omitted.

To set the pots for the correct voltages, start by selecting the 25V position and setting RV3 to give an output of 25V. The other two pots may then be adjusted to give their respective output voltages, but RV3 (which will affect all output voltages) should not be readjusted.

As with all *Blueprints*, component values are not gospel and you should experiment for the best results.

Andrew Armstrong

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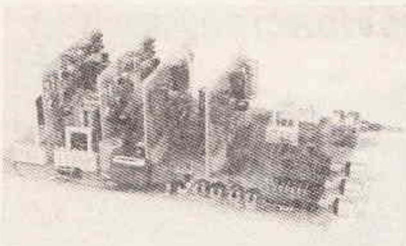

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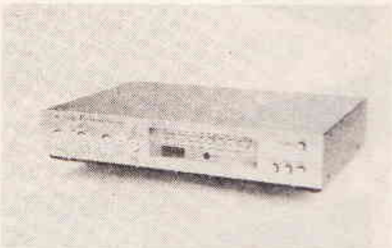

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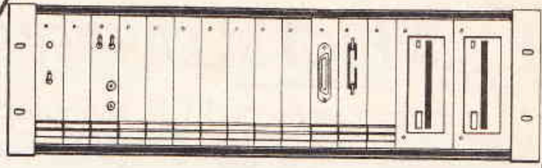

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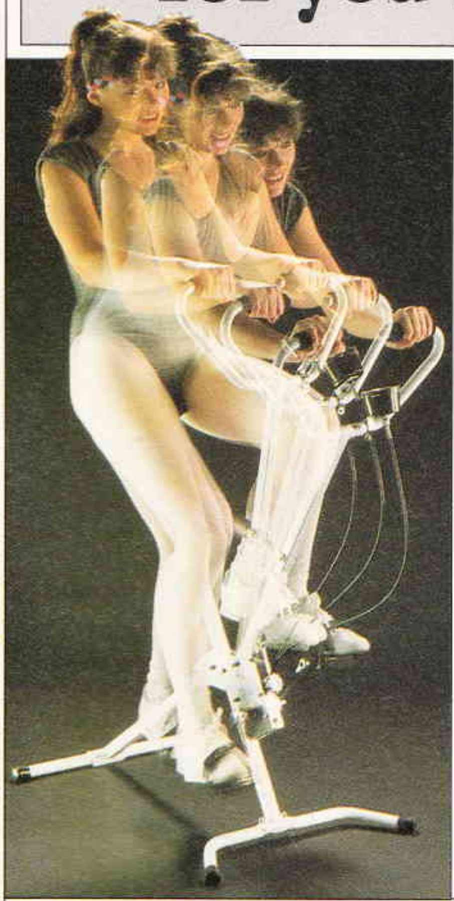

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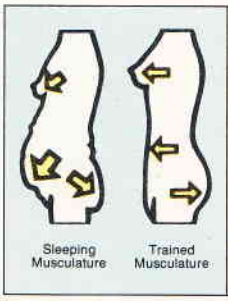

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