TWO NEW FEATURES & CB NEWS INSIDE

Hobby Electronics

May '81

ISSN 0142-6192

60p

For A Down-To-Earth Approach To Electronics

Electronic Organ - build it at home for under £100

- FIVE full octaves
- Special-offer kit

Electronics In Musical Instruments - what electronics has brought to music

GADGETS GAMES & KITS

NEW REGULAR PULL-OUT SUPPLEMENT

See centre pages

Audio Millivoltmeter - measures low-level AC voltages

PLUS 4 OTHER easy-to-build projects

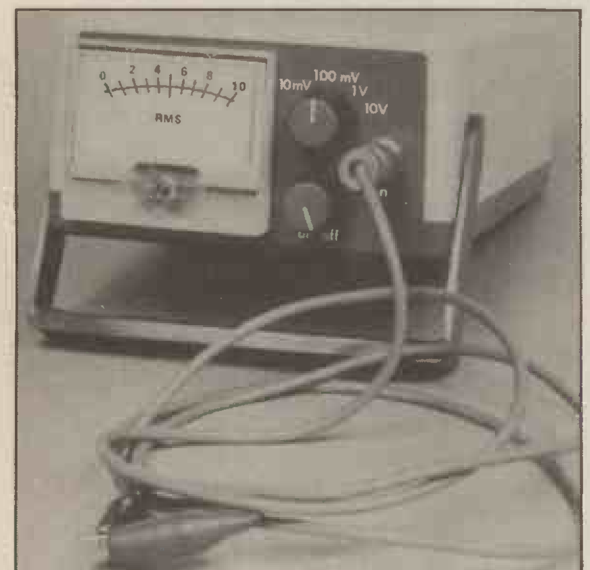

Ever wondered
who buys electronics today?
You'd be surprised!
ectronics market is rapidly expanding. Whether it's
equipment, accessoiries or what have you,
it's b g increasingly dificult to keep up with the latest
ents. Or to get them.
t's where we come in. We probably have just what you're
looking and a lot more besides. We stock all the top makes...
at prices will just make you love us. Simply phone, write or telex
WINTRoY Ltd., 103 High Street, Shepperton, Middlesex TW 17 9 BL,
England, Tel. Walton-on-Thames (STD 09322) 48145 and find out.
80-92
Or just simply call us.
TON AHLERS
ELEKTRONIKA B.V.
Aalsmeerderdijk 349, 1436 BH Rijsenhout - Holland, tel. 010 31 2977-2 86 11 (4 lines), telex 15181 tonel nl. (near Schiphol Airport).
Even the old boys circuit is getting electronicized. With our help.

Hobby Electronics

MAY 1981
Vol 3 No 7

Editor: Hugh Davies **Assistant Editor:** Keith Brindley
Drawing Office Manager: Paul Edwards **Group Art Editor:** Paul Wilson-Patterson BA
Managing Editor: Ron Harris BSc

PROJECTS



FEATURES

NEWS & INFO

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4

I.L.P

SIMPLY AHEAD and staying there

The range grows bigger...better...

New Profile Amplifiers - Two New Series

HY120

HY60

MOSFET

CHOOSE AN I.L.P MOSFET POWER AMP when it is advantageous to have a faster slew rate, lower distortion at higher frequencies, enhanced thermal stability, the ability to work with complex loads without difficulty and complete absence of cross-over distortion. I.L.P's exclusive encapsulation technique within fully adequate heatsinks has been taken a stage further with specially developed computer-verified 'New Profile' extrusions. These ensure optimum operating efficiency from our new MOSFETS, and are easier to mount. Connection is via five pins on the underside. **I.L.P MOSFETS ARE IDENTICAL IN PERFORMANCE TO THE COSTLIEST AMPLIFIERS IN THIS EXCITING NEW CATEGORY BUT ARE ONLY A FRACTION OF PRICES CHARGED ELSEWHERE.**

Model	Output Power RMS	Distortion Typical at 1KHz	Slew Rate	Rise Time	Signal/Noise Ratio DIN AUDIO	Price & VAT
MOS120	60W into 4-8Ω	0.005%	20V/μs	3μs	100dB	£25.88 + £3.88
MOS200	120W Into 4-8Ω	0.005%	20V/μs	3μs	100dB	£33.46 + £5.02

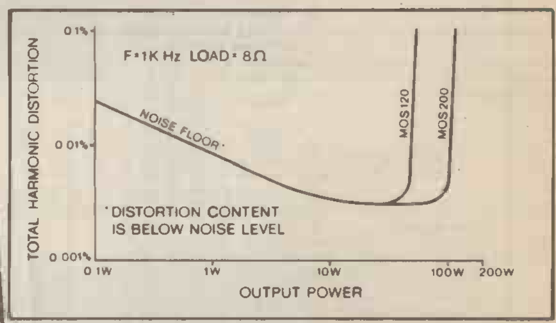
I.L.P POWER AMPS ARE ENCAPSULATED FOR THERMAL STABILITY AND LONGER LIFE

BIPOLAR

(Standard O-P Transistors)

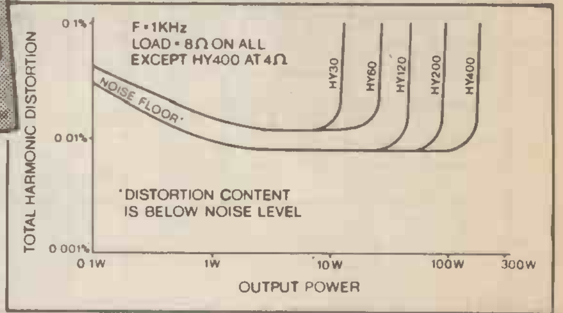
CHOOSE AN I.L.P BIPOLAR POWER AMP where power and price are first consideration while maintaining optimum performance with hi-fi quality and wide choice of models. From domestic hi-fi to disco and P.A., for instrument amplification, there is an I.L.P Bipolar to fill the bill, and as with our new Mosfets, we have encapsulated Bipolars within our New Profile extrusions with their computer-verified thermal efficiency and improved mounting shoulders. Connections are simple, via five pins on the underside and with our newest pre-amps and power supply units, it becomes easier than ever to have a system layout housed the way you want it.

Model	Output Power RMS	Distortion Typical at 1KHz	Slew Rate	Rise Time	Signal/Noise Ratio DIN AUDIO	Price & VAT
HY30	15W into 4-8Ω	0.015%	15V/μs	5μs	100dB	£7.29 + £1.09
HY60	30W into 4-8Ω	0.015%	15V/μs	5μs	100dB	£8.33 + £1.25
HY120	60W into 4-8Ω	0.01%	15V/μs	5μs	100dB	£17.48 + £2.62
HY200	120W into 4-8Ω	0.01%	15V/μs	5μs	100dB	£21.21 + £3.18
HY400	240W into 4Ω	0.01%	15V/μs	5μs	100dB	£31.83 + £4.77



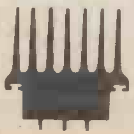
Load impedance both models 4Ω-∞ Input sensitivity both models 500mV

Input impedance both models 100KΩ Frequency response both models 15Hz-100KHz – 3dB



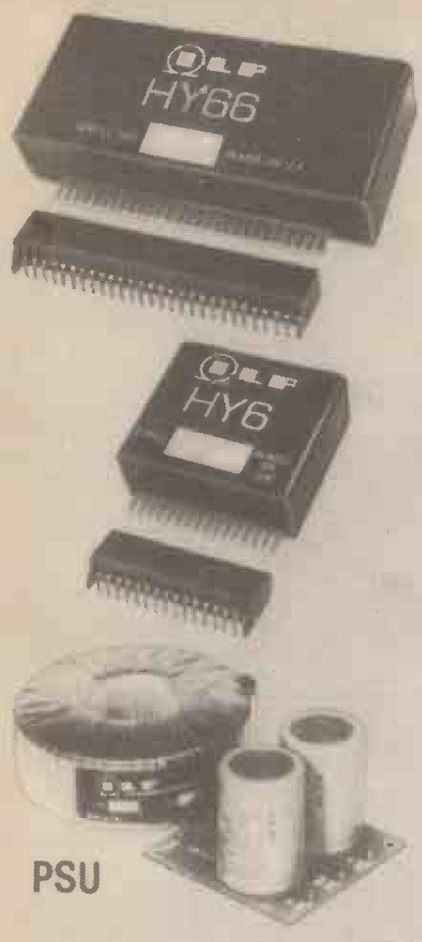
Load impedance all models 4Ω-∞ Input sensitivity all models 500mV

Input impedance all models 100KΩ Frequency response all models 15Hz-50KHz – 3dB



THE NEW PROFILE EXTRUSIONS

The introduction of standard heatsink extrusion for all I.L.P. power amplifiers achieves many advantages:— Research shows they provide optimum thermal dissipation and stability. Slotted shoulders allow easy mounting; standardisation enables us to keep our prices competitive. Surfaces are matt black, anodised for higher thermal conductivity. Extrusions vary in size according to module number.



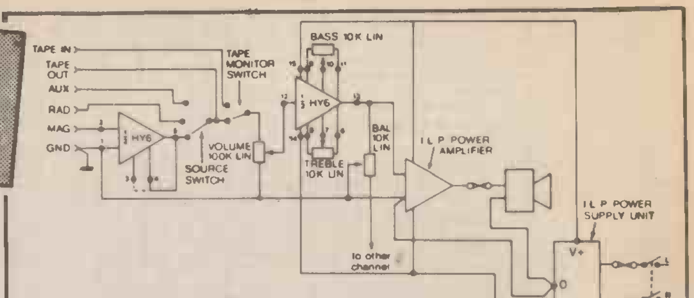
NEW PRE-AMPS

HY6 (mono) and **HY66** (stereo) are new to I.L.P's range of advanced audio modules. Their improved characteristics and styling ensure their being compatible with all I.L.P power-amps both MOSFET and BIPOLAR, giving you chance to get the best possible reproduction from your equipment. HY6 and HY66 pre-amps are protected against short circuit and wrong polarity. Full assembly instructions are provided. Mounting boards are available as below.
Sizes – **HY6** – 45 x 20 x 40 mm. **HY66** – 90 x 20 x 40 mm.
Active Tone Control circuits provide ±12dB cut and boost.
Inputs Sensitivity – Mag. PU. –3mV: Mic – selectable 1-12mV: All others 100mV. **Tape O/P** – 100mV: **Main O/P** – 500mV: **Frequency response** – D.C. to 100KHz – 3dB.

HY6 mono £6.44 + 97p VAT Connectors included
HY66 stereo £12.19 + £1.83 VAT Connectors included

B6 Mounting Board for one HY6 78p + 12p VAT
B66 Mounting Board for one HY66 99p + 15p VAT

COMPATIBLE WITH ALL ILP MODULES



SCHEMATIC BLOCK DIAGRAM OF HY6 PRE-AMP, WITH STEREO CONNECTION SHOWN

- **DISTORTION TYPICALLY 0.005%**
- **S/N RATIO – 90dB (Mag. P.U. – 68 dB)**
- **38 dB overload margin on Mag. P.U.**
- **LATEST DESIGN HIGH QUALITY CONNECTORS**
- **ONLY POTS, SWITCHES AND PLUGS/SOCKETS NEED ADDING**
- **NEEDS ONLY UNREGULATED POWER SUPPLY ±15 to ±60v**

NEW POWER SUPPLY UNITS

IN A RANGE OF 11 MODELS USING LATEST TOROIDAL TRANSFORMERS

Of the eleven power supply units which comprise our current range, nine have toroidal transformers made in our own factory. Thus these I.L.P power supply units are space-saving, more efficient and their better overall design helps enormously when assembly building. All models in the range are compatible with all I.L.P amps and pre-amps with types to match whatever I.L.P power amps you choose.

PSU30 ± 15V at 100mA to drive up to 12 x HY6 or 6 x HY66	**£4.50** + 0.68p VAT
● *THE FOLLOWING WILL ALSO DRIVE I.L.P PRE-AMPS*	
PSU36 for use with 1 or 2 HY30's	**£8.10** + £1.22 VAT
● *ALL THE FOLLOWING USE TOROIDAL TRANSFORMERS*	
PSU50 for use with 1 or 2 HY60's	**£10.94** + £1.64 VAT
PSU60 for use with 1 HY120	**£13.04** + £1.96 VAT
PSU65 for use with 1 MOS120	**£13.32** + £2.00 VAT
PSU70 for use with 1 or 2 HY120's	**£15.92** + £2.39 VAT
PSU75 for use with 1 or 2 **MOS120**	**£16.20** + £2.43 VAT
PSU90 for use with 1 **HY200**	**£16.20** + £2.43 VAT
PSU95 for use with 1 **MOS200**	**£16.32** + £2.45 VAT
PSU180 for use with 1 HY400 or 2 **HY200**	**£21.34** + £3.20 VAT
PSU185 for use with 1 or 2 **MOS200**	**£21.46** + £3.22 VAT

1971-1980
TEN YEARS OF PLANNED PROGRESS

When, in 1971, Ian L. Potts founded his now world-famous company, he saw the need for a different and more rational approach to exploiting to the full, the potential that lay in modular construction. New thinking was badly needed. The result was a range of modules revolutionary in concept. The rightness of this new thinking is shown by the size of the company today, its new factory, its vast exports, its acceptance by constructors as *the* modules to build with. The range grows bigger and better. Exciting new lines (in no way conflicting with existing ones) are well past drawing board stage. This is why I.L.P are simply ahead and staying there.

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Monitor

Successor To ZX80

Those of you who play with microcomputers will be familiar with the ZX80 from Sinclair Research. Early in March its successor was announced: the ZX81. This new computer features enhanced BASIC and it costs only £49.95 in kit form or £69.95 ready built. (The ZX80 cost £99.95.)

A total of 22 ICs were used in the ZX80: its main processing unit handled the data processing and also drove the display, using one ROM (read only memory). As a result, the data display on a TV screen suffered from 'flicker'.

By comparison, the ZX81 has only *four* ICs. One of these is a custom device from Ferranti which contains the functions of 18 of the chips in the '80. An additional feature of this device is a flicker-free operation.

The ROM in the '81 has double the storage of that in the '80, and it can be plugged directly into the earlier machine. All that's needed is an overlay for the keyboard, which is encouraging for ZX80 owners, who might have felt that their machine has become outdated. One problem, though: changing the ROM to the '81 type won't eliminate the flicker.

Scheduled for launch in June this year is a new printer for use with the '81. (It also can be used with the '80, if the computer is fitted with the '81 ROM.) This printer, priced at £49.95, uses electrosensitive paper and uses two styli, with one in contact with the paper at any time. It will enable a screen-full of information to be 'dumped' to paper in 12 s, or a complete listing of a program to be made, even if it exceeds screen length. The printer is also claimed to be compatible with Prestel — and Sinclair Research has unrevealed plans for this.

Screen display is 32 characters to the line — compatible with the US television market. A total of 40 characters/line are required for Prestel and, as pointed out by Clive Sinclair, managing director of Sinclair Research, this would require a change of the ROM and the reference crystal. He said that his company hadn't decided how to do it yet.

Sinclair Research is also launching into software, in the form of compact-cassettes, each containing between three and seven programs on computer-quality tape. Cost is £3.95 for each cassette, together with documentation. (Take note, though: ZX81 programs cannot be run on ZX80s without modification, and vice-versa.)

In comments to the Press early in March, Clive Sinclair said that he couldn't understand why the Sinclair system had not been chosen by the BBC for its planned series of computer literacy programmes. (The choice of the Beeb is a computer being manufactured specially for the BBC by Acorn Computers of Cambridge, and based on the forthcoming PROTON — see report in Computing Today, April 1981, page 6.)

Nonetheless, the ZX81, with its improved features over the '80, and with accessories such as printer, software and a plug-in 16K RAM (compatible with the ZX80) for memory extension, is likely to be highly successful.

Do-It-Yourself Kits From Blaupunkt

During May, Blaupunkt (Robert Bosch in the UK) is to launch four of its car radio and radio/cassette models — Hamburg, Tempelhof CR, Hamburg CR and Mannheim CR — in do-it-yourself packs.

Perhaps 'fit-it-yourself' would be more appropriate, because each take-away pack contains the radio (or radio/cassette combination), two loudspeakers and a fitting kit.

Although the fitting kit is claimed to add only £1.40 to the total cost, it enables you to fit the radio or combination in the dash panel (into a 7 by 2" slot or with just the knobs and control fascia showing) or under the panel.

Included with the kit is a detailed 8-page booklet 'Installing your Blaupunkt auto sound system', which gives well-illustrated instructions on how to do the fitting. For instance, it guides you on the choice of tools for the job and even includes a useful teach-in on wavebands and fading and interference problems.

What the kit *does not* include is an aerial (although you are advised on the choice) or any interference suppression components. Future special offers may feature free interference *diagnosis*, but Robert Bosch sees interference elimination as being a specialist job. (Elimination, that is, not a crackle-ridden compromise.)

HE hopes to do a step-by-step evaluation of one of these kits and to look at some other Blaupunkt products in a forthcoming Gadgets, Games & Kits supplement. Stay tuned to this channel.

Details on the Montreal CR and the kit from: Robert Bosch Ltd., PO Box 166, Rhodes Way, Watford WD2 4LB (Tel. 92 44233).

Montreal Has Station Search

Nothing to do with the Canadian city, Montreal CR is a car cassette/radio combination, priced at £162 plus VAT, from Blaupunkt. It has some of the features usually found on this company's higher-priced models, such as the Banberg QTS (£450 RRP), notably 'station search'.

Instead of the conventional chord-and-pulley tuning scale system, the Montreal has a line of 16 LEDs, each indicating one spot frequency on the LW, MW or VHF bands. (Who ever looks at the *precise* frequency when driving along?)

Station selection on VHF is merely a matter of pressing a two-way rocker switch: the receiver stops at each station in turn as it sweeps up or down the waveband. A knob has to be twiddled for MW or LW stations.

In common with the Banberg QTS, a quartz crystal controlled phase-locked-loop circuit is used for the automatic tuning. The difference is that the Montreal's tuning circuit is voltage-stabilised (satisfactory for the LED display) while that of the Banberg is frequency-synthesised (a must for digital read-out of frequency).

The price tag of the Montreal may seem high for in-car entertainment, but it's peanuts really, compared with the top-of-the-range Berlin 8000 model which sells for around £660 RRP.

Montreal has electronic station programming on VHF, last-station memory on MW and LW and a cassette replay frequency response of 40 Hz to 14 kHz. Audio output power is 10 W/channel. Illumination is provided on the front panel.

And Now The Bad News . . .

We're sorry to report that Hobby Electronics '81, which was due to be held at the Bristol Exhibition Centre from 29 to 31 May, has been *postponed*.

Because of lack of support from exhibitors we felt that we could not have put on as good an exhibition as we would have wished for you. And so we're postponing it until we are better supported and are certain that we can give you 'the best for the West'.

Meanwhile, the Wales and West schools' electronics project competition, which was announced along with the exhibition, is *still running*. We'll publish more details in the next issue of HE.

Lindström Cutters On Test

We heard recently from Bahco Tools, Oxford, that its series 80 cutters from Lindström had proven life in excess of a million cuts.

Must be worth trying, we thought, and put a pair of model 8140 diagonal side-cutting nippers on test. (By 'on test' we don't mean repeating the million-cut operation!)

These are without doubt high-quality tools intended primarily for production work. In the hobbyists hands they should give many years of use. Although the 8140 and 8141 models are not box-jointed (a precision screw-and-nut joint is used instead), cutting action was found to be positive.

It is claimed that the screw and nut, as well as the surfaces of the joint, are precision-ground to ensure smooth operation without play throughout working life.

Handles are made from 'non-slip impact-resistant plastic'. These were found to be comfortable in prolonged use.

Cutters are finished in black oxide to prevent reflection. This oxide is claimed to have high corrosion resistance.

Leaf springs on the insides of the handle shanks can be renewed.

Model 8140 has a bevelled cutting edge which is hard enough to cut iron wire. The 8141 has a sharp flush edge and is recommended for use only with copper wire. Clip-on off-cut retaining clips (to catch flying bits of wire) are also available for the two.

Both models cost £12.34 (plus VAT) each.

Details from: Bahco Tools Ltd., Beaumont Rd., Banbury, Oxon 0X16 7TB. (Tel. 0295 57461).

T & J's Latest Cat

Comprehensive has become the usual word to describe catalogues but it is true of this one from T & J Electronic Components, which covers a good variety of items, ranging from adaptors to zener diodes.

You should find many of the components and miscellaneous items used in HE projects in this 52-page book. Assorted packs of components are also available (these contain unused — but untested — items), together with a selection of tools, PCB materials and other hardware. Cost of the catalogue is 45p post paid.

T & J's services include photocopies of data sheets (25p/device) and a component enquiry postal service (SAE required with enquiries). The company has been in operation over the last 2½ years. Although most orders are handled by post, callers are welcome at the address below.

T & J Electronic Components, 98 Burrow Road, Chigwell, Essex IG7 4HB (Tel. 01-500 7073/ 9705)

Last Chance To Hear HE Organ

As mentioned in Monitor last month, a special demonstration of the HE Electronic Organ, starting this month on page 11, has been arranged by the Electronic Organ Constructors Society.

This organ is large as HE projects go, and so you may like to 'hear before you build'. We think it sounds very good: if you don't believe us, hear it for yourself at 2.30 pm on Saturday 16 May at:

St. David's Church Hall,
Lough Road,
London N7

Nearest Underground station is Caledonian Road (Piccadilly line).

New TVs For Old

No, not a special offer, but some incorrect information in the March '81 issue on one of the TVs shown on the cover of that issue.

The newest TV (centre) was described on the Contents page and in the article The Beginnings Of Real TV as a Colorstar TV made by Ferguson in 1968, on show at the Science Museum. Although noteworthy because it was the first all-transistor TV in the world, the 1968 receiver (model TX2000) was *not* the one in our pictures.

What we *did* show was the TX10 from Thorn-EMI, an example of which is also on show at the museum.

The TX10 is currently in production (first introduced in 1980), and it features some important technical advances. These include a chassis isolated from the mains supply and a single modular PCB. (The PCB is made up as one board in production and then 'cracked' into two and folded into an L-shape.) This chassis will take 90 or 110° tubes ranging in size from 20 to 26". Operation is from 165 to 265 VAC, and black level power consumption is only 70 W.

Component count is low, and it uses a SAW (surface acoustic wave) filter in its IF (intermediate frequency) section. This results in a dramatic reduction in IF coils.

Amateur Radio Rally In Kent

A radio rally and exhibition is to be held on Sunday 3 May at the YMCA Sportscentre, Melrose Close (off Cripple St), Maidstone, Kent.

Doors open at 9 AM (trade halls 11 AM) until 5 PM, and many items of interest to the radio amateur and electronics enthusiast alike will be on show. HE was told that a good variety of electronic components will be on sale in an 'Aladdin's cave'.

The Amateur Radio Society running the event has been in existence since before the last War, and it is closely associated with the YMCA. All proceeds from the event will go to the Maidstone YMCA and ARS funds.

Put Your Club On The Map

We would like to have details of all electronics and amateur radio clubs operating in the UK. If we get sufficient response then we will publish a regular list in HE, giving details of coming events.

It is HE's policy to give as much support as possible to groups or individuals participating in electronics — as a hobby.

Frequencies On Display

If you have £77.55 (plus VAT) to spend and would like to measure frequencies between 5 Hz and 100 MHz or more then the MAX-100 portable frequency counter could be the answer.

Available from Global Specialities Corporation (used to be known as Continental Specialities Corporation), the MAX-100 has eight 11 mm-high LED digits and it can be operated from alkaline or NiCad rechargeable cells or from a 7.5 V to 10 V supply.

Frequencies up to 999 999 Hz are displayed directly, and above 1 MHz a decimal point indicates the MHz position. 'Battery low' is indicated by the entire display flashing.

The MAX-100 comes complete with input cable, terminated in crocodile clips, and is supplied in a carrying case. A number of options are available, including the PS-500 prescaler (£30 plus VAT) to increase the measurement range up to 500 MHz.

Overall size is 45 by 143 by 197 mm and weight is 680 g including batteries.

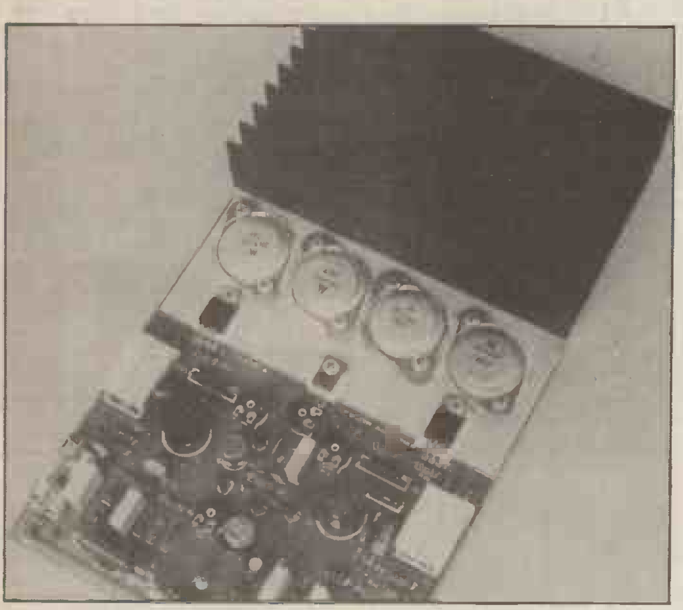
More information from: Global Specialities Corporation, Shire Hill Industrial Estate, Saffron Walden, Essex CB11 3AQ (Tel. 0799 21682).

Hobby Electronics

THE JUNE ISSUE IS ON SALE MAY 8th

Power Amplifier

Our hi-fi system continues next month with details of a very high quality (and very loud — over 100 W/channel) power amplifier. It looks good, sounds good and will be available as a kit — what more can we say?



Radio

This article traces the development of radio, from the earliest concepts, through tuned-radio-frequency receivers to modern-day superheterodyne types. As you will see from Radio, there's more to the average 'tranny' than many people realise.

Envelope Generator

An easily-built musical effect, which alters the structure of a musical instrument, enabling it to sound like another. With practice, you can make your guitar sound like a violin, your organ sound like a drum, or your piano sound like a guitar.

Continuity Tester

The beauty of an audible continuity tester such as ours is that you can concentrate on positioning the probes without having to look away from the item under test. You can literally *hear* the differences between short circuits, open circuits, coils and low resistances with this cheap (£5 or under) and simply-constructed project. It's great for beginners, or 'not-so-beginners' alike.

How To Use An Oscilloscope

A step-by-step instructional guide, which teaches you (even if you've never seen a 'scope before) the basics of oscilloscope use. This article unearths some of the mysteries surrounding oscilloscope measurements.

News And Information

For all ages, for all interests, there'll be something for you next month. Projects, regular features, your own letters and viewpoints, CB are all in Hobby Electronics — the magazine that's written for the electronics enthusiast and hobbyist.

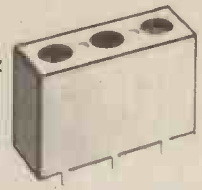
Items mentioned here are those planned, but unforeseen circumstances may affect the actual contents

Chokes, block filters, ceramic filters, resonators, IFTs, oscillator coils, audio filter blocks etc.

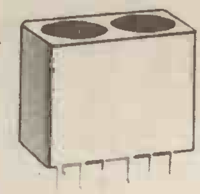
LOW PASS FILTERS

Now from 10kHz to 20MHz

TOKO's recently expanded LPF series covers from the audio spectrum through to 20MHz in a series of LPFs for mpx, video, radio etc.



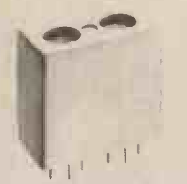
The LPFs are based on 7&10mm formats with up to 4 LC tuned elements per block. Many stock types available.



HELICAL FILTERS for VHF and UHF:

2 & 3 elements available

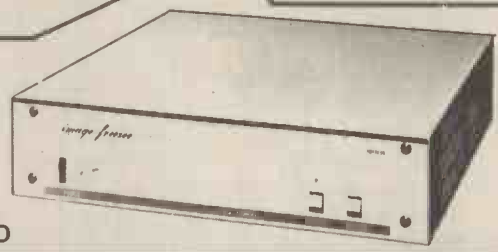
Featuring low insertion losses, -80dB at the +/- 21.4MHz points. Ask for details.



CERAMIC RESONATORS & PIEZO SOUNDERS

Audio buzzers now down to 1kHz - low cost 400-600kHz crystal replacements for MPUs, RCs etc. Low cost - wide range.

VIDEO FRAME STORES



- ★ 525/625 operation
- ★ 512 pixell/line
- ★ Local or remote control
- ★ Top/bottom & L/R reverse
- ★ Models available with digitized I/O

Video frame stores are a new addition to TOKO's memory product range. They permit easy analysis of low dose X-Ray pictures, digital processing of picture information (including the VFM10D with 8" disk drive) with much better resolution than available from VTR.

AMBIT international

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200 North Service Road, Brentwood, Essex

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LINEAR ICS

TBA120S	1.00
L200	1.95
U237B	1.28
U247B	1.28
U257B	1.28
U267B	1.28
LM301H	0.67
LM301N	0.30
LM308TC	0.65
LM324	0.64
LM339N	0.66
LM348N	1.86
LF351N	0.49
LF353N	0.76
LM374N	3.75
LM380N-14	1.00
LM380N-8	1.00
LM381N	1.81
ZN419CE	1.98
NE544N	1.80
NE555N	0.30
NE556	0.50
NE560N	3.50
NE562N	4.05
NE564N	4.29
NE565N	1.00
NE566N	1.60
NE570N	3.85
SL624	3.28
TBA651	1.81
uA709HC	0.64
uA709PC	0.46
uA710HC	0.65
uA710PC	0.59
uA741CH	0.66
uA741CN	0.27
uA747CN	0.70
uA748CN	0.36
uA753	2.44
uA758	2.35
TBA820M	0.78
TCA940E	1.80
TDA1028	2.11
TDA1029	2.11
TDA1054	1.45
TDA1062	1.95
TDA1072	2.69
TDA1074A	5.04
TDA1083	1.95
TDA1090	3.05
HA1137	1.20
HA1196	2.00
HA1197	1.00
TDA1220	1.40
LM1303	0.99
LM1307	1.55
MC1310P	1.90
MC1330	1.20
MC1350	1.20
HA1370	1.90
HA1388	2.75
TDA1490	1.86
MC1496P	1.25

SL1610P	1.60
SL1611P	1.60
SL1612P	1.60
SL1613P	1.89
SL1620P	2.17
SL1621P	2.17
SL1623P	2.44
SL624C	3.28
SL1625P	2.17
SL1626P	2.44
SL1630P	1.62
SL1640P	1.89
SL1641P	1.89
TDA2002	1.25
ULN2242A	3.05
ULN2283B	1.00
CA3080E	0.70
CA3089E	1.84
CA3090AQ	3.35
CA3123E	1.40
CA3130E	0.80
CA3130T	0.90
CA3140E	0.46
CA3189E	2.20
CA3240	1.27
MC3357P	2.85
LM3900N	0.60
LM3909N	0.68
LM3914N	2.80
LM3915N	2.80
KB4400	0.80
KB4406	0.60
KB4412	1.95
KB4413	1.95
KB4417	1.80
KB4420B	1.09
TDA4420	2.65
KB4423	2.30
KB4424	1.65
KB4431	1.95
KB4432	1.95
KB4433	1.52
KB4436	2.53
KB4437	1.75
KB4438	2.22
KB4441	1.35
KB4445	1.29
KB4446	2.75
KB4448	1.65
NE5044N	2.26
NE5532N	1.85
SD6000	3.75
SL6270	2.03
SL6310	2.03
SL6600	3.75
SL6640	2.75
SL6440	POA
SL6690	3.20
SL6700	2.35
ICL8038CC	4.50
MSL9362	1.75
MSL9363	1.75
HA11211	1.95

HA11223	2.15
HA11225	1.45
HA12002	1.45
HA12017	0.80
HA12402	1.95
HA12411	1.20
HA12412	1.55
LF13741	0.33
SN76660N	0.80

FREQ. DISPLAY AND SYNTH. DEVICES

SAA1056	3.75
SAA1058	3.35
SAA1059	3.35
11C90DC	14.00
LN1232	19.00
LN1242	19.00
MSL2318	3.84
MSM5523	11.30
MSM5524	11.30
MSM5525	7.85
MSM5526	7.85
MSM5527	9.75
MSM55271	9.75
MSL2312	3.94
SP8629	3.85
SP8647	6.00
95H90PC	7.80
HD10551	2.45
HD44015	4.45
HD12009	6.00
HD44752	8.00
MC145151	12.45
MC145156	8.75

MISC

ICM7106CP	9.55
ICM7107CP	9.55
ICM7216BP	19.50
ICM7555	0.94

4000 series

4000	0.18	4068	0.25
4001	0.18	4069	0.25
4002	0.24	4070	0.30
4007	0.30	4071	0.24
4008	0.80	4072	0.24
4008AE	0.80	4073	0.24
4009	0.58	4075	0.25
4010	0.58	4076	0.90
4011AE	0.24	4077	0.35
4011B	0.24	4078	0.30
4012	0.56	4082	0.28
4013	0.55	4093	0.86
4015	0.95	4175	1.15
4016	0.52	4503	1.15
4017	0.80	4506	0.68
4019	0.60	4510	0.99
4020	0.98	4511	1.49
4021	0.82	4512	0.98
4022	0.96	4514	2.55
4023	0.25	4518	1.03
4024	0.76	4520	1.09
4025	0.25	4521	2.36
4026	1.80	4522	1.49
4028	0.79	4529	1.61
4029	1.04	4539	1.28
4030	0.59	4549	3.50
4035	1.20	4554	1.73
4040	0.98	4560	2.18
4042	0.85	4566	1.59
4043	0.85	4568	2.18
4043AE	0.93	4569	3.03
4044	0.94	4572	0.30
4046	1.30	4585	1.00
4047	0.99		
4049	0.52		
4050	0.55		
4051	0.78		
4052	0.79		
4053	0.78		
4060	1.54		
4063	1.18		
4066	0.57		

TTL

TTL	'N'	'LSN'
7400	0.13	0.20
7401	0.13	0.20
7402	0.14	0.20
7403	0.14	0.20
7404	0.14	0.24
7405	0.18	0.26
7406	0.36	
7407	0.38	
7408	0.19	0.24
7409	0.21	0.24
7410	0.18	0.24
7411	0.26	0.32
7412	0.27	
7413	0.32	
7414	0.51	
7415		0.40
7416	0.30	
7417	0.30	
7420	0.19	0.24
7421	0.38	0.24
7423	0.27	
7425	0.27	
7427	0.32	0.35
7428	0.35	0.35
7430	0.17	0.26
7432	0.32	0.28
7437	0.40	
7438	0.33	0.35
7440	0.20	0.28
7441	0.74	
7442	0.70	0.99
7443	1.15	
7444	1.12	
7445	1.05	
7446	1.32	
7447		0.89
7448	0.56	0.99
7449		0.99
7451	0.20	0.25
7453	0.20	

TTL	'N'	'LSN'
7454	0.20	0.30
7455		0.30
7460	0.20	
7463		1.24
7470	0.40	
7472	0.30	
7473	0.35	0.45
7474	0.35	0.35
7475	0.56	
7476	0.41	0.45
7478		0.50
7480	0.52	
7481	1.20	
7482	0.75	
7485	1.04	0.99
7486		0.40
7489	2.05	
7490	0.42	0.90
7491	0.85	1.25
7492	0.50	0.78
7493	0.57	0.99
7494	0.85	
7495	0.70	1.15
7496	0.58	1.20
7497	1.85	
74107		0.45
74109	0.63	
74110	0.54	
74111	0.68	
74112		0.41
74113		0.75
74114		0.40
74118	0.85	
74120	1.15	
74121	0.48	
74122	0.46	
74123	0.73	
74124		1.80
74125	0.55	0.46
74126	0.57	0.46

TTL	'N'	'LSN'
74128	0.74	
74132	0.73	0.78
74136		0.40
74138		0.72
74141	0.75	
74142	2.65	
74143	3.12	
74144	3.12	
74145		0.97
74147	1.75	
74148	1.09	1.19
74150	0.99	
74151	0.55	0.90
74153	0.70	0.85
74154	1.30	
74155	0.75	1.10
74156	0.80	
74157	0.78	0.70
74158		0.71
74159	2.10	
74160	0.99	1.30
74161	0.99	0.98
74162		1.30
74163	0.99	0.95
74164	1.20	1.30
74165	1.20	1.45
74167	2.50	
74169		2.10
74170	2.30	2.88
74174	1.05	1.20
74175	0.87	1.10
74176	0.80	
74177	0.84	
74181	2.80	3.50
74183		2.98
74184	1.35	
74185	1.34	
74190	0.92	
74192	1.20	1.80
74193	1.42	1.80

TTL	'N'	'LSN'
74194	1.05	
74196	1.34	1.20
74197	1.10	
74198	1.60	
74199	1.60	
74247		0.93
74257		1.08
74260		0.89
74279		0.88
74283		1.20
74293		1.32
74365		0.66
74366		0.65
74367		0.64
74368		0.92
74374		1.80
74377		1.99
74379		2.15
74393		1.40

VOLTAGE REGS.

