Electronics Today

INTERNATIONAL NOVEMBER 1980

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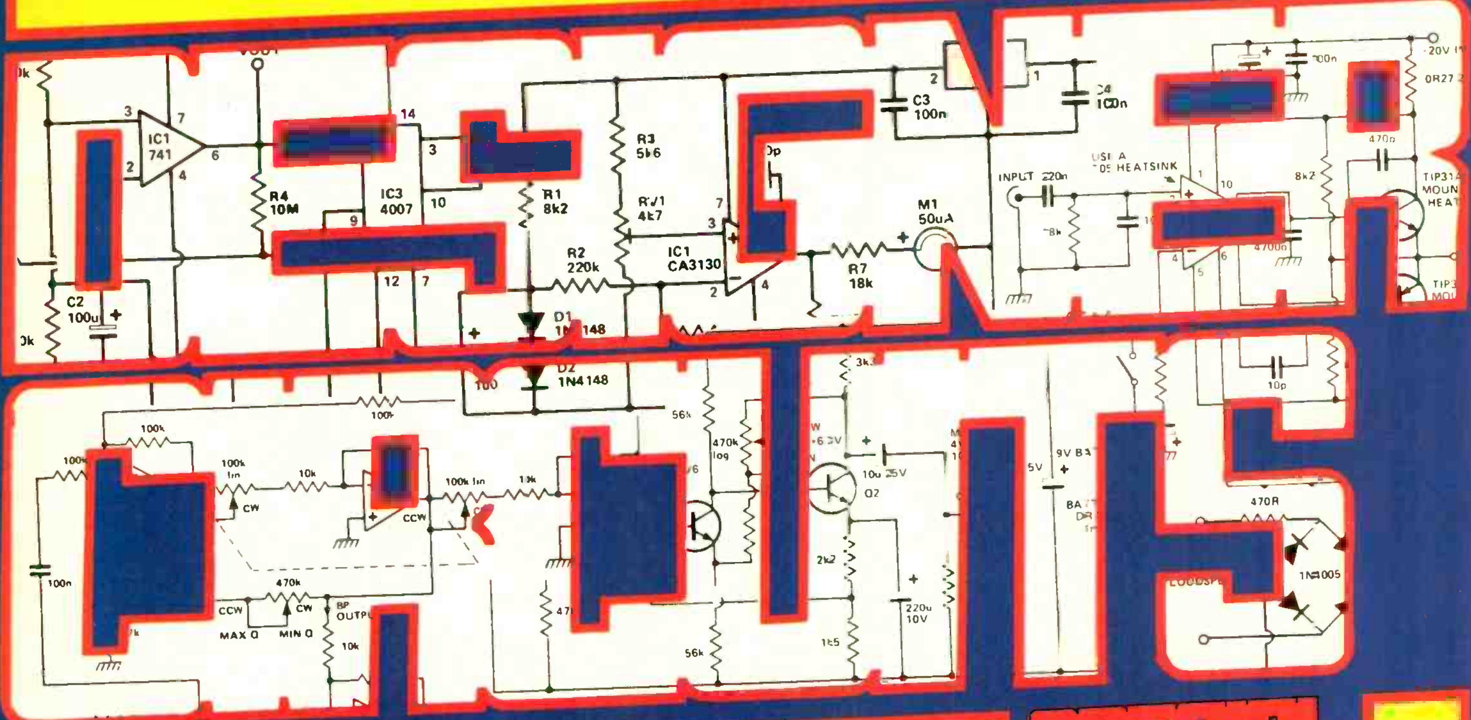
MM70924

DESIGNER CIRCUITS SPECIAL



Starship Daedalus
IR Remote Control
Hi-Fi Cassettes
Using Thermistors

Guitar Practice Amplifier

0 57438 70924 11

arkon electronics ltd

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special

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MA 1023 Car Clock Module $19.95
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3 chnl. colour organ, 300W. $22.75

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(Elementry Electronics)
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new items

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74LS92	$ .95	74LS245	$10.95
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382	$1.80	2206	$7 50	4N30	$1 50
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7555	$2.00	3046	$1.25	4N37	$1.65
556	$ .95	3140	$2.50		
565	$1.80	3302	$ 95		
566	$1.75	3401	$ 95		
567	$1.80	3900	$1 25		
709	$ 45	3914	$5.95		
733	$1.75	3915	$5.95		
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4002	$ 50	4011	$ .70	4042	$1.70	4085	$1 25
		4012	$ .60	4044	$2.50	4086	$1 95
		4013	$ .75	4046	$1.75	4089	$3 50
		4015	$1.65	4049	$ 50	4093	$1 00
		4016	$ .60	4050	$1.30	4094	$2.50
		4017	$2.00	4052	$1.80	4501	$3.25
		4018	$1.60	4053	$1.50	4502	$2.10
		4019	$1.60	4060	$2.50	4508	$3.50
		4020	$1.50	4063	$2.00	4510	$2.00
		4021	$1.50	4066	$1.50	4511	$2.00
		4022	$1.80	4068	$ 60	4512	$1.60
		4023	$ 50	4069	$ 50	4515	$5.50
		4024	$1.50	4070	$ 50	4516	$1 45
		4025	$ .50	4071	$ .50	4518	$2.00
		4026	$1.90	4072	$ 50	4519	$1.00
		4027	$ .95	4073	$ .50	4520	$2 00
		4028	$1.75	4075	$ .50	4522	$2 15
		4029	$1.60	4076	$ 80	4526	$2.50
		4030	$ .50	4077	$ .50	4528	$1 65
		4033	$2.15	4078	$ 60	4531	$1.90

74C08	$ .75
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74C165	$1.50
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4585	$1.50
4532	$3 50
4543	$2 25
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7404	$2.00	7430	$ .50	7495	$1.00	74193	$ 95
7405	$ .60	7432	$ .90	74107	$ 85	74194	$1 70
7406	$ .50	7433	$ .75	74121	$ 60	74365	$1 40
7408	$ .83	7437	$ .63	74122	$1 10		
7410	$ .30	7440	$1.10	74123	$1.05		
		7441	$1.15	74125	$1 15		
		7442	$1.40	74141	$1.00		
		7447	$1.75	74145	$1 75		
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		7451	$ .65	74153	$ 75		
		7454	$ .65	74154	$1 65		
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		7474	$1 40	74161	$1 60		
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		1858	$ 2.50
		1859	$ 2.50
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		R03 2513	$13.95
		AY-3-1015	$12.95
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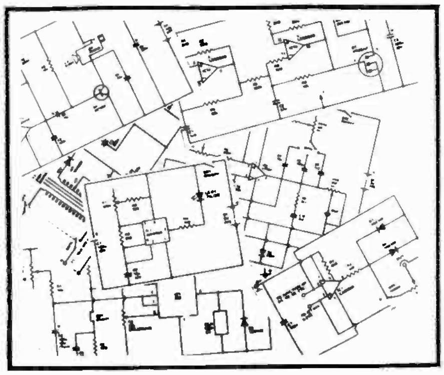
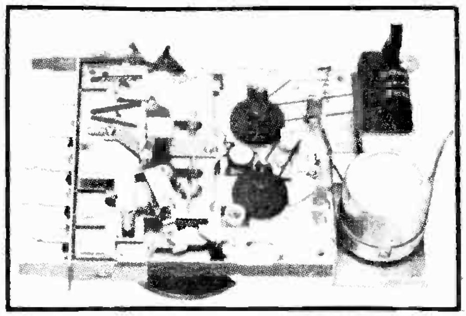
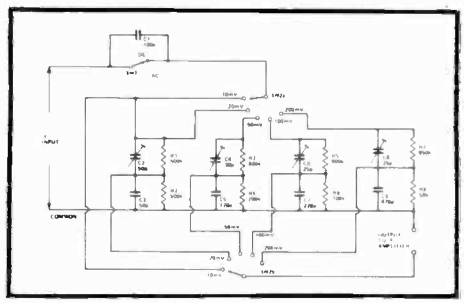
FEATURES



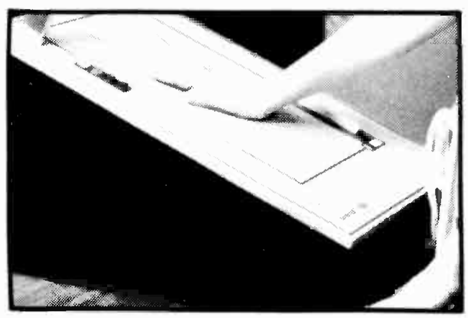
Designer Circuits Special, p.19



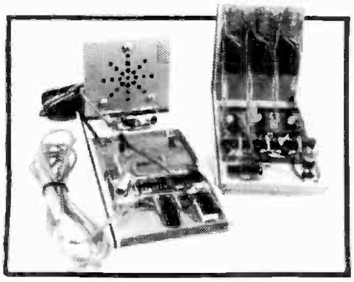
Cassette Decks and Tapes, p.29



Attenuator Circuits, p.34



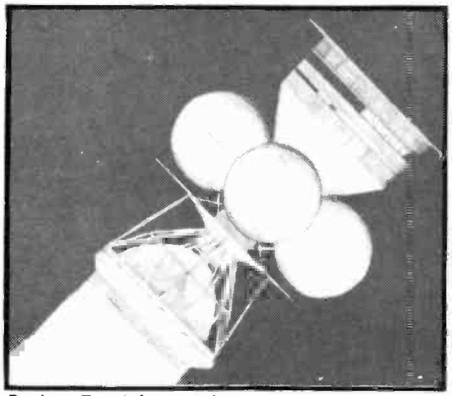
Identimat, p.39



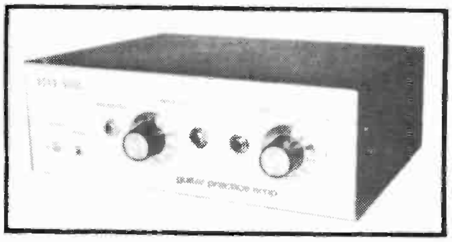
Cover: We've got a lovely selection of professionally designed circuits for you, see page 19.

ISSN 0703-8984

PROJECTS



Project Daedalus, p.53

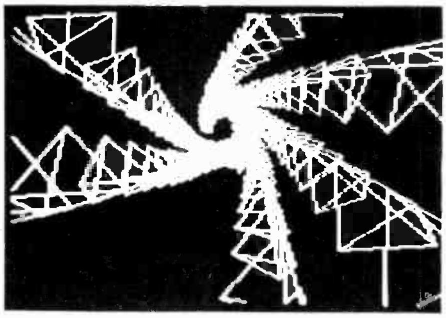


Guitar Practice Amplifier, p.13

Infra-Red Remote Control, p.59

COLUMNS

NEWS / INFO



What's New, p.47

ADVERTISERS' INDEX

LIABILITY
Whilst every effort has been made to ensure that all constructional projects referred to in this magazine will operate as indicated efficiently and properly and that all necessary components to manufacture the same are available, no responsibility whatsoever is accepted in respect of the failure for any reason at all of the project to operate efficiently or at all whether due to any fault in design or otherwise and no responsibility is accepted for the failure to obtain component parts in respect of any such project. Further no responsibility is accepted in respect of any injury or damage caused by any fault in the design of any such project as aforesaid.

EDITORIAL QUERIES
Written queries can only be answered when accompanied by a self-addressed, stamped envelope. These must relate to recent articles and not involve the staff in any research. Mark such letters ETI-Query. We cannot answer telephone queries.

BINDERS
For ETI are available for $6.75 including postage and handling. Ontario residents add 7% PST.

SELL ETI
ETI is available for resale by component stores. We can offer a good discount and quite a big bonus, the chances are customers buying the magazine will come back to you to buy their components. Readers having trouble in buying ETI could ask their component store manager to stock the magazine.

COMPONENT NOTATION AND UNITS
We normally specify components using an international standard. Many readers will be unfamiliar with this but it's simple, less likely to lead to error and will be widely used everywhere sooner or later. ETI has opted for sooner!
Firstly decimal points are dropped and substituted with the multiplier, thus 4.7uF is written 4u7. Capacitors also use the multiplier nano (one nanofarad is 1000pF). Thus 0.1uF is 100n, 5600pF is 5n6. Other examples are 5.6pF=5p6, 0.5pF=0p5.
Resistors are treated similarly: 1.8M ohms is 1M8, 56k ohms is the same, 4.7k ohms is 4k7, 100 ohms is 100R and 5.6 ohms is 5R6.

PCB SUPPLIERS
The magazine does not supply PCBs but these are available from the following companies. Not all companies supply all boards. Contact these companies direct for ordering information.
B&R Electronics, P.O. Box 6326F, Hamilton, Ontario, L9C 6L9
Spectrum Electronics, Box 4166, Stn 'D', Hamilton, Ontario, L8V 4L5
Wentworth Electronics, R.R. No.1, Waterdown, Ontario L0R 2H0
Danocinths Inc. P.O. Box 261, Westland, MI 48185, USA.
Exceltronix Inc., 319 College St., Toronto, Ontario, M5T 1S2
Arkon Electronics Ltd., 409 Queen St. W., Toronto, Ontario, M5V 2A5.
A-1 Electronics, 5062 Dundas St. West, Islington, Ontario M9A 1B9. (416) 231-4331.

NEWS

Getting Faster

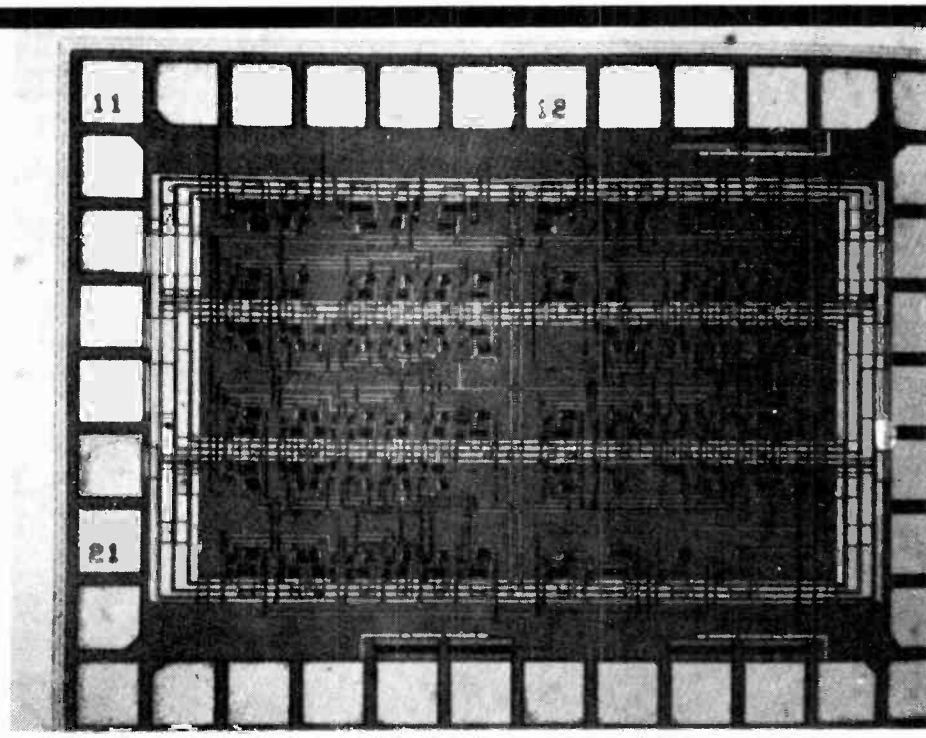
As the use of microprocessors and high speed communications mushrooms, the need for greater speed has become the watchword of semiconductor manufacturers.