78 series	0.95
79 series	1.00
78M series	0.65
78L series	0.35
79L05	0.85
78MGT2C	1.75
79MGT2C	1.75
723CN	0.65
L200	1.95
TDA1412	0.75
NE5553N	1.25
LM317MP	1.48
LM337MP	1.48

MICROMARKET

8080A/2	7.50
8212	2.30
8214	3.50
8216	1.95

MICROMARKET

8224	3.50
8251	6.25
8255	5.40
6800P	7.50
6810	5.95
6820	7.45
6850	4.90
6852	4.85
MC2708	6.00
2114	6.50
4027	5.78
2102	1.70
2112	3.40
2513	7.54
HM4716	4.00
81LS97	1.25

LEDS LEDS

FLAT TOP LEDS:
SHAPES............
SQUARE 3x3mm
RECT. 2.5x5mm
TRIA. 2.5x5mm
TRIA. 3x3mm
TRIA. 5x5mm
ROUND 3mm
ROUND 5mm

PRICED BY COLOUR:

Red	17p
Green	20p
Yellow	20p
Orange	26p

LEDS

STD DOMED TYPES

5mm RED	12p
3mm RED clr	15p
3mm RED	15p
2.5x5 RED	17p
5mm GRN	15p
3mm GRN clr	16p
3mm GRN	16p
2.5x5 GRN	20p
5mm YL	15p
3mm YL clr	16p
3mm YL	18p
2.5x5 YL	20p
5mm ORA	20p
5mm ORA clr	29p
3mm ORA	19p
2.5x5 ORA	24p
5mm Infra Rd	56p
BPW41 IF Det	1.51
IF Opto Cplr	1.44
5mm Clip	5p

TRANSISTORS

BC237	8p
BC238	8p
BC239	8p
BC307	8p
BC308	8p
BC309	8p
BC413	10p
BC414	11p
BC415	10p
BC416	11p
BC546	12p
BC556	12p
BC550	12p
BC560	12p
BC639	22p
BC640	22p
2SC1775	18p
2SA872A	14p
2SD666A	30p
2SB646A	30p
2SO668A	40p
2SB648A	40p
2SD760	45p
2SB720	45p
2SC2547	19p
2SA1085	20p

TRANSISTORS

BF256	38p
2SK55	28p
2SK168	35p
J310	69p
J176	65p
40823	65p
40673	3SK51
3SK45	49p
3SK51	54p
3SK60	58p
3SK88	1.24
MEM680	75p
BF961	70p
BF194	18p
BF195	18p
BF224	22p
BF241	18p
BF274	18p
BF440	21p
BF441	21p
BF362	49p
BF395	18p
BF479	66p
BF679S	55p
BFR91	1.33
BFW92	60p
BFT95	99p
BFY90	90p
40238	85p
2SB753	2.34
2SB723	2.34
2SK134	3.10
2SJ49	3.10
2SK135	4.25
2SJ50	4.25
2SK227	3.55
2SJ83	3.55
VN66AF	95p
2N3866	85p

CRYSTALS

32.768kHz	2.70	10.245	2.00
100kHz	3.85	10.6985	2.50
455kHz	5.00	10.700	2.00
1.000MHz	2.95	10.7015	2.50
3.2768	2.70	11.00	2.00
4.000	2.00	11.115	2.00
4.1934	2.00	11.520	2.00
4.096	2.00	8.9985	2.00
4.032	2.00	9.0015	2.00
4.433619	2.00	21.000	2.00
4.800	2.00	24.000	2.00
5.000	2.00	25.000	2.00
6.5536	2.00	26.000	2.00
7.000	2.00	18.000	2.50
7.68	2.00		
8.000	2.00		
9.000	2.00		
10.000	2.00		
10.240	2.00		

XTAL FILTERS

10M4B1; 10.7Mhz, 15Khz BW, 8 pole. 14.50

10M22D; 10.7Mhz, 2.4Khz BW, SSB, 8 pole. 17.20

RADIO CONTROL

RC XTALS
AM TX/RX
FM RX:
3rd ot/30pF HC25U 1.65
FMTX: Fund 20pF HC25U ½ freq 1.85
PAIRS...AM 3.10
PAIRS...FM 3.25
CHANNELLING:
27MHz. 50kHz
35MHz: 20kHz

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This listing gives a brief insight into the wide range of active and passive components available from AMBIT. Our full catalogues & pricelist include the LARGEST STOCK RANGES OF COILS, CHOKES, CERAMIC/MECHANICAL/CRYSTAL FILTERS, all types of radio modules for AM/FM/SSB - plus the most sophisticated DIY FM tuner parts in the world. £1.85 (inc) will get you full set of catalogues (pts. 2,3 & 4) or 75p per individual section.

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200 North Service Road, Brentwood, Essex

Electronic Organ

This is the ideal project for the home constructor with an interest in music. Our do-it-yourself electronic and polyphonic organ is no toy but a real musical instrument yet it should cost you under £100

ONE OF THE MOST expensive single items in an organ is the keyboard and inevitably (in an effort to keep the total price as low as possible), manufacturers often skimp in this area by using a short type of, say 3½ octaves (ie from tenor F to the C two octaves above middle C). This is a pity, because genuine organ music is written for a longer keyboard extending down to the C, two octaves below middle C.*

Our organ has a keyboard of five octaves; ie, 60 notes. This long span is advantageous to the music student learning to play organ at home, and to the on-stage performer. And yet we have still kept the overall price low by avoiding the use of expensive (about 30p each *note*) electrical contacts. Instead, the HE Organ uses contacts which are *made* at home by the builder for a *total* cost of just a few pence.

Included in the organ is a 2 W monitor amplifier which is sufficient to drive a loudspeaker at sufficient volume for home listening. This monitor amplifier can also drive a pair of headphones. There is a provision to connect the organ to an external power amplifier if greater volume is required. These three listening modes therefore allow the organ's use in at least three ways:

- as a practice instrument
- for family pleasure
- as a concert instrument.

A modular construction of four printed circuit boards (PCBs) enables the hobbyist to build up each section step by step, rather than relying on one large board with everything on it. This is better when building such a large and complex circuit because each stage can be tested before moving on to the next, and faults (if they occur) can be more easily found and repaired.

Housing for the HE Electronic Organ is left up to the reader as we appreciate that many of you will have different ideas on how an organ should look. A view of a typical layout of the project can be seen in the photographs of our prototype but this needn't be adhered to if you prefer another. As you can see, the overall dimensions are governed largely by the length of the keyboard. You should find our layout the easiest to follow.

Construction

Plan out and mount: the keyboard, the PCBs (on their guide rails), the three control panels and all electrical hardware on the baseboard. **Figure 6** shows a plan view of the layout.

The keyboard is fastened by first mounting it on two wooden blocks (about 1" square and 5" long), one at each end of the keyboard. Two 1" hinges should be screwed onto the back end of these blocks and the whole keyboard then screwed to the baseboard so that the hinges allow it to be lifted into a vertical position.

Next, mount the PCB guide rails (made from two 25" lengths of ⅜" aluminium angle bracket) using four small lengths of bracket. Screw the small pieces to the longer lengths using self-tapping screws and then to the baseboard using ordinary screws. You will have to drill the angle bracket to fit the self-tapping screws. **Figure 1** shows the arrangement.

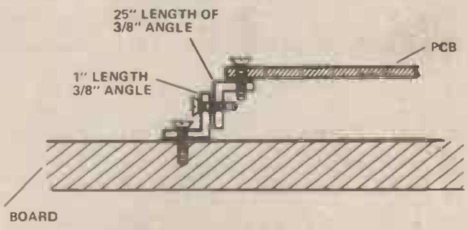


Figure 1. Section view of a PCB guiderail

Drill and fasten the PCBs to the guide rails in the positions shown using self-tapping screws, and leave them for the time being.

All three control panels should next be fastened to the baseboard and the four pots, three jack sockets, neon, fuse and holder, and grommet should be secured in their places.

Mount the transformer on the baseboard so that its secondary windings connections (ie 0 V, 12 V, 0 V, 12 V) can be soldered directly to the AC connection points on Board 1 later. Similarly, screw (or simply glue) the five-way terminal block at the side of the transformer so that short covered connections can be made from the transformer primary winding directly to it. The photograph in **Fig. 5** shows how your project should look at this stage.

* A shorter keyboard can be used but, to reproduce the lowest octave of notes, it is usually necessary to add a foot pedal unit — at extra cost — Ed

B

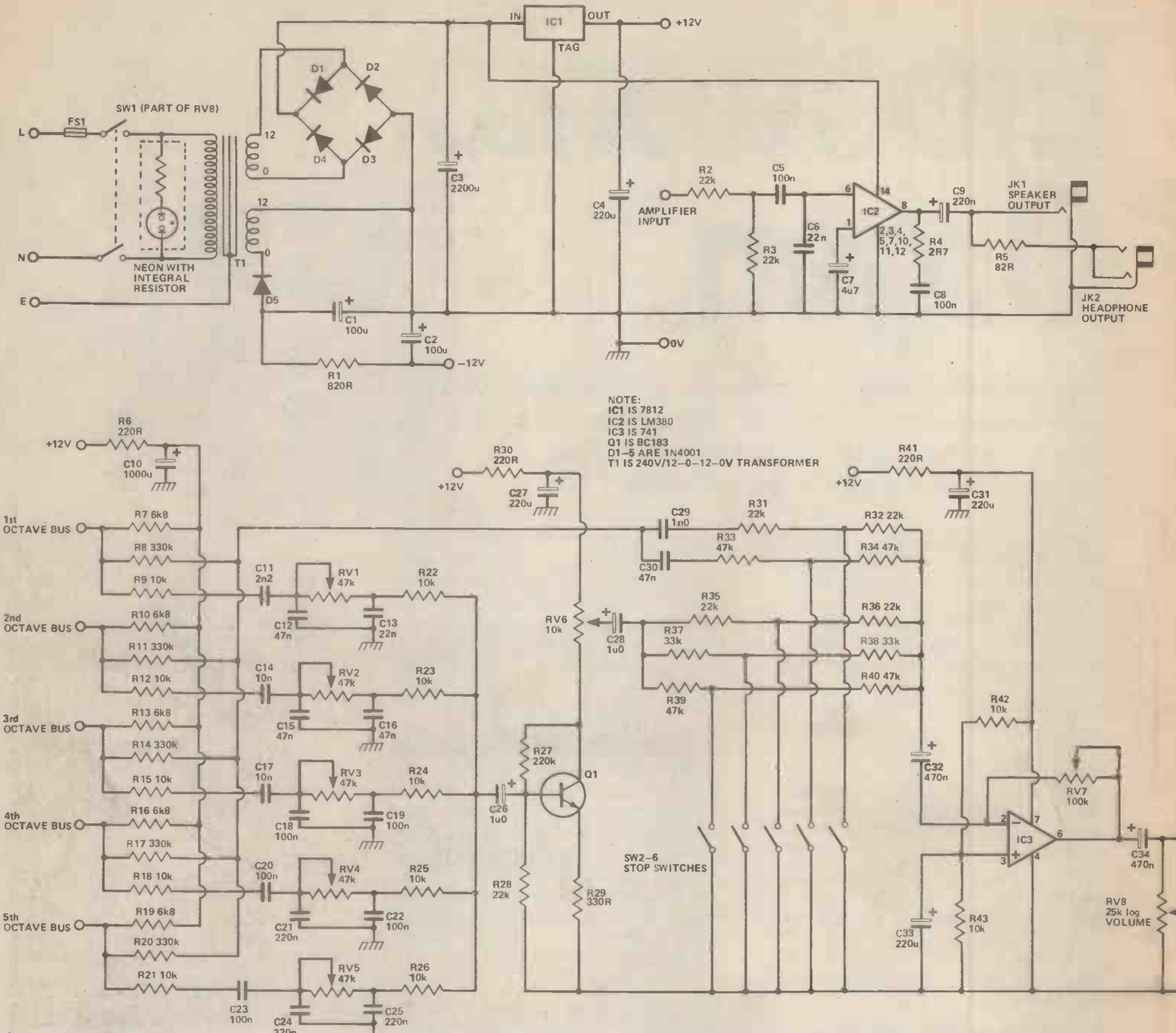


Figure 2. Circuit of Board 1 — the power supply, power amplifier, pre-amplifier and filters

Now, remove Board 1 from the guide rails and commence component insertion. Start by inserting and soldering the 23 PCB pins followed by all resistors, IC sockets (for IC2 and 3) and capacitors. Make sure that the polarised capacitors are the right way round.

Incidentally, a good tip when bending resistor leads immediately prior to insertion, especially when there are a large number as in the HE Organ, is to use a home-made jig — no, put your fiddle down, it's not a barn-dance but a short piece of wood, 1½" x ⅜" in cross-section. As you select each resistor for insertion and soldering, rest it across the ⅜" edge of the jig and bend down the leads against the wood. The resistor should then drop into its location ready for soldering.

The metal tab of integrated circuit IC1, a 12 V voltage regulator, is internally connected to the centre pin. Cut off this centre pin close to the body. Now insert and solder this IC, bend it back onto the board, and mark and drill the board so that you can bolt the IC down — the bolt makes an electrical connection between the earth track underneath and the metal tab (which is earthed) of the IC. Just before bolting the IC down, clean the copper track underneath around the bolt hole to ensure a good connection.

Screw the PCB back onto the guide rails and then wire up this board as shown in the connection diagram in **Fig. 7**. Start with the mains wiring and cover any open connections with heat-sink sleeving, to prevent probing fingers having a shocking experience. *Remember that 240 VAC can be dangerous, so be extra careful — we want you to buy HE again next month.*

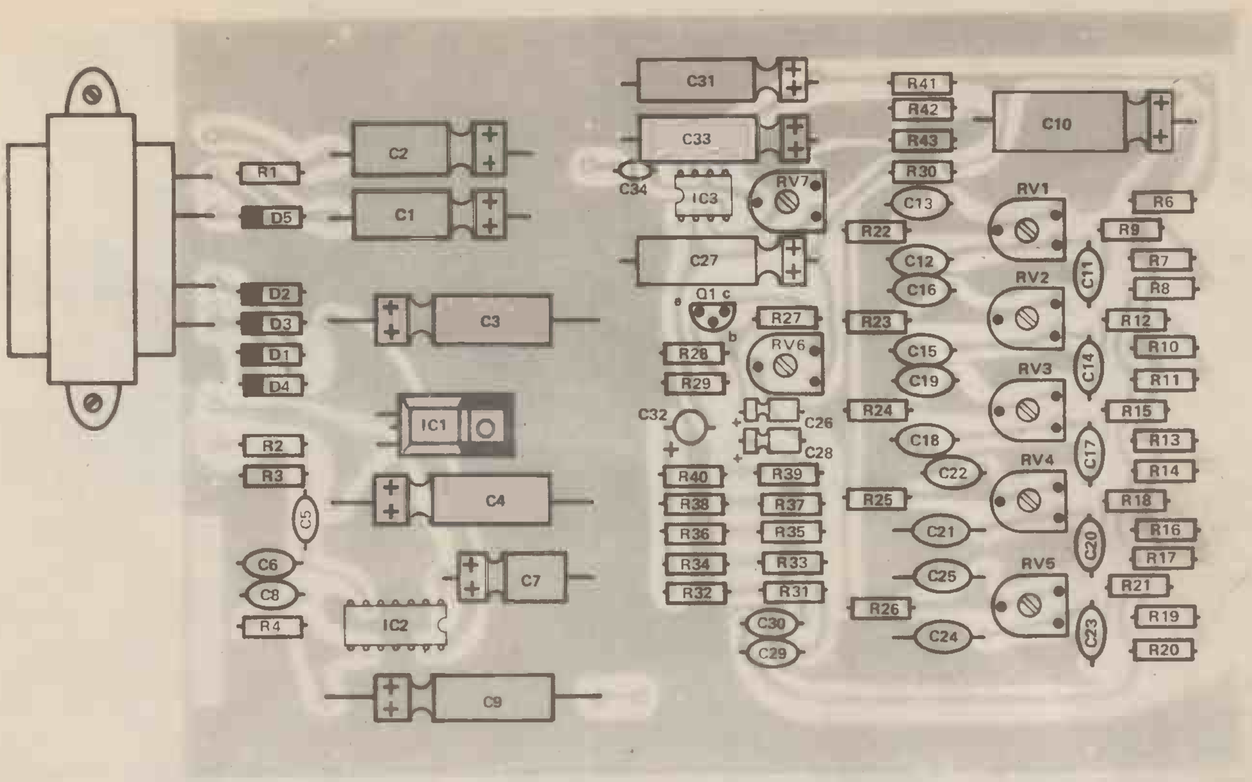


Figure 3. Overlay of Board 1

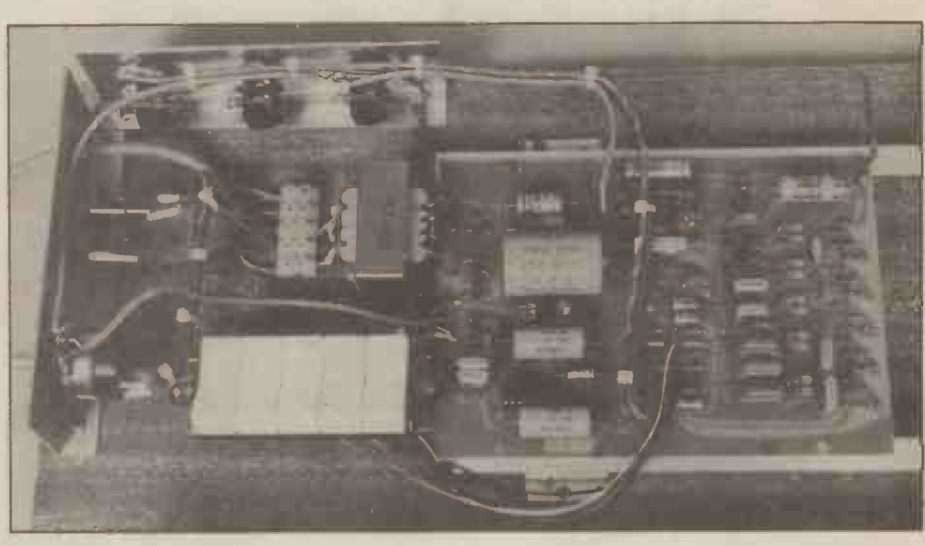


Figure 4. Close-up details of Board 1 wiring. Try to keep all mains leads away from low-level signal leads to prevent interference

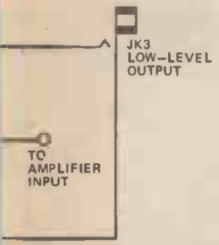


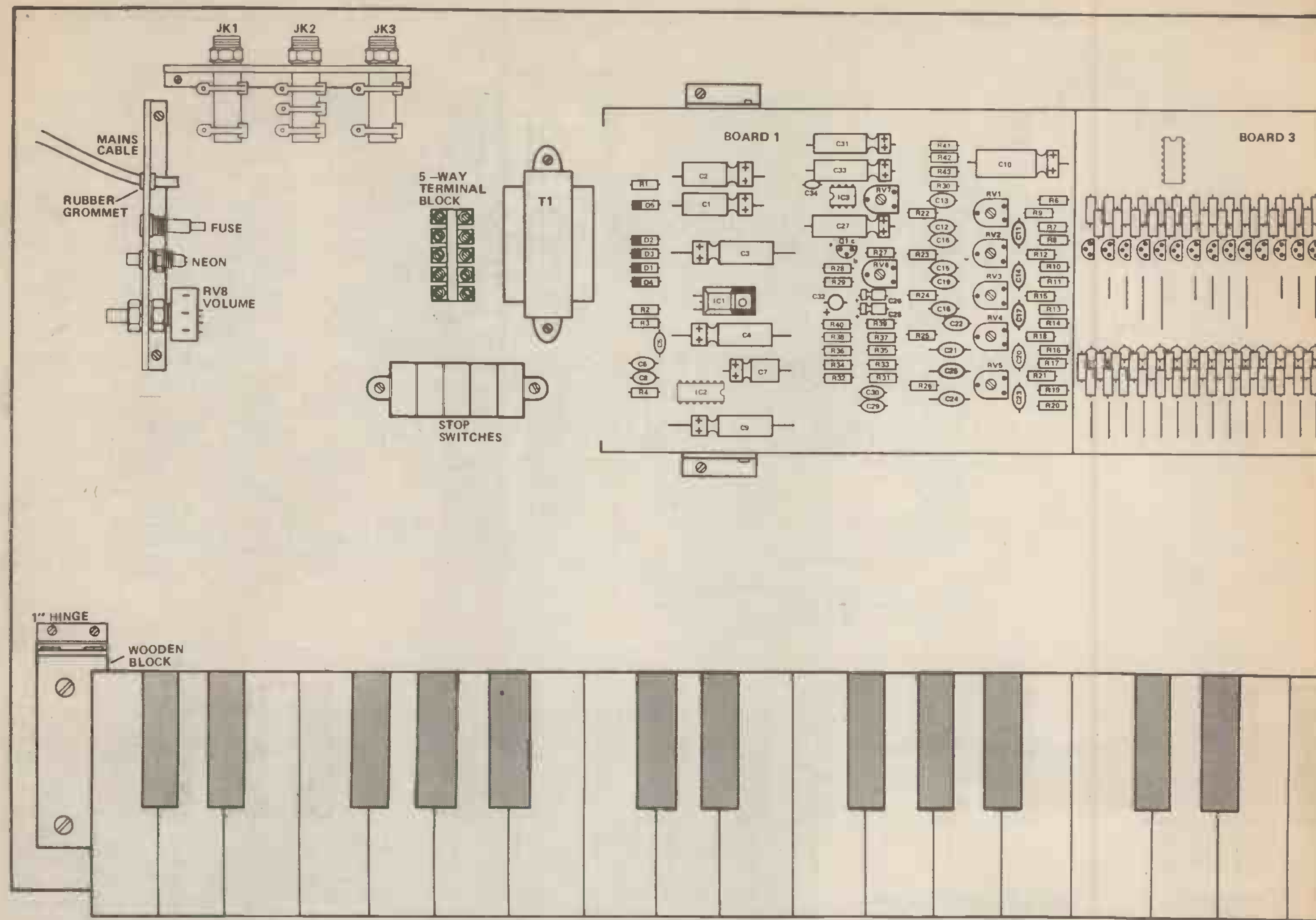
Figure 5. (Below)layout of project before PCB consturction or wiring-up

Wire up the low voltage circuitry next and finally tie any groups of wires together using cable ties — or simply string — for neatness.

This board is now ready for testing. Connect a loudspeaker (any speaker with an impedance of 4R or over, and which can handle 2 W or more) to the amplifier output via a ¼" jack plug and lead.

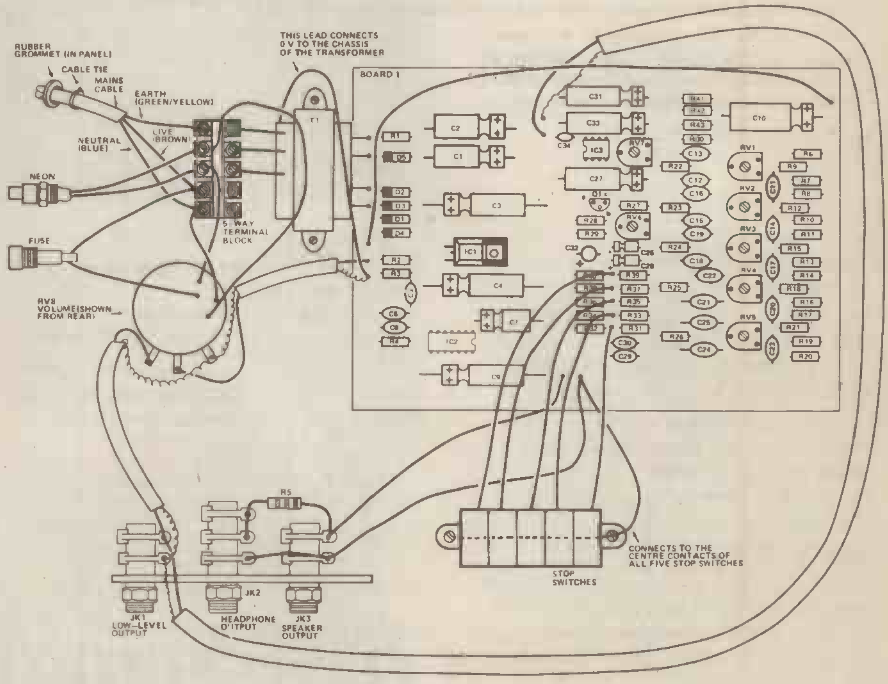
Switch on. The neon should light up indicating a 240 VAC mains connection. With a multimeter check that between points 1 and 2 (−ve lead on 1, +ve on 2) there is 12 VDC. Then, check that between points 3 and 1 (−ve lead on 3, +ve on 1) there is about 15 VDC.

Next, if you have a signal generator or an audio source of some description (eg, the pre-amplifier output of a cassette deck), take its earth connection to an earth (0 V) connection on Board 1, and take the signal lead to each of the filter inputs. You should get a filtered sound at the loudspeaker, adjustable by RV1 to 6 (depending on which filter section has been selected with the bank of five stop switches). Output amplitude should be adjustable by volume control RV7. If all these functions operate then you can be fairly sure that you have a working board.



▲ **Figure 6. Layout of main parts of HE Electronic Organ (not to scale). These comprise the keyboard, PCBs, transformer T1 and its terminal block, stop switches and brackets holding control potentiometers, sockets, neon indicator, fuse and mains cable grommet**

Figure 7. Connection details of Board 1 ▶



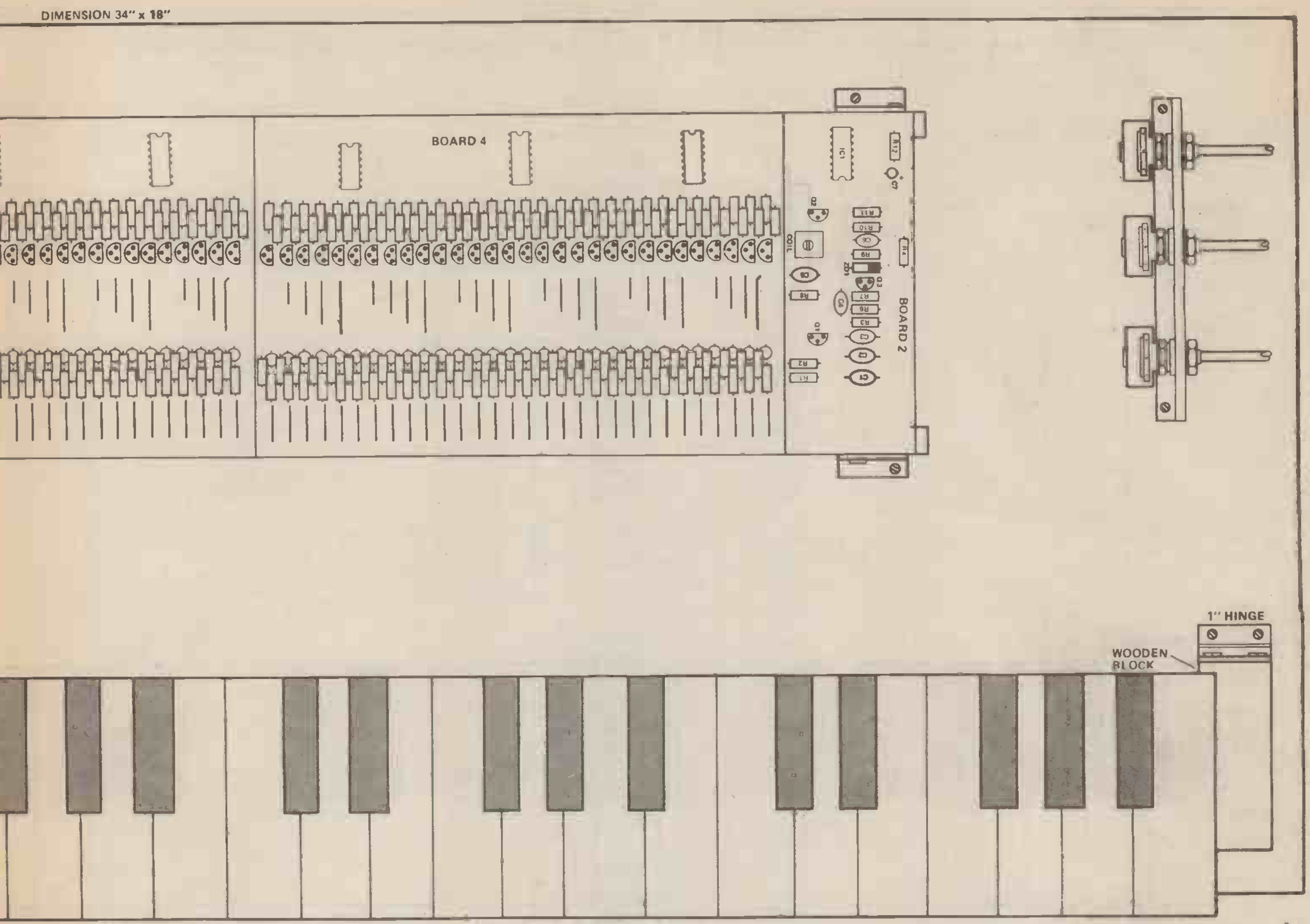
Buylines

A limited number of kits for the HE Organ can be obtained from:

Mr A. T. Hawkins
23 Blenheim Road
St. Albans
Herts. AL1 4NS

for the all-inclusive price of £95. The kits contain all metalwork, hardware and PCBs, as well as the keyboard and components. You only need to supply your own base-board and case.

For those readers who would prefer to buy the components themselves, Mr Hawkins is willing to supply the keyboards separately. None of the other items should be difficult to find.



Parts List

The following list consists of the parts needed for this month's construction ie, the HE Organ printed circuit board 1 and all metalwork and hardware.

RESISTORS (All ¼ W, 5%)

R1	820R
R2, 3, 28, 31, 32, 35, 36	22k
R4	2R7
R5	82R
R6, 30, 41	220R
R7, 10, 13, 16, 19	6k8
R8, 11, 14, 17, 20	330k
R9, 12, 15, 18, 21, 22, 23, 24, 25, 26, 42, 43	10k
R27	220k
R29	330R
R33, 34, 39, 40	47k
R37, 38	33k

POTENTIOMETERS

RV1, 2, 3, 4, 5	47k miniature horizontal preset
RV6	10k miniature horizontal preset
RV7	100k miniature horizontal preset
RV8	25k logarithmic potentiometer with double-pole, double-throw mains switch (SW1)

CAPACITORS

C1, 2	100u, 25 V electrolytic
C3	2200u, 25 V electrolytic
C4, 9, 27, 31, 33	220u, 16 V electrolytic
C5, 8, 18, 19, 20, 22, 23	100n polyester
C7	4u7, 16 V electrolytic
C10	1000u, 16 V electrolytic
C11	2n2 polyester or ceramic
C12, 15, 16, 30	47n polyester
C6, 13	22n polyester
C14, 17	10n polyester
C21, 24, 25	220n polyester
C26, 28	1u0, 16 V electrolytic
C29	1n0 polyester or ceramic
C32, 34	470n, 16 V tantalum

SEMICONDUCTORS

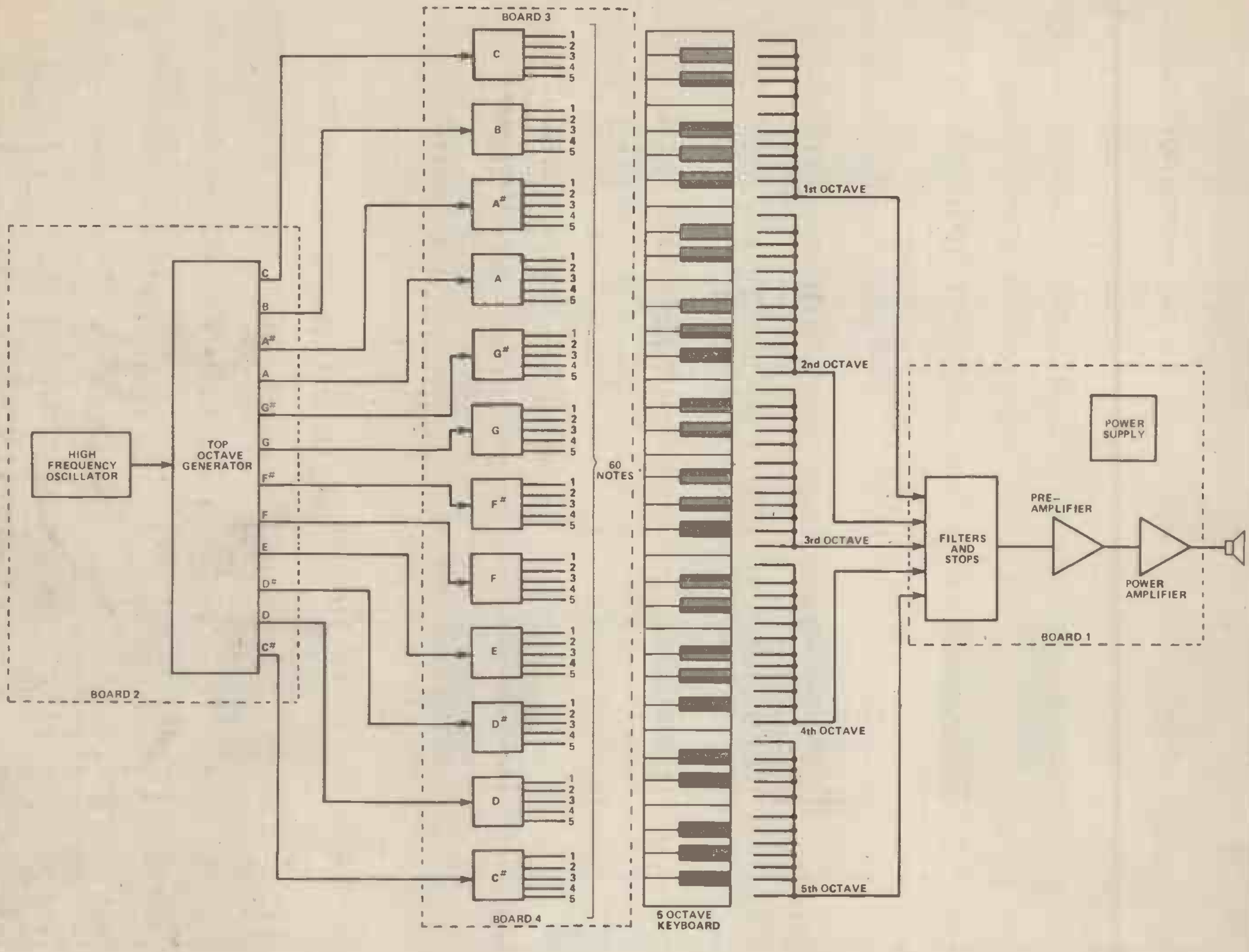
IC1	7812, voltage regulator
IC2	LM380, 2 W amplifier
IC3	741 operational amplifier
Q1	BC183 NPN transistor
D1-5	1N4001 diode

MISCELLANEOUS & HARDWARE

SW2-6	bank of 5 stop switches
T1	240 V/12 V + 12 V transformer (centre-tapped secondary winding)

Fuseholder + 1 A fuse
5-way terminal block
Rubber grommet
Mains indicator neon (with integral resistor)
2 x ¼" mono jack sockets
1 x ¼" stereo jack sockets
Cable ties
3 control panels approximately 5" by 3" (made from aluminium sheet)
2 lengths (25") of ⅜" aluminium angle bracket
4 lengths (1") of ⅜" aluminium angle bracket
2 blocks wood (1" sq) approximately 5" long
2 hinges (1")
Five octave keyboard (see Buylines)
Four printed circuit boards

How It Works



The 60 notes of the organ are all generated from a single high frequency oscillator, running at about 500 kHz. The signal from this oscillator is applied to a top-octave generator which divides the 500 kHz into the 12 different notes making up a top octave.

These 12 separate notes are now further divided into five octaves, thus producing a total of 12 x 5 = 60 notes.

Pressing a key on the keyboard allows that note to pass, via one of the five octave buses, to the filter and stops circuit, which shapes the notes producing the familiar organ sound.

A pre-amplifier and power amplifier are used to amplify the signal to a level suitable to drive a separate loudspeaker.

The diagram above shows how the circuit is sub-divided into four main parts, each one being built into a separate printed circuit board. The power supply for all four boards is included on Board 1.

Board 1 contains the power supply, the power amplifier, the filter and stops cicuitry and the pre-amplifier.

The positive power supply is formed around a standard voltage regulator IC providing up to 1 A or current at 12 VDC Most circuits in the HE Organ require only this single supply. However, the top octave generator on Board 2 needs a three-rail supply (ie, +12 V, 0 V, −12 V) but it only draws a few mA of current. This being so, a −ve supply needn't be of the same complexity as the above +ve supply. Diode D5 provides half-wave rectification of the 12 VAC from the transformer T1, and capacitors C1,2 and resistor R1 give adequate smoothing and filtering.

Integrated circuit IC2 is the familiar LM380, a 2 W amplifier IC, and this drives a loudspeaker via JK1, or headphones via JK2.

Each octave of notes generated passes through its own filter section (eg, C11-13, RV1, R22 for the first octave bus) and the preset within the filter allows the user to adjust the flute tone balancing between each octave to his or her own requirements.

Transistor Q1 mixes the signals from the five buses and preset RV6 sets the loudness of all flute tones.

Switches SW2-6 form the bank of five stop switches, selecting flute or string sounds, which are mixed and amplified by IC3, a pre-amplifier with variable gain set by RV7.

HE

TTLs by TEXAS

7400	11p
74S00	60p
7401	12p
7402	12p
7403	14p
7404	14p
7405	18p
7406	38p
7407	36p
7408	17p
7409	19p
7410	15p
7411	24p
7412	20p
7413	30p
7414	40p
74C14	90p
7416	27p
7417	27p
7420	17p
7421	40p
7422	22p
7423	34p
7425	30p
7426	40p
7427	34p
7428	36p
7430	17p
7432	30p
7433	40p
7437	35p
7438	35p
7440	17p
7441	70p
7442A	60p
7443	112p
7444	112p
7445	100p
7446A	93p
7447A	75p
7448	80p
7450	17p
7451	17p
7453	17p
7454	17p
7460	17p
7470	36p
7472	30p
7473	34p
7474	30p
7475	38p
7476	32p
7480	50p
7481	100p
7482	84p
7483A	90p
7484	100p
7485	110p
7486	34p
7489	210p
7490A	30p
7491	80p
7492A	46p
7493A	36p
7494	84p
7495A	70p
7496	65p
7497	180p
74100	130p
74107	34p
74109	55p
74116	200p
74118	130p
74119	210p
74120	110p
74121	34p
74122	48p
74123	60p
74125	75p
74126	60p
74128	75p
74132	75p
74136	75p
74137	50p
74141	50p
74142	200p
74145	90p
74147	190p
74148	150p
74150	130p
74151A	70p
74153	70p
74154	120p
74155	90p
74156	90p
74157	70p
74159	190p
74160	100p
74161	100p
74162	100p
74163	100p
74164	120p
74165	130p
74166	120p
74167	200p
74170	240p
74172	450p
74173	120p
74174	90p
74175	85p
74176	90p
74177	90p
74178	160p
74180	93p
74181	160p
74182	90p
74184A	150p
74185	150p
74186	500p
74188	325p
74190	120p
74191	120p
74192	100p
74193	100p
74194	120p
74195	95p
74196	95p
74197	80p
74198	150p
74199	150p
74221	160p
74251	140p
74259	250p
74278	290p
74279	110p
74283	140p
74284	360p
74285	360p
74290	150p
74293	150p
74298	200p
74365	100p
74366	100p
74367	100p
74368	100p
74390	200p
74393	200p
74490	225p

74LS SERIES

74LS00	14p
74LS02	18p
74LS03	18p
74LS04	18p
74LS05	25p
74LS08	22p
74LS09	21p
74LS10	20p
74LS11	40p
74LS13	40p
74LS14	50p
74LS20	20p
74LS21	40p
74LS27	38p
74LS30	20p
74LS32	27p
74LS37	30p
74LS38	38p
74LS42	70p
74LS47	75p
74LS51	24p
74LS55	30p
74LS73	35p
74LS74	27p
74LS75	38p
74LS76	45p
74LS83	70p
74LS85	80p
74LS86	40p
74LS90	40p
74LS92	70p
74LS93	60p
74LS96	110p
74LS107	45p
74LS109	80p
74LS112	40p
74LS113	90p
74LS114	45p
74LS122	80p
74LS123	80p
74LS124	180p
74LS125	50p
74LS132	80p
74LS133	30p
74LS136	55p
74LS138	65p
74LS139	75p
74LS145	120p
74LS147	220p
74LS148	175p
74LS151	80p
74LS153	60p
74LS154	200p
74LS155	80p
74LS156	80p
74LS157	60p
74LS158	60p
74LS160	90p
74LS161	75p
74LS162	140p
74LS163	100p
74LS164	90p
74LS165	140p
74LS166	180p
74LS173	110p
74LS174	100p
74LS175	100p
74LS181	320p
74LS190	100p
74LS191	100p
74LS192	100p
74LS193	100p
74LS195	140p
74LS196	120p
74LS197	90p
74LS221	120p
74LS240	175p
74LS241	175p
74LS242	170p
74LS243	170p
74LS244	150p
74LS245	150p
74LS247	140p
74LS251	140p
74LS253	90p
74LS257	90p
74LS258	180p
74LS259	160p
74LS266	100p
74LS273	170p
74LS279	90p
74LS283	90p
74LS298	160p
74LS323	400p
74LS324	200p
74LS348	200p
74LS365	48p
74LS367	70p
74LS368	100p
74LS373	150p
74LS374	150p
74LS375	120p
74LS377	180p
74LS378	140p
74LS390	120p
74LS393	120p
74LS399	200p
74LS445	150p
74LS670	400p

4000 SERIES

4000	15p
4001	22p
4002	20p
4006	95p
4007	20p
4008	80p
4009	40p
4010	50p
4011	20p
4012	25p
4013	50p
4014	84p
4015	84p
4016	45p
4017	70p
4018	89p
4019	45p
4020	100p
4021	110p
4022	100p
4023	27p
4024	50p
4025	20p
4026	130p
4027	50p
4028	84p
4029	100p
4030	55p
4031	200p
4034	200p
4035	110p
4036	295p
4039	295p
4040	100p
4041	80p
4042	80p
4043	90p
4044	90p
4046	110p
4047	100p
4048	55p
4049	45p
4050	45p
4051	80p
4052	80p
4053	80p
4054	160p
4055	125p
4056	135p
4059	600p
4060	115p
4063	120p
4066	50p
4067	450p
4068	20p
4069	20p
4070	30p
4071	25p
4072	25p
4073	25p
4075	25p
4076	107p
4081	27p
4082	27p
4086	72p
4089	150p
4093	70p
4094	250p
4095	95p
4096	95p
4097	340p
4098	120p
4099	200p
40100	220p
40101	132p
40102	180p
40103	180p
40104	99p
40105	120p
40106	90p
40107	60p
40108	470p
40109	100p
40110	300p
40114	250p
4502	120p
4503	70p
4507	55p
4508	290p
4510	99p
4511	120p
4512	80p
4514	250p
4515	300p
4516	110p
4518	100p
4520	100p
4521	250p
4526	108p
4527	150p
4528	100p
4532	140p
4534	550p
4536	375p
4538	120p
4543	180p
4553	320p
4556	72p
4560	200p
4569	250p
4572	40p
4583	110p
4584	90p
4585	150p
4724	250p
40097	90p
14411	700p
14412	1100p
14433	1100p
14500	700p
14599	290p

INTERFACE ICs

AD536A	£13
AD561J	1400p
AD7524	800p
DM8123	175p
DM8131	375p
DP8304	450p
DS8835	250p
DS8836	150p
DS8838	225p
MC1488	75p
MC1489	75p
MC3446	300p
MC3480	850p
25S10	350p
75107	160p
75110	325p
75150	175p
75154	175p
75182	230p
75324	375p
75361	300p
75363	400p
75365	200p
75451/2	72p
75491/2	70p
8T26	160p
8T28	250p
8T95	180p
8T97	160p
81LS95	120p
81LS96	140p
81LS97	120p
81LS98	140p
9602	220p

93 SERIES

9301	160p
9302	175p
9308	316p
9310	275p
9311	275p
9312	160p
9314	165p
9316	225p
9321	225p
9322	150p
9334	360p
9368	250p
9370	300p
9374	200p

74S SERIES

74S00	60p
74S04	60p
74S05	75p
74S08	75p
74S10	60p
74S20	60p
74S30	60p
74S32	90p
74S37	90p
74S64	60p
74S74	90p
74S85	300p
74S86	180p
74S112	120p
74S114	120p
74S124	300p
74S132	160p
74S133	75p
74S138	225p
74S139	225p
74S157	250p
74S163	300p
74S174	250p
74S175	320p
74S194	350p
74S241	450p
74S260	70p
74S373	500p
74S374	500p

LINEAR ICs

AY1-0212	600p
AY1-1313	668p
AY1-1320	320p
AY1-5050	140p
AY3-1270	840p
AY3-8912	650p
AY5-1224A	240p
AY5-1315	600p
AY5-4007D	520p
CA3019	80p
CA3046	70p
CA3048	225p
CA3080E	72p
CA3086	48p
CA3089E	225p
CA3090AQ	375p
CA3130E	90p
CA3140E	50p
CA3160E	100p
CA3161E	140p
CA3162E	450p
CA3189E	300p
CA3280	160p
DAC1408-8	200p
FX209	750p
HA1388	280p
ICL7106	850p
ICL8038	300p
ICM7555	80p
LF13331	310p
LF351	48p
LF356P	95p
LM10C	425p
LM301A	27p
LM311	70p
LM318	200p
LM319	225p
LM324	45p
LM339	75p
LM348	95p
LM358P	50p
LM377	175p
LM380	75p
LM381AN	180p
LM386	95p
LM393	100p
LM709	38p
LM710	50p
LM725	350p
LM733	100p
LM741	18p
LM747	70p
LM748	35p
LM2917	250p
LM3302	140p
LM3900	70p
LM3909	70p
LM3911	130p
LM3914	225p
LM3915	225p
LM3916	225p
LM13600	125p
MB3712	150p
MC1310P	150p
MC1458	48p
MC1495L	350p
MC1496	70p
MC3340P	120p
MK50398	750p
ML920	775p
MM57160	620p
NE531	150p
NE555	20p
NE556	70p
NE564	420p
NE565	130p
NE566	155p
NE567	140p
NE571	425p
NE5534A	250p
RC4136	80p
S566B	270p
SAD1024A	1250p
SFF96364	1100p
SL490	400p
SN76477	160p
SP8515	750p
TA7205	250p
TAA621	275p
TBA641B11	300p
TBA651	200p
TBA800	90p
TBA810	100p
TBA820	80p
TBA950	300p
TCA220	350p
TCA940	175p
TDA1004	300p
TDA1008	320p
TDA1010	275p
TDA1022	570p
TDA1024	120p
TDA10348	250p
TDA1170	300p
TDA2002V	325p
TDA2020	320p
TL071/81	45p
TL072/82	75p
TL074	130p
TL084	110p
TL170	50p
UAA170	175p
UDN6118	320p
UDN6184	320p
ULN2003	100p
UPC1156H	300p
XR2206	300p
ZN414	80p
ZN419C	225p
ZN424E	135p
ZN425E	400p
ZN427E	750p
ZN1034	200p

VOLTAGE REGULATORS
Fixed Plastic TO-220

1A	+ve		−ve	
5V	7805	60p	7905	65p
12V	7812	60p	7912	65p
15V	7815	60p	7915	70p
18V	7818	60p	7918	70p
24V	7824	60p	7924	70p
100mA	TO-92			
5V	78L05	30p	79L05	70p
12V	78L12	30p	79L12	70p
15V	78L15	30p	79L15	70p

OTHER REGULATORS

LM309K	135p	78HGKC	600p
LM317T	200p	78H05KC	550p
LM323K	500p	78MGT2C	135p
LM723	37p	79HGKC	600p
		TL497	300p

OPTO-ELECTRONICS

2N5777	45p	ORP60	120p
OCP71	90p	ORP61	120p
ORP12	120p	TIL78	55p

OPTO-ISOLATORS

ILD74	130p	TIL111	90p
MCT26	100p	TIL112	90p
MCS2400	190p	TIL116	90p

LEDS

0.125"		0.2"	
TIL32	65p	TIL220 Red	16p
TIL209 Red	13p	TIL222 Gr	18p
TIL211 Gr	20p	TIL228 Red	22p
TIL212 Ye	25p	Rectangular LEDs (R, G, Y)	30p
TIL216 Red	18p	NSB5881	570p
		TIL311	600p
		TIL312/3	110p
		TIL321/2	130p
		TIL330	140p
		7750/60	200p

DISPLAYS

3015F	200p
DL704	140p
DL707 Red	140p
FND357	120p
FND500	110p
FND507	110p
MAN3640	175p
MAN4640	200p

DRIVERS

9368	250p
9370	300p
UDN6118	320p
UDN6184	320p

TRANSISTORS

AC126	25p
AC127/8	20p
AC176	25p
AC187/8	25p
AF116	50p
AD149	70p
AD161/2	45p
AU107	200p
BC107/8	11p
BC109	11p
BC117	20p
BC147/8	9p
BC149	10p
BC157/8	10p
BC159	11p
BC169C	12p
BC172	12p
BC177/8	17p
BC179	18p
BC182/3	10p
BC184	11p
BC187	30p
BC212/3	11p
BC214	12p
BC237	15p
BC327	16p
BC337	16p
BC338	15p
BC461	38p
BC477/8	30p
BC516/7	40p
BC547B	18p
BC548C	16p
BC549C	18p
BC557B	16p
BC559C	18p
BCY70	18p
BCY71/2	22p
BD131/2	50p
BD135/6	54p
BD139	58p
BD140	60p
BD189	60p
BD232	95p
BD233	75p
BD235	85p
BD241	70p
BD242	70p
BDY56	200p
BF200	32p
BF244B	35p
BF256B	70p
BF257/8	32p
BF259	36p
BFR39	25p
BFR40	25p
BFR41	25p
BFR79	25p
BFR80	25p
BFR81	25p
BFX29	40p
BFX30	34p
BFX84/5	40p
BFX86/7	30p
BFX88	30p
BFW10	90p
BFY50	30p
BFY51/2	30p
BFY56	33p
BFY90	90p
BRY39	45p
BSX19/20	20p
BU104	225p
BU105	180p
BU108	250p
BU109	225p
BU126	150p
BU180A	120p
BU205	200p
BU208	200p
BU406	145p
E300	50p
E308	50p
E310	50p
MJ2501	225p
MJ2955	90p
MJ3001	225p
MJE340	50p
MJE2955	100p
MJE3055	70p
MPF102	45p
MPF103/4	40p
MPF105/6	40p
MPS6531	50p
MPS6534	50p
MPSA06	30p
MPSA12	50p
MPSA13	50p
MPSA20	50p
MPSA42	50p
MPSA43	50p
MPSA56	32p
MPSA70	50p
MPSU06	63p
MPSUD7	60p
MPSU45	90p
MPSU65	78p
OC28	130p
OC35	130p
TIP29A	40p
TIP29C	55p
TIP30A	48p
TIP30C	60p
TIP31A	58p
TIP31C	62p
TIP32A	68p
TIP32C	82p
TIP33A	90p
TIP33C	114p
TIP34A	115p
TIP34C	160p
TIP35A	225p
TIP35C	290p
TIP36A	270p
TIP36C	340p
TIP41A	65p
TIP41C	78p
TIP42A	70p
TIP42C	82p
TIP54	160p
TIP120	120p
TIP122	130p
TIP142	130p
TIP147	130p
TIP2955	78p
TIP4055	70p
TIS43	45p
TIS93	30p
ZTX108	12p
ZTX300	13p
ZTX500	15p
ZTX502	18p
ZTX504	30p
2N457A	250p
2N696	35p
2N697	25p
2N698	45p
2N706A	30p
2N708	30p
2N918	45p
2N930	18p
2N1131/2	36p
2N1613	25p
2N1711	25p
2N2102	70p
2N2160	350p
2N2219A	30p
2N2222A	30p
2N2369A	25p
2N2484	30p
2N2646	45p
2N2904/5	30p
2N2906A	30p
2N2907A	30p
2N2926	9p
2N3053	30p
2N3054	65p
2N3055	48p
2N3442	140p
2N3553	240p
2N3565	30p
2N3584	250p
2N3643/4	48p
2N3702/3	12p
2N3704/5	12p
2N3706/7	14p
2N3708/9	12p
2N3773	300p
2N3819	25p
2N3820	50p
2N3823	70p
2N3866	90p
2N3902	700p
2N3903/4	18p
2N3905/6	20p
2N4037	65p
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2N5089	27p
2N5172	27p
2N5179	90p
2N5191	90p
2N5194	90p
2N5245	40p
2N5296	55p
2N5401	50p
2N5457/8	40p
2N5459	40p
2N5460	80p
2N5485	44p
2N5875	280p
2N6027	48p
2N6041	160p
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Electronics In Musical Instruments

Tim Orr describes some advances in electronic musical instruments and how electronic organs and synthesisers work. He also outlines some currently-available instruments

ELECTRONIC MUSICAL INSTRUMENTS have always kept pace with developments in electronics. Up to 1960 most electronic circuits were designed around thermionic valves. These devices were fine for power amplifiers using only five or six valves but for the complex functions of, for example, an electronic organ, they were impractical. Most musical instruments of this period used mechanical sound generators (such as the tone wheels used in organs). The only job for the valve circuits was to amplify the signals from these generators.

The introduction of transistors enabled more complex circuits to be produced. Transistors were smaller and cheaper than valves and required much less power. (They also produced much less heat.) Early transistorised organs, for instance, made use of multivibrator circuits to generate the top-octave tones. These tones were then divided down by discrete transistor flip-flop circuits, to generate the tones for the lower octaves. A five-octave organ built along these lines might well have used several thousand components!

Around the end of the sixties a new type of device came to the public's attention, the music synthesiser. The synthesiser was greatly popularised by Moog and ARP in America and EMS in the UK. The device was a collection of all the common sound-generating and signal-processing systems that were being used in electronic music studios, but packaged into one machine. The early synthesisers were implemented with discrete transistor designs and were therefore limited in the range and quality of their performance. Tuning and stability of their oscillators was a major problem. The great increase in the number of integrated circuits available in the seventies made the job of electronic musical instrument design much easier and enabled far more ambitious projects to be undertaken. This generated a vast growth in the synthesiser and organ market.

There is now an enormous selection of products for sale. These include guitar, flute and drum synthesisers, keyboard instruments that simulate strings, brass, piano and virtually every natural instrument ever made, electronic echo units, devices that transpose the pitch of natural sounds, devices that can make musical instruments talk, and many others. And of course, the ubiquitous microprocessor has now found its way into the market. Initially it was used just to do simple jobs such as remembering sound structures and tuning oscillators, but it is now being used to control systems where the sounds are created digitally.

Apart from microprocessors, there are now several chips available which are totally dedicated to music production. One recent arrival, the Casiotone 201 electronic musical keyboard, uses only two LSI (large-scale integrated) chips to perform all the electronic functions inside the machine, a far cry from the several thousand parts that were used in keyboard instruments 15 years ago.

Electronic Organ Systems

Many instruments are based on the electronic organ principle. In this, the top octave semitones of the keyboard are generated and then divided down by binary dividers to produce the tones for the lower octaves (see Fig.1 and the HE Organ project this month). Several manufacturers make top-octave generator chips for this purpose, all of which operate in the same way. A high-frequency clock (about 1 MHz) is divided by 239, 253, 268 etc, and these divisions generate audio-frequency tones with a semitone spacing. The notes are not perfectly tuned, the usual error being about 1 cent or less (1 cent = 1/100 of a semitone, which is acceptable for most applications). The low cost of these chips has resulted in their widespread use. Where higher quality results are required individual oscillators (tunable inductor/capacitor devices) can be used for the top octave. In fact some organs use a separate oscillator for each note.

By controlling the envelope of the signal and by filtering it through a voicing network (see Fig. 2) it is possible to simulate the characteristics of many musical instruments. String and brass ensembles and electric pianos work on this principle. **Figure 3** shows a typical non-dynamic electric piano circuit. With the key not pressed, capacitor C1 is charged up to +12 V. When the key is pressed C1 is discharged into the network and so the voltage at point 1 discharges exponentially (see curve for point 1). When transistor Q1 is ON, it will short point 2 to ground. The transistor is turned ON and OFF by a mixture of two squarewaves F1 and F2. Thus the result of mixing these two is that Q1 is ON for one quarter of the period and OFF for three-quarters of the period. The result of this is that Q1 chops the waveform at point 1 at the frequency of F1 generating the waveform at point 2. If Q1 was controlled by a squarewave then the resultant output would only contain odd harmonics. However, by mixing F1 and F2 the output has both odd and even harmonics, which results in a much more interesting sound. If the key is released before C1 has fully discharged then the discharge curve is much faster because the value of C2 is much smaller than that of C1. This difference in discharge rates simulates the damping of the strings as the key is released.

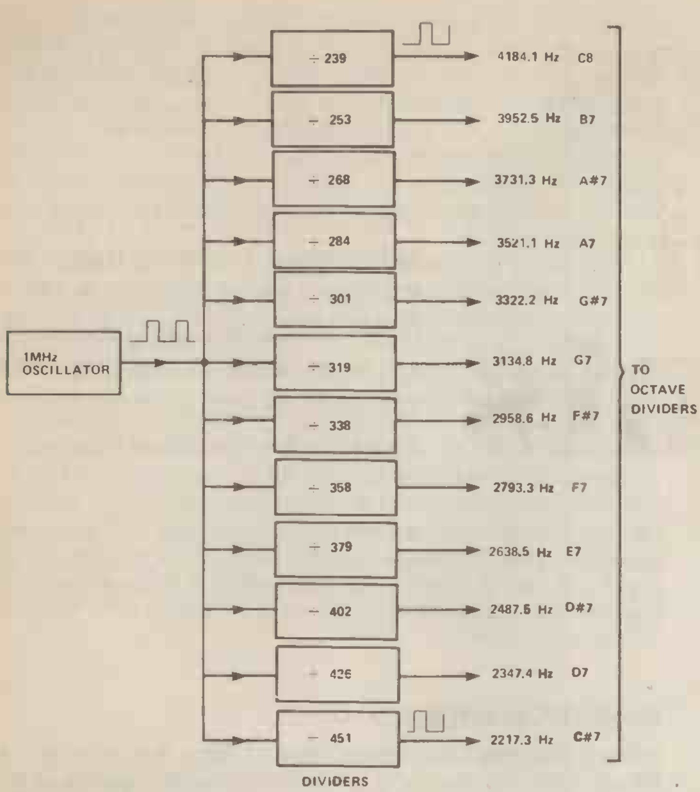


Figure 1. Block diagram of typical monolithic top-octave generator

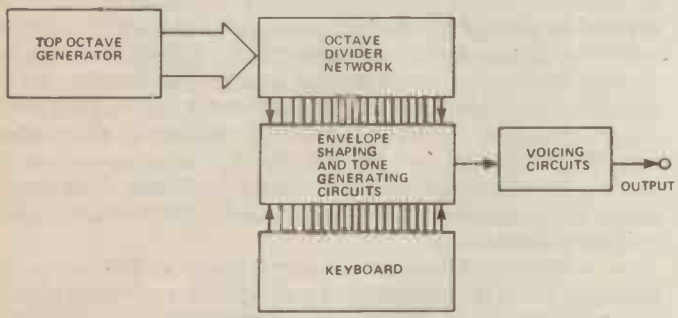


Figure 2. Block diagram of typical organ or electric piano system

Synthesiser Systems

The music synthesiser is based on the principle of voltage control. Sounds are generated and processed by a set of voltage-controlled stages, as shown in Figs. 4a to 4d. By voltage controlling these stages, the fundamental parameters that characterise the sound structure are also controlled.

The VCO (voltage controlled oscillator) shown in block form in Fig. 4a, generates the fundamental tones of the instrument. The control law is musical; that is, the pitch of the oscillator increases by one octave for a 1 V increase in control voltage. The control voltage is often generated by a conventional keyboard. Control voltages may be added together, so it is possible to perform transpositions and vibrato while still controlling the pitch from a keyboard. A choice of output waveforms is usually available. For example, a sawtooth waveform has both odd and even harmonics. The squarewave has only odd harmonics as does the triangular wave. By modulating the squarewave, a mixture of both odd and even harmonics can be produced. By controlling the VCO frequency and harmonic structure and by simply mixing together the outputs of several VCOs, rich and interesting sounds can be created.

The VCF (voltage controlled filter) as shown in Fig. 4b, is used to filter or colour an audio signal. The most common filter is the lowpass version, which attenuates all frequency components above the cut-off frequency. If a high resonance variety is used then the harmonics of the input signal *ring* as the filter resonant frequency is swept past them. Other frequency responses, such as bandpass and highpass are sometimes used.

The VCA (voltage controlled amplifier) generates amplitude contours (see Fig. 4c). A plucked instrument has an amplitude envelope that attacks (rises) very quickly and then decays slowly. A VCA can be used to synthesise this, where the control voltage input defines the envelope contour of the audio output.

Normally, the VCF and the VCA are driven by an ADSR (attack, decay, sustain and release) device (see Fig. 4d). It is the ADSR that is used to generate the amplitude contours and filter sweeps. The A,D and R parameters define the exponential time-constants of their respective portions, and the S parameter is a sustain level. The gate signal is derived from the keyboard; that is, when a key is pressed the gate signal goes high.

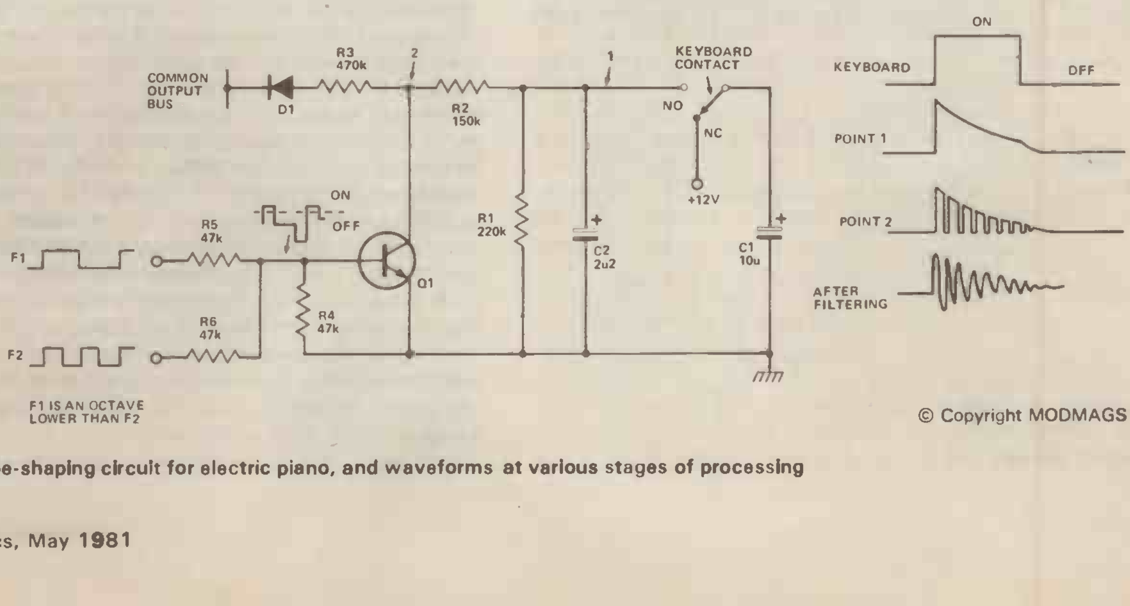


Figure 3. Envelope-shaping circuit for electric piano, and waveforms at various stages of processing

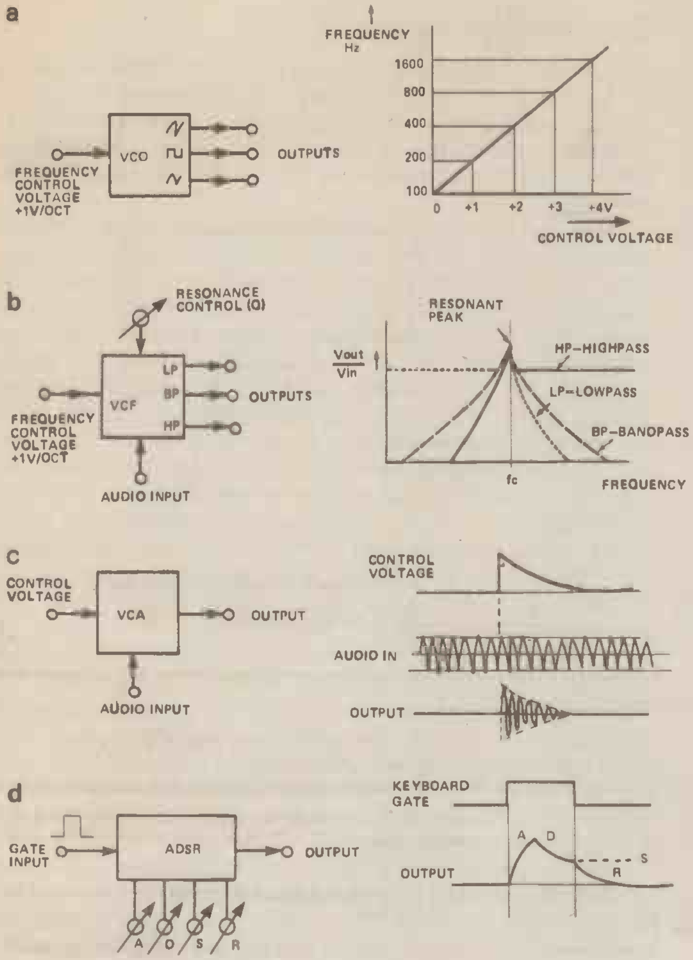


Figure 4. Principal voltage controlled stages found in a synthesiser: a) voltage controlled oscillator, b) voltage controlled filter, c) voltage controlled amplifier, d) attack, decay, sustain and release stage (envelope generator)

A typical synthesiser arrangement or 'patch' is shown in Fig. 5: it is known as a *voice*. Two VCOs are used to generate a rich sound: the VCF filters this sound and the VCA generates an amplitude contour. Two ADSR units are used: one sweeps the filter and the other generates the contour for the VCA. The original synthesisers were all monophonic (you could only play one note at a time). The problem with

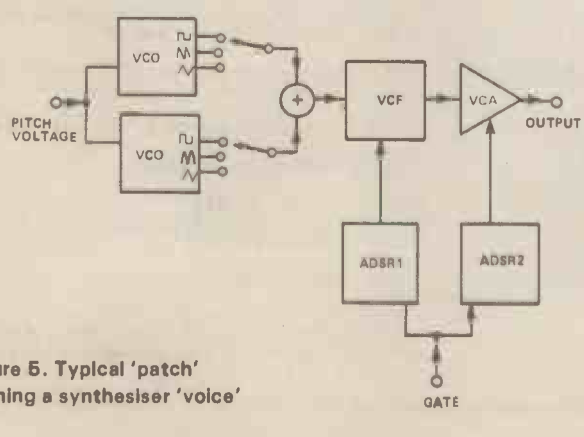


Figure 5. Typical 'patch' forming a synthesiser 'voice'

making, say, an eight-note polyphonic unit (where you can play up to eight notes on the keyboard at once) is that you need eight complete synthesiser voices. Each must be entirely voltage controlled and all their parameters must keep closely in step. This problem has been overcome by the integration of synthesiser units, namely the VCA, VCO, VCF and ADSR. These days the design of synthesiser voices has been simplified, and the complete assemblies are small and reasonably priced.

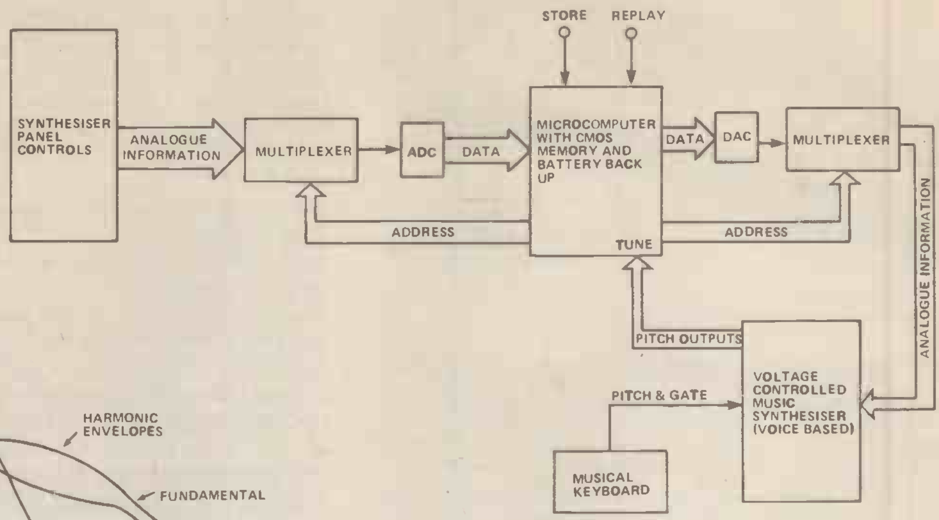
Polyphonic synthesisers produce a very interesting 'rich' sound as opposed to monophonic ones which often sound 'thin'. One problem with a polyphonic system is that it might contain 16 VCOs, all of which will tend to drift in frequency. Tuning 16 VCOs by hand is a very difficult job and it can take a long time. This problem can be overcome by using a microprocessor to do the tuning. The microprocessor looks at the pitch of all the VCOs and generates correction voltages to maintain the correct tuning, as shown in **Fig. 6**. The microprocessor also can be very useful in other ways. It can be used to store pre-set patches which can be recalled instantly. It can also scan the keyboard and determine which notes are being played. All this makes a microprocessor-controlled polyphonic synthesiser a very powerful musical instrument indeed.

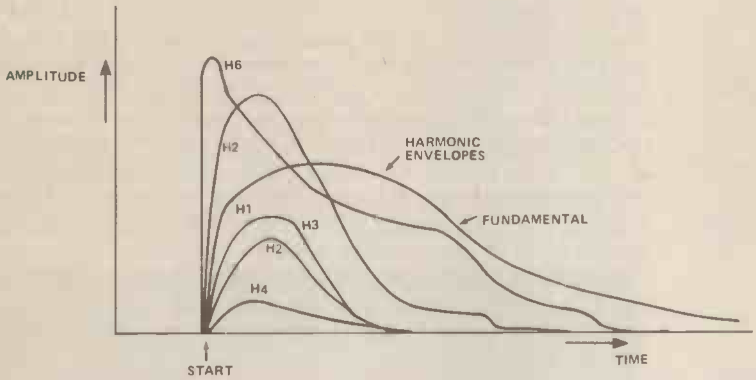
Digital Synthesis

All waveforms are constructed from harmonics. A squarewave consists of a fundamental harmonic plus an infinite series of 'odd' harmonics; that is, the third, fifth, seventh, and so-on. The amplitude of each harmonic is inversely proportional to its frequency. A squarewave could be synthesised by adding together all the harmonics in the correct proportion. For practical purposes a machine to do this might use only 32 harmonics. Although it is possible to hear the pitch of harmonics above number 32, they become inaudible when combined with the total sound. An analysis of natural sounds shows that their harmonics vary with time in a very complex manner. It is not possible to synthesise natural sounds with any great accuracy using conventional analogue techniques. Use of a swept lowpass filter to reshape a sawtooth waveform is no way to synthesise a highly complex waveform.

A machine that can define up to 32 harmonic envelopes, (such as those shown in Fig. 7), as a function of time would have to be very sophisticated. This is how digital synthesisers produce sounds: a harmonic envelope 'map' is produced for a particular sound. When a note is pressed on the keyboard, the pitch of the note is delivered to a vacant voice module. The voice has what is termed a look-up table from which it can obtain any one of 32 harmonics, the fundamental being defined by the pitch signal sent to the voice. The voice then extracts each harmonic and multiplies it by the amplitude parameter at that point in time (the amplitude parameter is obtained from the harmonic map). It then adds all the signals together and puts the result into a DAC (digital-to-analogue converter) to recover the waveform. The resultant waveform is the product of harmonic synthesis. Some systems employ a VDU (visual display unit) and a light pen for inputing data. Digital synthesis employs a lot of expensive hardware plus the invisible cost of the software. You can define the structure of your sound precisely using this technique, but to define every waveform can be very time-consuming! You can instead use the information compiled by other operators, and this is usually available in filing systems such as floppy discs.

We next look at some current electronic instruments.