One area that shows great promise is the use of MOS structure gallium arsenide (GaAs) technology, currently being developed by Lockheed Missile and Space Co.

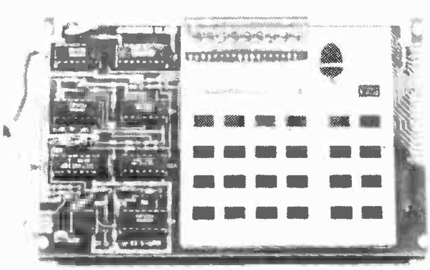
Typical gate propagation delays are 100ps, 20 times faster than ECL at 2ns and 100 times faster than TTL at 10ns. Anticipated production memory devices could have access times ranging from 10ns down to 2ns.

By 1985, IC device speeds of 4GHz should be possible. Discrete GaAs devices (used in microwave receivers and transmitters) will be able to operate in the 40 GHz region.

GaAs is not by any means the fastest available technology. The much talked about Josephson junction, under development by IBM, can achieve gate delays of only 13ps. On the other hand, such devices require cryogenic cooling in order to work.



Gallium Arsenide promises high speed and relatively low power consumption. There are a few problems, like an inability to grow insulating layers on the substrate. (Rockwell International)



Acorn Microcomputer

Available kit or wired, the Acorn System One is provided with 1K or RAM and 512 bytes PROM containing a system monitor. Consisting of two circuit boards connected by ribbon cable, the system features a click action 25-key hexidecimal keyboard, an 8-digit, 7-segment LED display, and built-in cassette interface.

The system monitor has some excellent features: reset, memory alter and examine, address increment, address decrement, go, break point, insert/remove, restore, tape store, load from tape. The system is based on the 6502 chip.

Also available in the Acorn System One is a single board microcontroller, and an extension Acorn Memory with provision for 8K of RAM and 8K of EPROM.

The System One is $239.95 for the kit and $319 wired. Available from Gladstone Electronic Supply Co. Ltd., 1736 Avenue Rd., Toronto, Ontario M5M 3Y7.

Easier Photo PCBs

Coval Industries, Inc. recently demonstrated a new imaging process called the "Re-Zolv" – a type of negative photo resist used in the production of printed circuit boards.

The process is unique in that it requires no chemical developers. It may be exposed using either incandescent or ultra violet light sources. It is developed with ordinary water spray. The process uses two solutions – one is the emulsion called Re-Zolv "A" which is mixed just before use with the second solution, a sensitizer, identified as Re-Zolv "B". One can coat up to 12 square feet of board with four ounces of emulsion combined with one ounce of sensitizer.

A high contrast negative is placed in contact with the dried emulsion and exposed to high intensity light. An indoor type 150 watt reflector bulb about 12 inches from the negative is adequate. Exposure – 15 minutes. With a simple spray wash of ordinary tap water, all of the unexposed emulsion is removed, leaving a strong green-coloured image of the ciruict path. The board can then be etched normally.

Further information may be obtained by writing to Coval Industries, Inc., 2706 West Kirby, Champaign, Illinois 61820 or telephone (217) 352-9336.

Still More LCDs

If your looking for an extra large LCD then check out the latest effort of Hamlin Inc. They now offer a 2" X 6" (yes, that's inches) LCD panel for outdoor applications. Designated the IS 3920/3980, the device apparently operates in a temperature range from minus 10 degrees to pius 90 degrees celsius. At the time of this printing, we couldn't get a picture, but it does bear checking out.

Write to Weber Electronics, 105 Brisbane Road, Downsview, Ontario M3J 2K6 or phone (416) 663-5670.

LOOKING BACK

Leader Oscilloscopes

Unfortunately the Reader Service Card number was left off the Leader ad on page 47 of our October issue. Readers interested in Leader products should circle No.54 on this month's Reader Service Card. The ad appears on page 38 of this month's issue. Our apologies to Omnitronix Ltd. and our readers.

Electronic Thermometer, September 1980

A pin number fell off the schematic during the production of this circuit. C2 should be connected between pins 1 and 8 of IC1.

Soil Moisture Detector, May 1980

The pin numberings of IC1d are incorrect as shown on the schematic. Pin 2 becomes 13, 1 becomes 12, and 3 becomes 11. The printed circuit overlay is correct.

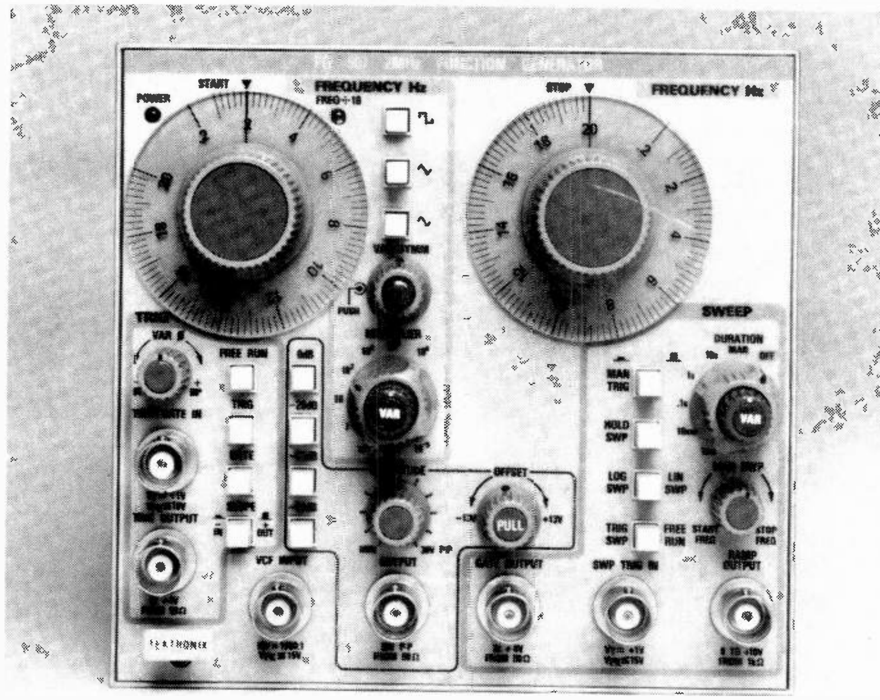
A Clean Sweep

Tektronix offers a novel 2MHz sweep function generator that allows the user to select the upper and lower limits of frequency range, linear or log sweep and direction. Designated the FG507, the instrument is intended for audio, telecommunications and other applications requiring low distortion.

The log sweep of the FG507 is mathematically derived and allows accurate plots when using log scales, log paper, or a storage oscilloscope. Separate start and stop frequency dials make frequency settings easy to set and interpret.

For example, the instrument will sweep down if the stop frequency is lower than the start frequency. A third frequency control allows you to manually sweep between the preset start and stop frequencies without disturbing their settings.

The FG507 provides a low distortion outputs from 0.002Hz to 2MHz, and is capable of generating five basic waveforms – square, sine, triangle, ramp, and pulse, at output levels up to 30 volts peak-to-peak with up to ± 13.0 volts of offset from a 50-ohm source.



Both instruments have a wide range of vaiable symmetry, from 5% to 95% which provides ramps and pulses. Pulse rise-time is equal to or less than 25ns.

The generator's audio sine wave distortion is less than 0.25% and audio amplitude flatness is within 0.1 dB. Because of this ability to generate low-distortion sine waves, the FG 507 is especially suited for audio dignal applications. For example, the FG 507 can be combined with the fully automatic AA 501 Distortion Analyzer and the SC 503 Bistable Storage Oscilloscope to make a versatile swept-response measurement package, ideal for numerous audio applications. Another version, the FG 501A, has all the specs of the 507, but without sweep.

For pricing and further information on the new FG 507 and the FG 501A, contact Tektronix Canada Inc., P.O. Box 6500, Barrie, Ontario L4M 4V3 or call (705) 737-2700.

Another Looking Back

Just when you think you've got everything covered, Murphy's law comes up in a new form.

Readers may recall the IBS 8500 Sovideo TV game data sheet that appeared in the April 1980 issue. We would like, at this time, to say most emphatically, APRIL FOOL! It may seem a bit pointless at this time, but to date we have received no less than five queries for further data and General Incinerations address. Some people will believe anything.

Meanwhile, some wag at our local Active Component Sales outlet has pinned a copy of the data sheet up with the inscription 'Now Available $14.95 US. For our more gullible readers, this is an untruth. The IBS 8500 does not exist.

Looking Back, Again

Also readers may have noticed that the Exceltronix Multiflex ad appeared twice in last month's issue. A mistake on our part , their second ad was left out. Unfortunately that ad is forever lost, but we do direct readers to their new one on page three of this issue. Our sincerest apologies to Exceltronix and our readers.

Expose Yourself

News Digest is a regular feature of ETI Magazine. Manufacturers, dealers and clubs are invited to submit news releases to News Digest, c/o ETI Magazine. Sorry, submissions cannot be returned.

Micro Reading Matter

A new Canadian Newsletter is now available entitled 'Bits & Bytes'. It will contain articles on hardware and software. Write to Bits & Bytes Newsletter, 502 Smallwood Crescent, Saskatoon, Sask. S7L 4S6 or phone (306) 384-7585.

De Facts

The Association of Computer Experimenters have recently published "De Facto", which consists of close to 600 pages of reprints from the clubs newsletter, Ipso Facto, for the past three years. The book comes prepunched for insertion in a standard three ring binder and costs $15.00 postpaid. (Before you rush out and get a money order, realize the clubs efforts are exclusively devoted to the 1802 COSMAC microprocessor) Send cheque or money order to Bernie Murphy, 102 McCraney St., Oakville, Ontario L6H 1H6. Telephone: (416) 845-1630.

Head On

Jana Electronics have introduced a line of stereo headphones. Of particular interest are the model JH2 headphones. These are lightweight (2.47 oz. less cord) sensitive units with a rated response of 20Hz to 25kHz. Sensitivity is given as 98dB @ 1kHz for 1mW input. Coil impedance is 25 ohms. Suggested retail price is $36.95 and should be available at Jana dealers now. Jana also has four other models. For more information write to Jana Electronics Ltd., 30 Hamelin Street, Winnipeg, Manitoba, R3C 2J3 or phone (204) 477-1893.

Mostek

Zentronics informs us that they now have Mostek devices available in all eight branch locations. Zentronics, 1355 Meyerside Drive, Mississauga, Ontario L5T 1C9.

In an effort to find our Leaderscope contest winner, Omnitronix and ETI have mounted an expedition into Northern Ontario. The picture above came back to us. Shown is Bill Paquette (left) receiving his oscilloscope from Henry Taub, the leader of the Expedition. Congratulations Bill.

Our brave and fearless leader did not return. We understand he has gone on further north to make his fortune selling refrigerators and Hioki DMMs to Eskimos.

Go for it Henry!!

Triplett Counter

A 5Hz–80MHz Universal Counter (Model 7000), introduced by Triplett Corporation utilizes a microprocessor controlled reciprocal counting scheme to offer frequency, period and event measurements usually found only on more expensive instruments. Its price is $300. US.

High resolution (6 digits) 5Hz–80MHz frequency measurement, plus totalize (event) counting to 1 billion and elapsed time measurement from 100us to 100 hours is offered. Another feature from the programmed circuitry is the Model 7000's convenient elapsed time readout in hours, minutes and seconds.

The Model 7000 offers excellent resolution with the reciprocal counting scheme that permits six digit resolution even at 5Hz in just one second of measurement time. The highly visible .43" LED readout with a floating decimal point is augmented with three annunciators that indicate proper reading levels of Hz/ms, K/u or M/n. A selectable X1 and X10 attenuator operates over the dynamic range of input signals to achieve an optimum signal/noise ratio.

Operation is extremely simple with the auto-ranging feature that permits a single colour-coded selection knob for six operating modes. Additionally, there is a self-testing feature. In the TEST mode, the Model 7000 microprocessor systematically verifies proper circuitry and display performance.

Further information on the Model 7000 Universal Counter is available from Len Finkler Limited, 25 Toro Rd., Downsview, Ontario M3A 2J6.

Satellite News

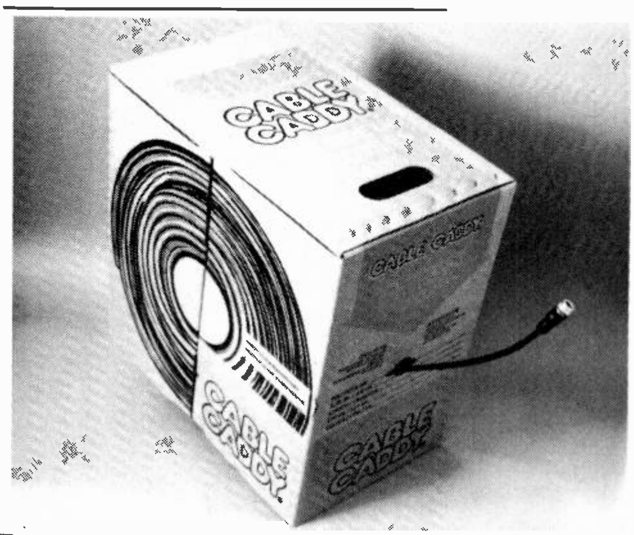
The Candian Radiotelevision and Telecommunications Commission (CRTC) recently released a statement concerning the legality of satellite downlinks.

The licensing of a station is a matter for the Department of Communications. Where the CRTC comes in is what the user does with the signal when he gets it. Any attempts to rebroadcast signals, whether by airwaves or cable is a "broadcasting undertaking" and as such falls under the jurisdiction of the CRTC. The CRTC has no interest in downlinks for individual use.

The Last Word

We're still wondering over some of the answers we got for the Link Contest. Most of you figured that it was something along the lines of $2/\sqrt{3}$ or $1/\sqrt{2}$. Some readers got very 'scientific' (!) and said that the resistance as you took in more resistors tended towards, but never quite reached, zero. Some came right out and said zero and even $1/\infty$.

Just about everyone appreciated that the answer had to be less than 1 ohm, except one answer of 100 ohms and at least five of infinity . . .



For Installers

Coaxial cable for RG, video, MATV, CATV, and CCTV applications is now available in a new lightweight compact dispenser from Amphenol North America.

The Amphenol Cable Caddy holds up to 305 meters of cable. The corrugated dispenser pays out cable without twists and tangles, stopping immediately when pulling action ceases, thereby eliminaing run on.

The Amphenol Cable Caddy is manufactured in Canada and is available through three Amphenol North America Canadian sales offices in Montreal, Toronto, and Vancouver., and through Amphenol's Canadian distributor network. Write to Amphenol North America, Canadian Operations, 44 Metropolitan Road, Scarborough, Ontario M1R 2T9.