▲ Figure 6. Programmable music synthesiser

◀ Figure 7. Digital synthesis of harmonics

Glossary

To describe the operation of synthesisers it has been necessary to use a few terms and abbreviations that may be unfamiliar to some HE readers. Printed below are some of the less-common terms and abbreviations used in this article.

amplitude contour	Shape of the complete 'sound' of a note, from where it rises in volume at the beginning, to when it dies away at the end
bandpass filter	Electronic filter that will only allow through a band of frequencies between sharply-defined limits (eg all frequencies between 2 kHz and 6 kHz, but none below 2 kHz and none above 6 kHz)
compression	Effect of making all input signals, whatever their amplitude, sound a similar volume at the output
exponential	Signal amplitude rising or falling at a rate determined by how much the amplitude differs from its final value ie, the closer the amplitude is to its final value, the slower it changes to get there
flip-flop	Simple bistable circuit which divides the frequency of an applied squarewave signal by two
floppy disc	Flexible plastic disc coated with metal oxide, used to record computer or microprocessor data in a permanent form
hardware	Physical components of a computer or computer system
Hexa-distortion	Effect provided by Roland GR-300 Polyphonic Guitar Synthesizer. It enables the 'fuzz' effect to be applied to individual guitar strings
highpass filter	Electronic filter that will only allow through frequencies above one sharply-defined frequency (eg all frequencies above 2 kHz, but none below 2 kHz)
light pen	No, not the opposite of a heavy one, but a hand-held probe which has a photocell at its tip. Information displayed on the screen of a specially-adapted VDU can be changed by bringing the probe in close contact with individual displayed characters
look-up table	Electronic store or memory of data in digital form. In synthesisers, this data takes the form of waveform information
lowpass filter	Electronic filter that will only allow through frequencies below one sharply-defined frequency (eg all frequencies below 6 kHz, but none above 6 kHz)
microprocessor	Integrated circuit containing main processing functions of a simple electronic computer; that is, arithmetic logic unit (ALU), accumulator, instruction register, random-access memory (RAM), read-only memory (ROM) and clock generator
multivibrator	Simple astable (oscillator) circuit providing squarewave output signal
parameter	Characteristic of electronic stage or circuit (eg signal amplitude of an amplifier stage)
patch	Way in which sound generating or sound processing stages or modules are coupled together electronically to produce desired voice or sound
polyphonic	Comprising many voices or sounds (such as those produced by several keys played together)
portamento	Gliding from one pitch to another
software	Programs for a computer or computer-controlled synthesiser system
tone wheels	Magnetic toothed wheels used in early electronic organs. As the wheels are rotated, an electromagnet detects the pulses produced by each passing tooth. Thus the faster the wheel is spun on its shaft, the higher the frequency of the tone, made up of a chain of pulses. If another wheel, having half the number of teeth of the first wheel is fixed to the same shaft, then its derived pitch will be one octave lower than that of the first
voice	Sound produced by a combination of electronic devices or stages (eg synthesised piano sound)
writing speed	Rate at which waveform information, in digital form, can be recorded
ADSR	Attack, decay, sustain and release (envelope generator)
DAC	Digital-to-analogue converter
VCA	Voltage controlled amplifier
VCF	Voltage controlled filter
VCO	Voltage controlled oscillator
VDU	Visual display unit — a cathode-ray tube (CRT) monitor, similar in appearance to a TV, but for display of data or graphics derived from a digital source (eg, computer or microprocessor)

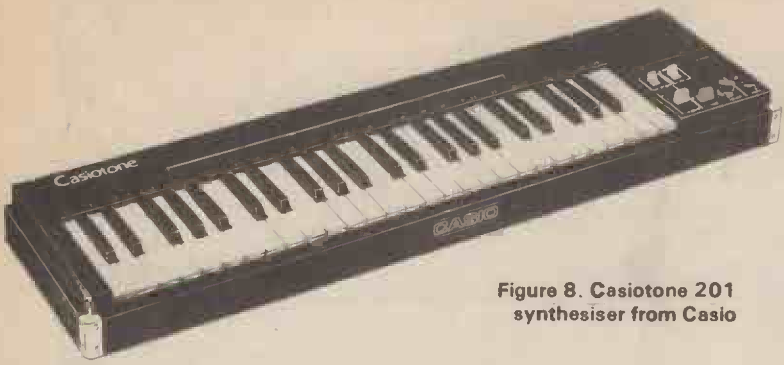


Figure 8. Casiotone 201 synthesiser from Casio

Casiotone

Casio, the company that brought you a wide variety of calculators and digital watches, has now moved into the music market, with a range of keyboard instruments. Its expertise in LSI digital circuits has enabled it to pack most of the electronics for a polyphonic keyboard instrument into two LSI chips. One such instrument is the Casiotone 201 (Fig. 8) which can play eight notes at once with a selection of 29 pre-set voices. These include electric guitar, harp, glöckenspiel, organ, trumpet, violin and many others.

Another instrument, the Casiotone M-10, is portable, with a choice of mains or battery operation, and it has its own speaker. The keyboard has 32 notes and can play eight of these at once with a choice of piano, violin, flute and organ pre-set voices.

Powertran

For those of you who like assembling kits there are many to chose from the Powertran range, and these include the Transcendent 2000 (Fig. 9). This is a monophonic keyboard synthesiser with all the usual synth features. To make the construction as straightforward as possible, the machine is virtually free of wires, with all potentiometers and switches mounted on the PCB.

On of Powertran's most recent kits is a four-voice polyphonic synthesiser (expandable to eight voices), the Transcendent Polysynth. Each voice is a complete synthesiser in itself, containing two VCOs, two ADSR units, a VCF and a VCA. This was only made possible with the recent arrival of Curtis synthesiser chips which provide the VCO and ADSR functions in this instrument. A comprehensive selection of modulation sources and a polyphonic portamento control make the Transcendent Polysynth a powerful music synthesiser.

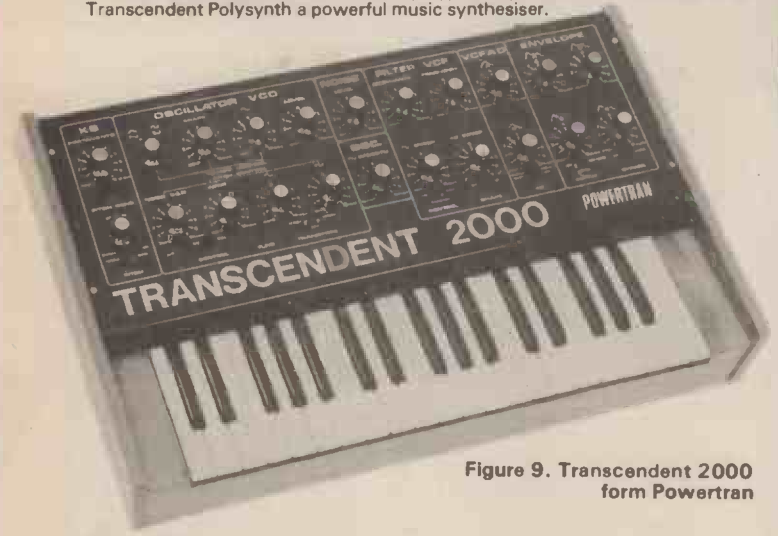


Figure 9. Transcendent 2000 form Powertran

Eventide

The H949 Eventide Harmonizer, from Eventide Clockworks Inc, is a sound processing unit which can transpose the pitch of the input sound, thus generating a harmony (if the shift is a musical interval). The pitch shift range is + 1 octave to − 2 octaves. One typical use might be to input a guitar signal, transpose it a fifth and mix the two sounds together, thus producing a synthetic accompaniment. True pitch transposition is, extremely difficult using an electronic device. All the frequency harmonics must be transposed without corrupting the time information (For example, speeding up a magnetic tape which has music recorded on it will not only transpose the harmonics but also the time information. In other words, the note may be higher in pitch but consequently shorter in length!) The Harmonizer overcomes this impossible problem in the following way. The input signal is turned into a digital code by an ADC, and this code is written into a small digital memory at a fixed speed. It is then (this is the clever bit) read out of the memory at a different speed! Then the code is turned back into a sound by a DAC. If, say, the machine is reading out of memory at twice the rate of the writing speed then the information contained in the memory will be repeated twice; that is, it will be transposed up an octave.

Roland

The Roland GR-300 Guitar Synthesiser enables guitar players to make use of a synthesiser. The guitar that forms part of the system is both a fully functioning electric guitar and provides a control input for the synthesiser. The GR-300 extracts the pitch of each of the six strings and converts it into a control voltage to drive the VCOs in the synthesiser. Thus the VCOs track with the pitch of the strings. If you 'bend' a note (that is, change the pitch of a note by stretching a string) then the synthesiser generates a bent note. The GR-300 is a six-VCO polyphonic synthesiser with envelope-following, vibrato and VCF facilities. Compression and what Roland terms Hexa-distortion (see Glossary) are also provided. Foot switches are used to change the operating modes.

Oberheim

Oberheim's OB-X is a four, six or eight voice polyphonic music synthesiser. Each voice is a 'standard' voltage-controlled synthesiser containing two VCOs, two ADSRs, one VCF and one VCA. The machine has a memory which can be pre-programmed with up to 32 different synthesiser sound structures, any one of which can be selected at the touch of a button. Virtually all the functions of the panel controls are also voltage controllable and so these may be programmed by the memory.

When a sound has been selected it is then possible to modify its structure by moving the desired parameter control. A microprocessor monitors the panel controls, handing back a particular parameter to manual control when it decides that a control has been moved. Thus it is possible to alter a 'called-up' sound. It is also possible to store your own patches either by writing them into the machine's memory or by recording them onto tape cassette. The tuning of each VCO is automatic: the microprocessor determines a VCO's frequency and, if necessary, applies a correction control voltage to individual VCOs. It is the microprocessor that makes this type of synthesiser powerful. It scans the keyboard and determines which notes are to be played. It generates all the control parameters and tunes all the VCOs. It monitors the panel controls and assigns them to manual control if necessary. It also handles all the memory read/write functions. The result is a polyphonic self-tuning synthesiser with instant patch changing.

Figure 10. Prophet-10 polyphonic music synthesiser from Sequential Circuits

Sequential Circuits

Prophet-10 (Fig. 10), from Sequential Circuits, is another voice based (10 voice) polyphonic synthesiser. It is programmable, and it has two keyboards so that each can play a different five-voice polyphonic sound. There are a total of 64 programs to choose from. This machine also has a polyphonic sequencer option. Music is recorded on a small data cassette as pitch and time information. Six different sequences may be recorded and played back.

New England Digital

Synclavier II is a digital harmonic synthesiser. It is polyphonic and is available with 8, 16, 24 or 32 voices. Up to 96 separate harmonics can be used to generate one polyphonic voice, and the machine comes with over 64 sounds already programmed in. The hardware consists of a keyboard unit and a computer which is housed in a separate box. The Synclavier has a large digital memory which can be used as though it were a 16-track recorder. You can record up to 16 different instruments, playing 16 completely different lines on 16 separate tracks, and play them all back at the same time in perfect synchronisation.

Fairlight Instruments

Fairlight CMI is, like the Synclavier II, another digital harmonic synthesiser. It has an eight-note polyphonic capacity and can generate up to 32 harmonics. Data can be entered via a floppy disc unit, an ASCII keyboard or a VDU/light pen. The harmonic envelopes can be displayed on the VDU and modified by the light pen. It is possible to call up the waveform at any point along the harmonic envelope and to draw it out on the screen.

An audio signal may be inserted into the machine, being first digitised and then stored in memory. The keyboard can then be used to play the sound and define the pitch. Also included in the CMI is an elaborate sequencer that can replay up to seven sequences while recording another.

Further Reading

Chamberlin, H. *Musical applications of microprocessors* Hayden Book Company, 1980
Hutchins, B. *Musical engineers handbook*, Electronotes, 203 Snyder Hill Rd., Ithaca, NY 14850, USA, 1975
The BYTE book of computer music, LP Enterprises, Barking, Essex
Solid State Microtechnology, *1979 data book*, 2076B Walsh Avenue, Santa Clara, California 95050, USA
Data sheets on a range of devices for electronic musical instruments are also available from Curtis Electromusic Specialities Inc., 110 Highland Ave, LOS GATOS, CA 95030, USA

HE

Voice Operated Switch

Enjoy automatic control of your cassette recorder or ham radio transmitter with this smart little project

HEVOX IS AN acronym! No, it's not some new integrated circuit. It stands for Hobby Electronics Voice Operated Switch. Okay, we know you don't spell switch with an 'X' but that *is* what it means!

The Hevox will turn on a relay whenever an audio signal of sufficient amplitude is applied to the input. Sensitivity is adjustable and you should be able to rig it up to your cassette recorder (if it's one with a remote control switch) or to your radio transmitter if you're a radio ham. A little judicious juggling of the component values of C6 and R7 will change the response times and you should be able to find values to suit your application. The circuit operates from a single 9 V battery and current consumption is about 1 mA when quiescent. However, note that a large battery should be used if the circuit is to drive any substantial load such as a relay. The poor little PP3s, even the alkaline ones, don't like supplying high currents for long!

In this age of the microchip we decided to design our circuit using transistors for a change, and the ubiquitous BC109 was pressed into service — though almost any small-signal NPN silicon transistor would do. If you do use a different type, remember to check its pin connections before soldering it into place as transistors are just as fussy as integrated circuits and will happily blow up if you get it wrong. A printed circuit board was chosen for our prototype because it enables a small and neat unit to be built.

Construction

If you aren't happy with PCBs or have no facilities for making them it's quite okay to employ some other construction method. Whatever method you choose, make sure you keep the component leads short and try to avoid the use of long connecting leads. The circuit is quite straightforward and lends itself to Veroboard design. Sloppy layout and untidy leads can result in spurious radio frequency oscillations which may be difficult to detect and eliminate.

If you use our PCB, start construction by soldering into place the diodes and resistors which lay flat on the board and then mount the tantalum capacitors and upright resistors. The transistors should be soldered in last. Check to make sure that no component leads are inadvertently touching each other or the transistor cans as this could cause a circuit malfunction. If everything looks okay, connect a small relay, or a LED and current limiting resistor, between the collector of Q4 and the positive supply and then couple an audio source to the input — for example a microphone or low level hi-fi output. By speaking or whistling into the microphone you should find a position for RV1 where the relay pulls in and drops out in time with your utterances. To change the response times you can experiment with the values of R7 and C6. Then all that remains is to choose a suitable case to house the project and make the world listen when you talk!

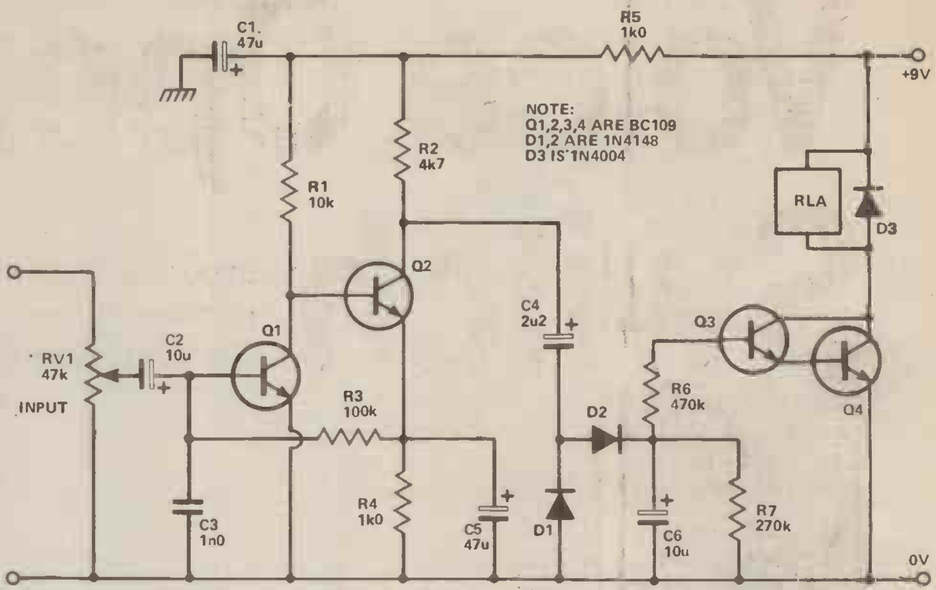
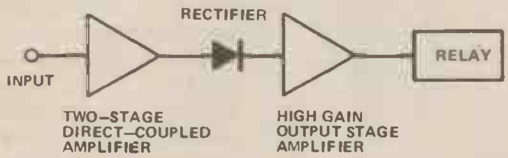


Figure 1 (above). Circuit of HEVOX. Almost any small-signal NPN transistors will work in this project, so don't worry if you can't find any BC109s

Figure 2. Close-up details of the printed circuit board of the project. Make sure that no component leads are shorting together

How It Works

The circuit consists of three main sections. An audio amplifier which drives a rectifier and in turn, a high gain output stage.



A two-transistor direct-coupled amplifier was chosen for the audio amplifier. The expression 'direct coupled' means that no coupling transformers or capacitors are used to pass the signal from one stage to the next. Thus, Q2 is direct coupled to Q1. Operation of the circuit can be best understood if you remember that a silicon transistor (eg, BC109) requires about 0.7 V bias across its base-emitter junction to turn on. This is called the 'base-emitter drop' and applies equally to single silicon junctions (ie, diodes). As the emitter lead of Q1 is connected to 0 V, we can assume that its base will need to be about 0.7 V positive in normal operation. Bias current for Q1 is supplied through R3. As the current flowing through R3 is very small, the voltage drop will be small and you'll find about 0.7 V across R4, C5.

Using the same logic, we can work out the voltage at the collector of Q1 and Q2. It is important to note that the circuit is self-stabilising. If Q1 begins to turn on too much its collector voltage will fall, turning off Q2 and reducing the base drive to Q1. Conversely if Q1 turns off, Q2 will turn on more, restoring base drive to Q1 which then begins to turn on again until equilibrium is reached. This process is called negative feedback and sets the DC operating points of the circuit.

To ensure that we end up with an amplifier with some gain, C5 is inserted in the feedback loop to 'decouple' R4. At audio frequencies, C5 presents a low-impedance path to ground and gives the circuit its frequency response. If C5 were reduced in value it would present a higher impedance to the low audio frequencies which would appear at the input as negative feedback, resulting in an amplifier with a 'high-pass' response. (It would sound tinny.) Simple resistor-capacitor combinations are frequently used to tailor the response of circuits so that undesired signals are eliminated or suppressed. Capacitor C3 is too small in value to have much effect at audio frequencies but helps to prevent the amplifier from oscillating at radio frequencies as a result of stray coupling and phase shifts within the circuit.

As both Q1 and Q2 operate in the common-emitter mode quite high gains can be achieved and RV1 enables the input signal to be set to a suitable level. Capacitor C2 blocks DC voltages to avoid upsetting the operation of the circuit.

The amplified signal appears at Q2 collector and is rectified by a 'diode pump' (D1, D2) resulting in a fluctuating DC voltage across C6.

When the voltage rises above 11.4 V (two base-emitter drops) transistors Q3 and Q4 will turn on. The 'super-alpha' connection of Q3 and Q4 effectively multiplies the gains of the transistors and gains of many thousand times can be obtained. With the components shown, Q4 can readily switch a small relay drawing between 20 and 30 mA. Diode D3 is included to prevent back EMF from the collapsing magnetic field of the relay coil from destroying the transistors.

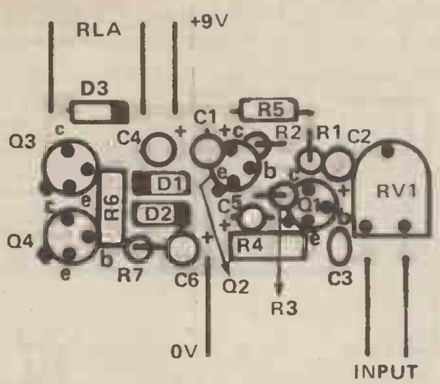


Figure 3. Overlay and connection details of the printed circuit board

Parts List

RESISTORS (All ¼W, 5%)	
R1	10k
R2	4k7
R3	100k
R4,5	1k0
R6	470k
R7	270k
POTENTIOMETER	
RV1	47k miniature horizontal preset
CAPACITORS	
C1,5	47u, 16V tantalum
C2,6	10u, 16V tantalum
C3	1n0 ceramic
C4	2u2 tantalum
SEMICONDUCTORS	
Q1,2,3,4	BC109 NPN transistor
D1,2	1N4148 diode
D3	1N4004 diode

MISCELLANEOUS
RLA — small 6-9 V relay
Case to suit (see Buylines)
Microphone (if used)

Buylines

None of the components in this project are critical and you should be able to obtain the parts listed or suitable substitutions from any of the large mail order companies or through your local stockist.

The case we used was from
West Hyde Developments Ltd.
Unit 9
Park Street Industrial Estate,
Aylesbury, Bucks.

It's order number is Samos 002.

The approximate cost of parts (excluding case and PCB) will be £6.

HE

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- **WHITE NOISE EFFECTS UNIT**, May '79 .... **£17.74**
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- Connecting wire pack, 5×9yd coils 65p
- Resistor colour code calculator 21p
- Towers International Transistor Selector £10.35
- AM-FM aircraft band portable radio £8.98
- 2 station desk intercom .... £7.48 3 station £8.98
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Substi-Tutorial

Tangled by transistor type numbers? Infuriated by IC index numbers? Ian Sinclair guides you on how to substitute similar devices for specified ones

HOW OFTEN HAVE you looked at a published circuit and wondered how long it would take to get the transistors or IC's? Do you find that you never seem to have a stock of the semiconductors that are needed for our short circuits? Take heart, we all have the same problems — what follows describes some of the ways round these problems.

One obvious way of seeking elusive semiconductors is to look up a chart of direct replacements, which will tell you that a 2N whatsit is exactly equivalent to a BC thingummyjig. That's sometimes useful, but it usually happens that you haven't any of these either. With a little bit of common sense, though, a stock of three or four types of transistors can be made to substitute for practically anything. My stock list is of five types. Type 1 has to be a good voltage amplifier transistor like the BC109 for substitution into pre-amps. Type 2 is a medium-power general-purpose switching transistor — I use the 2N2219 quite a lot. Type 3 is the PNP version of the 2N2219, which is the 2N2905. Type 4 is an RF transistor, such as the BF182 and finally, I keep a few MJE3055s handy for the high-power stuff.

But can you really slap one transistor type in place of another? You certainly can if you know what you are doing — and by the end of this article you should have a pretty fair idea. It's not such a task really, because different-numbered transistors are not necessarily all that different.

Making Sense Of Type Numbers

Why all the different type numbers? Well, it is largely a matter of history. In the early days of transistors, improved methods of manufacture were being invented almost every week, and the resulting transistors would be given a new range of type numbers. Later on, the numbers kept on coming because the manufacturers used different numbers to represent different grades of the same transistor. Nowadays, we can forget about the pre-historic types — if you find a book which has circuits using OC72s, you can throw the book away!

Silicon transistors have ruled the roost for more than 15 years now, so that all of this article relates to silicon transistors. What can be substituted for what?

Take a look first at **Table 1**.This shows the letter codes that are used for European types of transistors. If the first letter is B, it simply means that it's a silicon transistor, but the second one tells you what sort of transistor it is — and that's the useful bit. The usefulness of that second letter is that it is your guide to substitution. All transistors which are roughly equivalent will carry the same coding. For example, if you are looking for an audio transistor, then anything with a BC coding is a pretty good bet.

That isn't the end of it, of course, because there are some differences to look out for. Let's stick to the 'C' series for the moment. The differences we are likely to find between BC — coded transistors are:

- NPN and PNP types
- current gains ranging from 50 to 500 or so
- differences in maximum voltage and current

Now the codings won't tell you which are NPN and which are PNP, so you need a list of BC types to look that up. As far as the other differences are concerned, it shouldn't be difficult to find a substitute transistor with suitable (average) values of current gain (h_{FE}) and with maximum voltage and current ratings which will suit the job.

Table 1 PRO-ELECTRON code for transistors and diodes

The type number for transistors and diodes consists of two letters followed by a serial number.

The first letter indicates the material used:

A	germanium
B	silicon
C	gallium arsenide
D	indium antimonide
R	compounds such as cadmium sulphide

The second letter indicates what the device is used for:

A	detecting diode, switching diode, mixer diode
B	variable capacitance diode
C	transistor for AF, low power
D	power transistor for AF
E	tunnel diode
F	transistor for RF, low power
G	assembly of several transistors and diodes in one case
H	magnetic sensitive diode
K	Hall magnetic detector
L	power transistor for RF
M	Hall modulator or multiplier
P	radiation detector (photocell)
Q	radiation generator (LED)
R	trigger device (thyristor or diac)
S	switching transistor, low power
T	low power trigger device
U	switching transistor, high power
X	multiplier diode
Y	rectifier, booster or efficiency diode
Z	voltage reference (zener) diode

We can go a bit further than this, in fact. If you're looking for a transistor which is for a circuit operated at 9V and with only a few milliamps flowing, any transistor from the same series will do! The only way you're likely to be caught out is by the bias being wrong, because the substitute transistor may have a *very* different value of h_{FE}.I've emphasised very, because any reasonable circuit design will have taken into account the considerable differences in h_{FE} values you get between transistors of the same type number. **Figure 1** shows how bias can be checked and adjusted using the two most common bias methods for single transistors.

*PRO ELECTRON organisation, with its headquarters in Brussels, is an international association of most leading manufacturers of electronic components in Western Europe, including European subsidiaries of many of the largest US corporations. Its primary purpose is the allocation of type numbers to electronic devices according to a commonly agreed code, and the registration of their technical characteristics

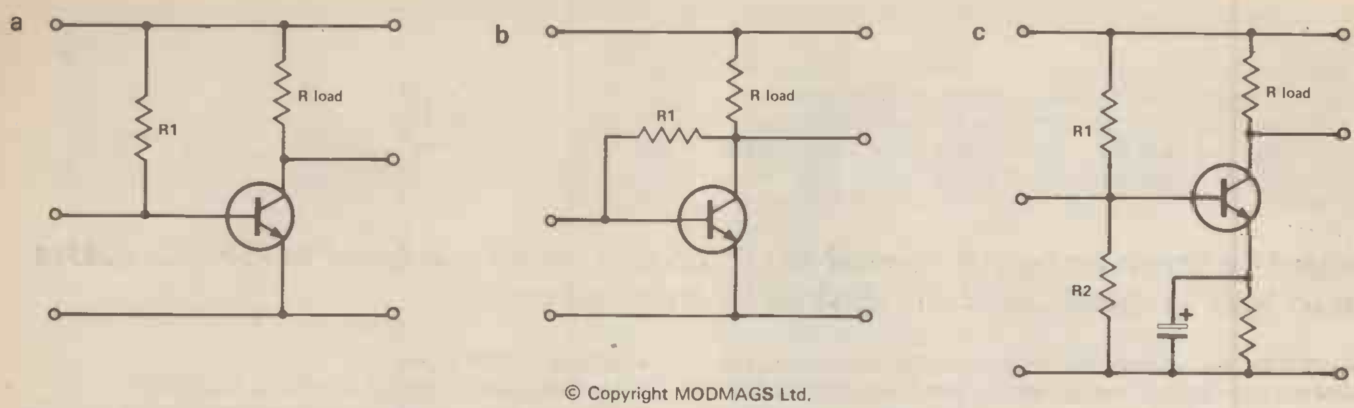

Figure 1. Adjusting bias. Whichever of these three bias systems is used, adjusting resistor values will correct the bias. If the transistor is underbiased (collector voltage nearly equal to the supply voltage), reduce R1 or increase R2. If the transistor is over-biased (collector voltage nearly zero), reduce R2 or increase R1

US Types

That's all very well, of course, when the transistors carry the European type marking, but what about the American 2N series? There's no answer to that, as Eric and Ernie used to say, because the 2N numbers are simply registration numbers, like serial numbers. All you can guess from them is that a 2N5162 came a bit later than a 2N3711. A few helpful suppliers (are you listening, other suppliers) group their 2N types according to function such as audio, GP and switches, RF, Power, etc, just like the European type groupings.

General-purpose And Audio Transistors

So far, we've been talking about audio transistors, the C types. They're the safest for substitution, because one audio circuit is pretty much like another, and even when they are used in circuits which have little resemblance to audio circuits, one device can usually be substituted for another. Incidentally, a W or Y as a third letter indicates an 'industrial' type, usually meaning closer specifications or higher voltage ratings.

A lot of medium-power switching transistors can be substituted for each other and for BC types. Old favourites for this business include the venerable 2N696, 2N1711, 2N2219, 2N3053 among the US types and the BFY50, 51, 52, . . . among the European numbers. These are all NPN types: the PNP counterparts are BFY38, 39, 40, . . . These medium-power types are very versatile transistors indeed: I use them in RF circuits (below 10 MHz), in pulse circuits, in audio circuits and in output stages (around 1 to 1.5 W). They are, in fact, as near as you can get to a universal transistor, and they're ideal for trying out ideas and 'short' circuits. Points you may have to watch when you substitute these for other types are:

- gain is sometimes on the low side, so that some bias adjustment may be needed
- they may result in higher distortion (probably not noticeable unless you have a very high quality audio amplifier)
- the metal cases are connected to the collector, so that they mustn't be allowed to short to each other or to other wires

If the low-current gain is a difficulty, then the devices can be used in pairs, as shown in Fig.2. Providing that the transistors are not 'leaky' (that is, suffering from high reverse leakage of electrons), no problems should be encountered. Switching circuits such as multivibrators are, of course, ideally suited for these versatile transistors.

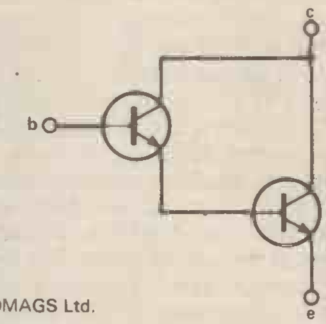

Figure 2. Connecting transistors in pairs (Darlington pair) so that the two transistors act as one, but with much higher current gain

RF Transistors

We encounter more serious problems when we start to substitute RF transistors. The general rule, unfortunately, is DON'T! Things may not be *quite* so critical, though, so let's take a look at what is possible.

The problem with RF amplification is that the capacitances between the electrodes of the transistor play an important part in the action of the circuit. At high frequencies, a lot of the tuning of the circuit may be done by the transistor capacitance, so that substituting one transistor for another may cause tuning changes. Re-tuning is usually necessary even if the correct replacement is used, so that substituting transistors in RF circuits should not be done unless some method of re-tuning is available.

The other effects are more serious. A transistor used as an RF amplifier loads the tuned circuits it's connected to as well as contributing to the tuning capacitance. The loading resistance of the transistor decides such matters as gain bandwidth and stability of the amplifier. For example, if our substitute transistor loads an RF amplifier stage more heavily, then gain will be down and bandwidth will be greater. If the loading is less, gain may be greater and bandwidth less, but oscillation may start. It's not enough, therefore, to replace one transistor in the RF circuit by any other. What we need to do is to look up the inter-electrode capacitances for each type. **Table 2** shows some values for commonly-used RF transistors.

In addition to the above, not all RF transistors will operate at high frequencies. The frequency limit at which a transistor can operate is decided, among other things, by the thickness of the base layer: a thick base means a low frequency. This limit is measured in different ways by different manufacturers. A figure that is often used is f_T, meaning the frequency at which the gain is unity. The f_T figure for an RF transistor must be well above the frequency at which it is operated.

In general, substitution of transistors which work at the lower frequencies, as in AM (amplitude modulated) medium-wave or long-wave radio, is easy. Substitution of higher-frequency types, such as those in FM (frequency modulated), VHF, TV and Intermediate-frequency (IF) stages is less straightforward and a bit of care is needed to match up the transistor types along with some circuit adjustment. Substitution of really high-frequency types, such as those used in TV tunerheads is just not on, unless you have a lot of experience with these circuits. The trouble here is that the position of every piece of wire is critical in these tuner circuits, as well as the demands made on the transistors.

Table 2 High-frequency transistors

Type	Frequency range	C_{re}	f_T
BF155	UHF	0.4 pF	600 MHz
BF160	VHF	0.8 pF	600 MHz
BF161	UHF	0.3 pF	550 MHz
BF166	VHF	0.4 pF	500 MHz
BF167	IF	0.15 pF	600 MHz
BF173	IF	0.23 pF	1 GHz
BF222	VHF	0.4 pF	400 MHz
BF233	IF	0.5 pF	500 MHz
BF271	IF	0.22 pF	900 MHz
BF272A	UHF	0.05 pF	850 MHz
BF273	IF	0.41 pF	600 MHz
BF274	IF	0.41 pF	700 MHz
BF287	IF	—	600 MHz
BF288	IF	0.24 pF	500 MHz
BF316A	UHF	0.25 pF	600 MHz
BF455	VHF	0.5 pF	400 MHz
BF479	UHF	—	1.4 GHz
BF516	UHF	0.05 pF	850 MHz
BF679	UHF	0.07 pF	1 GHz

NOTE: C_{re} is reverse capacitance, common-emitter connection. f_T is transition frequency: maximum frequency for unity gain, common emitter (Note that the f_T for common-base operation is usually higher).

Power Transistors

That leaves us with the power transistors. The low-power types are easily substituted by the 2N2219/2N2905 switching types mentioned earlier, so that failure of the output transistors of a radio or cassette recorder can be dealt with fairly easily, unless ICs have been used. The higher-power types can be replaced *except* in the highest of hi-fi amplifiers. These circuits are (or should be!) designed around the power transistors, and no substitution is usually possible. For lesser circuits, including, dare we say it, any home-built equipment, any modern high-power silicon transistor should do. My own favourites are the NPN MJE3055s, which are on a TO-92 base, making them easy to mount and heatsink. If you need matched PNP and NPN, then there is a PNP version (the MJE2955) but in an emergency, we can call on the old faithful switching types to make up the circuit shown in **Fig. 3**. They're not exactly equivalent, but they'll work in most circuits.

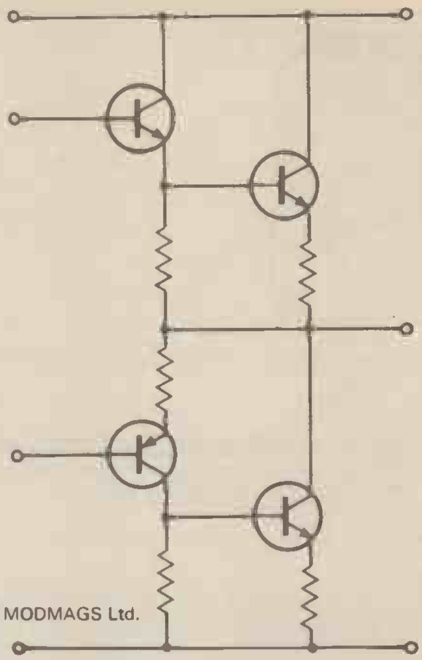

Figure 3. Using high-power NPN transistors in a complementary circuit — this arrangement is called a quasi-complementary circuit

Sorting Out The Lead-outs

One problem which is more difficult to deal with is the lead configuration of different transistors. Many transistors use a straightforward e-b-c layout, and these types are easily interchangeable, but arrangements such as e-c-b can sometimes be difficult to fit in if space is limited on the PCB or if the leadout wires are very short. A more awkward problem is knowing what the layout is. Some types of package, such as the TO-5, always have the same leadout configuration, but others including the TO-92 do not. As long as you know whether the transistor is NPN or PNP, the leadout wires can be identified by the following methods.

Multimeter Method

If you have a multimeter, switch it to a low OHMs range and find out the polarity of the test leads. This is important, because most multimeters have their negative (black) lead connected, however indirectly, to the positive terminal of the battery inside the meter (see **Fig. 4a**). How do you find out the polarity? One way is to connect the multimeter, still set to ohms, to a voltmeter (say reading 0 to 10 VDC). If, for example, the needle of the voltmeter moves in the correct direction when the black lead of the multimeter is connected to the positive terminal of the voltmeter, then the black lead is indeed at a positive potential.

If you haven't got a spare voltmeter then you can try connecting your multimeter, still reading ohms, to a semiconductor signal diode. One end of the diode (the 'anode' end) should be marked with a coloured band or spot. Try connecting the meter leads to the diode lead-out wires: if no (or a very high-resistance) reading is obtained, then try reversing the connections. When the lowest reading (say under 20 ohms) is indicated, the lead connected to the wire nearest the end with the band or spot will be connected, however indirectly, to the *negative* terminal of the internal battery.

Battery, Meter And Resistor Method

If you are without a multimeter, then try using a battery (1.5 V), a current meter (0 to 10 mA full-scale deflection) and a

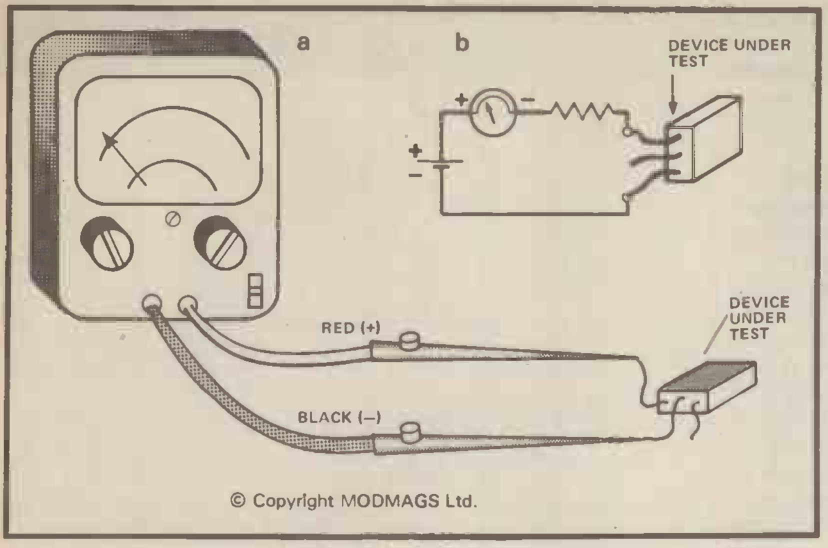

Figure 4. Measuring resistance with a) a multimeter (note polarity of leads), and b) a battery, meter and resistor (see text for details)

resistor (150 ohms) connected as shown in **Fig. 4b**. This time you will be able to see which lead is connected to which terminal of the battery.

Identifying The Transistor

With either of the above methods, clip the lead which is at a *positive* potential to one lead-out wire of the transistor under test and connect the other one to each of the other wires in turn. When you find that *both* connections conduct, the (+) lead is clipped to the base. If you don't find it first time, select another lead-out wire to test. The idea here is that with the base positive, an NPN transistor has a low resistance to either the collector or the emitter. For a PNP transistor, the test method is the same, but the 'negative' lead is clipped to the wire which we assume to be the base.

Integrated Circuits

Last of all, of course, come ICs. Substitution here is seldom possible, apart from replacing manufacturer A's device with one having an identical type number from manufacturer B. When an audio output IC fails (in a car radio, for example) the choice is to replace — if you can ever find a replacement — or to substitute with another type of audio IC. Substitution usually means rewiring, as the pinout (circuit functions of the various pins) is most unlikely to be the same, and a lot of painstaking work may be necessary to get the signal levels right and to prevent instability (oscillation) from occurring.

Digital ICs sometimes allow more scope. You can't swop TTL for CMOS unless you really know what you are doing, but complete circuits designed for one type of logic can usually be built with the other type, remembering that TTL must be operated at 5 V, and that the TTL circuits have a low input resistance. Simple gate and flip-flop stages work the same way, but oscillator circuits designed for CMOS will not work with TTL devices because of the difference in input resistance values. **Figure 5** shows some typical oscillator circuits.

Display drives (output voltages for LED or LCD display devices) also differ, but the designs are standardised so that a complete TTL design can be switched for a complete CMOS design. Remember, of course, that TTL circuits need a lot more current than CMOS circuits, so that battery operation is not advisable (even if you have a 5 V battery!).

There it is then — you can cut down your transistor inventory to just a few main types for most experimental purposes. One item you do need though, is an up-to-date list of transistors with their pinouts!

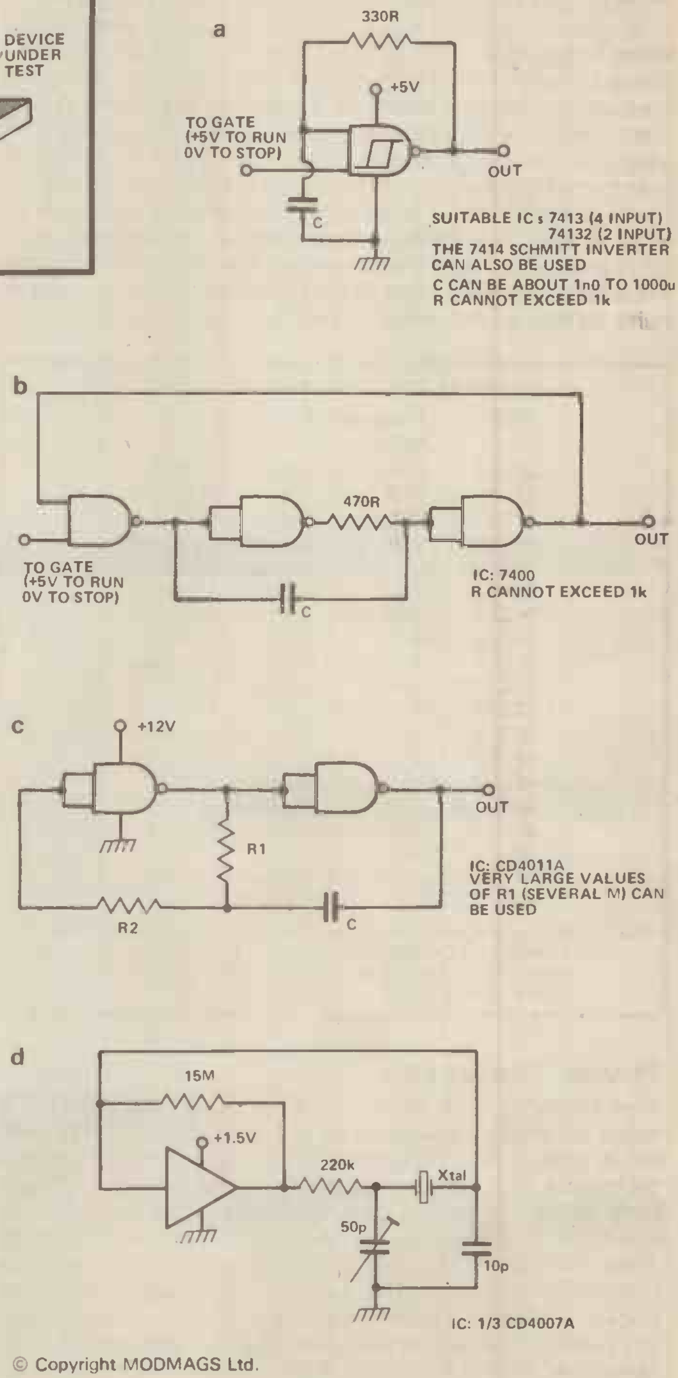

Figure 5. Digital IC oscillator circuits: a) using a Schmitt gate — the most reliable type of TTL oscillator, b) using three of the gates of a 7400, c) an RC CMOS oscillator. Resistor R2 should be about three times the value of R1, d) a CMOS crystal oscillator — this design uses a very low supply voltage

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AC176	24
AC176K	40
AC187	25
AC187K	40
AC188	25
AC188K	40
ACY17	50
ACY18	50
ACY19	50
ACY20	50
ACY21	50
ACY22	50
AD130	75
AD140	70
AD142	85
AD143	85
AD149	70
AD161	40
AD162	40
AD161/162 M/P	30
AF114	50
AF115	50
AF116	50
AF117	50
AF118	65
AF124	50
AF125	50
AF126	50
AF127	50
AF139	50
AF239	42
AL102	1.90
AL103	1.80
ASY26	50
ASY27	50
ASY28	50
ASY29	50
AU104	1.90
AU110	1.90
AU113	1.90
BC107	10
BC107A	11

BC107B	11
BC107C	12
BC108	10
BC108A	11
BC108B	11
BC108C	12
BC109	10
BC109A	11
BC109B	11
BC109C	12
BC113	16
BC114	17
BC115	18
BC116	19
BC116A	20
BC117	20
BC118	17
BC119	29
BC120	35
BC126	25
BC126	30
BC132	18
BC134	18
BC135	18
BC136	20
BC137	20
BC138	28
BC139	32
BC140	25
BC141	28
BC142	25
BC143	25
BC144	40
BC145	46
BC147	09
BC148	09
BC149	09
BC150	20
BC151	22
BC152	20
BC153	25
BC154	19
BC157	10
BC158	10
BC159	10
BC160	26
BC161	38
BC167	11
BC168	10
BC169	10
BC169C	11
BC170	09
BC171	09
BC172	09

BC173	09
BC174	15
BC175	35
BC177	14
BC178	14
BC179	14
BC180	12
BC181	10
BC182	10
BC182L	10
BC183	10
BC183L	10
BC184	10
BC184L	10
BC186	15
BC187	18
BC207	11
BC208	11
BC209	12
BC212	10
BC212L	10
BC213	10
BC213L	10
BC214	10
BC214L	10
BC225	26
BC226	36
BC237	13
BC238	14
BC239	15
BC251	16
BC251A	16
BC261	18
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BC301	28
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BCY30	80
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BCY32	85
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BCY72	15
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BCZ12	70
BD106	50
BD115	50
BD116	50
BD121	65
BD123	65
BD124	75
BD131	35
BD132	35
BD131/132 M/P	80
BD133	40
BD135	35
BD136	35
BD137	35
BD138	36
BD139	38
BD140	38
BD139/140 M/P	80
BD155	50
BD175	60
BD176	60
BD177	68
BD178	68
BD179	75
BD180	75
BD185	68
BD186	68
BD187	75
BD188	75
BD189	78
BD190	78
BD195	90
BD196	90
BD197	95
BD198	95
BO199	99

BD200	99
BD201	80
BD202	80
BD201/202 M/P	1.70
BD203	80
BD204	80
BD203/204 M/P	1.70
BD205	80
BD206	80
BD207	80
BD208	80
BD222	47
BD225	47
BD232	85
BD233	65
BD234	55
BD235	55
BD236	58
BD237	65
BD238	65
BS293A	50
BD240A	50
BD239A/240A	1.00
BD240	45
BD241	45
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BD508	38
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BDY17	1.80
BDY20	80
BDY55	1.40
BDY56	1.60
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BFR41	25
BFR50	25

BFR52	25
BFR62	24
BFR79	28
BFR80	28
BFW10	55
BFX29	25
BFX30	30
BFX84	24
BFX85	26
BFX86	26
BFX87	26
BFX88	26
BFX90	55
BFY50	20
BFY51	20
BFY52	20
BFY53	20
BFY90	80
BIP19	38
BIP20	38
BIP19/20 M/P	30
BRY39	39
BSX19	20
BSX20	20
BSX21	21
BSY95	13
BSY95A	13
BU105	1.60
BU105/02	1.95
BU204	1.40
BU205	1.40
BU208	1.90
BU208/02	2.25
GP300	40
MJ480	95
MJ481	1.05
MJ490	95
MJ491	1.15
MJ2955	90
MJE340	50
MJE370	55
MJE371	60
MJE520	45
MJE521	65
MJE2955	90
MJE3055	65
MJE3440	52
MP8113	52
MPF102	60
MPF104	35
MPF105	35

MPSA05	20
MPSA06	20
MPSA55	20
MPSA56	20
ND120	18
OC19	85
OC20	1.85
OC22	1.50
OC23	1.50
OC24	1.35
OC25	1.00
OC26	1.00
OC28	90
OC29	95
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OC36	90
OC41	20
OC42	22
OC44	24
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OC71	15
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OC82D	30
OC83	26
OC84	38
OC139	80
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OC169	80
OC170	80
OC171	80
OC200	46
OC201	95
OC202	1.20
OC203	85
OC204	90
OC205	1.15
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R2010B	2.60
TIC44	29
TIC45	35
TIP29	30
TIP29A	55
TIP29B	42
TIP29C	44
TIP30	38

TIP30A	40
TIP30B	42
TIP30C	44
TIP31	38
TIP31A	40
TIP31B	42
TIP31C	44
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TIP32C	44
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TIP41C	48
TIP42A	44
TIP42B	46
TIP42C	48
TIP2955	60
TIP3055	50
TIS43	20
TIS90	20
TIS91	22
TIS92	22
UT46	20
ZTX107	10
ZTX108	10
ZTX109	10
ZTX300	12
ZTX301	12
ZTX302	16
ZTC303	16
ZTX304	20
ZTX330	15
ZTX500	13
ZTX501	12
ZTX502	16
ZTX503	12
ZTX504	25
ZTX531	25
ZTX550	25
2N388	36
2N388A	56
2N404	20
2N404A	24
2N524	40
2N527	50
2N598	40
2N599	46
2N696	24
2N697	24
2N698	30
2N699	32
2N706	10
2N706A	12

2N707	48
2N708	14
2N711	30
2N717	30
2N718	25
2N718A	50
2N726	29
2N727	29
2N743	20
2N744	20
2N914	20
2N918	30
2N929	20
2N930	18
2N946	20
2N1131	24
2N1132	24
2N1302	25
2N1303	28
2N1304	28
2N1305	28
2N1306	35
2N1307	35
2N1308	40
2N1309	40
2N1599	35
2N1613	28
2N1711	30
2N1889	45
2N1890	45
2N1893	40
2N2147	75
2N2148	70
2N2192	38
2N2193	38
2N2194	38
2N2217	25
2N2218	25
2N2218A	28
2N2219	28
2N2219A	30
2N2220	20
2N2221	20
2N2221A	22
2N2222	20
2N2222A	20
2N2368	18
2N2369	14
2N2369A	14
2N2411	25
2N2412	25
2N2646	47
2N2711	22
2N2712	22

2N2714	22
2N2904	24
2N2904A	26
2N2905	24
2N2905A	26
2N2906	18
2N2906A	20
2N2907	20
2N2907A	22
2N2903	15
2N2924	15
2N2925	15
2N2926G	10
2N2926Y	09
2N29260	09
2N2926R	09
2N2926B	09
2N3010	20
2N3011	20
2N3053	22
2N3054	45
2N3055	42
2N3402	21
2N3403	21
2N3404	29
2N3405	42
2N3414	16
2N3415	16
2N3416	29
2N3417	29
2N3614	1.00
2N3615	1.05
2N3616	1.05
2N3646	09
2N3702	09
2N3703	09
2N3704	09
2N3705	09
2N3706	10
2N3707	10
2N3708	09
2N3708A	09
2N3709	09
2N3710	10
2N3711	10
2N3771	1.40
2N3772	1.60
2N3773	2.20
2N3819 (FET)	18
2N3820 (FET)	35
2N3821 (FET)	60

2N3823 (FET)	60
2N3903	12
2N3904	12
2N3905	12
2N3906	12
2N4058	12
2N4059	14
2N4060	14
2N4061	12
2N4062	12
2N4220 (FET)	35
2N4284	28
2N4285	28
2N4286	28
2N4287	28
2N4288	28
2N4289	28
2N4290	28
2N4291	28
2N4292	28
2N4293	28
2N4860 (FET)	60
2N4923	65
2N5135	10
2N5138	10
2N5172	14
2N5194	56
2N5245	40
2N5294	50
2N5296	50
2N5448	12
2N5457 (FET)	32
2N5458 (FET)	32
2N5459 (FET)	35
2N5551	36
2N6027 (P.U.T.)	34
2N6121	70
2N6122	70
2N6289	70
2S301	50
2S302	43
2S302A	43
2S303	56
2S304	71
2S305	80
2S306	80
2S307	80

DIODES

AA119	08	BB104	30	BY176	75	OA79	10
AA120	08	BAX13	07	BY206	30	OA81	10
AA129	09	BAX16	08	BY210/600	09	OA85	10
AAY30	09	BY100	22	BYZ10	45	OA91	07
AAZ13	15	BY101	22	BYZ11	45	OA91	07
AAZ17	15	BY105	22	BYZ12	40	OA95	07
BA100	10	BY114	22	BYZ13	40	OA182	13
BA102	20	BY124	22	BYZ16	41	OA200	08
BA144	09	BY126	11	BYZ17	36	OA202	08
BA148	15	BY127	12	BYZ18	36	IN34A	07
BA154	12	BY128	16	BYZ19	36	IN60	06
BA155	14	BY130	17	OA5	60	IN914	04
BA156	14	BY133	21	OA10	35	IN916	05
BA173	15	BY156	08	OA47	08	IN4148	04
BA248	18	BY164	51	OA70	08	IS44	05

74 SERIES TTL

7400	14	7437	30	7485	95	74153	65
7401	12	7438	30	7486	28	74154	1.00
7402	12	7440	15	7489	1.95	74155	70
7403	12	7441	60	7490	36	74156	70
7404	13	7442	60	7491	75	74157	70
7405	13	7443	1.00	7492	50	74160	90
7406	28	7444	1.00	7493	36	74161	90
7407	28	7445	90	7494	75	74162	90
7408	20	7446	90	7495	65	74163	90
7409	20	7447	65	7496	65	74164	1.00
7410	13	7448	65	74100	1.10	74165	1.00
7411	20	7450	15	74104	50	74166	1.00
7412	22	7451	15	74105	50	74167	2.30
7413	30	7452	15	74107	32	74174	90
7414	50	7453	15	74110	46	74175	80
7416	28	7454	15	74111	60	74176	85
7417	28	7460	15	74118	95	74177	85
7420	14	7470	32	74119	1.20	74180	90
7421	32	7472	28	74121	36	74181	2.30
7422	24	7473	32	74122	46	74182	85
7423	28	7474	30	74123	60	74184	1.35
7425	28	7475	44	74124	60	74190	1.00
7426	30	7476	35	74136	65	74191	1.00
7427	28	7480	48	74141	60	74192	95
7428	34	7481	95	74144	2.50	74193	1.00
7430	14	7482	70	74145	80	74194	90
7432	28	7483	68	74150	1.00	74195	90
7433	36	7484	95	74151	65	74196	95

CMOS

CD4000	18	CD4021	1.05	CD4042	78	CD4081	26
CD4001	19	CD4022	95	CD4043	88	CD4082	26
CD4002	20	CD4023	23	CD4044	88	CD4085	90
CD4006	92	CD4024	70	CD4045	1.50	CD4093	70
CD4007	22	CD4025	20	CD4046	1.10	CD4501	28
CD4008	80	CD4026	1.50	CD4047	95	CD4502	1.20
CD4009	40	CD4027	48	CD4048	65	CD4503	70
CD4010	48	CD4028	80	CD4049	45	CD4506	70
CD4011	22	CD4029	1.00	CD4050	45	CD4507	60
CD4012	22	CD4030	55	CD4052	80	CD4508	2.95
CD4013	45	CD4031	2.00	CD4054	1.25	CD4510	99
CD4014	84	CD4034	1.95	CD4055	1.25	CD4511	1.15
CD4015	84	CD4035	1.20	CD4056	1.35	CD4516	1.10
CD4016	42	CD4036	3.30	CD4068	25	CD4518	1.00
CD4017	80	CD4037	95	CD4069	25	CD4520	1.00
CD4018	85	CD4038	1.15	CD4070	29	CD4528	1.10
CD4019	45	CD4040	95	CD4071	25	CD4531	1.50
CD4020	99	CD4041	78	CD4072	25	CD4561	1.00

VOLTAGE REGULATORS

MVR7805-MVR7824	all 59p Ea.
MVR7905-MVR7924	all 63p Ea.
78LO5-78L24	all 28p Ea.
79LO5-79L24	all 55p Ea.
LM309K	1.25
UA79MGHC	2.50
LM320 15v 12v, 15v 24v	95p Ea.

74 LS SERIES TTL

74LS00	13	74LS78	46	74LS165	1.20	74LS279	85
74LS01	13	74LS83	68	74LS166	1.70	74LS280	2.40
74LS02	15	74LS85	75	74LS168	1.80	74LS283	85
74LS03	15	74LS86	38	74LS169	1.90	74LS290	90
74LS04	15	74LS90	38	74LS170	2.50	74LS293	1.00
74LS05	22	74LS91	1.30	74LS173	95	74LS295	1.90
74LS08	21	74LS92	68	74LS174	95	74LS298	1.50
74LS09	21	74LS93	58	74LS175	95	74LS299	3.50
74LS10	20	74LS95	95	74LS181	2.70	74LS323	3.50
74LS11	22	74LS96	1.10	74LS183	2.80	74LS324	1.90
74LS12	26	74LS107	40	74LS190	95	74LS325	3.00
74LS13	34	74LS109	70	74LS191	95	74LS326	3.20
74LS14	50	74LS112	38	74LS192	95	74LS327	3.10
74LS15	34	74LS113	86	74LS193	90	74LS348	1.90
74LS20	18	74LS114	38	74LS194	95	74LS352	1.50
74LS21	26	74LS122	38	74LS195	85	74LS353	1.50
74LS22	26	74LS123	60	74LS196	1.00	74LS365	45
74LS26	38	74LS124	1.60	74LS197	85	74LS366	55
74LS27	35	74LS125	45	74LS221	1.00	74LS367	63
74LS28	35	74LS126	45	74LS240	1.60	74LS368	80
74LS30	18	74LS132	60	74LS241	1.60	74LS373	1.45
74LS32	22	74LS136	50	74LS242	1.60	74LS374	1.45
74LS33	34	74LS138	60	74LS243	1.60	74LS375	1.10
74LS37	28	74LS139	68	74LS244	1.50	74LS378	1.20
74LS38	28	74LS145	1.15	74LS245	2.20	74LS386	75
74LS40	25	74LS147	2.00	74LS247	1.20	74LS393	1.10
74LS42	55	74LS148	1.60	74LS248	1.20	74LS395	2.00
74LS47	72	74LS151	70	74LS249	1.20	74LS398	2.70
74LS48	80	74LS153	68	74LS251	1.20	74LS399	2.00
74LS49	90	74LS155	65	74LS253	90	74LS490	1.40
74LS51	24	74LS156	60	74LS257	90	74LS670	2.50
74LS54	28	74LS157	60	74LS258	1.10		
74LS55	28	74LS158	60	74LS260	85		
74LS63	1.40	74LS160	85	74LS259	1.50		
74LS73	30	74LS161	75	74LS261	4.00		
74LS74	30	74LS162	1.00	75LS266	72		
74LS75	38	74LS163	90	74LS273	1.65		
74LS76	42	74LS164	90	74LS275	3.50		

COMPUTER I.C.s

2114 L-3	2.40
2708	3.50
2516/2715-5v	4.90
4116	2.25

LINEAR I.C.'s

CA270BE	95	LM324N	48	72709	46
CA280O	85	LM337T	1.35	709P	35
CA3011	98	LM339N	65	UA710C	40
CA3014	1.75	LM348N	90	72710	30
CA3018	65	LM380	85	UA711C	32
CA3020	1.75	LM381	1.45	72711	32
CA3028	80	LM382N	1.20	UA723C	45
CA3035	2.30	LM384	1.45	72723	45
CA3036	1.00	LM386	85	UA741C	24
CA3042	1.60	LM387	1.10	72741	24
CA3043	1.85	LM1458	42	741P	17
CA3046	70	LM3900	58	UA747C	60
CA3052	1.60	LM3909N	70	72747	60
CA3054	1.10	LM3915N	2.20	UA748	35
CA3075	1.50	LM3914N	2.20	748P	35
CA3080	65	LM3911N	1.20	SN76013N	1.60
CA3081	1.50	LM3916	2.45	SN76023N	1.65
CA3085	95	MC1304	1.90	SN76110	1.50
CA3089	2.00	MC1310P	1.45	SN76115AN	1.90
CA3090	3.60	MC1312	1.70	SN76660N	90
CA3123E	1.50	MC1350	1.20	TAA550B	35
CA3130E	90	MC1352	1.40	TAA621	2.00
CA3140E	48	MC1469	2.70	TAA661B	1.50
LF351N	55	MC1496	90	TBA120B	70
LF353N	88	NE555	20	TBA540	1.40
LF356N	90	NE556	55	TBA641A	2.20
LH0042CH	2.25	NE565	1.20	TBA800	85
LM301A	25	NE566	1.50	TBA810S	95
LM304	1.60	NE567	1.70	TBA820	70
LM308	75	72702	46	TBA920Q	2.50
LM309K	1.25	UA703C	25	TCA270S	1.40
LM311	65	UA709C	25	ZN414	90
LM317H	2.50			ZTK338	15
LM318H	1.95				

SILICON RECTIFIERS

200mA	
IS920 50v	06
IS921 100v	07
IS922 150v	08
IS923 200v	09
IS924 300v	10
1 Amp	
1N4001 50v	04½
1N4002 100v	05
1N4003 200v	06
1N4004 400v	06
1N4005 600v	07
1N4006 800v	07
1N4007 1000v	08
1.5 Amp	
IS015 50v	09
IS020 100v	10
IS021 200v	11
IS023 400v	13
IS025 600v	14
IS027 800v	16
IS029 1000v	20
IS031 1200v	25
3 Amp	
IN5400 50v	11
IN5401 100v	12
IN5402 200v	14
IN5403 300v	15
IN5404 400v	16
IN5405 500v	17
IN5406 600v	18
IN5407 800v	22
IN5408 1000v	25
6 Amp	
BYX38-300	45
BYX38-600	60
BYX38-300R	45
BYX38-600R	60
10 Amp	
IS10/50 50v	30
IS10/100 100v	35
IS10/200 200v	40
IS10/400 400v	50
IS10/600 600v	60
IS10/800 800v	70
IS10/1000 1000v	85
IS10/1200 1200v	95

BRIDGE RECTIFIERS

1 Amp RMS	
BR1/50v	20
BR1/100v	22
BT1/200v	25
BR1/40v	29
2 Amps RMS	
BR2/50v	35
BR2/100v	40
BR2/200v	44
BR2/400v	50
BR2/1000v	65
6 Amps RMS	
BR6/50v	75
BR6/100v	80
BR6/200v	88
BR6/400v	95

THYRISTORS

1 Amp TO39 CASE	
THY1A/50v	34
THY1A/100v	38
THY1A/200v	42
THY1A/400v	50
THY1A/600v	65
THY1A/800v	78
BT101/500R	80
BT102/500R	80
BT106	1.25
BT107	93
BT108	98
2N3228	70
3 Amp – TO66	
THY3A/50v	35
THY3A/100v	37
THY3A/200v	40
THY3A/400v	50
THY3A/600v	60
THY3A/800v	75
5 Amp – TO64	
THY5A/50v	36
THY5A/100v	45
THY5A/200v	50
THY5A/400v	57
THY5A/600v	60
THY5A/800v	75
5 Amp - TO66	
THY5A/50v	36
THY5A/100v	45
THY5A/200v	50
THY5A/400v	57
THY5A/600v	60
THY5A/800v	75
2N3525	77
BTX30/50L	40
BTX30/400L	70
BT116	1.50
C106D	38
BTY79/400R	95
5 Amp – TO220 PLASTIC	
THY5A/50vP	35
THY5A/100vP	45
THY5A/200vP	47
THY5A/400vP	50
THY5A/600vP	60
THY5A/800vP	70
10 Amp – TO48	
THY10A/50v	45
THY10A/100v	50
THY10A/200v	55
THY10A/400v	60
THY10A/600v	80
THY10A/800v	1.10
16 Amp – TO48	
THY16A/50v	65
THY16A/100v	80
THY16A/200v	90
THY16A/400v	1.20
THY16A/600v	1.50
THY16A/800v	2.00
30 Amp – TO94	
THY30A/50v	1.30
THY30A/100v	1.50
THY30A/200v	2.95
THY30A/400v	4.00
THY30A/600v	4.20

TRIACS

2 Amp – TO39	
TRI2A/100v	30
TRI2A/200v	42
TRI2A/400v	50
10 Amp – TO48	
TRI10A/100v	55
TRI10A/200v	80
TRI10A/400v	90
4 Amp – TO202	
TRI4A/400v	55
8 Amp – TO220	
TRI8A/400v	64
10 Amp – TO220 – PLASTIC	
TRI10A/400P	68
6 Amp – TO220	
TRI6A/100v	45
TRI6A/200v	52
TRI6A/400v	60
12 Amp – TO220	
TRI12A/400V	70
DIACS	
BR100	20
D32	20

ZENER DIODES

400W 1.3V-39V	all at 8p
1.3W 1.3V-100V	all at 15p
10W 1.3V-100V	all at 35p

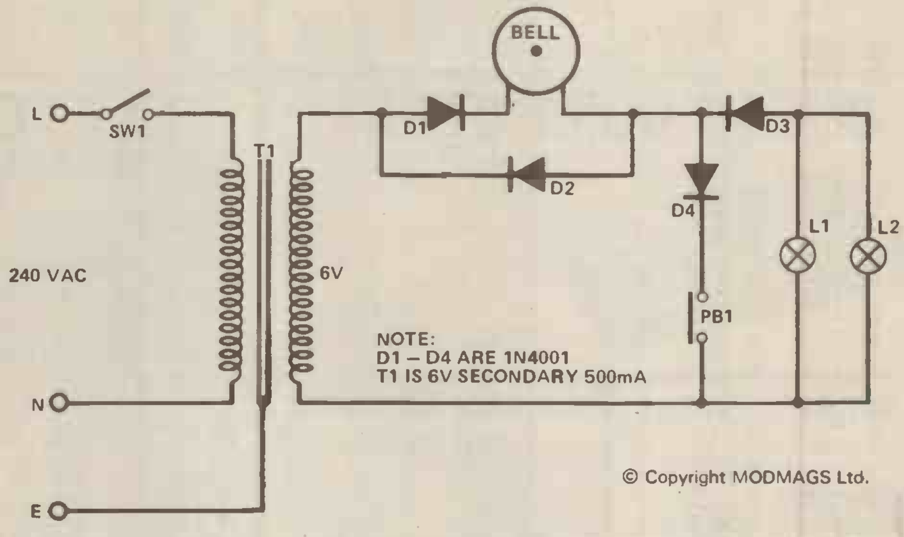
Quick Project: Two-Down-One

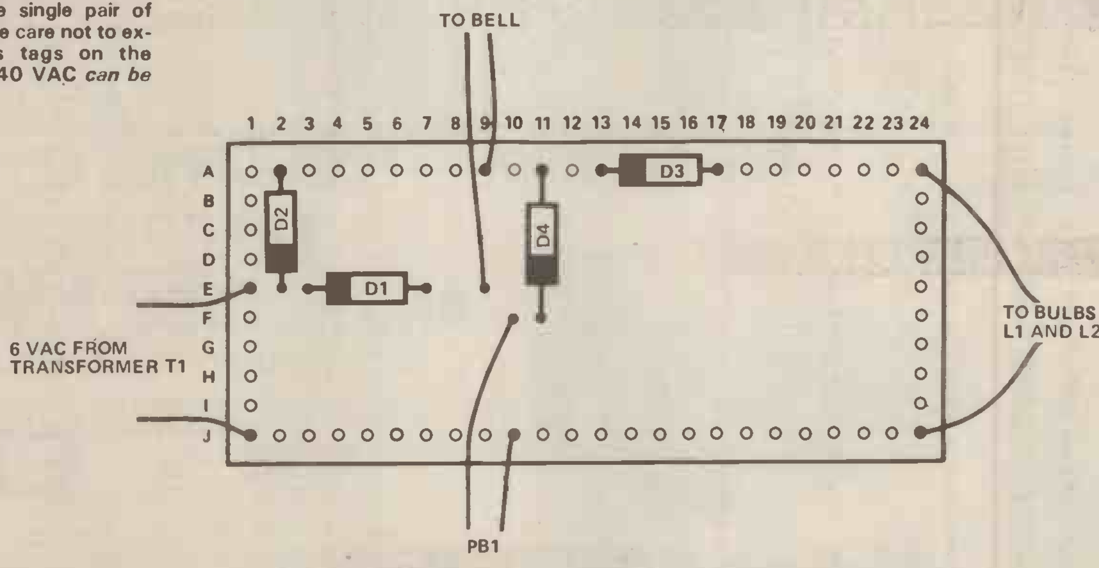
An easily-built circuit which enables two apparently separate voltage supplies to be taken from one pair of leads. A reader's design for a short circuit that we've selected for a project

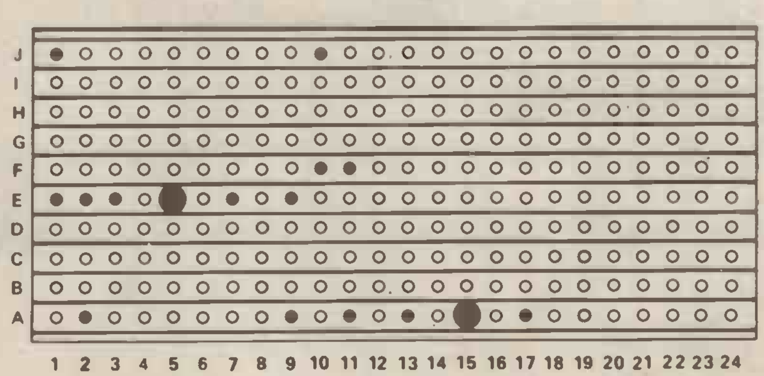
This circuit allows you to obtain two sources of voltage from only one pair of wires from a bell transformer. It was designed so that people who have an illuminated door-bell can run a separate bulb over the door number without the need for a second set of wires from the transformer. If you try to use the same pair of wires to run a second bulb the increase in current will probably make the hammer of the bell 'tremble'.

By using only one half of the AC cycle from the transformer to illuminate the bulbs whilst the other half of the cycle rings the bell, the problem is overcome. Diodes D1 to D4 are all that is required to complete the circuit and the whole project fits neatly onto one of our standard-sized (10 strips x 24 holes) piece of Veroboard.

Other uses for the circuit could be to send two separate control signals down the single pair of wires. Finally, take care not to expose the mains tags on the transformer — 240 VAC *can be dangerous*.







GADGETS GAMES & KITS

Welcome to HE's new free supplement, which you should find in the centre of future issues.

Each month, GG&K will carry items such as:

- **What's New — preview of latest products**
- **News Round-up — recent happenings in gadgets, games and kits market**
- **On Test — appraisal of selected items**
- **What's on Show — exhibition previews and reviews**

Readers may recall our popular Gadgets & Games special produced in December 1980. It gave a wide coverage of many items under its two main headings. This new supplement takes in kits as well, and aims to bring you information on new products every month.

This month we look at the Tantel, a Prestel adaptor from Tangerine Computer Systems and two recent products from Casio, the CA-90 watch and the MA-1 alarm clock. We also play with four electronic games and review a couple of kits.

Use Tantel To See Prestel

Prestel seems to be one of those topics that you're either violently averse to or fervently in favour of, like Concorde, nuclear disarmament or The Osmonds. In principle, the system relies on the combination of two previously separate communications media — telephone and television.

The simple act of plugging your telly into the phone line has far-reaching implications. Television is a one-way medium. Signals are broadcast from the transmitter to you, never the other way round. The addition of a telephone introduces the possibility of two-way communication. You can get information out of the system and display it on the box. You can also respond to questions on the screen or invitations to order goods, book holidays, hire cars, etc.

Pros and Cons

We looked at the latest Prestel adaptor, a unit from Tangerine Computer Systems. Tantel is an attractive little box about the size of a desk-top calculator. The sloping front panel has a 16-key touch-sensitive control panel and an instruction panel explaining the function of the keys.

Tangerine's national advertising boasts '180,000 pages of information instantly available'. That information ranges from the news headlines and sports results to regional events, services, etc. If you want to know, for example, what train to catch to get to Euston by nine o'clock every morning and how much your season ticket will cost, it's on Prestel.

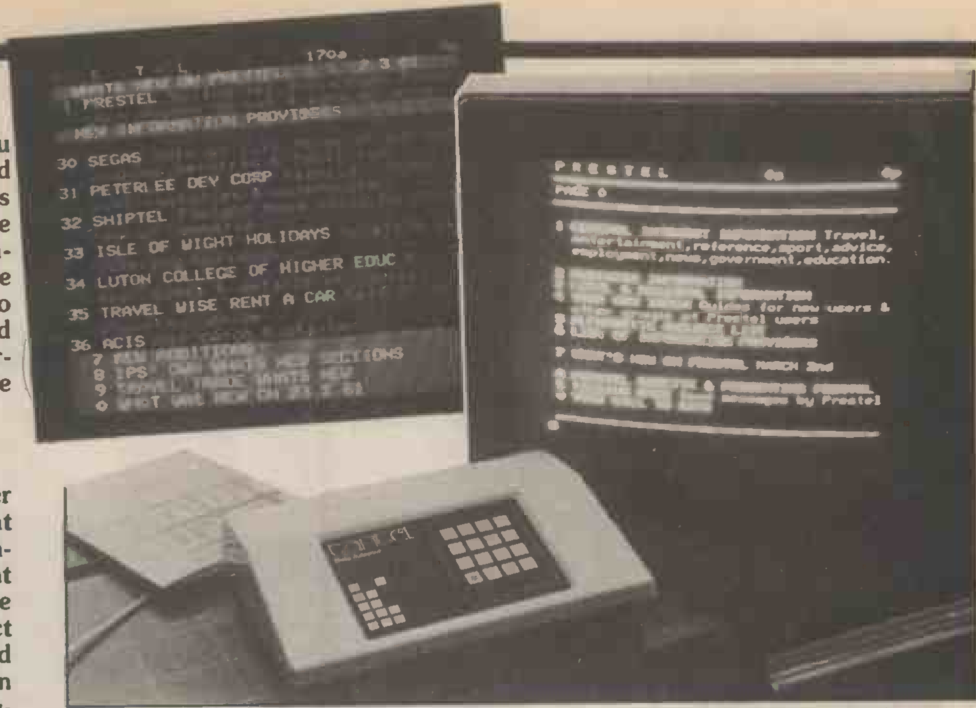
But. . . . .

However, we did find that a small fraction of the information was out of date, no fault of Tantel, of course. The biggest disadvantage of Prestel is that you have to pay for it, because you use your telephone to access information. Much of Prestel's news, weather, sports, travel and other information is also available on teletext, which is free — it's broadcast to anyone who can receive and decode it.

Back to Tantel. How do you use it? The first thing to do is register it with British Telecom. The Prestel computer has to know that you exist and identify your terminal when you switch on. All the necessary leads are supplied. First you plug one end of the UHF lead into the back of your television in place of the aerial lead and the other end into Tantel. Next you plug the funny-looking jack plug into the type 96A socket that BT will come and fit to your telephone. It only remains to plug in the mains lead, switch on and tune a spare channel into Tantel.

You can buy an adaptor that will allow you to plug Tantel *and* your aerial into the telly at the same time. Otherwise you have to unplug Tantel every time you want to watch Blue Peter.

With the TV sound turned up, you can hear dialling tones, recorded messages, etc. When your Tantel is commissioned, the computer phone numbers will be remotely programmed into it. Useful features include autodialling (manual dialling also available at the touch of a key) and the ability to record pages of information on a domestic cassette recorder.



Merry Christmas

The information is organised rather like a Christmas tree. You start at the top with page 0 — the main index. If you choose to have a look at the latest news, you can look at the national news headlines or select regional news. When you've selected your region, you can narrow it down even further by using the county-by-county index. At the end of most pages, you can carry on along that particular branch with more choices of information or return to the main index. If you know what page the information you want is on, you can go straight to that page and miss out all the intervening information.

Impressions

The picture is rock steady and crystal clear. The device is easily controlled, sensibly laid out and reasonably priced compared with its rivals. We haven't yet worked Tantel into the ground, so these are really first impressions of the system and the first impressions are certainly favourable.

Prestel has been vehemently criticised since its inception because of the enormous public investment which has so far resulted in a relatively small number of users. Small, cheap, easy to install and use adaptors like Tantel should result in Prestel appearing on more British tellies . . . . providing the public wants Prestel, but that's another story.

Tantel is available for £170 + VAT from Tangerine Computer Systems Ltd, Forehill Works, Ely, Cambridgeshire CB7 4AE. Further information is available from Tandata at the same address for the price of a first class stamp.

Space Invaders Up Your Sleeve

These little creatures, in one form or another, get everywhere. Now they're lurking inside the latest watch from Casio — the CA-90.