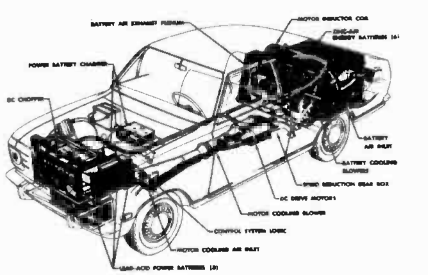
Electronics Today INTERNATIONAL

NEXT MONTH

At the time of going to press, the articles mentioned are in an advanced stage of preparation. However, circumstances may result in changes to the final contents of the magazine.

December 1980

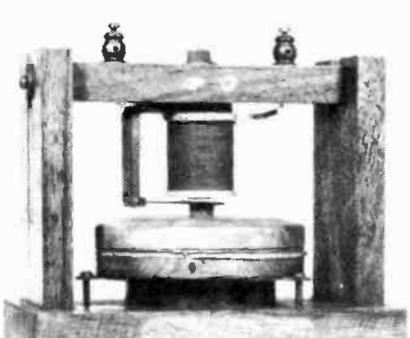
ELECTRIC CARS



For years and years we've heard that the electric car is just around the corner but apart from some handbuilt curiousities you're not able to buy one yet.

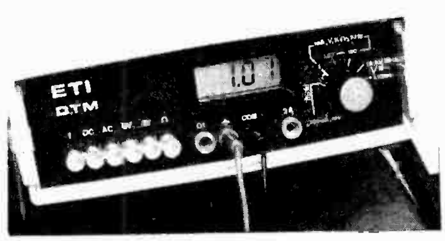
Next month Wally Parsons will be looking at how things stand at the moment.

TRANSDUCERS IN AUDIO



Transducers can be thought of as the interface between the real world and the world of the electron. In the audio field this includes pickups, microphones, speakers etc. Our feature examines these.

DIGITAL TEST METER

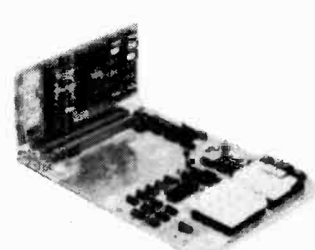


A really superb project which uses the latest 3½ digit LCD DVM module and acts as a combined 25-range DMM and a 5-range digital frequency meter.

10 TRANSISTOR CIRCUITS

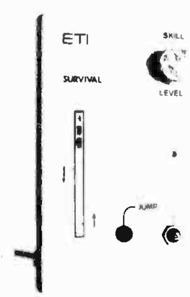
Ray Marston presents another of his articles describing circuits. Next month these include a preamp, a DC-DC converter, a lie detector, oscillator circuits and more.

WIN A COMPUTER!



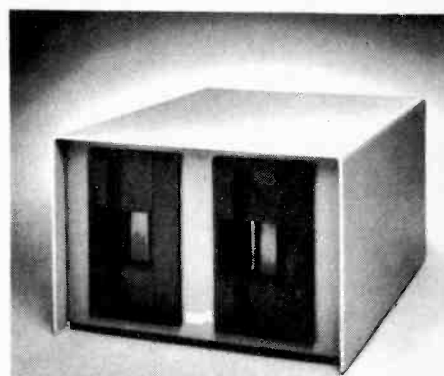
A free-to-enter contest with a mouth-watering prize: the new Multiflex Z80A microcomputer from Exceltronix.

SURVIVAL



A highly addictive but infuriating game: escape from the tyrannical machine if you can. The game includes sound effects, LED readouts and a skill level control.

FLOPPY DISKS



Next month John Van Lierde looks into floppy disks. He goes over the reasons for choosing this storage medium over tape cassettes, how they work and how they're controlled by the computer.

Your last chance for a subscription at the old rates: see page 6.

GUITAR PRACTICE AMPLIFIER

Simple construction, low cost, good performance and superb neighbour relations are the feature of this project!

THIS PROJECT has been designed to enable guitarists to put in long hours of practice and still keep that high power amp in the cupboard, where it belongs! It is a compact amp capable of about 7W into a 4 ohm load. This is enough power for practice purposes and just think of the greatly improved relations you will have with your neighbours.

We were in a considerable quandary as to how to present the project, whether it should be done as a complete practice unit with inbuilt speaker or simply as an amplifier to be connected to an external speaker. Finally we chose a compromise. The pc board has been designed in such a way that it can be used as a totally self-contained unit. The heatsinks for the output stage have been mounted on the pc board so that the only components separate to the board are the power transformer, power switch controls, input and output jacks. We have shown the project mounted in its own box with power transformer but it should be a simple matter to construct the whole unit inside a small loudspeaker cabinet.

The unit has two inputs so that two guitars can be mixed together using the relative settings of the two input level controls. A pre-amp output enables your main high power amp to be driven from the guitar practice amp using the practice amp as foldback.

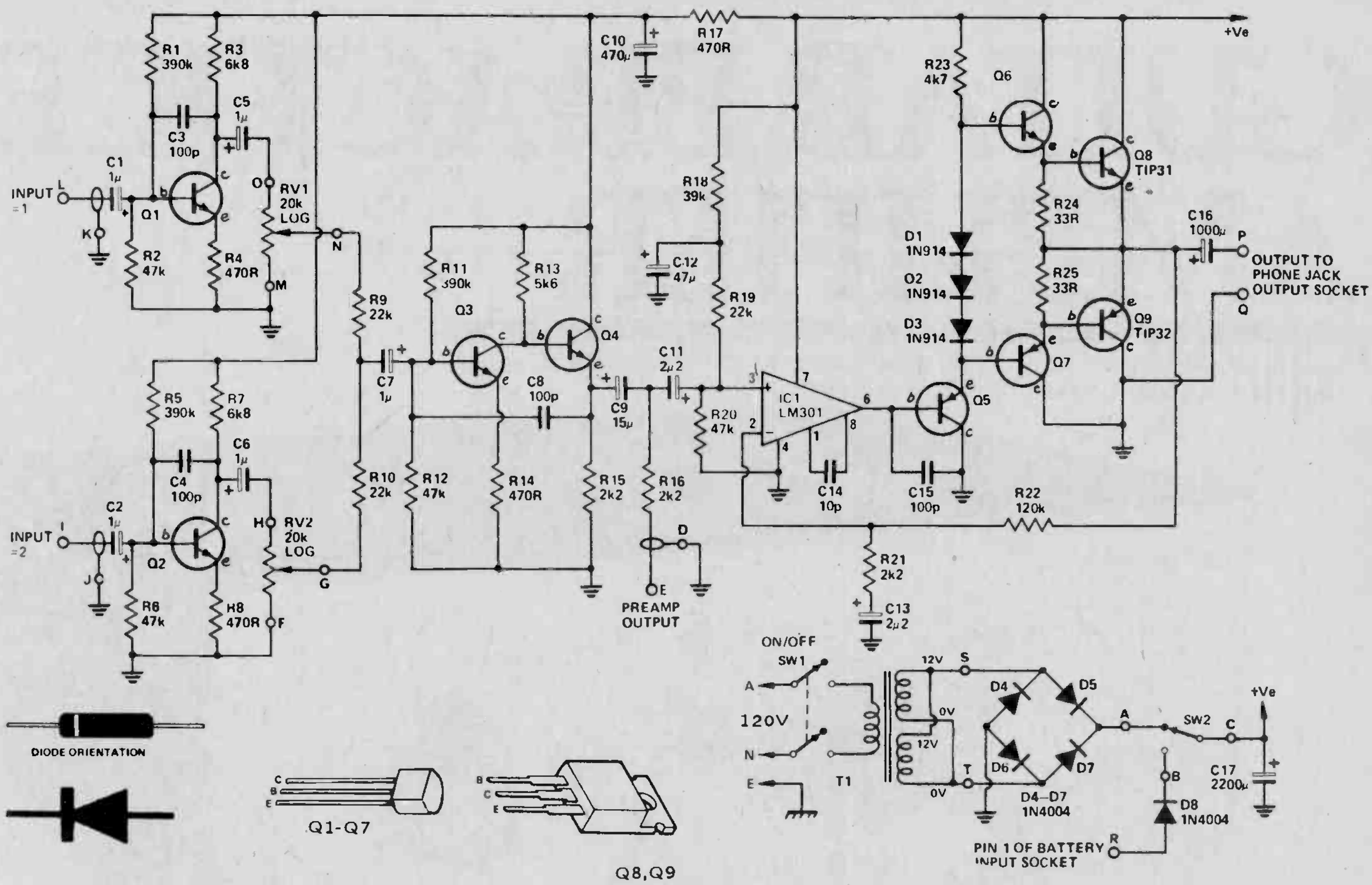
We provided the pc board with the necessary circuitry for a battery input but you might elect not to use this feature. If so diode D8 and the battery switch can be omitted with points 'A' and 'C' connected together by a wire link.

Construction

Construction of the project is reasonably simple since it is almost entirely devoted to construction of the pc board. Start as always by mounting the resistors and non-polarised capacitors. Mount the tantalum and electrolytic capacitors next, being careful to orient them correctly. These components could be irreparably damaged if inserted the wrong way around. Mount the LM301 IC transistors and diodes, again being careful to insert these the correct way round. Finally the output devices can be mounted. Cut the centre (collector) lead off. This lead is connected to the case of the transistor internally, so in this case, electrical connection is made through the mounting screw that also serves to hold the heatsink in place. Place the heatsinks on the pc board and secure with the lower nut and bolt (not used to mount the transistors). Bend the leads of the output transistors and, using a small amount of thermal compound (non-toxic, such as Chemtronics SL-1), mount the transistors with the leads protruding through the pcb.

Secure each transistor with a nut and bolt through both the transistor 'flag' and heatsink. Use a star washer between the head of the bolt and the copper pad on the pc board to ensure good electrical contact.

The prototype unit was constructed in a steel box measuring approx. 250 X 210 X 80mm. Mount the pots and switches to the front panel, using the pot and switch nuts to secure the front escutcheon if you have one. Mount the output and battery input sockets on the



HOW IT WORKS

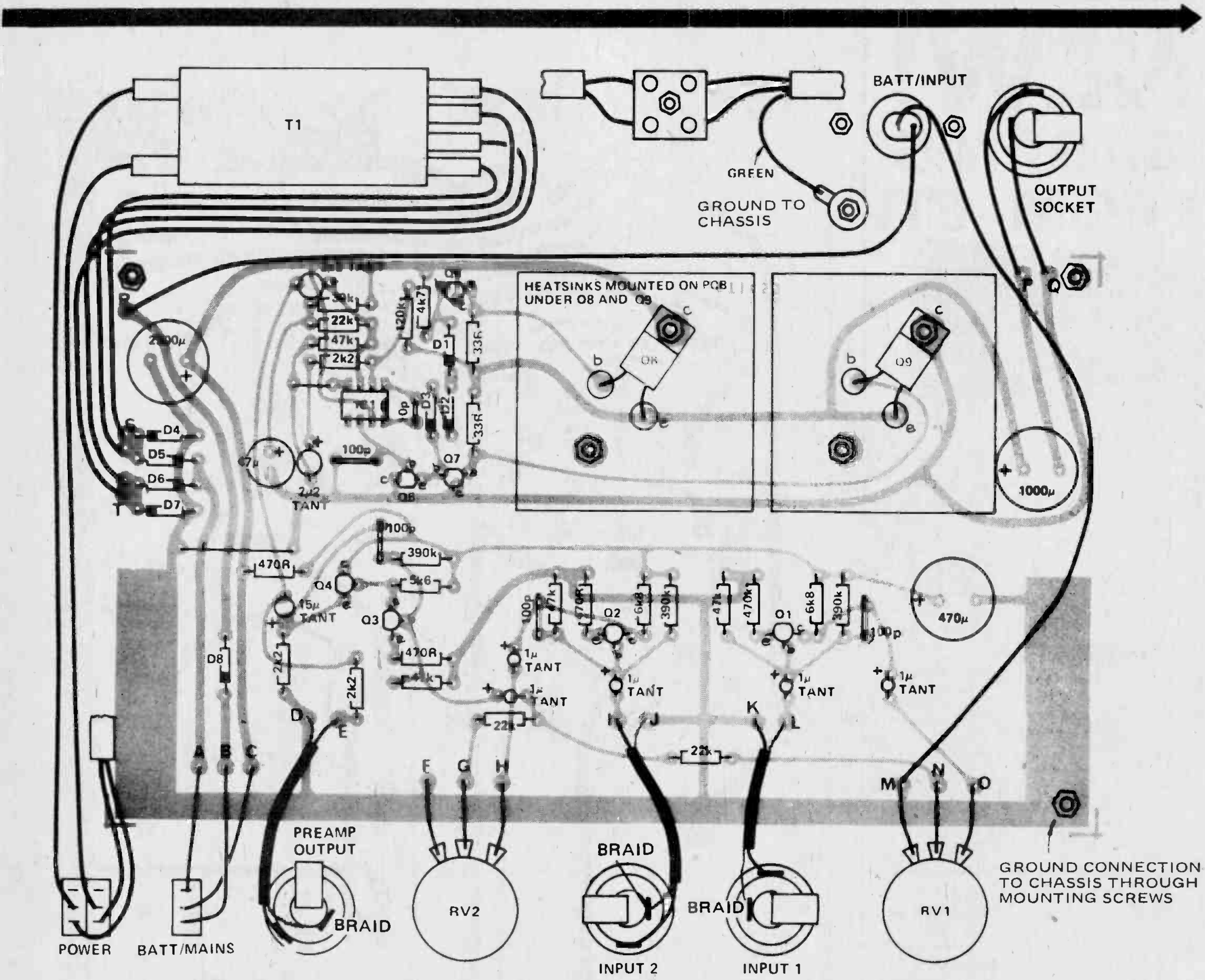
The two input stages formed around Q1 and Q2 are identical. Resistors R1, R2 and R4 form a very stable biasing configuration around Q1. The gain of this type of circuit is determined by the values of R3 and R4 (specifically, the gain is R3/R4). The load impedance on the output of the input stages is in parallel with R3, effectively decreasing the total value of impedance from collector to ground. Remember that, as far as signal is concerned, the positive supply rail is a short circuit to ground, since it is connected to ground through a 2200uF capacitor. When all these factors are taken into account the gain of the first stage is about 10 since the impedance from collector to ground is about 4k7.

The signal which should be around 200mV is then applied to the input of the second stage through potentiometers RV1 and RV2. The 22k resistors R9 and R10 prevent the output of one of the stages being shorted to ground when the other is turned right down.

The second stage works in exactly the same manner as the input stages; resistors R11, R12 and R14 forming the bias network for Q3. The voltage present on the collector of Q3 is around 9V which is approximately half the supply voltage. This is used to bias Q4 which is an emitter follower. This type of amplifier has no voltage gain but provides a low output impedance to drive the pre-amp output socket. Q3 has a gain of approx. 10. If the volume controls RV1 and RV2 are used in their middle positions the voltage out will be around one tenth of the voltage at their inputs since these are logarithmic pots. So, the signal voltages into Q3 should be in the order of 20mV. This will be amplified to a level of 200mV and applied to the input of the power amp. The power amp has been designed to deliver full power with an input voltage of 300mV, so the amp should be easily driven to full output with useable settings.