As an excellent example of the staggering rate of progress of ultra-miniaturisation of electronic circuits, this watch offers the following functions: ▶

Regular timekeeping	hours, minutes and seconds, with display of day and date
Calendar	month, date and year for about 2 seconds at the press of a button. The calendar is auto-programmed until the year 2002
Stopwatch	times events up to 23 hours, 59 minutes, 59.99 seconds (long enough?) with start, stop and lap functions
Alarm	bleeping alarm tone with suppression facility. Two bleeps on the hour can be selected
Dual time	one button selects 12 and 24 hour formats. Pre-set time, synchronised to normal displayed time, can also be selected
Calculator	standard +, −, ×, + functions and constant. Eight-digit display, with last two digits 'wrapped around' (in position of date digits)
Game	Space Invaders (see below for details)

With all the above contained in one watch module only 46 by 36 by 10.55 mm thick, together with two type 389 silver oxide batteries (life about 15 months), there isn't much room for space invaders. So they have been shrunk down to digits, which advance relentlessly from right to left across the display when the game starts. (Similar in operation to the Casio MG-880 calculator, which also includes the invader game.)

The object of the game is to first 'aim' — match a number with that of one of the invaders — and then to 'fire' — press a firing button before the leading invader reaches the end of the scale. Just as in the full-scale ▷

invader games, you have 'shields', displayed as three bars next to the aim number. Each time the leading invader 'lands' one of these is destroyed. To complete the picture there is also a 'UFO' coming up at random for bonus points.

All this is accompanied by the usual bleeping sounds you would expect with the game. There are nine rounds after which the more difficult Stage II starts. This second stage also has nine rounds: thereafter (if you succeed this far) you return to the start.

HE gave the CA-90 an on-the-arm test and we were generally impressed with its performance. Main niggle was about the size of the function keys: they were found fiddly to operate but there are obvious size restrictions on a watch.

The calculator took some getting

used to after being more familiar with conventional hand-held calculators. The 'clear display' button is sited on one edge while the +, ×, − and = buttons are along the opposite edge.

These criticisms applied equally to the game, where you needed great dexterity in a very confined space. We did find, however, that the buttons became easier to use after a few days. (Practice makes perfect?)

We liked it on all other points, though. The display is easy to read, the hour bleep is useful and it is handy to have so many functions in one timepiece.

The CA-90 comes in a resin-moulded case with a combined bracelet of the same material. It is available in two colours: black (CA-90-1) and brown (CA-90-5).

Normal RRP is £27.95, but it is available at a special discount price of £24.95 from Tempus, 'Talk of the Town', 19 to 21 Fitzroy Street, Cambridge, CB1 1DB (Tel. 0223 312866 /67503).

Wake Up To Mozart

Casio's MA-1 alarm clock gives you two alarm functions: repetitive bursts of electronic bleeps or about 30 seconds of a simplified — but recognisable — rendering of Symphonie No. 40 G moll (W.A. Mozart K.550). (This piece was so popular that one arrangement reached the pop charts a few years back.) Volume of both alarm signals can be preset by a three-position slide switch.

If you prefer a snooze function, you are first woken up with the melody followed by an electronic buzzer sound seven times for 60 seconds at intervals of 4 minutes. If you stop the snooze function at any point the whole business, starting with the melody, is repeated after about 7 minutes.

If the hourly time signal is set, 'pips' count down the last three seconds before each hour, with one long peep on the hour.

Hours, minutes, seconds, PM, SNZ (snooze), hourly time (bell symbol) and alarm are displayed on a *blue* LCD. This blends in nicely with the blue front bezel but is not as easy to read as some of the dull-looking standard LCD displays.

Case of the MA-1 is in white plastic, with a 30 mm-wide alarm stop button which doubles as back-light switch for the display. Loudspeaker is on the top of the case, with volume, alarm mode select and time setting controls to the right of it. These controls allow adjustment of error up to ±30 seconds. Accuracy is specified as being within ±3 seconds/day at 15 to 35°C.

Power source is three AA-size manganese cells giving, it is claimed, between 1 year and 15 months depending on the type of cell used.

HE view of MA-1? Good value for money (see below for price). Apart from the lack of contrast in the display, the clock has some useful functions.

The RRP of the MA-1 is £11.95, but it is available at a special discount price of £9.95 from Tempus, 'Talk of the Town', 19 to 21 Fitzroy Street, Cambridge CB1 1DB (Tel. 0223 312866/67503)

Kit Review

We looked at two kits from the Chip Shop Kit series from Electroni-Kit. Kit No. 2 is a soldering iron. (No, you don't have to build it yourself.) This kit is really a misnomer. All you have to do is connect a suitably fused (1 A) mains plug. The accompanying information sheet covers care of your new soldering iron and elementary soldering techniques.

So, now you can set about building the next kit that we looked at — Kit No. 19, a four-transistor radio. The step-by-step assembly instructions are just about idiot-proof.

Construction

Construction shouldn't present any problems. All you need supply is a 9 V battery. A clear component diagram shows the positions of all the components on the printed circuit board. We found that excess heat when tinning the three tuning capacitor pads on the PCB (ie holding the soldering iron on them too long), resulted in a puff of smoke as the copper separated from the mica board. If you feel up to it, a simple 'How It Works' section explains... ...how it works.

Sounds

What does it sound like? Well, performance falls somewhat short of hi-fi as you might expect. Considering that we tried the radio at the top of a building in west London, within a gnat's whisker of several megawatts of shop and office lighting and heating switching on and off at a rate of knots, reception was surprisingly good. Weaker medium wave stations can be received by attaching a few feet of wire to the ferrite rod aerial — useful if you live in a poor-reception area.

Summing Up

If these two kits are typical of Chip Shop Kits, then they are a good buy for the beginner. Documentation is brief but complete and clear. The soldering iron comes with all appropriate warnings and advice, and the four-transistor radio assembly instructions assume no specialist knowledge. If you don't have Chip Shop Kit No.2 (soldering iron) the radio instruction sheet includes advice on the soldering iron you should use and a note on soldering technique.

Once you've caught the electronics bug, you'll want to know why the component bit with the pretty coloured rings does what it does. The instruction sheet recommends a couple of books which may be of assistance.

Both the above kits cost £5.00, plus 50p post and packing charge for each. Around 20 different kits are available from the range. Kits and books are available direct from Electroni-Kit Ltd. Rectory Court, Chalvington, E. Sussex BN27 3TD — Tel. 032 183 579.

Games Review

The Mating Game

The chess computer family grows and grows. If you don't want to shell out £200-plus for the more sophisticated of the games, Electronic Chess CC-700 may be more to your liking. At £29.95 from Kramer & Co., Electronic Chess is a compact hand-held unit with a magnetic chess set and board.

Playing Around

How do you drive the thing? Power can be provided by a PP3 or a 7V5 (150 mA) mains adaptor (plug tip positive). Switch on and an 'L' appears on the seven-segment display, requesting a level number. Levels 1 to 6 evaluate the board situation quickly and select the best move. If a satisfactory move isn't found, a more thorough evaluation is carried out. The changeover to a more thorough evaluation is quicker at higher levels. Level seven only carries out the more thorough evaluation. Level eight is used to solve mate in two moves. Don't select level eight unless you have the odd weekend to spare. It can take up to 10 hours to solve a complicated problem. You can change the level in mid-game, though, to speed things up.

Once you've chosen your level, 'BP' on the display asks for a board position. Pressing A gives the conventional board opening position. Pressing B allows you to set up the board as you wish. Now you're faced with an 'O', requesting an opening game. Keys 1-4 select a standard opening listed in the instruction booklet. Key 5 chooses one of the four openings at random.

The computer normally plays black unless you select otherwise. From now on Electronic Chess is much the same as its relatives. It can cope with castling, pawn promotion, en passant capture, position verification, adding pieces to the board, etc. It will even play against itself, if you're into spectator computer chess. Illegal moves are not accepted.

Playtime

The initialisation or setting up procedure may seem to be rather longwinded, but the computer prompts are logical and easily understood (L means level, BP means board position, etc.). You won't have to keep referring to the instructions to decipher strange codes or heiroglyphics. So, no problems there.

All in all, a nice little game at a reasonable price, ideally suited to newcomers to chess who need lots of game practice, but can't always rustle up an opponent of the appropriate skill level.

Electronic Chess is available, cost £29.95 plus £1.70 p&p from Kramer & Co, 9 October Place, London NW4. Tel: 01-203 2473. A mains adaptor is also available, cost £5.50. Batteries cost £1.40 per set.

Watch/Game Combo

Three small watch/game combinations caught our eye. Each game has two options.

The names don't give a great deal away — 'Fire', 'Ball' and 'Vermin'. The object of Fire is to catch tiny LCD figures jumping from a burning building. You can move your pair of rescuers with their catch-net left or right to get underneath the falling figure. BUT the figure bounces when it hits the net, so you have to keep underneath it until it bounces into the waiting ambulance and you score a point.

If you miss the unfortunate refugee from a flaming demise, he or she (the display resolution makes sexing impossible) becomes a crumpled heap on the ground. The fall is inevitably fatal and an angel appears on the display. If you amass three angels, the game is over. The maximum score you can get is 999.

Having dealt with Fire in such detail, it is sufficient to say that Ball and Vermin are very similar. Ball involves controlling the hands of a juggler so that he always catches the falling balls and Vermin involves moving a mole-catcher about to hit a mole with a hammer as it emerges from the ground (whatever next?).

One wouldn't describe the games as rivetting after the first few minutes, but they are the sort of games that you *might* go back to occasionally. So, if the games aren't all that exciting, would you buy Fire or its fellow gadgets as timepieces? That's doubtful. The time is shown in a small area in the top-right corner of the display — the game score position. It would have been preferable to have shown the time in large digits, using most of the display. How accurate is it? The manufacturer claims an accuracy of ± 3 seconds per day.

With a price tag of around £18, these watch/games seem to be very expensive paperweights for what they do.

Fire, Ball and Vermin are available form NIC, Unit 5, 61 Broad Lane, London N15. Tel: 01-808 0377.

THESE SPACE INVADERS WILL ALARM YOU — the price won't!

The space invaders are back. This time right on your wrist!

CA-90 game

The keyboard is effectively divided in half. Any or all of the left-hand buttons (1, 2, 4, 5, 7, 8) become AIM and any or all of the right-hand buttons become FIRE.
The random digital invaders attack from the bottom right and move across the display. Every time you tap AIM your missile number, displayed top right, progresses by 1. When your missile number coincides with an invader, tap FIRE and that spaceship will disappear, adding to your score. Since this is a speed game, the earlier you destroy an invader, the higher it will score. The game is over if 3 of the 16 spaceships in an encounter penetrate your defences.
There are 2 stages, each stage having 9 encounters. In stage 1 the game speeds up with each encounter and in stage 2 the invaders attack from a closer position. After stage 2 the game reverts back to the beginning of stage 1, but the score, which is added and displayed after each encounter, is carried forward.
Depending very much on your skill, one game can last for as much as an hour or more. The highest score so far will be retained in a non-volatile memory. (This will be erased if the stopwatch function is utilised).

- Calculator
- Stopwatch
- Alarm
- Dual time
- Digital invader game

game display

CASIO'S MOST AMAZING WATCH EVER

CA-90 SPECIFICATION

Time: Hours, minutes, seconds, am/pm, day and date. One-touch changeover between 12/24-hour formats.
Calendar: Automatic; day, date, month and year pre-programmed until the year 2002.
Calculator: 8 digits (7 digits for negatives). Four basic calculations, with constants for +, −, ×, ÷.
Alarm: 24-hour reminder alarm with "alarm on" symbol.
Hourly time signal: Every hour, on the hour. The signal, with display symbol, can be switched on or off.
Stopwatch: Professional 1/100 second stopwatch measuring net, lap and first and second place times.
Dual time: An alternative time (second time zone) can be memorised. Hours and minutes; 12- or 24-hour format.
Tone control: Pitch can be varied in 10 steps.
Game: Additive digital space invader speed game.
Dimensions: 46.0 × 36.0 × 10.55mm. Resin case/strap. Metal keys. Stainless steel back. Mineral glass face.

All this for

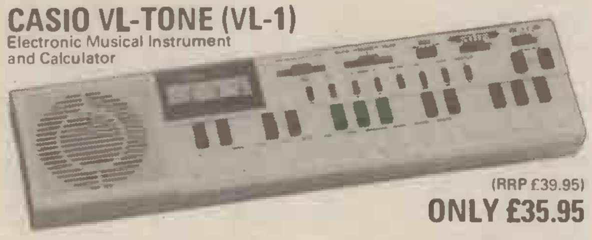
ONLY £24.95
(RRP £27.95)

BECOME AN INSTANT MUSICIAN NO EXPERIENCE NECESSARY

Create your own music with a VL-TONE. You combine the sound, rhythm and tempo and the VL-TONE plays it back . . . beautifully!

CASIO VL-TONE (VL-1)

Electronic Musical Instrument and Calculator



(RRP £39.95)
ONLY £35.95

VL-1. Utilises very large scale intergral circuit advanced technology. This complete 29-note synthesiser records and plays back. The octave shift switch expands the range of the keyboard to almost 5 octaves.
Preset sounds: Piano, Violin, Flute, Guitar, Fantasy and ADSR (sound wave that can be varied in over 80 million ways).
Auto play: ONE-KEY or MANUAL playing can be recorded and will be played back in the form of a melody.
Auto rhythm: 10 built-in rhythms, all with variable tempo and volume balance, can be incorporated in manual playing or added to your recording.
Built-in melody: Pre-programmed German Folk Song with rhythm accompaniment. Play it anytime and practice tempo changes with the tempo control.
Facilities: LCD numerical display shows pitch, including sharps and programming information. Built-in amplifier and speaker. Output jack. Pitch control.
Calculator: 8 digits, +, −, ×, ÷, square roots, %, constants and full memory.
Power source: Four AA size batteries or AC adapter type AD-4160 (price £5).
Dimensions: 30mm x 300mm x 75mm (1⅛in. × 11¾in. × 3in).
This compact, battery powered lightweight (438g, 15.4oz) can be played anywhere.

Please order now for May delivery.

OTHER CASIOTONE KEYBOARDS

MT-30 Polyphonic, 22 instruments over 3 octaves. Battery/mains (RRP £115) £95.
CT-301 Polyphonic, 14 instruments over 4 octaves. 8 × 2 rhythm accompaniments. Vibrato, delayed vibrato. Pitch control. Output jacks. AC only (RRP £285) £245.
CT-401 As CT-301 but with Casio Auto Chord for one finger accompaniment. Plays major, minor and seventh chords with bass. Integral sustain and hold. (RRP £345) £295.

ILLUSTRATED CATALOGUE

Send 20p (postage) for details of CASIOTONE keyboards, CASIO watches and calculators and selected SEIKO watches.

Offers subject to availability.

A CLASSIC IN ITS TIME

You don't have to be a highbrow to appreciate the beauty of this clock. Battery powered, it is ideal for office, lounge, kitchen, bedroom, caravan or boat. Compact and lightweight, it can be used as a travel alarm clock or car clock.

MA-1 ALARM CLOCK

ONLY £9.95
(RRP £11.95)

Blue LCD display, as seen on "Tomorrow's World" 5/3/81. Elimination of polarising filter allows wide angle viewing. Full display of time. Symphonic alarm or buzzer, with snooze facility. Hourly time signal. Integral loudspeaker and amplifier with 3-position volume control. A large top button gives night time illumination and switches the alarm off. Alarm function: "Symphonie Nr. 40 G moll" (W. A. Mozart K.550) for about 30 seconds or buzzer for 60 seconds. Three AA size batteries last approx. 15 months. Quartz accuracy.
Dimensions: 43mm x 115mm x 76mm (1¾ x 4½ x 3 inches).

CASIO'S BEST SELLING WATCHES

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M1200

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LCD ANALOGUE/DIGITAL ALARM CHRONOGRAPH with countdown alarm. AA-81 chrome, s/s bracelet £29.95. AA-81G. Gold plated £49.95. AA-82. all s/s £39.95. 12 MELODY ALARM CHRONOGRAPHS with countdown alarm. M-12 resin case/strap. £24.95. M1200 all stainless steel £29.95.
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Building Site

Are your semiconductors too hot to handle? Keith Brindley explains what to do when the heat is on

MOST CIRCUITS and projects that the hobbyist builds don't handle large amounts of power. The formula for power P is given by:

$$P = IV,$$

where P is the power in watts, I is the current in amps and V the voltage in volts.

This tells us that a circuit, at 10 VDC, consuming 10 mA of current, would generate

$$P = 0.01 \times 10 = 10\,\text{mW of heat.}$$

Nothing in this typical circuit would even be lukewarm to touch, and so there would be no need to worry about excessive heat.

Things change dramatically if you consider the type of semiconductor circuits broadly known as power stages (high-powered hi-fi amplifiers, DC motor controls etc) running with high current and high voltage. A power stage may take over 10 A of current and at, say 50 VDC the overall power is:

$$P = 10 \times 50 = 500\,\text{W}$$

— enough to fry an egg if all the power is dissipated as heat! And *all* semiconductors are damaged by too much heat, so here we run the risk of 'frying' not breakfast but expensive transistors or triacs.

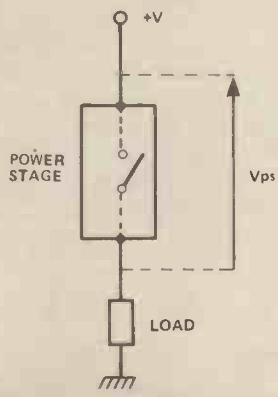


Figure 1. Showing the voltage developed across a semiconductor power stage, when driving a load

Actually, things aren't just that easy. Let me explain. **Figure 1** shows a simplified diagram of the power stage of a circuit, driving a load. The load could be a loudspeaker, or a large motor, or in fact any device which is controlled by a semiconductor power stage. Now, the system would be ideal if the power stage acted as the 'perfect' switch as shown, but, the well known Murphy's Law states specifically that nothing in electronics is ideal. You see, a *perfect* switch would have zero resistance when closed. Thus, with say, 10 A of current through it, and zero resistance, the power dissipated will be

$$P = 10^2 \times 0 = 0\,\text{W}.$$

But no semiconductors can exhibit zero resistance. A transistor might only show a resistance of a fraction of an ohm, but at high current it becomes significant and a voltage is developed across it (V_{ps} in **Fig. 1**) according to Ohm's Law:

$$V = I \times R.$$

And using whichever formula for power you wish,

$$P = IV = I^2R = \frac{V^2}{R}$$

you find that a certain amount of power is generated as heat. If the heat causes the semiconductor temperature to rise above the manufacturer's recommended maximum value, irrepairable damage may occur and the device will no longer function, even when it cools down again.

Cool It

Now, obviously this doesn't mean that we can't use semiconductors in power stages, we just have to find ways in which we can keep the semiconductors cool enough to be within the maximum temperature. For this job we use heatsinks. (In electronics the term to sink means to take in and use up — thus a current sink will take in and use current, and a heatsink takes in and uses up, or gets rid of, excess heat.)

Various types of heatsink can be bought, shaped to fit all kinds of semiconductor devices. **Figure 2** shows a selection, ranging from push-fit or clip-on types (suiting small flexible-lead transistors) to large bolt-on types (meant for high-power semiconductors).

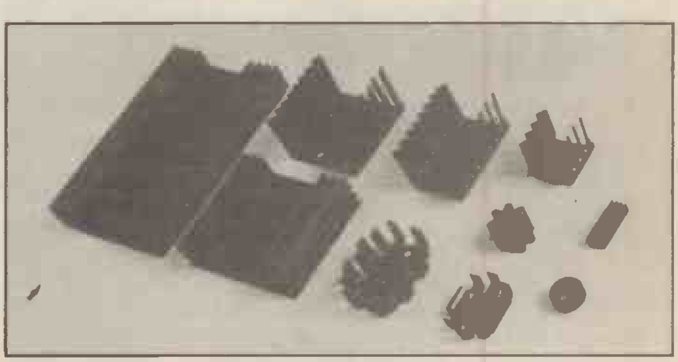


Figure 2. A selection of available heatsinks

DIY

Incidentally, you don't *always* need to buy a commercially available heatsink, because you can sometimes make your own. In situations where only a small amount of heat is dissipated by a device, a simple piece of metal could do the job (see **Fig.3**) and the increase in surface-to-air contact obtained with this method may be enough to keep the device cool. Painting the metal with matt-black paint also helps dissipation.

In slightly hotter applications you can mount the device on the metal case of your project as in **Fig.4**. Neither of the above two methods are as efficient as a bought heatsink but *as long as the device's maximum operating temperature is not exceeded* — who cares?

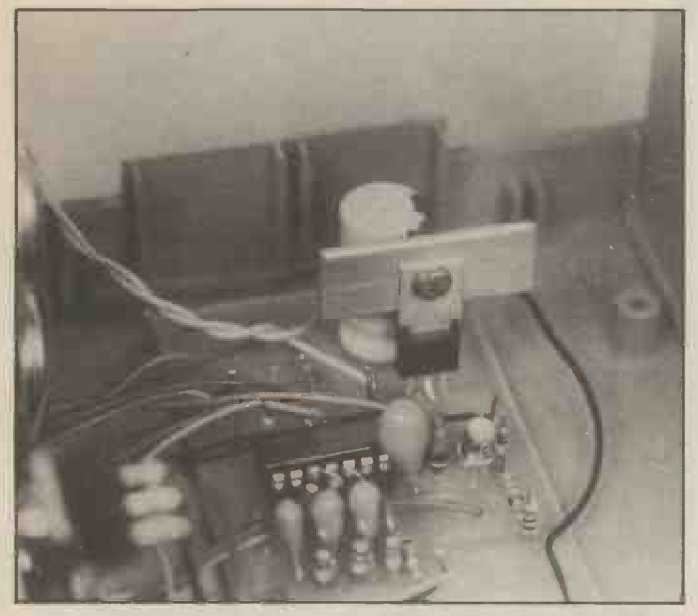


Figure 3. In many power circuits a small piece of metal, bolted to the semiconductor, will keep the device cool enough

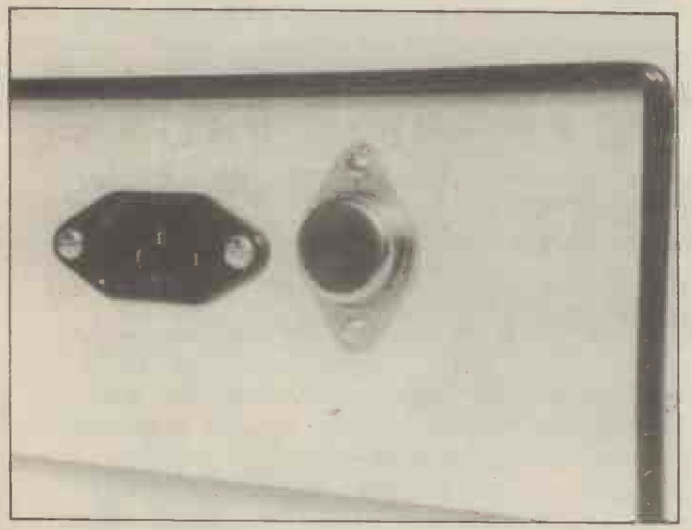


Figure 4. If your project is housed inside a metal case you can use one of the case sides as a heatsink

Compound Interest

As the whole idea of heatsinking is to reduce the build-up of heat on the semiconductor then any method to aid the reduction is a valuable asset. A dry contact between the semiconductor and the heatsink can be quite slow to conduct the heat, and the process can be speeded up, by a factor of about two, by smearing the surfaces with a thermally-conductive silicon compound before fastening them together. A tube of this stuff will last a long time and it doesn't go 'off', so the initial outlay is well worth it.

Electrical Isolation

Finally, in **Fig.5** is a sneak preview of the power amplifier to be featured as a project next month. This is of particular interest because of the number of transistors mounted on its large heatsink. In all, six devices are mounted (although the same problem will arise if only two transistors are on one heatsink) — and this can be troublesome, because the case of most transistors is internally connected to the transistor's collector. Now, two different transistors may have their collectors at different voltages, so the transistors need to be electrically isolated to prevent short circuits.

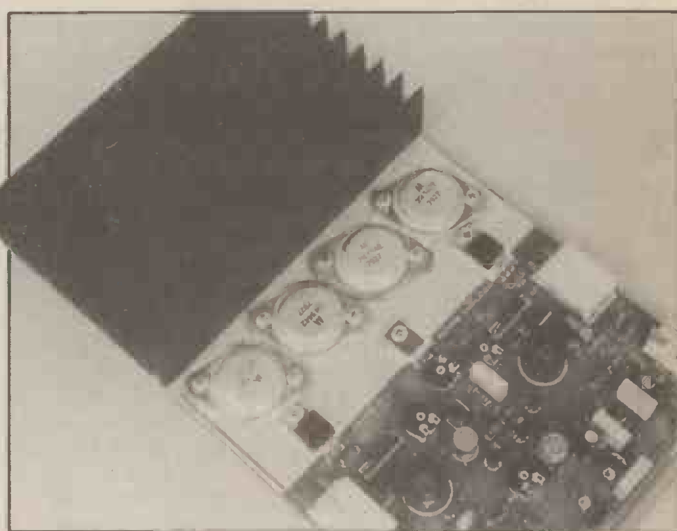


Figure 5. When more than one semiconductor is fastened to a heatsink as above, they must be electrically isolated

Special mica washers and insulating bushes are used for this job and can be bought to fit the particular size and shape of semiconductor you use. **Figure 6** shows a diagram of a T03 size transistor and how the mica washer is fitted. Remember to smear all four surfaces of semiconductor to washer to heatsink with heatsink compound before bolting them together — although you want *electrical* isolation your still need *heat* conduction.

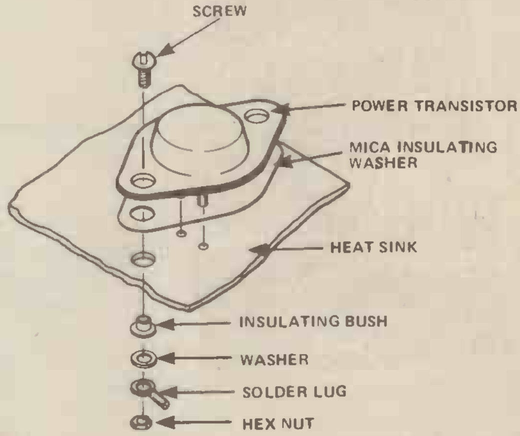


Figure 6. Use a mica washer to electrically insulate the semiconductor from the heatsink

HE

Your Letters

This new page features a selection of your letters to the Editor

HE's Editor receives hundreds of letters from readers each month and finds it impossible to answer evey one of them. As a help (especially to the Editor!) this new page has been created to enable readers to air their views, make suggestions or put forward questions.
Hugh Davies will try to answer as many letters as he can *directly*, but only if they are accompanied by a stamped addressed envelope. Please try to keep your letters as short as possible.
Clever Dick, chained in the depths of the HE dungeon, 145 Charing Cross Road, will continue to sigh, smile, rant or rage over his own heap of correspondence

First out of the bag this month (March) is from a reader who, after suffering the consequences of an error in a diagram for one of our projects, had the patience to try again.

Dear Sir,
As a late starter to this electronics game may I first applaud your mag for its contents. I very humbly point out that your Bench amp — Hobby Electronics January '81 — article is just what we beginners need, with the exception of the two mistakes in the wiring up diagram which I discovered to my cost after using a battery eliminator connected as per the middle of three diagrams (+ — wrong way round and transistor 1 out of place). This, as you would imagine, has made me sit up and take notice of what I am doing.

Perhaps you would like to inform other readers of these mistakes as many may not have the patience to try again.
J. Williams
Bradford, W. Yorks

Sorry about the error in Fig. 2, page 38 in the January issue: we covered it (somewhat late, you might say) in the Errata column under Monitor in the March '81 issue. (The connections to the battery clip should be reversed and transistor Q1 should be moved down one complete strip on the Veroboard.)

Dear Sir,
I should like to take up electronics as a hobby. After buying Februarys H.E mag. I was very interested in the heart beat monitor, and would like to attempt to make one.

How do I get the stuff? What tools would I require? Am I aiming to high? Please help. Any info would be of great assistance.

At present I am a student E.E.G. technician.
R. Sawyer
Ormskirk, Lancs

If you are just starting out in electronics and are considering the Heartbeat Monitor as a first project, then I think that you are definitely aiming too high. It would be better to start off with something simpler, such as the Doorbell Monitor (March '81 issue, pp 32 to 33).

Most components are available from the stockists advertising in HE (some offer complete kits). Details of where any components which may be particularly difficult to obtain are usually given under Buylines for each project.

What tools would your require? Have a look a Building Site in the April '81 issue for some guidance (pp 29 to 30).

Dear Sir,
According to your Index to volume 2 published in the January 1981 issue of H.E., the November and December 1979 copies of H.E. don't exist!

Furthermore, the November and December 1980 and the January 1981 issue (all from volume 3) have crept in.

I (and maybee a few other loonies who have also got all 24 of your mags so far) would appreciate it if you could print a revised index.
M. Osborne
Wokinham, Berks

P.S. I was beginning to lose faith, but the last few issues have been ace.

P.P.S. How about a cheap, simple, short wave receiver which accidently picks up 27 MHz?

First, the November and December '79 issues of HE *do* exist . . . and second, you are the first reader to spot the omissions in our Vol 2 index. Yes, it was as if the whole index had shifted on its foundations, and edged into Vol 3! We'll try and sort out the discrepancies in the next index to be published (January '82).

As to your P.P.S., see the comments made in answer to the next letter.

Dear Sir,
I know you must be a busy man, but can I take a little of your time, to ask you if you have a circuit diagram for a C.B. unit for the use on the new legalized 27 MHz F.M. band. Could you send me the diagram please, to the above address, or would you print it in the next issue. Thank you for your time.
V.M. Holness,
Ashford, Kent

Unfortunately, I can't help you on at least three counts. First, the exact specification of equipment suitable for use on 27 MHz 'FM' has yet to be published by the Home Office. Second, unless you have the specialised knowledge of building something as complex as a multi-channel transceiver or receiver, it would be better to buy one when it becomes available. If the (illegal) AM versions are anything to go by, then your purchase will probably work out cheaper than buying all the individual components. Third, such a project would be too tricky for many HE readers. (See also Rick Maybury's comments in Breaker One Four on page 61 of the April '81 issue.)

Dear Sir, or Ed,
I wish to quote from your magazine Hobby Electronics February 81 edition. On the front cover. "Oscilloscope Feature — How they work and how to use them". I have read this article on How they work etc., but please will you point out where in the article it shows or explains how to use a scope?

I have read the part on the scope, how to operate and basically what the channels, time base and C.R.O. etc do but you do not stress how to use the probes, where to put them. Let me quote a jigsaw puzzel "You have and know the pieces, now where do you put them".

The main point of this letter is where to place the probe's to find the piece of information I wish to see on the screen.

We are not all experts.
R. Johnson
Oldham, Lancs

You're not the only reader to comment on the shortage of information in this feature on how to use oscilloscopes. I would like to thank those who wrote in about this — but don't despair! We aim to print a special article dedicated to the use of a simple oscilloscope in the June '81 issue.

Dear Sir,
Referring to the current publication of "Hobbies Electronics", being of the older generation, I was extremely interested in the article dealing with the scanning disc etc, relating to the first television efforts.

In 1934 or there abouts I made up, as instructed in the periodical "Wireless World"? a set comprising of scanning-disk, neon bulb, transformer, small, rev. motor, (low revs) coil, plus other items that cannot be recalled.

I wonder if you have any knowledge of such a set, or perhaps you could tell me where I may be able to obtain a set of working drawings with details of components.

For posterity and very old interest I would like to make that particular set just for the sheer enjoyment in doing so.

I know that the impossible does happen sometimes, so perhaps you might be able to assist, if not, well we tried.
J.A. Pearson
Stafford

Several readers (especially those from the 'older generation') expressed their interest in 'Beginnings Of Real TV', by Ian Sinclair.

More than one mentioned early attempts to building Baird-style receivers based on the scanning disc principle.

I cannot meet your request, but perhaps some of our readers can lend a hand. Send any information you may have (in the attic perhaps?) to me at HE.

That's the lot for this month: we'll try and print a fresh batch in the June issue.

HE

Infra-Red Remote Controller

This easily constructed project lets you control electrical equipment at the press of a remote button. It is designed and produced as a kit by TK Electronics

AVAILABLE TO THE hobbyist are two main methods of achieving simple remote control — infra-red and ultrasonic (we have discounted radio-control because of its complexity). Of these two kinds, ultrasonic control has been more popular in the past because of the lack of suitable infra-red devices. Recently, however, some new developments on the infra-red scene have led to the introduction of much simpler (but every bit as good) infra-red systems. The system we have chosen for the HE Infra-red Controller uses some of this 'latest technology' to provide remote control of electrical equipment at a distance of up to 30 feet.

Our system can operate in two modes: an alternate on/off action whenever the transmitter is operated; or a timed-on mode (ie, it turns the equipment on for a set period). The constructor can choose whichever mode he or she desires by the positioning of only one component on the printed circuit board at construction stage.

Our infra-red Remote Control project has been available to HE readers for a few months now from TK Electronics. The Transmitter is built into a hand-held case, and being battery operated it is completely portable. The Receiver/Controller will switch up to 2 A of current at 240 VAC (with adequate precautions! — see the Construction section). It can be positioned in circuit anywhere between a mains outlet and the equipment to be controlled. For example, you can see that our prototype controller is mounted in a small plastic box and a 13 A mains socket is inserted in the front panel. It is possible that some of our readers will want to build their Receiver/Controller into the equipment to be controlled (the printed circuit board *is* small enough). However you choose to construct yours, the only point to bear in mind is that a 2 A fuse *must* be inserted somewhere in the mains lead *before* the Receiver/Controller.

As the HE Infra-red Controller consists of two parts; the Receiver/Controller and the Transmitter, we will deal with constructional details of the parts separately. Details of the Receiver/Controller are shown below and those of the Transmitter will follow next month.

Construction

Build up the printed circuit board (PCB) of the Receiver first, following the overlay details in Fig.2. The PCB is very compact, so all low-level components (ie, resistors, IC sockets, diodes D2, 3, 4, 5, zener ZD1) should be inserted and soldered first, otherwise you will find their insertion later on tricky. Connect the free end of resistor R6 to point A on the PCB if you require alternate switching action. Connect R6's free end to point B if you require a timed-on action. Use a fine-tipped soldering iron for all joints.

Next insert and solder capacitors, transistors and the triac, making sure

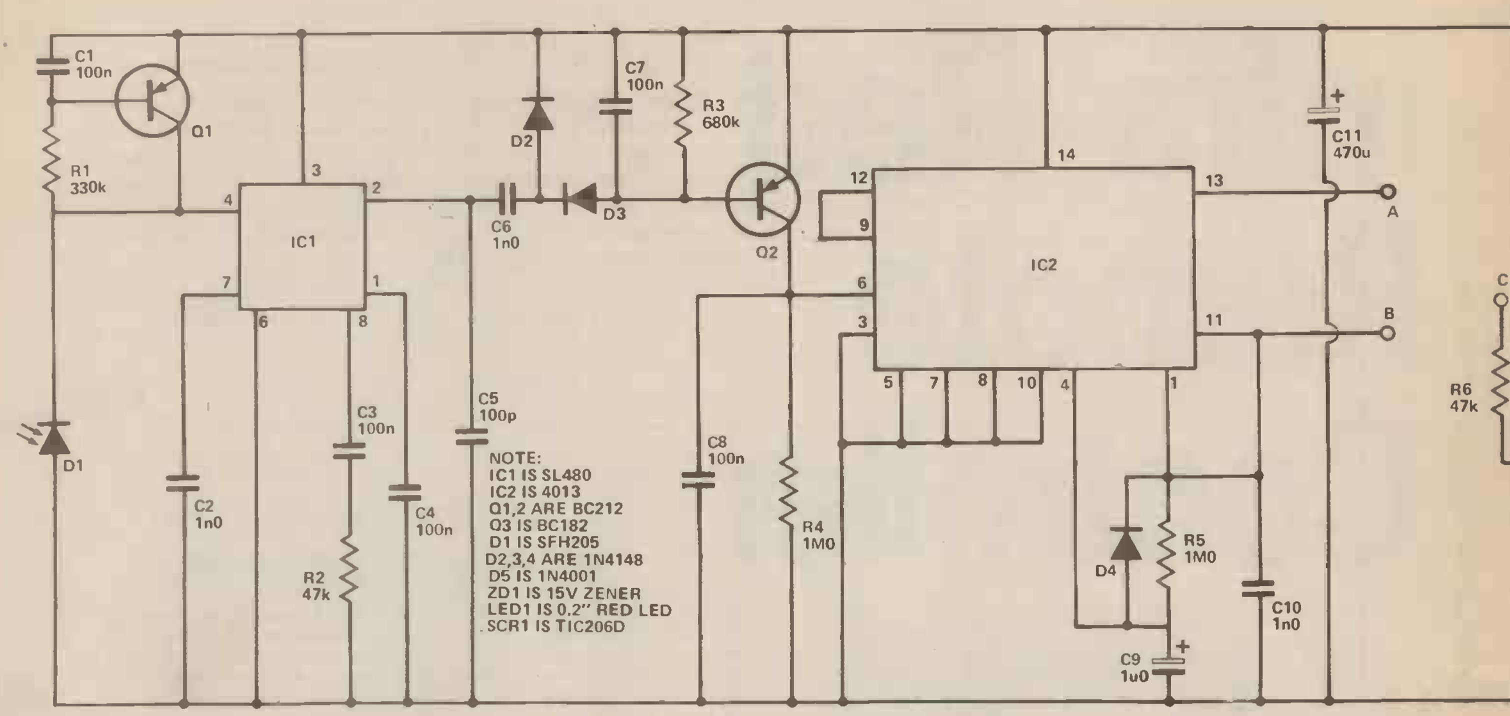


Figure 1. Circuit diagram

that you have them polarised correctly where necessary. Fit the two ICs into their respective sockets the correct way round.

Cut and strip off three 1" lengths of mains wire taken from a length of cable and insert one end of each into the three terminals of one side of the terminal block. Tighten down the screws to hold them in. Next push the three free ends of stripped mains cable into the three holes at the bottom right-hand corner of the PCB so that the terminal block fits flush to the board. Solder the three 1" pieces of mains cable to their three solder pads of track.

Diodes D1 and LED1 can be soldered directly to the board, or fastened to your case's front panel, or, as in our prototype, a mixture of the two methods can be used. In the photograph you can see how we fastened the LED into a clip on the front panel and attached it with flying leads. The photodiode is, however, mounted on short lengths of stiff wire directly onto the PCB so that when the box is closed up D1 is positioned directly behind the front panel. A small hole drilled into the panel allows infra-red light to enter the box.

You must put some form of heatsink onto the triac SCR1 if the Receiver/Controller is to be used to switch equipment using over 250 W of power. We used a commonly available clip-type of heatsink in the prototype. A discussion of heatsinks and hints on how to make your own can be found in Building Site on page 43.

Finally, details for connecting the Receiver/Controller in the same way as ours, with a 13 A mains socket, are shown in **Fig.2.**

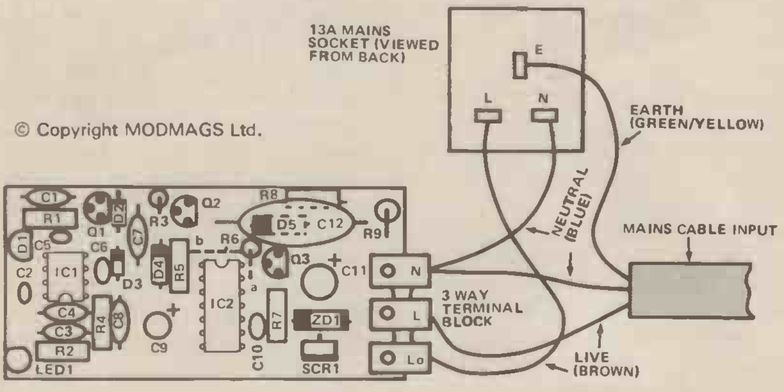
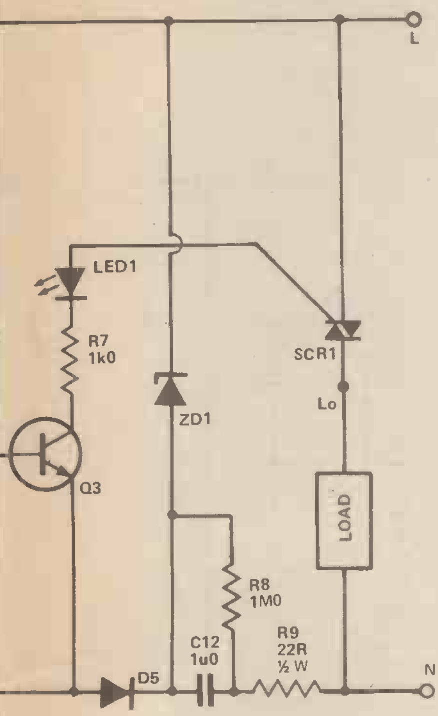


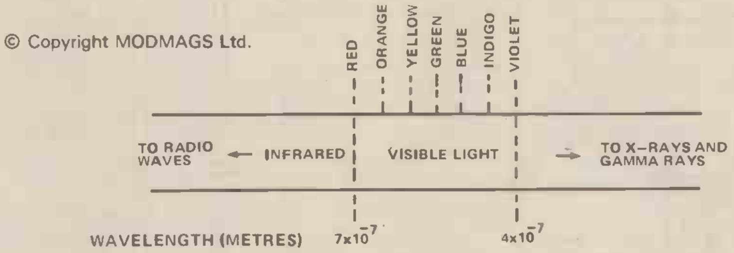
Figure 2. Overlay and connection details

Buylines



How It Works

Infra-red is the name given to light having a wavelength beyond that of red light. If you look at the region of visible light in the electromagnetic spectrum, below, you will see how visible light, consisting of its various colours, occupies a fixed part of the waveband. Infra-red light is in the region immediately to the left of visible light, and is thus invisible to the eye. (Light, as part of an electromagnetic spectrum, was first conceived by James Clark Maxwell — see Famous Names, page 63.)



Infra-red energy is received by photodiode D1. Transistor Q1 and associated components filter out any infra-red radiations which may be picked up by the receiver from 'natural' sources of infra-red light, such as the sun or tungsten and fluorescent lamps.

Integrated circuit IC1 amplifies the pulses picked up by the photodiode, its gain being defined by R2 (increasing R2 decreases the amplifier's gain).

The output of the amplifier is rectified by 'diode pump' D2 and 3, and stored across C7 as a negative-going pulse which turns transistor Q2 on. In turn, Q2 triggers a monostable formed around the first half of IC2. The output of the monostable at pin. 1 is thus high for a period determined by C9, every time the receiver is triggered by infra-red light.

This pulse is then used in one of two modes: either fed directly to the base of Q3, thus turning triac SCR1 on for the period of the monostable; or fed to a bistable formed by the second half of IC2, which turns Q3 and SCR1 on and off alternately.

A 15 VDC supply for the circuit is taken directly from the mains via C11 and 12, ZD1, D5 and R7.

HE

Parts List

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

R1	330k
R2,6	47k
R3	680k
R4,5,8	1M0
R7	1k0
R9	22R, ½ W

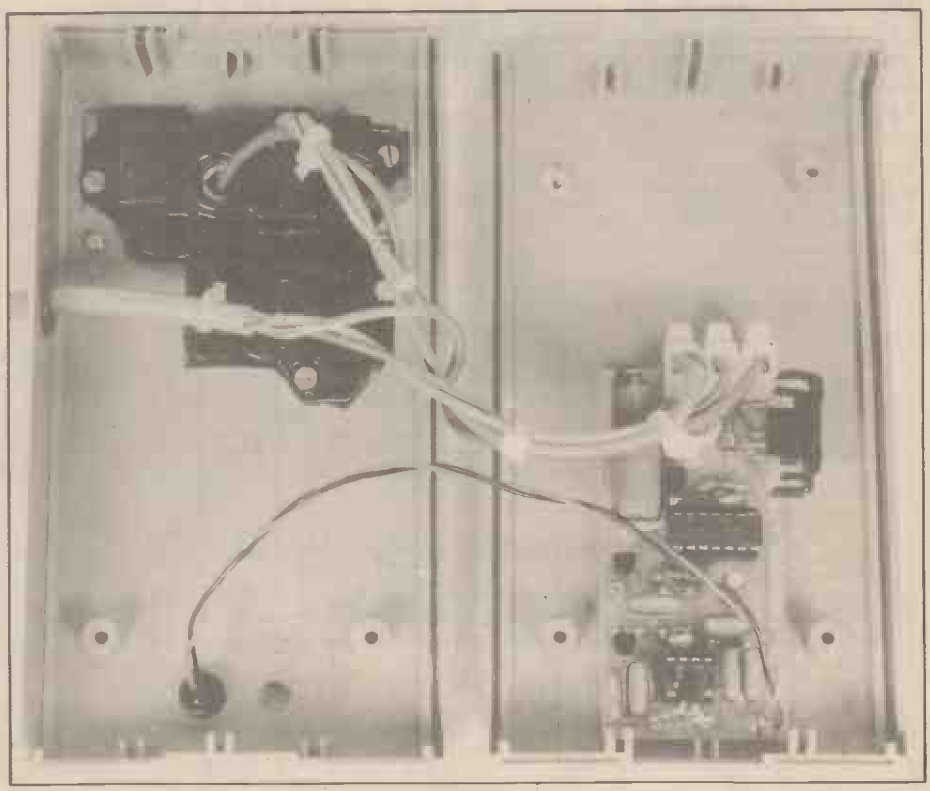
CAPACITORS

C1,3,4,7,8	100n polyester
C2,6,10	1n ceramic
C5	100p ceramic
C9	1u0, 63 V printed circuit mounting electrolytic
C11	470u, 16 V printed circuit mounting electrolytic
C12	1u0, 400 V polyester

SEMICONDUCTORS

IC1	SL480 infra-red pre-amplifier
IC2	4013 dual D flip-flop
Q1,2	BC212 PNP transistor
Q3	BC182 NPN transistor
SCR1	TIC206D triac
D1	SFH205 photodiode
D2,3,4	1N4148 diode
D5	1N4001, 1 A diode
LED1	0.2" red LED
ZD1	15 V zener diode

MISCELLANEOUS
3-way terminal block
8-pin IC socket
14-pin IC socket
Heatsink (to suit triac SCR1)
13 A mains socket
Case to suit (ours is 202-21040F from Vero)
Rubber grommet
Cable ties



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DCvolts:- 0 — 05 — 25 — 10 — 50 — 250 — 1000
DCcurrent:- 0 — 10ua — 25ua — 500ua — 0 — 5 ma — 50 ma — 500 ma — 10 amp
AC current:- 10 amp
Resistance:- 0 — 20 ohms — 200 ohms — 5 K ohms — 200 K ohms — 50 K ohms — 200 K ohms — 5 meg ohms — 50 meg ohms

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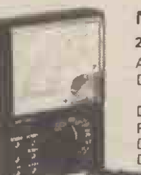

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20,000 opv
AC volts:- 0 — 10 — 50 — 100 — 250 — 500 — 1000
DC volts;- 0 — 0.5 — 5 — 25 — 125 — 250 — 500 1000
DC current:- 0 — 50 ma — 0.5 ma — 250 ma
Resitance:- 0 — 3 K ohms — 300 K ohms — 3 meg ohms
Deibels:- — 20 to +63 db
Dims:- 127 x 90 x 32 mm

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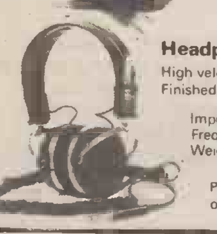

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K192 25 RGP10B 100V 1A switching diode

O Level Q & A

Amplifiers are on the menu this month. Nick Walton looks at amplifier operation and explains impedances and feedback

IT IS VERY difficult to penetrate far into the world of electronics without coming across the word amplifier (look, there it is already!), so this month we will try to consider it in some detail.

Basically an amplifier is a device which will produce a big signal from a small one: it makes an electrical mountain out of an electrical molehill you might say. This idea can often lead the newcomer into believing he or she is getting something for nothing — but alas, life is not like that. So it is probably worth sneaking a quick look into our amplifying black box. This is not because we would ever be required to know details of amplifier circuits but because it can help us firm up on general principles of things already covered, like Ohm's Law. Our quick look will also help in understanding the process of amplification.

Amplifier Principles

Suppose, then, that our peep reveals a positive and negative supply line, a couple of resistors and a transistor, arranged as in **Fig. 1**. We see that the transistor is connected in series with the 1k0 resistor across the supply lines. Sometimes the transistor conducts well (if given a suitable base current) and sometimes, with no base current, it acts like a very high resistance. Now how does Ohm's Law apply to two (fixed) resistances in series? Perhaps you were a one-resistance person when it came to Ohm's Law, but if you expand your horizons to two resistances, you discover an extremely useful result. This is that the voltage dropped across two resistors in series is in proportion to the values of the resistors themselves.

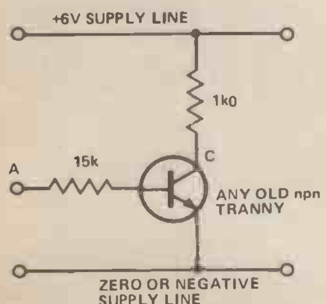


Figure 1. Simple amplifying circuit

To amplify (!), let us suppose in **Fig. 2** that R1 has a resistance of 1k0 and R2 has a resistance of 5k0. It does not take a genius to discover that the current flowing down the pair of them is 1 mA (voltage divided by total resistance). Now considering the resistors separately and doing a V = IR on each we find that the voltage across R1 is 1 V and that across R2 is 5 V. Thus a one-to-five ratio applies to the voltage dropped across R1 compared with the voltage dropped across R2, and this is the same ratio as R1 to R2 (in ohms).

Try for yourself a similar analysis if we keep R1 as 1k0 and drop R2 to 200R. Now more voltage is dropped across R1 than R2 in a 5:1 ratio.

Finally, if R2 is very much larger than R1 (perhaps 1M0 compared with 1k0), then by far the most voltage is dropped across R2. The actual ratio is one to a thousand, all but a tiny bit, and if the value of R2 is tiny compared with R1 then virtually all the voltage is dropped across R1. So if R2 could change as suggested in the examples above, the voltage at the junction between R1 and R2 (marked as X in **Fig. 2**) could vary from about 6 V to about 0V.

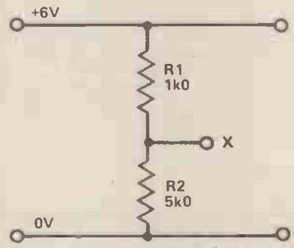


Figure 2. Using two resistors in series to demonstrate how the circuit in Fig. 1 operates. The voltage drop across R1 and R2 is measured from point X

Transistor As An Amplifier

Having bent your mind round that little chunk of theory you could be forgiven for wondering what on earth it has to do with transistors and amplifiers. The answer is that with R2 changing its value from being a very high resistance to a low one it is doing what a transistor does when you alter its base current. Indeed the very name transistor is a shortened version of 'transfer resistor' which was the phrase used by the original inventors to describe its behaviour. If you can lash up the circuit in **Fig. 1** and have access to a reasonable voltmeter or two, then there is a most instructive experiment you can do to investigate the amplifying action of this circuit. Suppose we regard the input as being at the free end of the 15 k resistor (point A) and the output at the transistor's collector C; ie, between the transistor and the 1k0 resistor. The aim is to investigate how changes of voltage at the input affect the output voltage. Both voltages are measured relative to the negative or zero supply line — the bottom line in the diagram. The complete setup is shown in **Fig. 3**, which is the same as

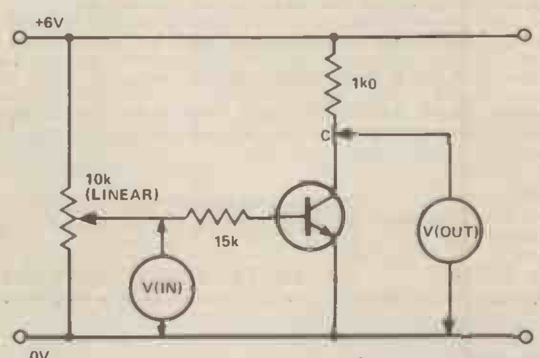


Figure 3. Circuit to investigate operation of simple one-transistor amplifier

Fig. 1 but with the addition of two voltmeters to measure the input and output voltages, called V (in) and V (out), and also a 10k potentiometer to allow different values of input voltage to be set. (If by any chance you happen to be at a school which runs the Nuffield A-level Physics course and you have a friendly physics teacher he or she might give you access to something called a basic unit which is effectively **Fig. 1** already made up for you.) Do the experiment if you possibly can and plot the graph of output against input voltages. If you cannot do it because you are reading this article in the bath or like Einstein you prefer thought experiments, the results you should get are shown in **Fig. 4**. Details will vary but you should certainly end up with a graph where the output voltage drops steeply and uniformly from near 6 V to about 0 V over a variation of the input voltage of something like 0.5 V to 1 V.

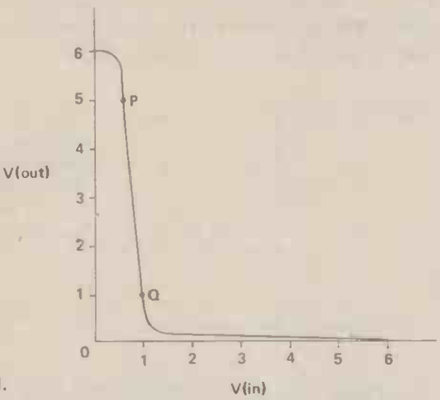


Figure 4. A plot of V (out) against V (in). This can be called the transfer characteristic

Close examination of this graph can tell us quite a lot. Suppose for example that the point P shown on the graph has 5 V for output voltage and 0.6 V for the input voltage. At Q we have come down to an output voltage of just 1 V and also 1 V for input voltage. Suppose further that we have what is effectively a straight line between P and Q, then the crucial question to ask is 'What change of output voltage has been caused by what input voltage change?' — between P and Q, that is. Looking at the graph we can say that the output voltage dived down from 5 V to 1 V (a change of 4 V) as a result of the input going from 0.6 V to 1 V (a *change* of 0.4 V). Notice the factor of ten between the output and input voltage changes. Thus in the PQ region (called the linear region because the graph is straight) we can say that a small change of input voltage will cause a tenfold change in output voltage. In the jargon we say that the voltage gain, or amplification, is 10. Properly, the voltage gain is defined as the ratio of change in output voltage to change in input voltage, and it is often denoted by A_v, given by:

$$A_v = \frac{\text{Change in output voltage}}{\text{Change in input voltage}}.$$

If we had done a similar thing with currents instead of voltages we could have found the current gain to be the ratio of change in output current to change in input current (A_i), given by:

$$A_i = \frac{\text{Change in output current}}{\text{Change in input current}}.$$

Last but not least we often want to calculate the power gain of the amplifier, and since power (in watts) is the product of volts and amps it is not surprising to discover that power gain A_p is the product of voltage gain A_v and current gain A_i, where $A_p = A_v \times A_i$.

Input & Output Impedance

If we now pop the lid back on the box and let it revert to being a device with an input and an output, we now have to consider the important idea of input and output impedance. Let us think of the output terminals as being a source of voltage available perhaps to drive a loudspeaker. You are probably aware that a pure voltage source hardly ever exists on its own, but between those terminals lurk some ohms hidden away waiting for a chance to make things difficult. When you first meet Ohm's Law you are presented with the idea of a battery that is merely a source of, say 1½ V and it happily produces that voltage regardless of what current is drawn. But sadly, real batteries just do not live up to these high expectations and there is always a resistance between the terminals, even though it can often be ignored.

Now it is a fact of electrical life that if you have a resistor (we'll call it the external resistor) in a circuit with one of these real-life batteries containing real internal resistance then the way to get the maximum power transfer into that external resistor is *not*, surprisingly, to make it as small as possible (to maximise the current). Instead, the external resistance must be made equal to the internal resistance. The proof of this is not easy, but it can be verified by considering a simple circuit like that shown in **Fig. 5**. Let the external resistance R take values ranging from 4R to 8R and, for each value chosen, find the current in the circuit (by dividing the voltage — 12 V — by the total resistance present; ie, 6R for the internal resistance, plus the chosen R value). Power in R is most easily found from I^2R, and we discover that it reaches a maximum value of 6 W when R is given the value of 6R; ie, the same as the internal resistance value. The same result holds for any source of voltage and, of course, that includes the output of an amplifier which also has ohms lurking internally between its terminals. This is referred to as being its output *impedance*, and if we are to maximise the power transferred to our speaker with its 8R speech coil, then we need the output impedance of the amplifier also to be 8R. This is what is called impedance matching and a similar exercise needs to be performed at the input where we might need to match the impedance of, say, a record player's pickup with the input impedance of the amplifier used. As mentioned in the December article, if you have problems, for instance in matching your output impedance to a speaker, you can always connect the speaker to the amplifier through a transformer with a suitable turns ratio (where the impedance ratio is equal to the square of the turns ratio).

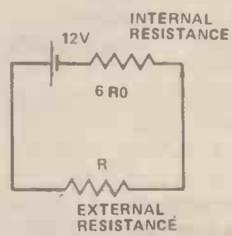


Figure 5. Battery with internal resistance of 6R connected to an external resistor R

Applying Some Feedback

When you have an amplifier it is quite common to take some of the output signal and feed it back to the input. This is called feedback and depending on whether the bit of output signal tends to reinforce or oppose the input signal it is called positive or negative feedback. A public address system which starts to howl is a good example of positive feedback producing a state of unwanted oscillations. The howl occurs when the microphone is positioned close to the speaker. The microphone will pick up a little noise from the speaker, and this will be amplified by the system and come out of the speaker much louder. This in turn gives a larger signal to the microphone to feed in to the amplifier and very quickly the whole works is screaming at you at full blast.

If you actually *want* to produce an oscillation, clearly you *can* do it with positive feedback. A microphone with a speaker close to it is not the only way to get an amplifier to chase its tail: a direct connection can be used. Oscillators fall into two main groups: those producing a sine waveform (like our old friend AC — see **Fig. 6a**) and those producing a non-sinusoidal form, the most common of which are probably squarewaves or sawtooth waves (**Figs. 6b** and **6c**).

I wonder into what category of oscillator you would put the brainchild of a Victorian inventor who is supposed to have attached a small musical box inside a young lady's dress. It was so arranged that when she sat down it started to play the national anthem and being a well brought-up young lady, this would oblige her to rise to her feet. The act of standing up would switch off the musical box thus leaving her with no reason for standing. So she would sit down again, which activated the musical box again . . .

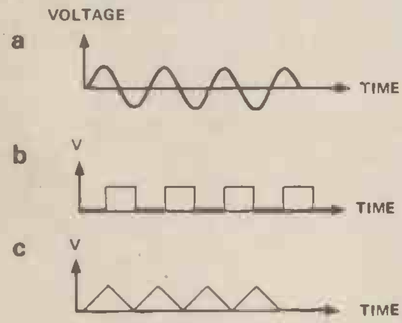


Figure 6. A variety of oscillator waveforms: a) sinewave, b) squarewave, c) sawtooth

Negative Feedback For Stability

I'll end on a somewhat negative note and not far from where we began. One of the problems with a very simple amplifying circuit such as the one we saw in **Figs. 1** or **3** is that it is not very stable: in other words it can change the way it performs without warning. The transistor may get warm and this could alter its gain which in turn might lead to the need to alter the biasing. A well established and simple way of beating this problem is to use negative feedback.

Referring back to the circuit in **Fig. 3** and its input-output characteristic shown in **Fig. 4** (otherwise called the transfer characteristic) we see that as the input voltage goes up the output voltage goes down; that is, for the linear region between P and Q. Here, feedback is negative because the output is going down when the input is going up, so they act in opposition. The overall effect is to stabilise the system but if you were able to do an actual experiment on a simple amplifier, for instance the basic unit mentioned earlier, you would remember it far better. The circuit in **Fig. 7** looks worse than it really is. We have three things to input: the bias to hold the transistor at the correct operating point (via R2), the end of the feedback loop (to R1) and the signal input from an oscillator (via C1). We set the oscillator to produce small oscillations at a suitable frequency (100 to 1000 Hz) which are then amplified with the feedback loop disconnected. As the amplitude of the input oscillations increases the signal becomes distorted — the top and bottom of the signal seem to get clipped off, as in **Fig. 8**, because the input signal is now going outside the PQ range of output, which would really like to extend beyond the voltage limits of the supply lines. These bits are shown dotted in **Fig. 8b**. If you now connect up the feedback loop, this effectively reduces the signal ultimately going in and thus the output signal now stays within the allowed range and is not distorted. This is why negative feedback is said to help prevent or reduce distortion.

If you have survived this far, you have done pretty well, especially if it is all new to you. Try another reading later, perhaps after you have put the finishing touches on your project or chosen topic — or if you are reading it purely for pleasure, when it has had time to sink in. It's a bit like John Ebdon, who used to finish his broadcasts: 'If you have been, thanks for listening'. And how did you listen? No doubt by courtesy of an amplifier carrying lots of negative feedback. Cheers!

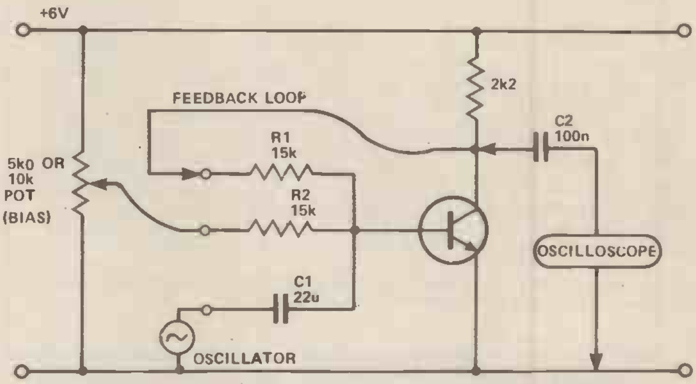


Figure 7. Circuit which can be used to investigate strong negative feedback

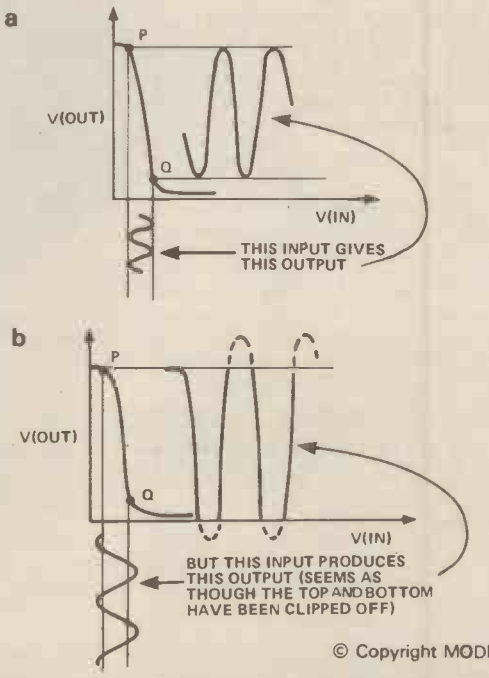


Figure 8. Comparing amplifier input and output waveforms: a) output waveform is linear (undistorted) copy of input waveform because input signal swings between points P and Q on the straight part of the characteristic, b) output waveform becomes 'clipped' (distorted) because input signal swings beyond the range of PQ HE

Clever Dick

Problems, suggestions and confusion: Clever Dick does his best to sort them out

I JUST NOTICED that HE's got a new letters page (Your Letters page 47). Despite the description of my office, it's business as usual from CD.

Righto, into the first one.

Dear Clever Dick,
I have some difficulty with a project described in last Year's March edition of your magazine, Hobby Chit-chat, Fig. 10.

The light chaser is not working properly. Instead of all lights except one lighting up and the blank moving across the board, all lights are simply flashing on and off. My wiring is correct and I am wondering whether the project is faulty.
Patrick Dean,
1420 Braine l'Alleud, Belgium

This one really confused us: the *project* 'Light Chaser' was published in the March *1979* issue (pp 7 to 10) but it had no Fig. 10 — and no errors as far as we are aware.

The *feature* 'Chit-chat' in the *June 1980* issue contained a collection of circuits using LEDs. Figure 10, page 51, shows an 'Intermittent moving dot display with 50% blank period' (getting warm?). No errors as far as we know. Must be a dud IC.

Someone with a suggestion next.

Dear Clever Dick,
I think it would be a good idea to make a chart of 'dry' battery milliamp hour figures or something similar. Car batteries have them, so why shouldn't dry ones. Has anyone produced such information or is this a chance for the HE workshop to prove its proficiency. It would be useful to know the figures for various types of battery eg — voltage, size, brand etc. The constructor or designer would find this useful for running cost calculations — after all, electronics needs batteries and this information would bind up the hobbyist's problems.
(N.B. the word bind).
John Boothroyd
Gaydon, Warwick.

Nice suggestion, we'll consider it for a future issue, but somehow I couldn't link 'bind' with battery — must be a bit under-charged.

A 'quickie' next. (Definitely the best ones, these).

Dear Clever Dick,
Can your minisynth (Nov/Dec 1980) be modified to produce more effects by adding more components e.g. another oscillator and if so could you do an article on it? Also, would you please announce increases in the price of H.E. prior to their happening.
Graham Jepps
Keith, Banffshire

Minisynth was a self-contained project and not really intended for enhancement or modification. Once the HE office is cleared of the clutter of organ keyboards, components, notes and musicians, maybe we'll think up another synth project that'll do a few more tricks than the last one.

If we get enough warning we'll try and give you advance warning of price increases.

Dear CD,
I am twelve and have just started getting interested in electronics. However I have found that your magazine is a bit beyond me. Therefore could you suggest an Electronics magazine for beginners?

Also I would like to know how one works out the amount of resistance needed in a circuit?
O. Devine
Farnham, Surrey
P.S. Thankyou for a superb mag.
P.P.S. Is a binder available at the moment please?!!

Sad to read that you think HE is a bit beyond you. We've got a few ideas in hand for those starting out in electronics — so stick with us.

A simple guide to resistance in circuits was given in O Level Q & A, HE November 1980, pp 49 to 51. Unfortunately, we have a high resistance to free binder grovellers.

Problems with a pre-amp next.

Dear C.D.,
I have been struggling with the "HE Guitar Preamp" from the November '80 issue of Hobby Electronics, for nearly 3 weeks now. For some reason it does not work!

I have checked all the components, connections etc. with both meters and oscilloscopes. As far as I and the people I have consulted can tell there is absolutely nothing wrong with the actual circuit board. Would it have any great effect if the treble potentiometer was only 470k and not 500k? We also wonder if the negative terminal on the battery should be connected to anything other than the one terminal on the jack socket?
N.J.M. Freeland
East Grinstead, Sussex.

There were two errors in this article. First, in the circuit shown in Fig. 1, page 36, capacitor C7 should have been 22u, not 22n as shown. Fault number two could be the cause of the trouble, though. There should be a break in the track (Fig. 2) at point J8.

In this kind of circuit, you wouldn't notice the difference between a 470k potentiometer and a 500k one.

The battery wiring to Jack 1 was correct: pulling out the plug switches off the circuit.

The next reader is very close to discovering my true identity.

Dear C.D.
Are you a joint effort between Charles + Diana? Well done! I'm glad you've got someone nice.

Now then. I intend to build the 6-Watt siren, featured in March '80. Three questions, five points each, here's your starter for ten.
a). Could the circuit run off 9 V, if so does it need changing? Would it be as loud?
b). Could the speaker be substituted for a tweeter (8R) Would this affect the volume?
c). Could a VN66AF be substituted for the VN67AF?

Have you noticed — I haven't asked for a binder. And all those loose copies of H.E. I have lying around at home too . . . shame innit? though I really would like to keep them in one place (HINT).
John Davies
Blackpool, Lancs

Answers:
a) Yes it will work from 9 V but it won't be as loud. And there's no way you could easily modify the circuit to boost the power for 9 V operation.
b) Not advisable to substitute a tweeter, because even if its power rating is the same, it may not be able to handle some of the lower-frequency tones from the siren.
c) Yes, you can substitute the VN66AF for the VN67AF.

Shame, innit, about all those loose copies.

Last, one from South Africa.

Dear Dick,
Firstly I must congratulate you on your excellent mag. I've been reading HE ever since it began. I occasionally miss out an issue but, thanks to your very efficient backnumbers dept., I now have a complete set.

Secondly, I would like to correspond with British electronics enthusiasts of my own age group ie. 12 — 15 YRS (I am 14 years old). If you know of anyone who may be interested, please let me know.
Warren Williamson
Cape Town, South Africa

Well, drop us a line if any of you would like to correspond with Warren.

This month's binder goes to John Boothroyd, by the way, for some subtle grovelling.

See you in time for the grovelling season.

HE

Pre-amplifier -2

The second part of our pre-amplifier project gives advice on housing and discusses power supply details

THE CASE USED with the HE Pre-amplifier is supplied with a satin-finished front panel and this panel is easily scratched, so take care — we advise that you set it to one side and leave the metalwork involved with it till last.

The rest of the case is black plastic coated and quite scratch resistant so you can commence housing your printed circuit board without fear of ruining the Pre-amplifier's appearance. The completed PCB is shown in **Fig. 1** and is how your board should look at this time. Begin by mounting the board to the base of the case using four mounting bolts and small spacers, allowing about ⅜" between the case and the underside of the PCB. The board should be positioned so that when the back panel is put in place, the panel is flush to and touches the rear edge of the board. Remember that the phono sockets stick out past the edge of the board and therefore the panel won't fit until cutouts for the sockets have been made. Now, fasten the board down with four nuts and washers.

Mark and cut out the rear panel for the ten phono sockets and also the 5-pin DIN socket (used as the power supply connection). The panel can now be bolted onto the case, and you should then make the power supply connections from the board to the DIN socket; ie, 0 V to pin 2 of the socket and the two 12 V connections to pins 1 and 3 (it doesn't matter which way round the two 12 V connections go!).

Also, make a connection from 0 V on the board to a solder tag, and secure this firmly to the PCB mounting bolt close by.

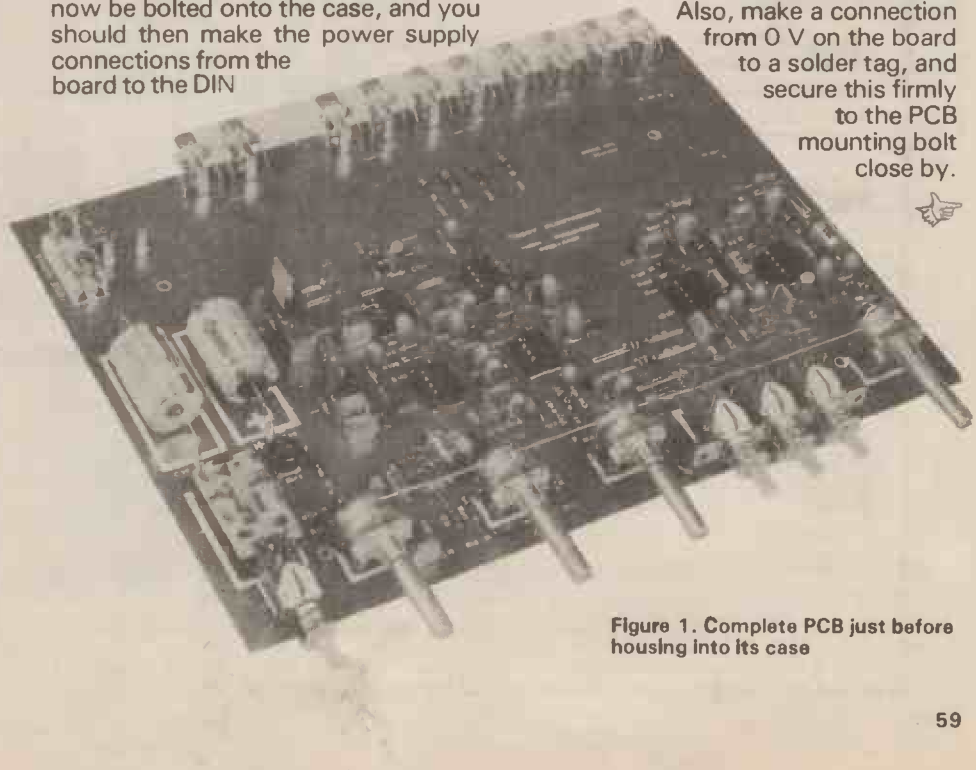


Figure 1. Complete PCB just before housing into its case

Figures 2 and **3** show the cut out and connection details of the project at this stage.

Next comes the tricky bit — drilling and filing the front panel cutouts. Mark out and drill all holes on the inside (the non-satin-finished side) of the panel. The holes for volume, balance and tone control spindles and the LED are all ¼" diameter, and are therefore easy. You will, however, need to file out the switch holes to fit the switch buttons. **Figure 4** is a photograph of the filed-out hole for the SW2 switch buttons of our prototype and shows the general idea. Most of these holes can be made by drilling, but the edges are best finished using needle files — this is a long and painstaking job but worth the time and trouble of doing well.