Since this is a guitar amplifier, it will spend most of its life hard into clipping. The output stage is the LM301 IC op-amp. This device gives all of the voltage gain in the power amp. The output of the IC is fed through a voltage follower Q5. This has no voltage gain and, like Q4, serves to decrease the impedance feeding the output stage. The three diodes, D1, D2 and D3, maintain 1.8 volts between the bases of Q6 and Q7. Each of these transistors will drop approximately 0.6 volts across their base-emitter junctions. This leaves a total of 0.6 volts to be dropped by the two 33R resistors, R24 and R25. Since these are of equal value they will each drop 0.3 volts and hold this voltage across the base-emitter junctions of the two output transistors Q8 and Q9. As these transistors require 0.6 volts to turn on they will remain off until the applied signal voltage causes the voltages on their bases to rise above 0.6V. The extra 0.3 volts needed to turn on the output devices will be supplied by a mere 10mA of current through the 33R resistors. Resistor R22 forms a feedback loop around the entire output stage to decrease distortion, stabilise the dc output voltage and set the overall gain of the power stage. (A process too difficult to go into here).

The op-amp will at all times attempt to make the dc voltage at the output equal to that voltage set up on its positive input. This voltage is determined by the potential divider formed by R18, R19 and R20. Since this is also the main input to the power amp any noise which might be on the positive supply rail (and supplies can get very noisy sometimes!) will be communicated directly to the input of the power amp, only to be amplified and applied to the loudspeaker. Capacitor C12 prevents this from happening by bypassing to ground any noise above a frequency of around 0.1Hz.



PARTS LIST

Resistors all ½W, 5%

R1	390k
R2	47k
R3	6k8
R4	470R
R5	390k
R6	47k
R7	6k8
R8	470R
R9, R10	22k
R11	390k
R12	47k
R13	5k6
R14	470R
R15, R16	2k2
R17	470R
R18	39k
R19	22k
R20	47k
R21	2k2
R22	120k
R23	4k7
R24, R25	33R
RV1, RV2	20k log potentiometer

Capacitors

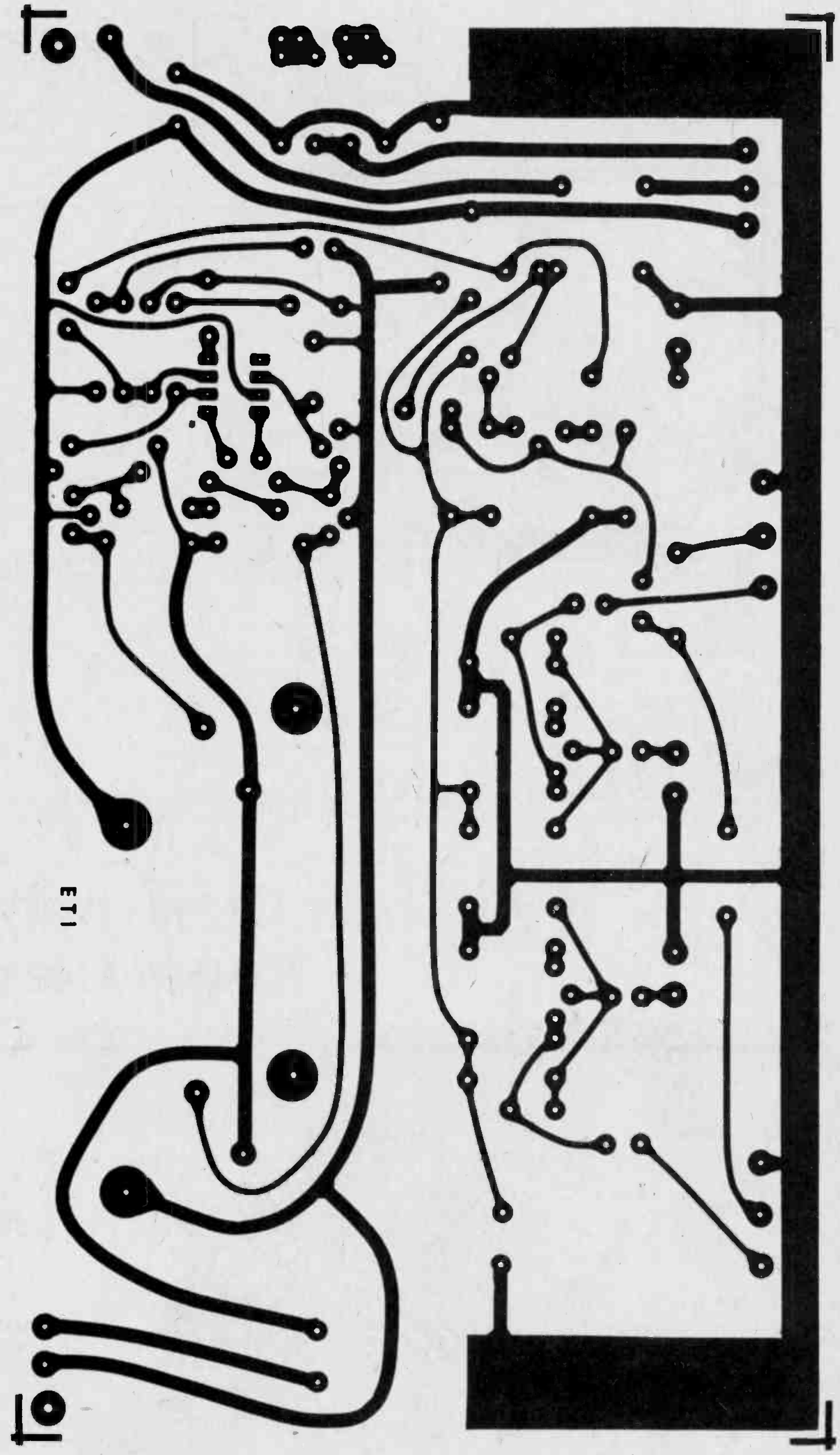
C1, C2	1µ 35V tantalum
C3, C4	100p disc ceramic
C5–C7	1µ 35V tantalum
C8	100p disc ceramic
C9	15µ 16V tantalum
C10	470µ 25V electrolytic
C11	2µ2 35V tantalum
C12	47µ 25V electrolytic
C13	2µ2 35V tantalum
C14	10p disc ceramic
C15	100p disc ceramic
C16	1000µ 25V electrolytic
C17	2200µ 25V electrolytic

Semiconductors

Q1–Q4	2N3906
Q5	2N3904
Q6	2N4401
Q7	2N4403
Q8	TIP31
Q9	TIP32
D1–D3	1N914
D4–D8	1N4004
IC1	LM301 op-amp

Miscellaneous

Box to suit, pc board, power transformer 12V@1.5 amps, 2xTO3 type heatsink for pc board mounting, line cord and plug, DPDT switch (power on/off), DPST switch (battery/mains switch), four phone jacks (mono), two knobs, grommets, nuts, bolts, pc board pins, four pc board mounting spacers.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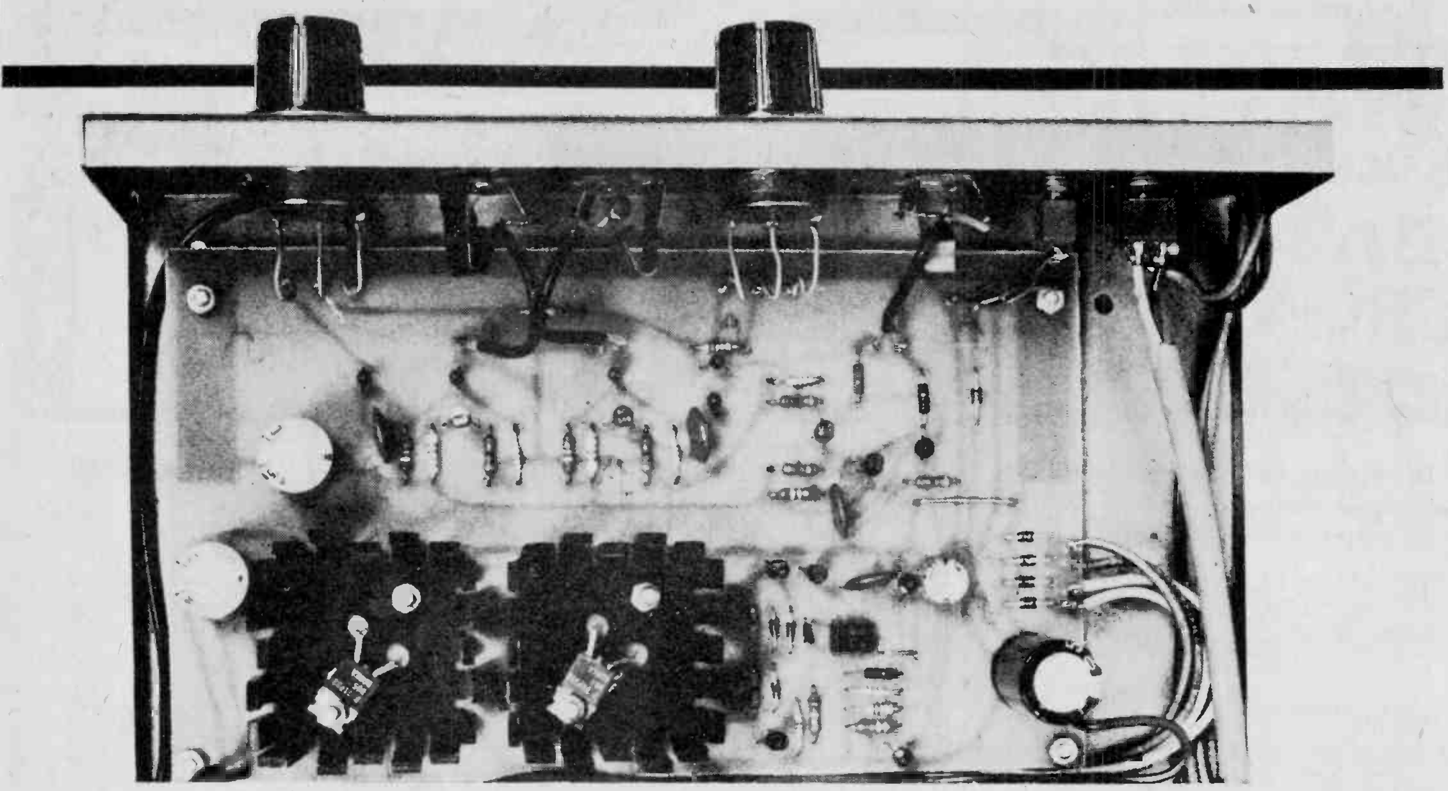


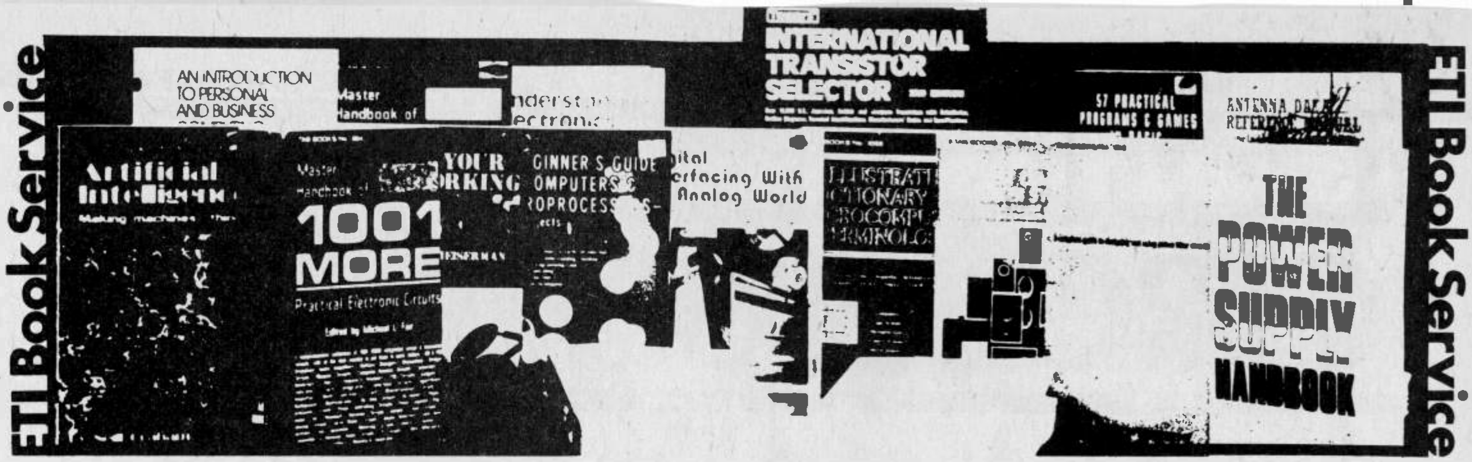
rear panel. If you are using a battery input socket use something different to the output socket (which is usually a ¼" jack socket) to avoid confusion.

Finally, the fully-loaded pc board can be secured into the case using short metal spacers. If pc board pins are used, all the connections to the board can be made after the board has been mounted.

Connect the front panel controls, rear panel sockets and input sockets as shown in the wiring diagram. Use short lengths of shielded cable to make the connections to the two inputs and the pre-amp output.

Powering Up

Make a final check of the wiring and pc board. If all is well, apply power. A slight turn-on thump should be heard at the moment of turn on. If the 'Input 1' volume control is now wound up some hiss should be heard from the loudspeaker. Do the same check on the other input. There is no set up procedure since the power amp stage is operating in class B and requires no bias adjustment. ●



To get yours, fill in the order form in this issue or write to ETI Magazine, Unit 6, 25 Overlea Boulevard, Toronto, Ont. M4H 1B1.

Master Handbook Of 1001 Practical Circuits
TAB No. 800 — **$18.30**
Master Handbook Of 1001 More Practical Circuits
TAB No. 804 — **$18.35**

Here are IC and transistor circuits for practically anything and everything – with ALL the data needed to put them to work. The ideal schematic sourcebook for all active technicians, engineers, experimenters, amateurs – for anyone who must occasionally or regularly construct or adapt electronic circuits for any purpose whatsoever. You'll find any circuit you're ever likely to need in the pages of this rich volume. The schematics are classified according to general application, and the Sections themselves appear in alphabetical order.

99 Test Equipment Projects You Can Build
TAB No. 805 — **$11.75**

Here's the A to Z guide you need to build all sorts of electronic test equipment – from a simple signal tracer to a sophisticated modularized 50 MHz counter – and virtually everything in between! Here are voltmeters and ammeters, capacitance meters, resistance and impedance measurers, testers for solid-state components, digital volt-meters, calibrators and frequency standards, signal generators, frequency counters, oscilloscopes, and a variety of RF test equipment. The variety is incredible and almost endless . . . virtually every test instrument you could possibly want to build for yourself. It's perfect for the hobbyist – and indispensable for the professional because you can incorporate each one – or a combination of several – into your work bench setup or other gear.

The Power Supply Handbook
TAB No. 806 — **$11.75**

A complete one stop reference for the hobbyist and engineer. Contains high and low voltage supplies as well as mobile and fixed units. Everything you need to keep your project perking with the right volts and amps.

Build Your Own Working Robot
TAB No. 841 — **$8.55**

Here are complete instructions – plans, schematics, logic circuits, and wiring diagrams – for building Buster. Not a project for novices, Buster is a sophisticated experiment in cybernetics. You build him in phases, and watch his personality develop as you add progressively more advanced circuitry to his mainframe. The first of this three-phase robot, Buster I, is "leash-led" and dependent on his master for decision-making; you create the "animal" and give him wheels, steering capability, and the capacity to "understand" your basic commands. Phase II makes Buster more independent. Now he has a basic brain he can use to decide when he's in need of a battery charge, or trapped into a physically binding situation he can't get out of.

57 Practical Programs & Games In Basic
TAB No. 1000 — **$11.55**

From arithmetic progression to statistical permutations to one-arm bandits, here are 57 practical, useful and fun programs designed to help you really put your minicomputer to work!

Game programs include blackjack, one-arm bandit, craps, and two space war games. Math and accounting programs include compounding, straight-line depreciation, statistical permutations, instant derivatives, and solutions for integrals – even a whole section of geometric solutions for modern-day Euclids. For history buffs, there is a Day-of-the-Week program for any date back through 1753.

Each program begins with an introductory paragraph describing its capabilities, and continues with a typical program sequence and flowchart. All programs will run on any floating point BASIC.

Tower's International Transistor Selector
TAB No. 1010 — **$9.85**

Here are transistor substitutions, outline diagrams, terminal identifications, manufacturers' codes and specs for more than 13,000 devices made in the U.S., Japan, Europe, and England. This ultra-complete reference-guidebook is an absolute MUST for anyone who deals with transistors or the equipment in which they're used . . . makes it as easy to locate transistor substitutes for Japanese and European imports as for mass-market U.S. consumer electronic products. Contains info on device ratings, characteristics, case and terminal identification, applications, manufacturers and addresses, and voltage ratings – collector-to-base, collector-to-emitter, and emitter-to-base.

A Beginner's Guide To Computers & Microprocessors – with projects
TAB No. 1015 — **$9.70**

Here's a plain-English introduction to the fascinating world of the microcomputer – its capabilities, parts, functions, and programming . . . and how you can have one in your own home. Numerous projects, using actual computer parts, demonstrate the operation of a computer and lead to the assembly of a working minicomputer capable of performing many useful functions around the home and office.

A typical family-sized computer, with video screen, printer, and keyboard, is fully described.

How To Design, Build & Test Complete Speaker Systems
TAB No. 1064 — **$11.85**

If you've always wanted to build your own speaker system, here's a book crammed with everything you need to know to do it right . . . the first time! It contains a variety of ready-to-build speaker system projects, from simple speaker-in-a-box setups to complex multi-driver systems, plus all the information even a beginner needs to design and build his or her own.

This clear guide shows you exactly how a speaker works, how its power and resonance are attained, and how speakers may differ from one another. It's as thorough a book as you'll find on the complete subject of speakers, speaker systems, and enclosures.

Digital Interfacing With An Analog World
TAB No. 1070 — **$12.35**

Are you looking for ways to really put your microcomputer to work? This book tells you how to go about it – how to convert energy produced by pressure, force, position, temperature, etc. into an electrical voltage or current that your microcomputer can deal with. It's for the user who views the microcomputer as a bit of hardware to be applied, and who views software as either a simple set of instructions to make the machine go or, more importantly, as a valid substitute for hardware. It presents information, in handbook style, for users of microcomputers who want to design a device or system with a microcomputer at its heart.

Very simply, this book is for the microprocessor/computer user who wants to use the machine to measure certain conditions, or to control external devices.

The Complete Handbook Of Robotics
TAB No. 1071 — **$10.90**

Create your own robot? All the information you need to build a walking, talking friend and companion or a helpful servant appears in this book!

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Whether you want a robot for a experimenting, for a security application or to perform some task suitable for a "smart" machine, all the ideas you need are packed into this book.

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Artificial intelligence is the branch of computer science devoted to programming computers to carry out tasks that, if carried out by human beings, would require intelligence. Here is a book that deals with the entire subject of artificial intelligence. It describes what we consider intelligence where computers are concerned, and presents an interesting summary of the step-by-step advancement of computer complexity toward the rudiments of human-type intelligence.

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The Active Filter Handbook
TAB No. 1133 — **$9.75**

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For anyone interested in electronics, this handy one-stop guide to modern filter technology will prove invaluable. It introduces filters and their purpose, compares different filters, and covers LC passive filter operation, op amps, Butterworth filters, Chebyshev filters, low-pass filters, high-pass filters, etc. This all-inclusive manual offers coverage of electronic math and basic electronic theory also. Cannot be beat for a complete and practical discussion and examination of filter techniques.

Antenna Data Reference Manual
TAB No. 1152 — **$11.75**

Since the antenna system has a large influence on what you get out of a ham or CB station or get into a shortwave or an AM/FM receiver, best results are obviously achieved with the best possible antenna. This book will show you how to make and install hundreds of antennas, among them half-wave dipoles, inverted vees, verticals, yagis, quads, deltas, FM broadcast, and CB antenna and transmission line, plus limited space and hidden antennas. Included are precise specifications for a huge variety of different designs tuned to work on most amateur, marine, international broadcast, AM/FM broadcast and CB bands.

The Giant Handbook Of Computer Projects
TAB No. 1169 — **$13.75**

If microcomputers have caught your interest, or if you've been through the ready-made hardware routine, you're ready for this book. It's a huge collection of ready-to-use information designed for the enterprising hobbyist who wants more flexibility – and practicality – than that offered by systems assembled for the mass market.

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TAB No. 1174 — **$9.75**

This all new and complete revision will thoroughly acquaint you with everything you need to know about model radio control – how it works, how to design a system, how to install it, and how to operate model airplanes, cars, boats, toys or virtually anything by radio control. Starting out with fundamental RC concepts, the author takes you through all the latest and most modern equipment, including coding and coders, relays, superregenerative receivers, decoders, power control circuits, servo motors, tone-operated and proportional control systems and much more!

If you want to keep up with the changes in radio-controlled modeling, or if you want to get in on the ground floor of the hobby, this lucid guide should be part of your library.

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If you really want to get some truly great sounds out of your audio system, this unique new book shows you 21 good ways to do it. From simple closed-box systems to complex omnidirectional speakers, you get complete descriptions, design and construction details for 21 build-it-yourself projects – virtually every kind of audio speaker you could want. You can pick and choose your own project – from the simplest to the most advanced . . . for home or car, stereo or quad . . . even for a van or RV.

How To Build Your Own Self-Programming Robot
TAB No. 1241 — **$11.75**

This is a straightforward how-to book about machine intelligence – a practical guide that shows you how to build a robot capable of learning how to adapt to changing circumstances in its environment. The unique little creature described in this book, named Rodney, can pick up signals and stimuli from his environment and develop perceptions just like humans and higher animals do. Yet Rodney is fully trainable, and his "personality" can be altered and molded by human intervention. All in all, Rodney is in a class by himself, and is a most remarkable and fascinating machine – he can program himself to deal with the problems of the moment and devise theories for dealing with similar problems in the future. Yes, Rodney is self-programming, and as a result no two Rodneys behave exactly the same way. In fact, if you wipe out his self-generated memory, he'll develop another one that's somehow different from the first.

An Introduction to Personal & Business Computing
SYBEX C200 — **$10.75**

This is a basic introductory text on microcomputers. Its main goal is to answer the question: "What do I need for . . . ?" in specific detail. No previous technical background is assumed. The author addresses progressively all the essential topics of interest to the microcomputer user (as opposed to the designer). How a system works. Which modules are required for which function. How much memory is needed. Which perpheral should be used. The cost. The software. Differences between existing microcomputers. Is a mini-BASIC sufficient? The real cost of a business system. Its limitations. Can you really manage a mailing list on a floppy disk? Packages and other programs. The traps for the hobbyist. Application techniques. New systems and facilities.

The book is designed to educate the reader in all the aspects of a system, from the selection of the microcomputer to the required peripherals. No computer background is required.

Programming the 6502
SYBEX C202 — **$18.75**

An educational text designed to teach you programming from the ground up. Already one of the most successful programming books ever published, it has been revised and expanded at both the low end and high end of the spectrum. The range of programming concepts and techniques presented is such that it addresses the needs of virtually every programmer interested in using the 6502 microprocessor, from beginner to expert.

Programming the Z80
SYBEX C280 — **$20.75**

This book has been designed both as an educational text and as a self-contained reference book. As such, it can be used as a complete introductory book on procramming, ranging from the basic concepts to advanced data structures manipulations.

It also contains a comprehensive description of all the Z80 instructions as well as its internal operation, and should provide a comprehensive reference for the reader who is already familiar with the principles of programming, but wishes to learn the Z80. All concepts are explained in simple yet precise terms, building progressively towards more complex techniques.

Programming the Z8000
SYBEX C281 — **$22.75**

This book was designed as both an educations text and a self-contained reference manual. This book presents a thorough introduction to machine language programming from basic concepts to advanced programming techniques. Detailed illustrative examples and numerous programs show the reader how to write clear, well-organized programs in the language of the Z8000.

With over 113 illustrations, a thorough index, and 5 appendices, Programming the Z8000 is an indispensable text for engineers, students, PDP-11 users and anyone interested in learning machine language programming skills.

6502 Applications Book
SYBEX D302 — **$18.75**

This book presents practical applications techniques for the 6502. You will build a complete home alarm system, including fire detection, as well as an electronic piano, a motor speed-regulator, a time-of-day clock, a simulated traffic control system, and a Morse code generator. You will also design an industrial control loop for temperature control, including analog-to-digital conversion, and your own simple peripherals from paper-tape reader to microprinter.

Truly the "input-output" book for the 6502, it includes more than 50 exercises designed for testing yourself at every step.

6502 Games Book
SYBEX G402 — **$18.75**

This book is designed as an educational text on advanced programming techniques. It presents a comprehensive set of algorithms and programming techniques for common computer-games. All the programs are developed for the 6502 at the assembly language level.

The reader will learn how to devise strategies suitable for the solution of complex problems, typical of those encountered in games. He/she can also use all the resources of the 6502, and sharpen his/her skills at advanced programming techniques. All the games presented in this book can be played on a real board (the SYM), and require a very small amount of additional components.

All prices include postage & handling.

Prices subject to change without notice.

DESIGNER CIRCUITS

HF TTL OSCILLATOR

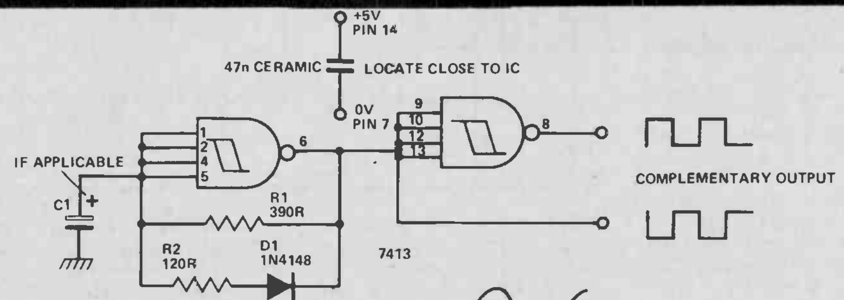
A squarewave oscillator with complementary outputs and with a frequency range of 20 Hz to 10 MHz can be made from one IC, a 7413 which is a TTL dual Schmitt trigger. The oscillator is always self starting and runs from a 5 V supply, current drain 20 to 30 mA. The 7413 is a Schmitt trigger with hysterysis levels (at its input) of +0.9 V and +1.7 V. That is, when the input level exceeds +1.7 V the output jumps to a low condition (+0.2 V). When the input voltage is lowered it needs to fall below +0.9 V before the output jumps back to a high condition (+3.4 V).

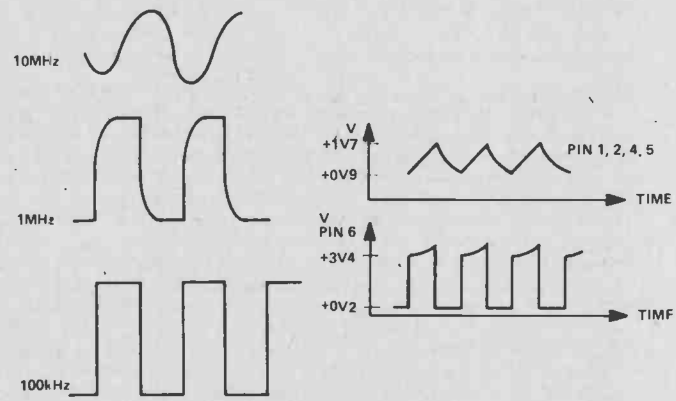
When the Schmitt trigger is connected up as shown in the diagram the device will oscillate. Imagine the output is high. C1 is charged up via R1. When the voltage on C1 reaches +1.7 V, the output falls to +0.2 V. C1 is now discharged via R1 in parellel with R2 (D1 is now forward biased) until the voltage on C1 reaches +0.9 V. Then the output jumps to a high state and the process repeats itself. The second Schmitt trigger merely inverts the squarewave output. The frequency of operation is given by the formula:

$$F_{osc} = \frac{2 \times 10^{-3}}{C1}$$

where F_{osc} is in Hz and C1 is in Farads.

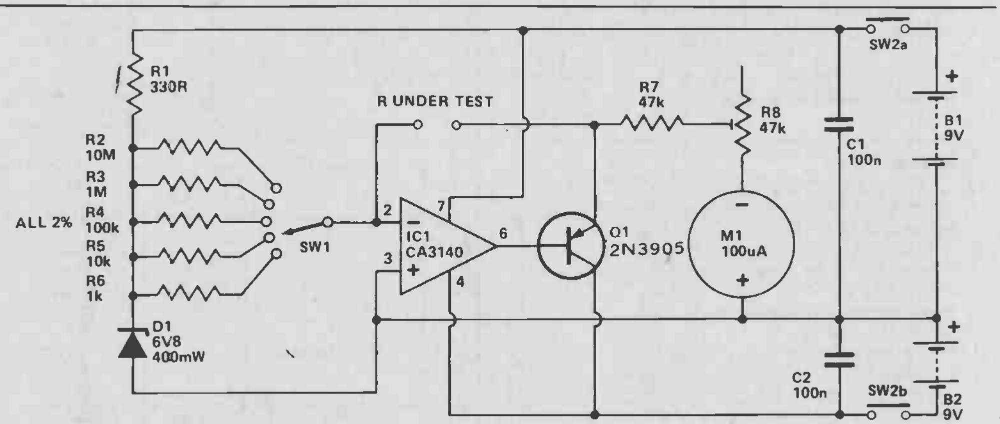
therefore for:
10 MHz, C1 = 220 pF (polystyrene or ceramic)
1 MHz, C1 = 2200 pF (polystyrene)
100 KHz, C1 = 22 nF (polyester)
10 KHz, C1 = 220 nF (polyester or electrolytic)
1 KHz, C1 = 2.2 uF (electrolytic)
100 Hz, C1 = 22 uF (electrolytic)
20 Hz, C1 = 100 uF (electrolytic)





WAVEFORM DEGRADATION WITH FREQUENCY

LINEAR SCALE RESISTANCE METER



Although even the most simple of multimeters have resistance ranges, many instruments only have a few ranges, and these have a reverse reading, non-linear scale. This often results in poor accuracy and inconvenience in use. This simple circuit has five measuring ranges from 1k to 10 Megohms FSD (full scale deflection) with a forward reading linear scale on all ranges.