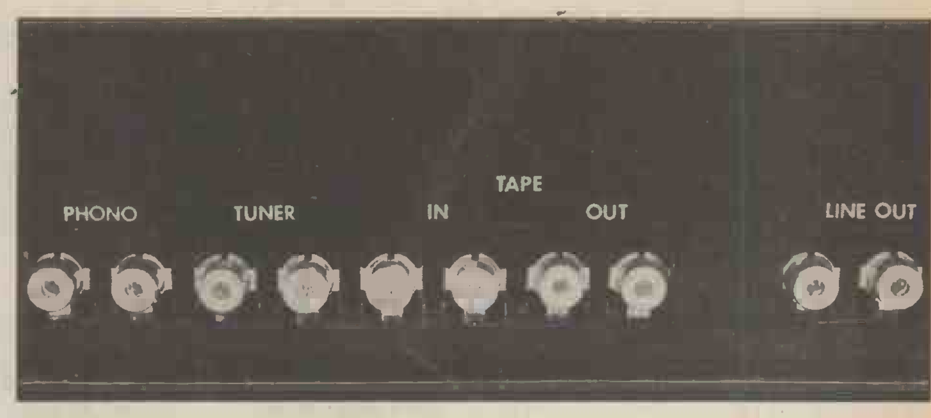


Figure 2 (above). Cutout details of the rear panel

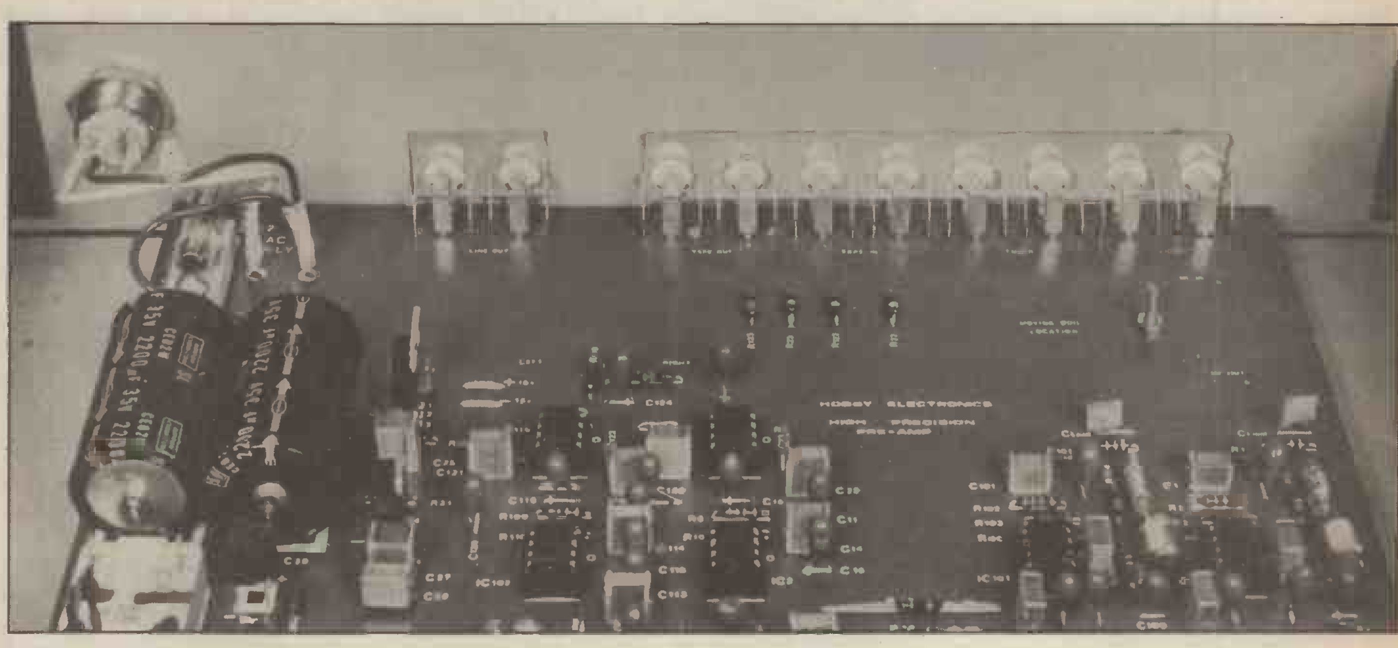


Figure 3. Internal photograph of the Preamplifier showing power supply connection details

Figure 4. By carefully filing out the switch holes you can make your project look as good as ours

Finally, bolt on the front panel with ¼" spacers between the panel and the case. The panel should be inset only about $^1/_{16}$" from the front edge of the case giving a very neat appearance. Insert LED 1 into the panel using its clip and then connect it to the two terminals on the switch, as shown in last month's overlay of the PCB. You can see the project as it should now look, in **Fig. 5**.

May The Power Be With You

In the power supply diagram last month, the section of the supply shown in a broken-lined box is extraneous to the Pre-amplifier and should be housed separately. If you intend building the Power Amplifier to be described in next month's issue you will find that a suitable 12 VAC outlet to power the Pre-amplifier is included. However, if you don't build the Power Amplifier you will need to build a 12 VAC supply for the Pre-amplifier and construction is as follows:

The supply shown on page 59 consists of a mains transformer with a 240 VAC primary winding and either 24 V centre-tapped, or two 12 V secondary windings, and a fuse and an on/off switch. Mount the components in a small metal case and make a point of providing a good earth connection to the case. This not only gives protection if a short circuit occurs, but reduces the alternating magnetic field around the box which might otherwise cause hum pickup problems with the Pre-amplifier.

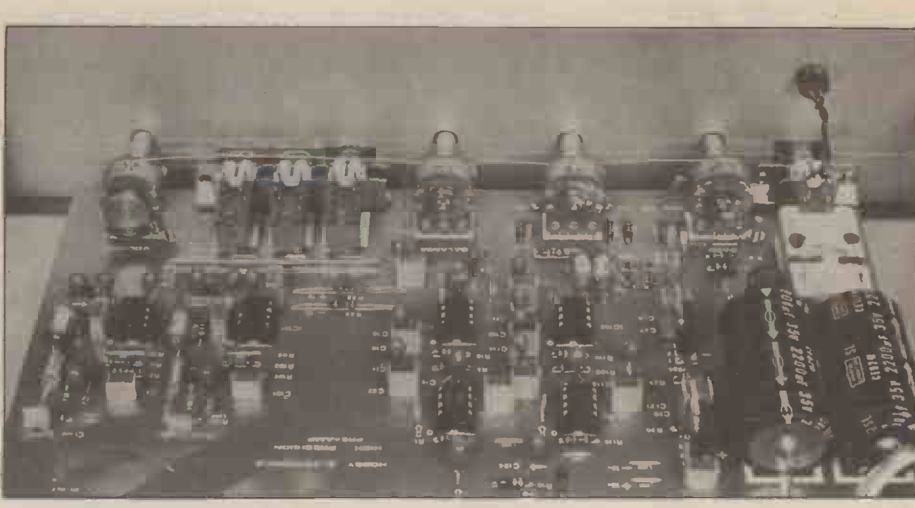


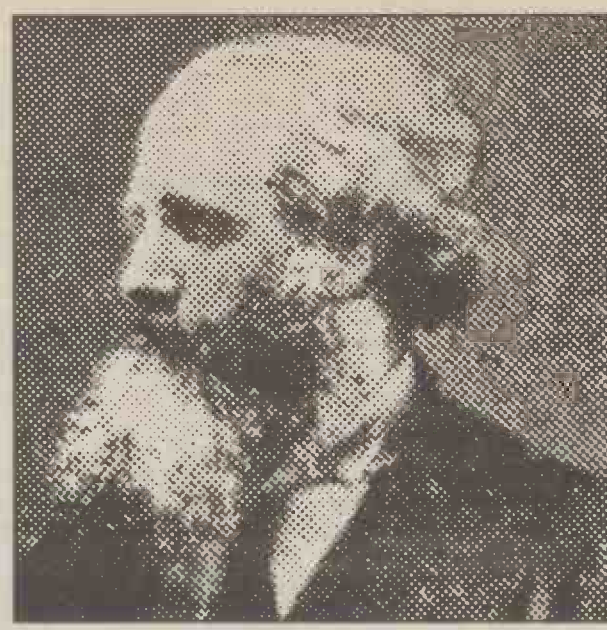
Figure 5. Inside view of completed front panel

As you can see, we used a Sink Box to house our power supply, but any metal case large enough to take the transformer, with adequate clearance from any terminals, will be fine. Insert a 5-pin DIN socket in the back of the case. Connect the centre connections of the transformer (ie, 0 V) to pin 2, and the two 12 V connections to pins 1 and 2 of the socket — in other words the socket should be wired in the same way as the socket on the Pre-amplifier case.

A 3-core lead, with a 5-pin DIN plug at each end should be used for power connections between the supply and the Pre-amplifier. Make sure you connect corresponding pins of one plug to the same pins of the other plug.

HE

Famous Names



James Clark Maxwell

This is the second part of our new series about some of the men who have made enormous contributions to electricity and electronics. Many of these started out as practical engineers who soaked up a lot of theory as they went along. James Clark Maxwell was not one of these: he was an academic of great brilliance who, in one single act of genius, directed the efforts of engineers to a complete new world — the world of radio waves

MAXWELL WAS BORN in 1831, and had a brilliant school career, followed by an equally brilliant university course at Edinburgh. By the age of 19 he had already had two papers published by the Royal Society, which led him directly to Cambridge, first to Peterhouse and then to Trinity. He graduated in mathematics in 1854, and achieved such distinction in theoretical physics that he was appointed Professor of Physics at Marishal College, Aberdeen, in 1856, aged 25.

His main interest at that time was the kinetic theory of gases: the idea that gases consist of molecules which are continually in motion, and which are, on average, large distances apart compared with their own diameters. Nowadays, anyone who does A-level physics at school learns simple kinetic theory, but the theory which Maxwell produced was as far beyond simple kinetic theory as a home computer is beyond a one-transistor amplifier.

All very academic, you might say, and nothing to do with electronics? Well, as it happens, the way that molecules in a gas behave is often very similar to the behaviour of electrons inside a conductor, so that the mathematical methods which Maxwell devised have been very useful to later researchers. They did Maxwell's career quite a lot of good too. In 1860 he was appointed as Professor of Physics at Kings College, London, where he remained until late in his life, when he became the first Cavendish Professor of Physics at Cambridge.

What was the work which justified these plum academic appointments? Most of them would take too long to explain, but one is of such outstanding importance that we have to take a stab at it, even at the risk of missing out bits in order to simplify what it's all about. That one was the theory of electromagnetic radiation, Maxwell's masterpiece.

In the 1860s, electrical theory was doing quite nicely, thank you. Ohm and Kirchoff had established the laws which are as familiar today as they were then and which are the fundamentals of electrical circuit theory. Thanks to the practical work of Faraday and the theory of Biot and Savart, electricity and magnetism were recognised as being two aspects of the same thing. For some time also, electrostatics had also been recognised as being part of electricity, but the place of electrostatics in relation to electricity (that is, electrical current flow) was not sufficiently recognised. It's easy for us now to see that electrostatics is the study of electrons at rest, and current electricity is the study of moving electrons. It wasn't quite so easy in the 1860s because the electron hadn't been discovered: it was only dimly suspected.

Maxwell was not impressed by this apparent progress, because he sensed something missing. Even now, over a hundred years later, it's not easy to describe what was missing without using the natural language of physics, which is mathematics. The mathematics that's needed is a bit above A-level standard, though, and we'll have to make do with second best — a bit like describing music with colours.

Distinguishing Lines Of Force

Maxwell, so like Faraday before him, was fascinated with 'lines of force'. Let's refresh our memories on this topic. Take a bar magnet, place a sheet of glass over it, and sprinkle iron filings on top. Now tap the plate, and the filings take up the pattern which we call the lines of force. These lines are just a contour map of the strength and direction of the magnetic field around the magnet — or are they? Maxwell, like many theoretical physicists before him, saw these lines as being something much more significant — a visible indication of invisible strains in the material around the magnet. Each line of force around a magnet is just one kind of line of force. An electrostatically charged object can also reveal lines of force — electrostatic 'lines' — which behave quite differently from the magnetic ones.

In the midst of all the work which was going on with regard to electric current in conductors, Maxwell took quite a different view. To him, a conductor was simply where an electrostatic line of force ended or started, and around which a magnetic line of force was coiled. Maxwell's interest was drawn to the space around the conductor, the space which supported these invisible lines of force. By one deduction, he predicted an effect which was not confirmed for twenty years but which has totally altered the world. That deduction was displacement current.

Another Kind Of Current

In the 1860s three effects were well known. One was that an electric field in a conductor (produced by a voltage applied between the ends of the conductor) caused a *current*.

That little lot was the work of Georg Simeon Ohm. They knew also that a current flowing through a conductor caused a magnetic field: this had been the work of Oersted. Finally, as a result of Faraday's painstaking work, they knew that a changing magnetic field would create a voltage. All these three effects can be described in equations, which Maxwell wrote down and studied, as many must have done before. Maxwell saw something missing, a fourth equation which was needed to complete the set. His genius was not only to see that something was missing but also to predict what it must be. His deduction was that a changing electrostatic field should behave like a current, but a current which should be able to exist in space without conductors. Maxwell called this a 'displacement' current, and he saw this as a normal part of any alternating current circuit which included capacitors.

Maxwell laid his displacement current equation alongside the others, and saw a familiar pattern. Merged together, these four separate equations formed a single equation, an equation well known to physicists as that of a wave. What it boiled down to was that changing electrostatic and magnetic fields could cause a wave motion. More remarkably, the equations enabled the speed of this theoretical wave to be calculated, and the calculated value was identical to the measured speed of light.

Maxwell published the details of his remarkable theory at once. His conclusions were completely revolutionary. Light, he maintained, was an electromagnetic wave, and not a completely separate effect. More important, there must be a complete family of such electromagnetic waves, all capable of travelling through empty space at the same speed of three hundred million metres per second, all capable of carrying energy from one place to another through empty space. These waves, he predicted, would differ only in having different frequencies and wavelengths.

Maxwell's work was politely ignored. It was regarded as an interesting piece of academic research, but without practical applications. Don't feel too superior, because the same is said about nearly every great scientific discovery — as much now as it ever was. Remember that light seemed unaffected by electric or magnetic fields — though Faraday had shown that the plane of polarisation of light could be rotated by the effect of a magnetic field on a crystal. Remember also that there was no evidence for any of these other electromagnetic waves at the time. The evidence was to come later when Heinrich Hertz discovered radio waves, measured their speed, and showed that these were indeed the waves which Maxwell had predicted. By that time though, Maxwell's career had come to an end with his death in 1879.

One little side-line is worth noting, and it also illustrates a very practical side to Maxwell. In the middle of his work on electromagnetic waves, Maxwell produced the first colour photograph. He had seen that a colour photograph could be produced by projecting three images, one in each primary colour, so that they superimposed. This was in 1864, and it was some ninety years before family photograph albums were being decorated with colour photographs as a matter of routine. With that, and the prediction of radio waves, how much more ahead of his time could he be?

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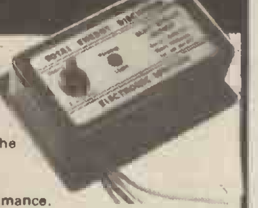

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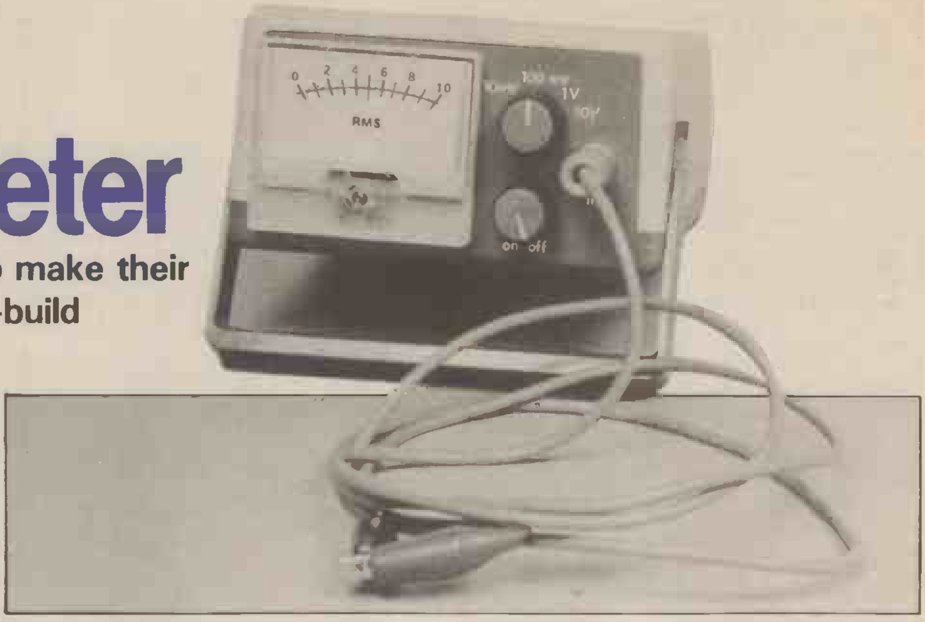
Audio Millivoltmeter

For the hobbyists who like to make their own test gear, this simple-to-build project is ideal



ANYONE WHO TAKES up electronics as a hobby soon accumulates various pieces of test equipment. One of the most essential is a multimeter, of course, but nevertheless, it still has its limitations. Perhaps the most serious drawback, particularly if you count audio as one of your interests, is the instrument's inability to measure small AC voltages. Help is at hand though — all you need is the HE Audio Millivoltmeter described here, and you will be able to measure the frequency response of a power amplifier, check the action of tone controls, and work out signal-to-noise ratios etc.

Described simply, the project is a sensitive voltmeter with a switchable full-scale deflection (FSD) of 10 mV to 10 VRMS. (RMS means root mean squared — you can think of this as being the average size of an AC voltage). Unlike most published circuits which do the same job, this one uses only one IC and as such the project is simple-to-build and an ideal project for beginners and long-standing hobbyists alike.

Uses

There are many uses for an accurate millivoltmeter such as this, but lack of space rules that we can only state two of the most important:

● Because the circuit is AC-coupled it can be used to measure small AC voltages superimposed on a DC voltage. Typical of such measurements is the determination of ripple voltages on power supplies. Let us explain!

A mains-operated power supply unit (PSU) never gives a completely smooth output, but always shows a 'ripple' (an up and down motion of a few millivolts impressed on the DC voltage). The AC coupling of our millivoltmeter, because of capacitor C1, means that the meter will totally ignore the standing DC voltage. A 'good' PSU should exhibit a ripple of less than about 1% (120 mV with a standing voltage of 12 VDC).

● The frequency range of the meter extends up to about 200 kHz and so it can be used to measure the frequency response of power amplifiers. To do this a signal generator which will supply sinewaves is also required. The generator output is fed into the input of the amplifier and the amp's output is monitored with the millivoltmeter.

Now, the frequency response of an amplifier is defined by what engineers sometimes term 'the -3 dB points' — the two points at the lower and upper end of the amplifier's frequency range where the output voltage amplitude exhibits a size reduction of 3 dB. In case you are wondering, a fall of 3 dB means a reduction in voltage amplitude of

$$\frac{V}{\sqrt{2}}$$

where V is the maximum amplitude.

Simplifying,

$$\frac{V}{\sqrt{2}} = \frac{V}{1.414}$$

$$= 0.707\,V.$$

So, the -3 dB points occur at the frequencies where the amplitude falls to 0.707 times the maximum.

Feed a 1 kHz sinewave into the amplifier's input and adjust the volume control until a reading of 7 V is indicated on the meter. Now sweep the sinewave frequency downward until the meter reads 5 V. It just so happens that:

$$0.707 \times 7\,V = 5\,V,$$

so at this point the response of the amp has fallen by 3dB.

Repeating this procedure for high frequencies will reveal the upper -3dB point by the meter reading falling to 5 V again.

Construction

Start construction with the Veroboard. Carefully make the breaks in the tracks, indicated in Fig.2 using a cutting tool or a small (about ⅛") hand-held drill bit. Check that no small pieces of copper swarf produced by this track-cutting process bridge adjacent tracks, forming short circuits.

Now, insert and solder each component into the board as shown in Fig.2, starting with the resistors, followed by capacitors and finally the semiconductors. If you wish, an IC socket can be used to hold IC1.

Next mark, drill and cut out the holes in the case to take the meter, the two switches and the phono socket, and fasten them into the case.

Finally, mount the circuit board in the case and then wire-up your project as the connection details show. Note that the input lead (both inside the project and also the probe lead) should be of screened cable, which will be necessary with a circuit having such a high gain and high input impedance. The screened cable will help to reduce interference and hum pick up which, because the hum and interference are AC, would give a false reading on the meter.

The Audio Millivoltmeter requires no setting up since the resistors have been scaled to read the RMS value of sinewaves. Simply switch on and you're ready to go.

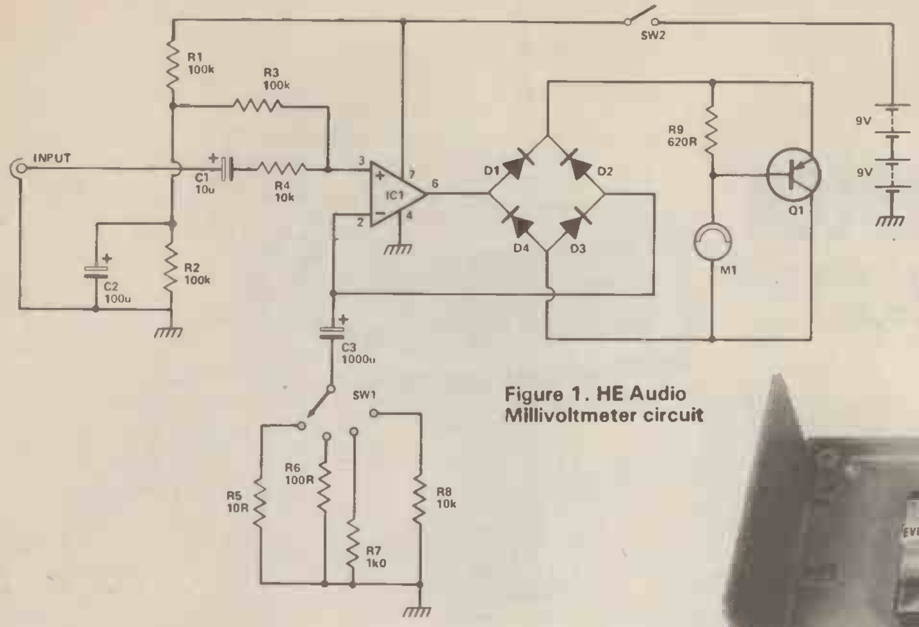


Figure 1. HE Audio Millivoltmeter circuit

NOTE:
IC1 IS LF351 OR LF356
Q1 IS BC558A
D1–4 ARE 1N4148

Buylines

The only component which may be difficult to obtain is the meter, M1. This is a type (series 920) stocked by Ambit International.

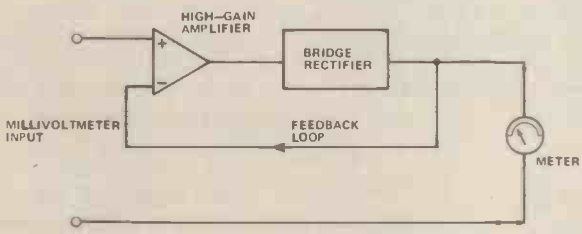
Vero Electronics Ltd can supply the case (order number 65-2760D) for £4.00 including p&p. Please add VAT at 15%.

The approximate cost for components (excluding the case and Veroboard) should be about £12.

Internal photograph of the Audio Millivoltmeter

How It Works

The small AC voltage under measurement is first amplified by a high-gain amplifier with four switchable gains. Conversion of AC to DC is done with a bridge rectifier in the feedback loop of the amplifier. This speeds up the action of the circuit of the millivoltmeter and also makes it more accurate. A moving-coil meter is then used to measure the amplified and rectified voltage.



Integrated circuit IC1 forms the high-gain amplifier and is in a non-inverting configuration. This type of circuit allows a very high input resistance to be obtained which does not 'load' the circuit whose voltage is under test. Switch SW1 connects various resistors (R5-8) into circuit, each having a different value, to define the gain of the amplifier.

A bridge rectifier is formed by diodes D1 to D4, within the feedback loop of the amplifier. The output of the bridge rectifier is connected across M1 in series with R9, and thus the measured voltage is displayed on the meter scale.

Resistor R9 and transistor Q1 act as an overcurrent monitor to protect the meter if the measured signal is much larger than is necessary to drive the meter to FSD. Their action is quite clever and depends on the fact that the voltage between the base and the emitter of the transistor needs to be over 0.7 V before the transistor conducts and, under normal conditions, the voltage across R9 remains less than 0.7 V. However, if too large a voltage measurement is attempted, more current will be driven through R9 and the meter. From Ohm's Law:

$$V = I \times R$$

So, as the current, I, goes up, the voltage must too!

As soon as the voltage reaches 0.7 V, transistor Q1 conducts and prevents any further current flowing through R9 and M1.

Parts List

RESISTORS (All ¼W, 5% except where stated)

R1, 2	100k
R3	100k 2%
R4	10k 2%
R5	10R
R6	100R
R7	1k0
R8	10k
R9	620R

CAPACITORS

C1	10u, 16 V electrolytic
C2	100u, 16 V electrolytic
C3	1000u, 16 V printed circuit mounting electrolytic

SEMICONDUCTORS

IC1	LF351 or LF356 operational amplifier
Q1	BC558A PNP transistor
D1–4	1N4148 diode

MISCELLANEOUS

SW1	three-pole, four-way rotary switch
SW2	double-pole, double-throw rotary switch
M1	200 uA moving-coil meter (see Buylines)
SK1	phono socket

2 x PP3 batteries and clips
8-pin IC holder
Veroboard
Case to suit (see Buylines)
Knobs to suit

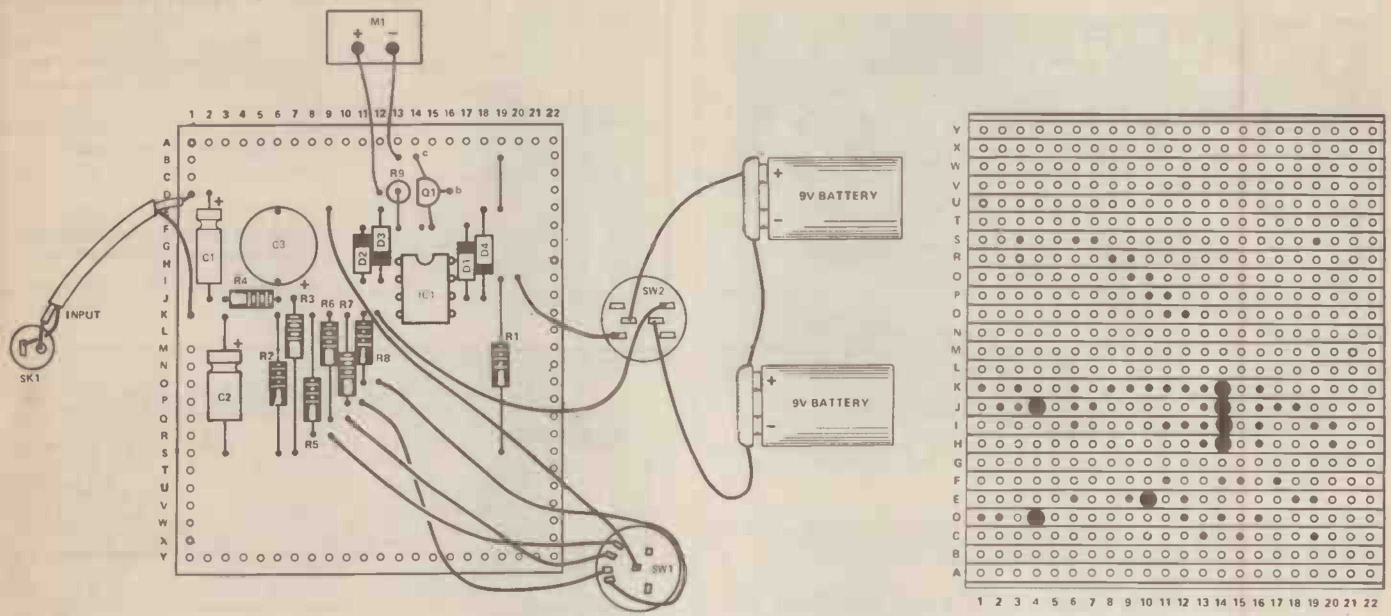


Figure 2. Veroboard layout of the project, showing component positions, track breaks underneath the board and connection details. Make sure you use screened cable for the input lead

HE

CB Breaker One Four

The publishers of HOBBY ELECTRONICS would like to point out that it is as present a contravention of the Wireless Telegraphy Act of 1949 and 1968 to use, manufacture, install or import CB transmitting equipment. It is not the intention of Modmags Ltd to incite, encourage or condone the use of such equipment.

So it's FM in Autumn, but what does this mean in practice? Rick Maybury gives his views

UNLESS YOU'VE BEEN LIVING in a cave for the past few weeks you will have heard all about the recent Home Office announcement. Broadly speaking, it now means that by the Autumn we will have in this country a personal two-way communications system. Much has been said about the wisdom of adopting an FM service in favour of an AM system. In general, two points have been raised that I would like to clarify.

First range. The range is dependent on two factors, namely frequency and power. We can forget antennas for a moment as there are no differences between AM and FM antennas. Taking this all into account there should be no significant difference between two similar CB rigs, one using FM and one using AM. In practice the FM rig will be marginally better because of a phenomenon called the capture effect.

Second cost. I have been hearing countless tales of FM rigs costing upwards of £400 etc. This will not be true. In fact FM equipment is actually cheaper to manufacture, and development work will be minimal as FM equipment for CB has been around for some time.

I can now reveal that one major British company is about to announce a range of six CB rigs operating on 27 MHz FM, costing from £69.95. The base station model will be £99.00. I can't reveal this company's name just yet but read Citizens' Band (May issue) for more details.

Worse or Better Service?

Taking these two facts into consideration there is no reason to suppose that an FM service will be any worse than the current AM service. I suspect that it could be better, especially when you consider the problems with AM interference (TVI and radio control) and high levels of skip activity at the moment. There are still a lot of problems to be ironed out, not least the exact specifications for the new service. This I hope will be published by the time you read this. I hope to have more details next month.

Record Turn-out?

If you have been reading the CB press lately you will know that there are at least 10 CB exhibitions planned for the next six months. Last month I went along to the First National CB Eyeball and Family Jamboree. This was held on March 22nd at Donington Park Race Track. To set the scene, I should first tell you that this was a bitterly cold day: it was very windy and there was snow, sleet and rain to liven up the proceedings. An estimated 20,000 (yes, *twenty thousand)* turned up to witness what must be the largest CB gathering in this country. Trade stands from all over the country were selling equipment, accessories and even rigs, and the organisers laid on a number of events for the breakers. It was a very good day for everyone, especially the gentleman selling straight 40-channel AM rigs at £120.

Look out for reports on the forthcoming CB eyeballs in the coming months. In the meantime, well done to the organisers at Donington and look forward to seeing you next year, perhaps?

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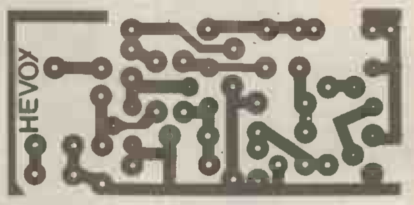
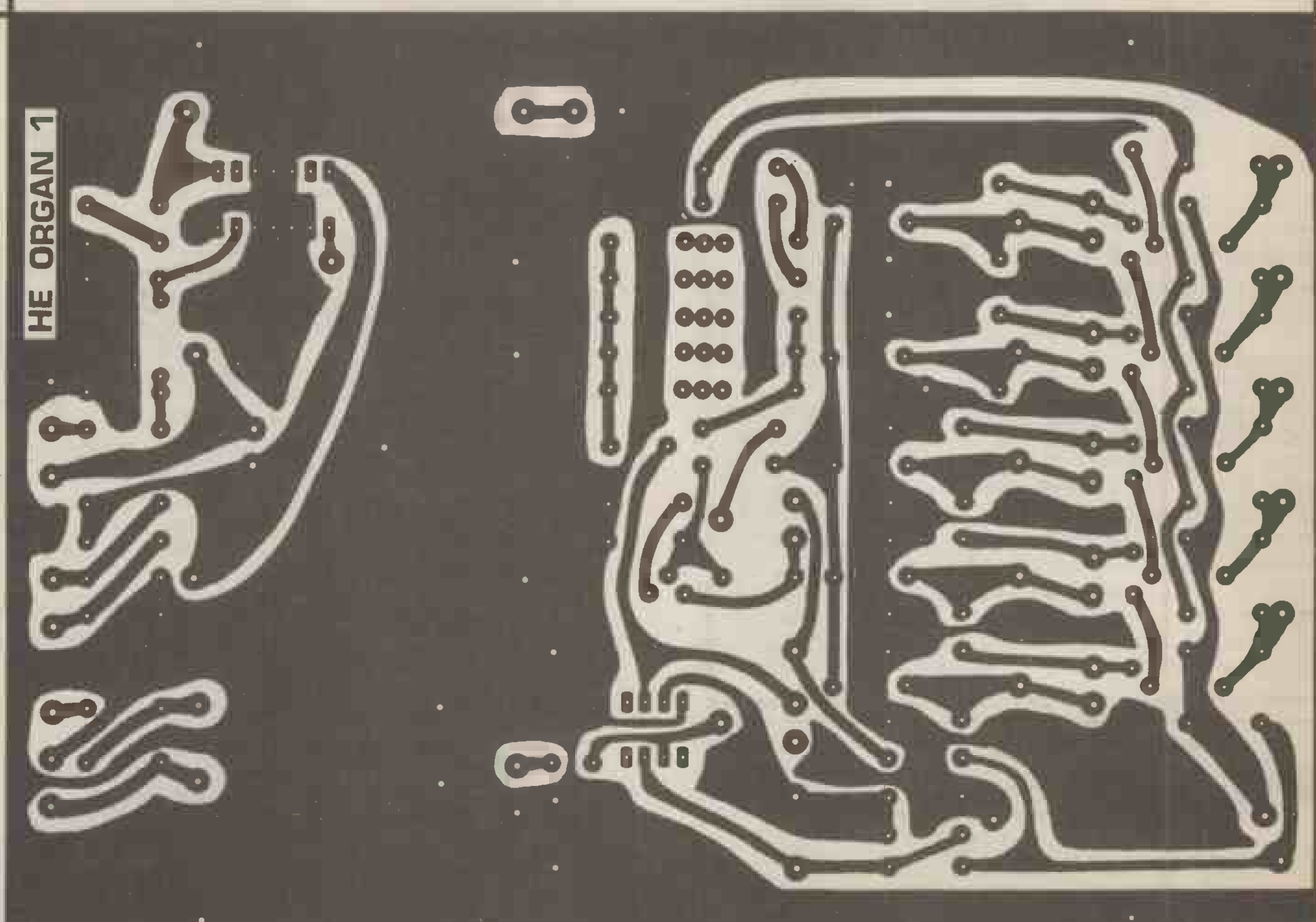


Above. Hevox PCB pattern



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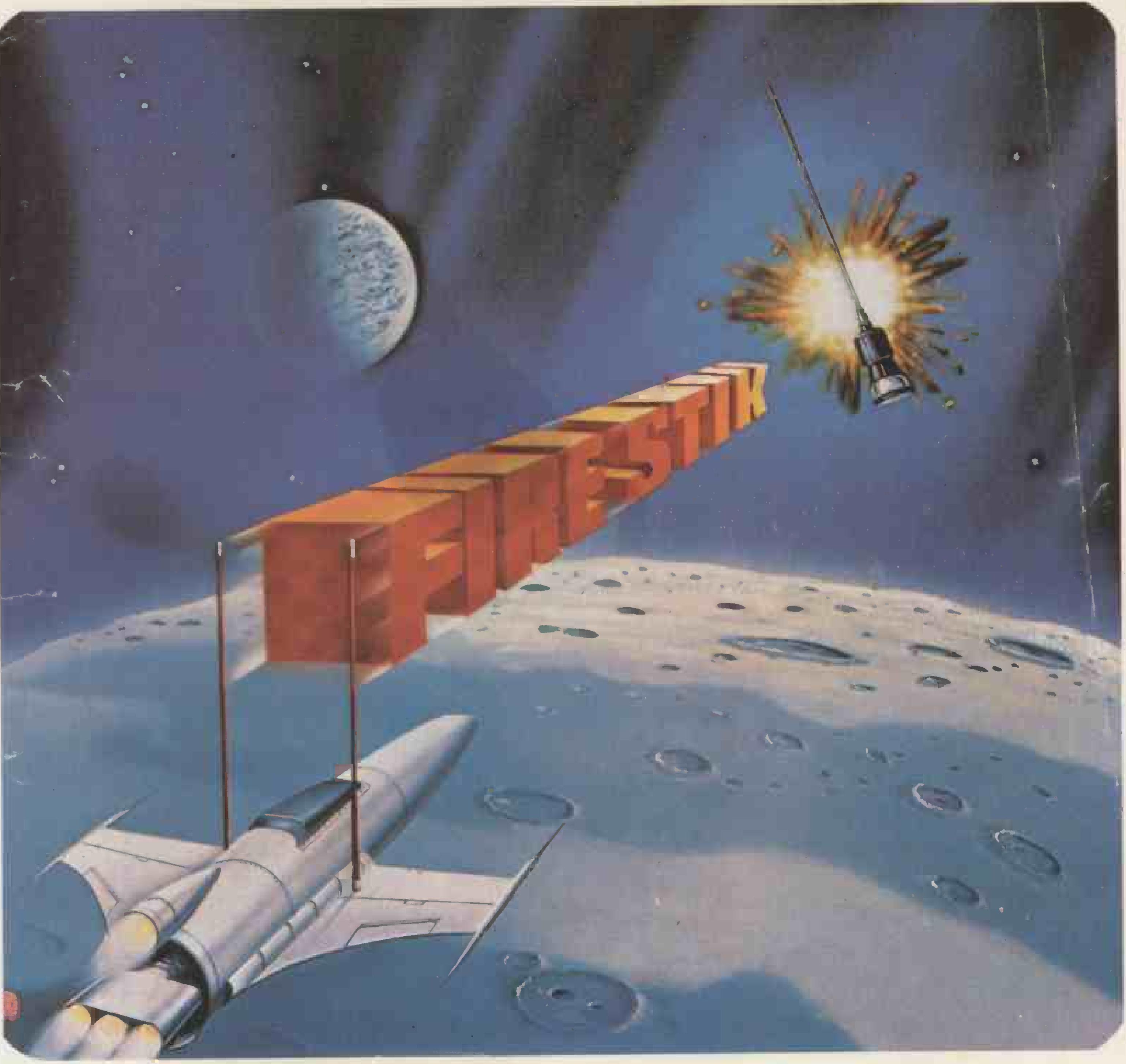

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