The unit consists basically of an operational amplifier used in the inverting amplifier mode. Transistor Q1 is used as an emitter follower output buffer stage, and on the 1k range the output sink current capability of the amplifier would be inadequate without the inclusion of this stage. R1 and D1 provide a stable reference voltage of 6.8 V (nominal) which is fed to the input of the amplifier. The gain of the amplifier is determined by two resistors, one of which connects the input signal and the inverting (—) input of the op amp. This resistor is one of R2 to R6, depending upon the setting of SW1. The other resistor connects between the amplifier output and the inverting input, and in this case is the resistor under test.

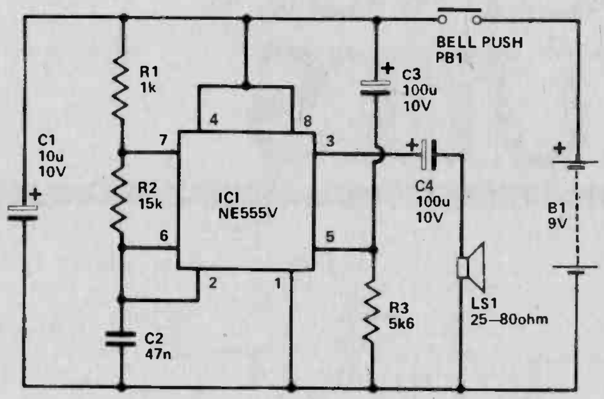
The voltage gain of the circuit is equal to the value of the input resistor divided by the value of the test resistor. Thus, with SW1 switched to the 10k range for example, a 10k test resistor would give a voltage gain on one, and the output would swing 6.8V negative. This would give FSD of the simple voltmeter circuit comprised of R7, R8 and M1, which is connected across the output and has a FSD sensitivity equal to the reference voltage. If the test resistor had a value of 5k, then the circuit would have a voltage gain of only 0.5, and only half FSD of M1 would result. A resistor of 1k in value would give a gain of 0.1 and a deflection of only 10% of FSD. As will be apparent from this, there is a linear relationship between the test resistor value and the meter reading, and the FSD value is equal to that of the resistor selected by SW1.

SW2 is the on/off switch and should be a non-locking push-button switch, or some other type biased to the off position. This is only operated when the resistor has been connected to the test clips as the meter will be deflected beyond FSD if power is applied to the circuit with no test resistor connected (or one of greater value than the FSD value of the range). The meter will not be damaged if this is accidentally done since a maximum meter overload of only about 30% or so can occur.

In order to calibrate the unit, connect a close tolerance resistor of the same value as that selected by SW1 across the test clips and adjust R8 for precisely FSD of M1.

555 I.C. PROJECTS

THE 555 IC is one of the most useful devices to the electronics hobbyist, and three examples of its use in the astable (oscillator) mode are given here.



Electronic Doorbuzzer.

This design provides a novel doorbuzzer signal which starts at a low pitch and gradually rises in frequency.

The normal method of oscillation for the 555 is for the timing capacitor (C2) to charge up two thirds of V+ via two timing resistors (R1 and R2). The IC is then triggered and C2 is discharged through R2 and an internal transistor of the 555. The IC resets when the charge voltage drops to one third of V+, with the discharge transistor switching off and C2 commencing to charge up to the trigger potential once again.

This particular circuit does not oscillate in precisely this basic way, since the network comprised of R3 and C3 is used to shunt the potential divider (within the IC) which sets the trigger voltage. When SW1 is initially closed, C3 will be discharged and the trigger voltage will be raised. This increases the charge and discharge times of C2, and reduces the frequency of operation. C3 is quickly charted through R3 though and after about one or two seconds the trigger voltage will have fallen to a level set by R3 and the integral potential divider. R3 pulls the trigger voltage below its normal level, reducing the charge and discharge times of C2 and causing an increase in the operating frequency. Thus, as C3 charges up, the output frequency is swept upwards, producing a novel and effective signal.

The main output at pin 3 of the 555 goes high during the charge period, and low during the discharge period, producing a rectangular waveform of low enough impedance to drive a speaker with up to a few hundred milliwatts of signal.

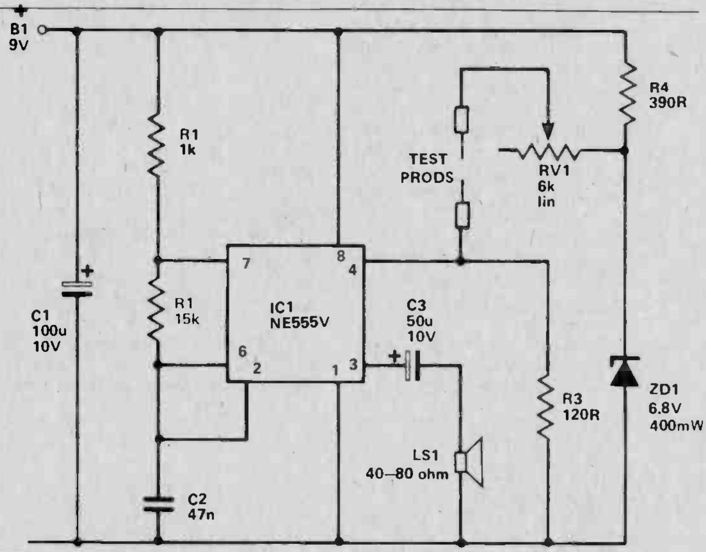
Continuity Tester.

A common failing of simple continuity tester circuits is that they will give an indication of continuity between the test prods when there may actually be a resistance of a few hundred ohms or more. This is often of no importance, but it can sometimes give misleading results. This simple design can be adjusted so that it will not respond to resistances of more than a few ohms.

The circuit is basically just a standard 555 astable operating at a frequency of about 800 Hz and feeding a high impedance speaker. However, reset terminal pin 4 is tied to the negative supply rail by R3, and this blocks the astable action. Pin 4 must be taken positive by about 0.5V. or more in order to produce an audio output.

RV1 is adjusted so that with the rest prods shorted together there is only just sufficient voltage at pin 4 to enable oscillation to take place. Therefore, with genuine continuity between the test prods the unit will produce an audio output, but with a resistance of more than about 7 or 8 ohms in circuit, the voltage at pin 4 will be inadequate due to the voltage drop across this resistance. RV1 is fed from a stabilised supply provided by R4 and D1 so that minor variations in the supply voltage do not necessitate readjustment of RV1. Occasional readjustment of RV1 may still be needed if this is very critically adjusted for optimum discrimination.

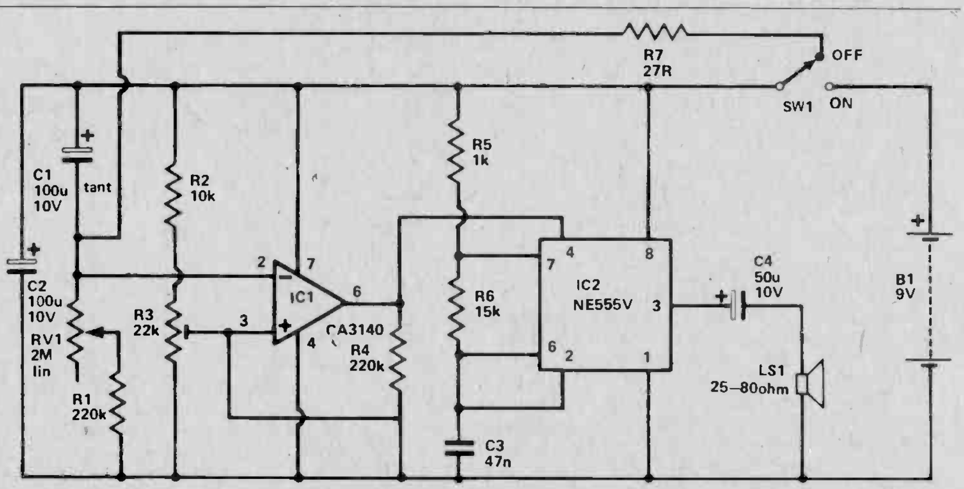
Note that the circuit will consume power when the test probes are not connected together (about 6 mA.), and so on/off switch SW1 is required.



Simple Timer.

This general purpose timer gives an audible alarm so predetermined time after the unit is switched on. With the specified values the time is variable from about 30 seconds to 5 minutes, but this can be altered to suit individual requirements.

When the unit is switched on using SW1, C1 begins to change via R1 and RV1. Initially the voltage at the inverting (-) input of IC1 will be higher than that appearing at the non-inverting (+) input, and so IC1 output will assume a very low voltage. As C1 charges up, the voltage fed to the inverting input gradually falls until it starts to go below the voltage at the non-inverting input. IC1 output then begins to rise in voltage and due to coupling through R4 this increases the voltage at the non-inverting input. This causes a further increase in output voltage, and a regenerative action takes place which causes IC1 output to rapidly swing to almost the full positive supply potential.



The 555 is used to generate the alarm signal using a circujt which is basically the same as the continuity tester circuit described above. However, the reset terminal is, of course, controlled by the output of IC1 rather than by the test prods and potential divider circuit.

The charge rate of C1 and thus the length of the timing interval can be altered by changing the resistance of RV1. The time delay is approx. 1.4 CR (with C in uF, R in Meg., and the time in seconds), but due to the high tolerances of the timing components it is impossible to obtain highly predictable results. R3 has therefore been included so that the trigger voltage of the circuit can be varied, and by trial and error R3 can be adjusted to give the appropriate timing range.

When the unit is switched off, SW1 discharges C1 through current limiting resistor R7 so that the unit is ready to start a new timing run almost immediately.

SOUND TRIGGERED FLASH

The introduction of inexpensive electronic flash guns has made possible a number of effects in photography. The duration of an electronically produced flash is of course very brief, normally about 1/500th of a second. If the camera shutter is left open in the dark or subdued light and the flash is made, it is the timing and duration of the flash which controls what is imprinted on the film rather than anything done by the camera.

Electronic flash guns are "fired" by making a switch and it can be seen that an electronic switch can do this job. If in turn this switch is activated by sound then some very interesting effects can be obtained. A champagne cork leaving the bottle is one idea but the various gimmicks are limited only by the imagination.

The circuit shown is completely solid state and instead of a relay being used, a SCR is employed. This is cheaper and for this function just as good.

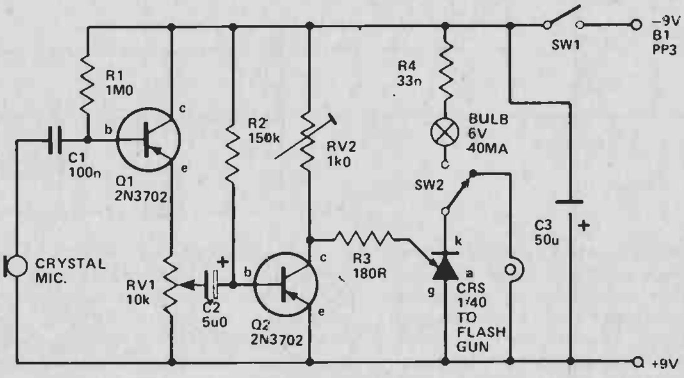
The first stage of the circuit is an impedance convertor. A crystal mike is used. Normally these have rather poor quality but in this circuit we are not too interested in quality, we are only using it as a device for converting sound into an electrical pulse. Q1 is connected as a common collector stage; this has very high input impedance to correctly match the high impedance of the crystal microphone. The potentiometer RV1 is the emitter resistor and the sounds produced appear across this at a workable impedance. The output from this is fed to the conventional common emitter amplifier, Q2 with RV2, a preset pot, as the collector load. The collector of this transistor is connected to the gate of the SCR via a resistor R3. For setting up the SCR is connected to a bulb, these two being across the battery supply.

When a sound is produced it is amplified by Q1 and Q2 and this causes Q2 to draw rather more current at the peak of the sound. This reduces the voltage at the collector of the transistor and this is fed to the gate of the SCR. At the correct setting of RV1 this will cause the SCR to switch on and light will pass through the bulb. The bulb can be a 9 V type but as these are hard to come by it can just as well be a 6 V type with a 33 ohm resistor in series.

The bulb is used for setting up only. To continually trigger the flash gun in order to find the correct settings will be wasteful, especially as the flash tube has a limited life. Once the correct settings have been found, SW2 can be made and the SCR applied across the flash gun terminals. There are two variables in the circuit, RV1 and RV2. RV2 will normally only require setting once.

With the slider of RV1 at about a quarter the way up the track from the positive line, RV2 should be set so that the SCR just triggers on the loudest sound that can be made near the microphone. When this is done RV1 should give control over a wide range of sounds and acts as the sensitivity control.

The circuit should be tested to obtain the correct level setting of RV1 before every shot is taken with the test bulb in series. Once the correct settings are obtained the switch can be made to the flash gun having first made sure that the SCR is not on at that point. The SCR will stay switched on until the supply voltage is removed and so it is necessary to switch off the circuit using SW1 before switching over.



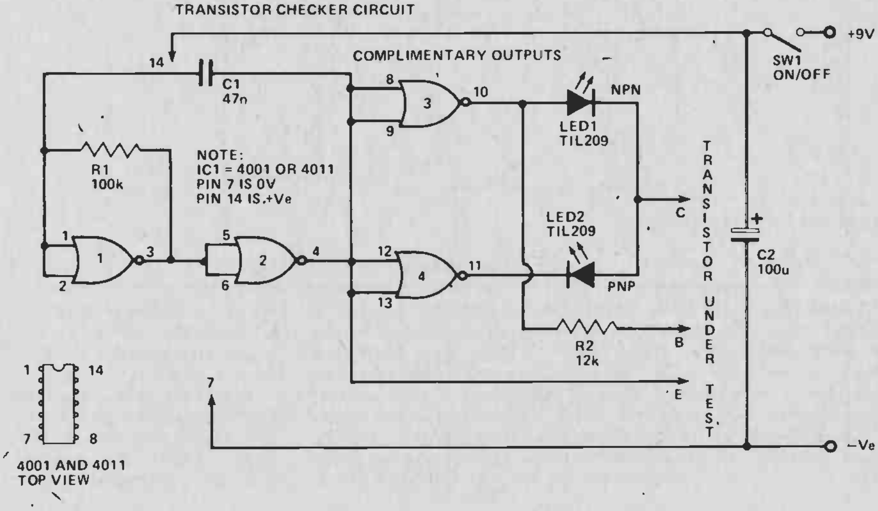
QUICK TRANSISTOR CHECKER

This very simple and inexpensive circuit is not designed to measure any transistor performance figures, but is intended for quick testing to show whether or not the test device is functional. The basic method of testing a transistor is to first connect a supply to its emitter and collector terminals and check that no significant current flows. If the base terminal is then given a small forward bias, this will be amplified in the form of a large collector-emitter current.

This circuit is based on a CMOS quad 2 input NAND or NOR gate IC. Either type is suitable as each gate has its two inputs connected together so that it acts as an inverter. The first two inverters are used in conjunction with R1 and C1 as a conventional CMOS oscillator operating at a frequency of a few hundred Hz. The other two inverters are connected in parallel, and fed from the output of the oscillator so that they provide a complementary output. In other words, one output will be positive and the other will be negative except during the brief periods when the outputs change state.

The collector and emitter of the transistor are fed from the outputs via D1 and D2, and the base is fed from one output via R2. If we assume that an NPN device is being tested, when gate 2 output is positive and the other output is negative, the transistor will not be forward biased by R2 (it will be reverse biased in fact) and it should pass no significant collector current. If it is a short circuit device and does pass such a current, this will pass through D2 which will light up and indicate the fault. When the outputs are in the opposite states, the transistor will be forward biased by R2 and should conduct heavily, causing D1 to pass a current and light up. Failure of D1 to come on indicates an open circuit or very low gain device. PNP devices operate with the opposite polarity, and so when testing one of these it is D2 that should switch on, and D1 which should remain off.

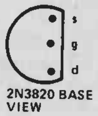
TRANSISTOR CHECKER CIRCUIT

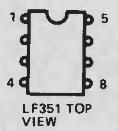


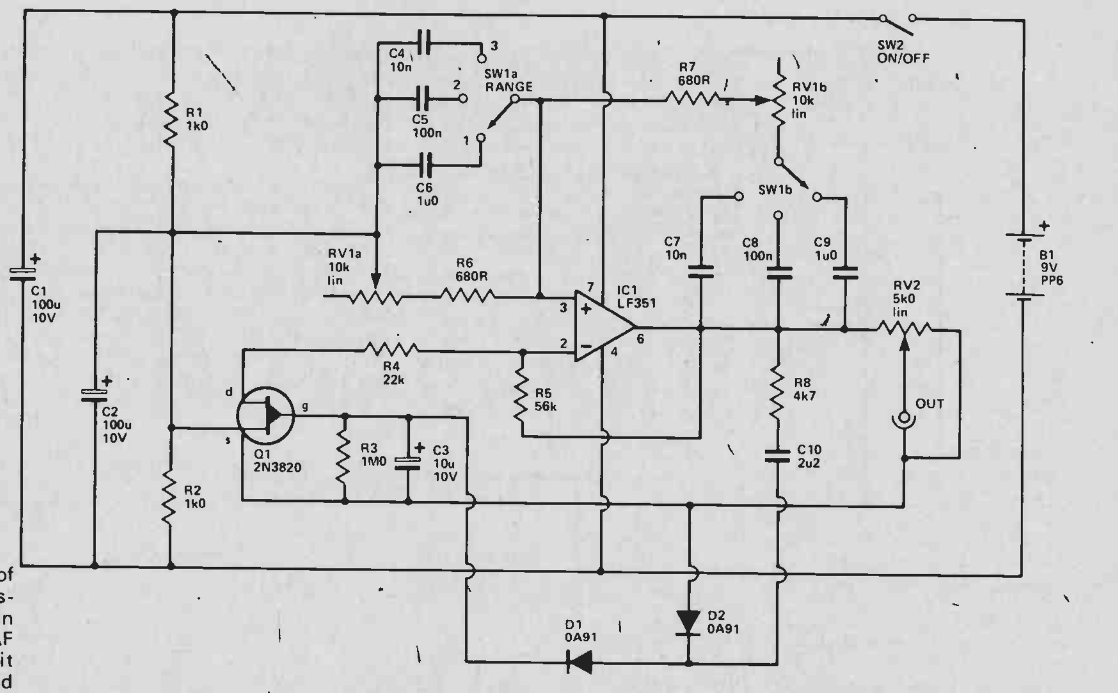
Summary

One LED on = functional device, type (ie PNP/NPN) as indicated.
Both LEDs on = short circuited device.
No LEDs on = open circuit or very low gain device.
Diode or rectifier testing (anode to collector, cathode to emitter).
D1 on = functional device.
D2 on = connected with wrong polarity.
Both LEDs on = short circuited device.
No LEDs on = open circuit device.

A.F. SIGNAL GENERATOR







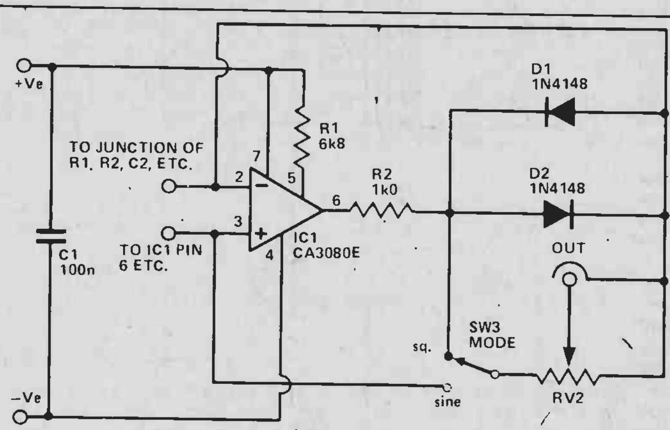
One of the most useful items of test equipment to have, especially if one has an interest in any type of audio gear, is an AF signal generator. The circuit shown here provides a good quality sinewave output over three continuously variable ranges (Range 1, below 20Hz to above 200Hz; Range 2, below 200Hz to over 2kHz; and Range 3, below 2kHz to over 20kHz) covering more than the entire audio frequency spectrum.

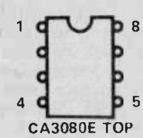
The circuit uses the usual Wien Bridge type circuit, and this form of oscillator consists of an amplifier having frequency selective positive feedback provided via a C-R network. The capacitive elements of this network are whichever two capacitors are selected by SW1, the three sets of capacitors giving the unit its three ranges. The resistive elements are R6, R7 and RV1, the latter permitting the unit to be tuned over the ranges quoted above. This network provides positive feedback over operational amplifier IC1, which is a FET type giving low noise and distortion levels. VR1a and R6 also bias the non-inverting input of IC1 to a central tapping on the supply produced by R1, R2 and C2.

The closed loop gain of IC1 must be maintained at precisely the correct level if good results are to be attained. Insufficient gain would lead to less than full compensation for the losses through the C-R Wien network, with insufficient feedback and consequent violent oscillation with the output signal becoming clipped and seriously distorted. An automatic gain control (AGC) circuit is used to maintain stable operating conditions and a constant output level. R5, R4 and the drain to source resistance of Q1 form a negative feedback network which controls the closed loop gain of IC1. Initially Q1 is forward biased by R3 so that there is enough gain to give strong oscillation. Some of the output from IC1 is coupled by R8 and C10 to a rectifier and smoothing network comprised of D1, D2 and C3. These produce a positive bias which tends to cut off Q1, producing reduced circuit gain. The stronger the circuit oscillates, the larger the bias, and the lower the gain becomes. Lack of oscillation produces reduced bias, more gain, and stronger oscillation. The required stabilising action is thus obtained.

Variable attenuator VR2 enables the output to be adjusted from zero up to about 1.5V RMS. The current consumption of the circuit is about 7 mA.

SINE TO SQUARE CONVERTER



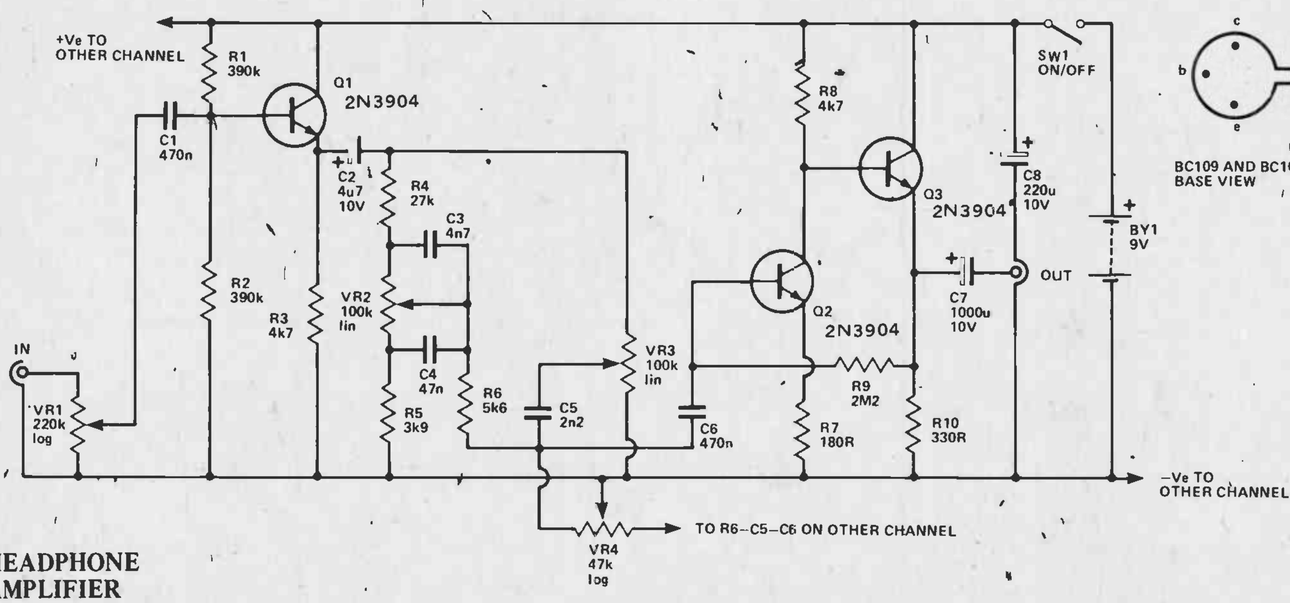


This circuit provides an optional squarewave of about 1.2 volts peak to peak when used with the signal generator circuit described above. The above circuit requires no modification, other than the omission of output attenuator potentiometer RV2 which is included in this section of the unit instead.

The squaring circuit is based on operational transconductance amplifier IC1. This device is in some ways similar to an ordinary operational amplifier, but it is the output current rather than the output voltage that is a function of the input voltages. The inverting input of the device is biased to the central tapping on the supply lines, and the non-inverting input is fed with the sinewave output from the main signal generator circuit. When fed with positive going half cycles, the non-inverting input is taken to a higher voltage than the inverting one, resulting in a forward bias being applied to D2 by way of current limiting resistor R2. This produces a positive potential of about 0.6 volts across D2. When the circuit is fed with negative going half cycles the non-inverting input is taken to a lower potential than the investing one, causing a forward bias to be applied to D1, and producing a negative output potential of about 0.6 volts.

Thus the output is switched from one polarity to the other as the input signal changes polarity, producing the desired squarewave signal. The CA3080E device has a high slew rate (50 V/uS) and is therefore capable of producing a high quality squarewave signal even at the higher frequencies covered by the unit. The gain of the CA3080E can be varied by altering the bias fed to its pin 5, but this feature is of no use in this application and R1 provides a strong bias to the device so that it operates at high gain. SW3 is the mode switch, and merely connects RV2 and the output socket to the output of the sinewave generator or squaring circuit, as required.

The squaring circuitry only adds about 3 mA or so to the current consumption of the unit.



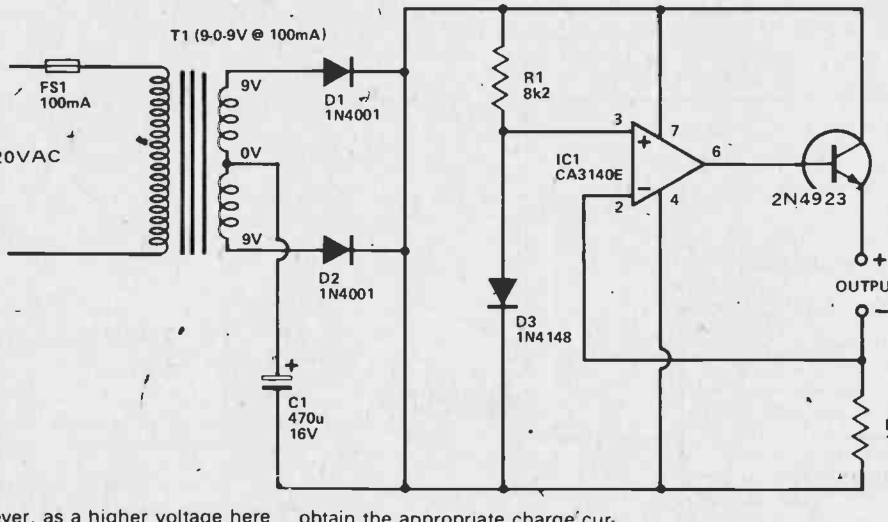
HEADPHONE AMPLIFIER

This simple stereo amplifier will drive a pair of stereo headphones, and can take its input from either a tuner or cassette deck. It has the advantage over a normal stereo amplifier of being small, completely self contained, and therefore very portable. Of course, many tuners and cassette decks have a headphone output, but this often lacks sufficient drive, and there are usually no tone controls (or volume and balance controls in some cases). This circuit gives the usual tone, balance, and volume control facilities, and also has plenty of drive. Ideally the unit should be used with phones having an impedance of a few hundred ohms each, and most good quality types fall into this category. It also seems to work perfectly well with inexpensive 8 ohm types.

The circuit shown here is for one channel, all the components being duplicated in the other channel except for S1, BY1, and RV4, which are obviously common to both channels. The two RV1s are a dual gang component, as are the two RV2s and the two RV3s.

The input signal is applied to volume control VR1, and from here it is coupled to a buffer stage based on Q1. This gives the unit a reasonably high input impedance of at least 100k. Its output feeds a conventional passive tone control circuit that can give bass lift or cut using RV2, and treble lift or cut using RV3. RV4 is used in the standard balance control arrangement. The output from the tone controls is coupled by C6 to a two stage direct coupled amplifier. This uses Q2 in the common emitter mode to give sufficient voltage gain for an output level of up to about 2 V RMS from most sources. Q3 is an emitter follower buffer stage which matches the output from Q2 to the relatively low impedance of the headphones.

The unit has a total current consumption for both channels of about 30mA.

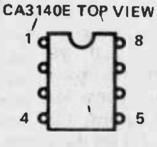


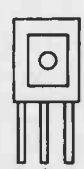
NICAD CHARGER

This charger is intended for use with the popular AA size NiCad batteries. A special charger is needed for NiCad calls because they have a very low internal resistance, leading to an excessive charging current even if the applied voltage is only marginally high. The charger must therefore incorporate a circuit to limit the charge current to the appropriate level.

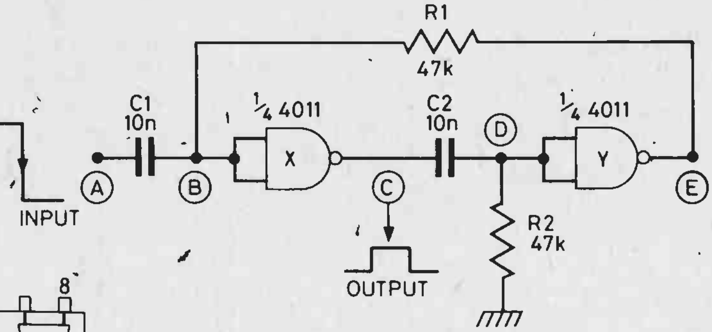
In this circuit, T1, D1, D2, and C1 form a conventional stepdown, isolation, fullwave rectifier, and smoothing circuit. The other components provide the current regulation. IC1 is used as a comparator with discrete buffer stage Q1 giving a suitably high output current capability for this application. IC1's non-inverting input is fed with a 0.65 V: reference potential provided by R1 and D3. The inverting input is taken to ground by R2 under quiescent conditions, causing the output to go fully positive. With a NiCad cell connected across the output a high current will attempt to flow, causing the voltage across R2 to increase. It can only rise to 0.6V, however, as a higher voltage here reverses the comparative input levels to IC1, resulting in the output going lower in voltage, and reducing the voltage across R2 back 0.65 V. The maximum output current (and the charge current obtained) is therefore the current produced with 0.65 V. across 10 ohms, or 65 mA. in other words.

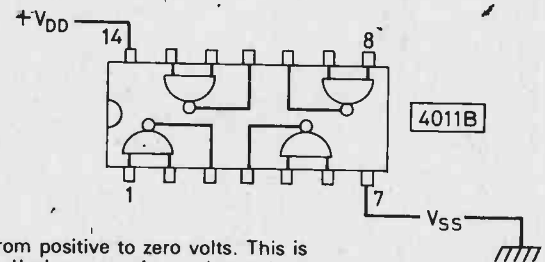
Some AA NiCad cells have a maximum recommended charge current of only about 45 or 50 mA, and for these types R2 should be increased to 13 ohms in order to obtain the appropriate charge current. Some rapid charge types will take 150 mA, and this necessitates reducing R2 to 4.3 ohms (3.3 ohms plus 1 ohm in series if a suitable component cannot be obtained). Also, T1 should be changed to a type having a current rating of 250 mA., and Q1 should be fitted with a small bolt-on finned heatsink. The unit can charge up to four cells (six if T1 is made a 12 V type), and these must be connected in series across the output, not in parallel.

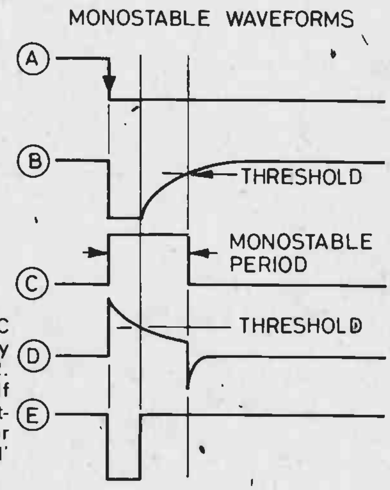




CMOS MONOSTABLE







A monostable is an electronic circuit that generates an output pulse of defined duration, when triggered by an input signal transition. The monostable action can be used for many different functions, for example: When a cheap push button is used to trigger digital circuitry, spurious pulses often find their way into the circuitry. This is due to the contracts inside the button bouncing, when it is pressed and released — digital circuitry will regard all of the bounces as valid input signals, and act accordingly — this can be disasterous in counting applications. A monostable can be used to 'debounce' the push button. By setting the output pulse duration for a period longer than the longest exprected bounce time, all the bounces will gave no effect on the main circuitry. So with a simple monostable between each push button and the input circuitry, the digital devices are protected from the horrors of untamed push buttons. There are hundreds of other uses for the monostable, this circuit is one of the cheapest way of constructing them.

Only two inverters are needed for a monostable circuit. Here, we have used a 4011B quad NAND package, as they are even cheaper than a CMOS inverter package and work just as well.

The monostable period is initiated by the transition of point A from positive to zero volts. This is called a negative-going edge. Transition of point A in the opposite direction (a positive-going edge) will have no effect.

A negative edge at A causes point B to go to zero volts momentarily. This will then drive point E to zero and this will hold point B at zero volts, even when the pulse at A is finished. The circuit will stay in this state while C2 charges. When C2 is fully charged, there will no longer be a current through R2 and point D will fall to zero again. E will go positive and so will B, after a time determined by the values of C1 and R1. Point C will fall to zero and C2 is fully charged, there will no longer be a current through R2 and point D will fall to zero again. E will go positive and so will B, after a time determined by the values of C1 and R1. Point C will fall to zero and C2 will be discharged, ready for the next pulse from A.

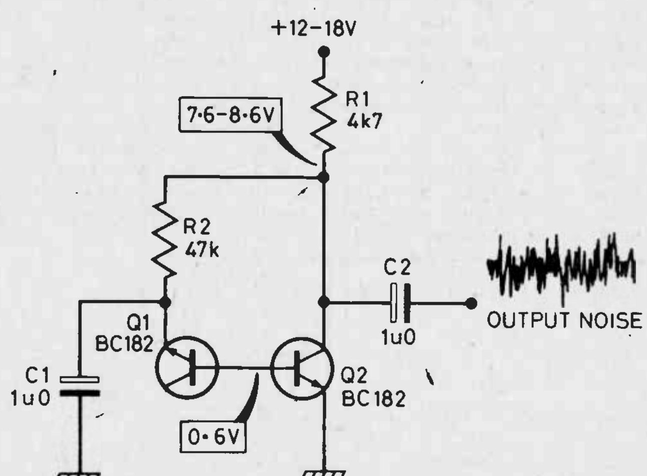
A length of time for which C remains positive is determined by the values of C1, R1, C2 and R2. This is called the 'time constant'. If either the resistance or the capacitance is increased, the time for which the monostable is 'triggered' will increase.

The equations for calculating the monostable period are given on the circuit diagram Polarised capacitors should not be used, and the resistance value of R should be kept within the range 10k to 10M.

If R1 = R2 and C1 = C2 then typical values are 10mS 100k, 68p; 10mS 1MO, 6nB.

MONOSTABLE PERIOD τ
$\tau = 0.69(R1 \times C1 + R2 \times C2)$
IF R1 = R2 AND C1 = C2 THEN
$\tau = 1.38(R1 \times C1)$

IF R = 47k, C = 10n THEN τ = 0.7 mS.



TWO–TRANSISTOR NOISE SOURCE

This simple circuit produces electrical noise. This may not seem like a sensible thing to want to produce, but in fact it is very useful. Of course, the sort of noise we mean is not the type neighbours complain about. This circuit produces an a steam train — or for testing electrical signal which, when suitably amplified, sounds like a hiss of escaping gas. This can be used for sound effect production — with a little additional processing, it can form the basis of sound effects ranging from surf hitting a beach to loudspeakers by feeding the amplified noise into them and listening to the output.

The operation of the circuit depends on the reverse-bias breakdown of Q1. This occurs when the voltage across the emitter and base of the transistor reaches 7 to B volts. At this voltage the semiconductor physics of the transistor cause it to do a very useful thing — produce noise. The rest of the circuit is dedicated to keeping the current throug h Q1 to just the right level (too little — no noise; too much — dead transistor!) and also to amplifying the result.

Power is supplied to the circuit through R1. This, along with C2 and Q2 form an amplifier which boosts the level of the noise. The bias for Q2 comes through Q1. If Q1 passes a lot of current, Q2 will turn on more and the voltage at the bottom of R1 will drop. This will cause the voltage accross Q1 to drop and the current through it will decrease. In this way the current it passes is kept to a reasonable level. C1 provides a path to ground for the noise which appears on the collector of Q2. This ensures that the fast changes in the amount of current through Q1 (and this is, after all, what we are after) are not 'adjusted' in the same way and lost.

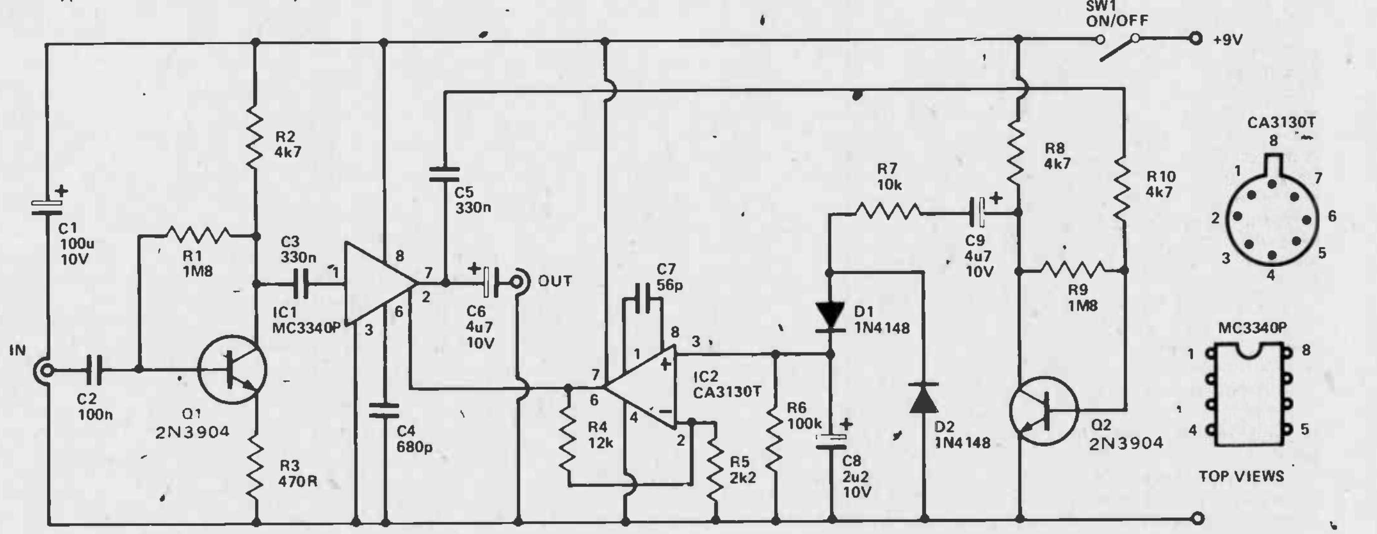
SUSTAIN UNIT

Normally each note from a guitar has a high initial volume that rapidly decays to a much lower level, and the gradually fades out. A sustain unit provides a relatively constant output level when used with an electric guitar, despite the wide range of input levels. The most simple form of sustain unit is a clipping amplifier, but these inevitably introduce quite large amounts of distortion. A better method, and the one used in this unit, is to use a compression circuit having fast attack and decay times. This type of circuit is basically a voltage controlled amplifier, the gain of the circuit being controlled by an output level sensing circuit which varies the gain to produce a fairly consistent output level. Little distortion is produced using this method.

Q1 is used as a low noise preamplifier having a voltage gain of about 20dB. Its output is fed by C3 to the input of IC1, the voltage controlled amplifier device. This has a quiescent voltage gain of about 13dB, but this can be reduced to an attenuation of over 70 dB by taking pin 2 of the device several volts positive. C6 couples some of the output from IC1 to the output socket, and C5 couples the remaining output to a common emitter amplifier based on Q2. The amplified signal at Q2 collector couples via C9 and R7 to a conventional smoothing and rectifier network. The positive bias produced by this network is fed to the control input of IC1 via a low gain amplifier and buffer stage based on IC2.

With low input levels (below about 1mV) the control signal is too small to affect the gain of IC1. Higher level signals produce a proportionately larger control voltage and lower gain through IC1, preventing the output level from rising much above about 30mV RMS, and giving the required virtually constant output level. The attack and decay times of the circuit are both quite short so that the unit responds suitably rapidly to changes in input level, but neither of these time constants are so short as to cause serious distortion.

The unit will be most effective with the volume control on the guitar set at maximum, unless the output should then be so high as to overload the unit and cause distortion.

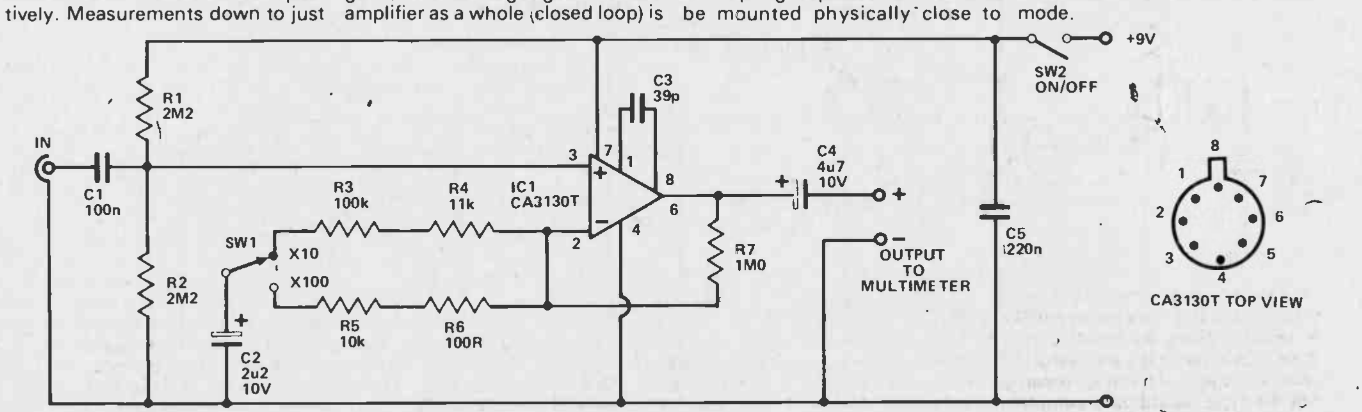


AC METER BOOSTER

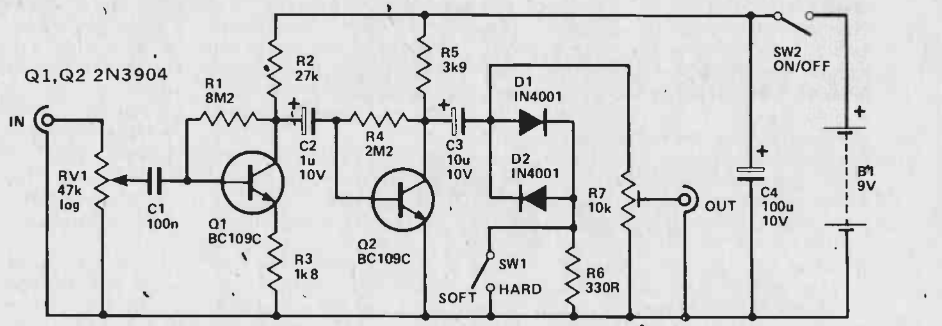
Measuring small audio frequency signals is often impossible using an ordinary multimeter because most of these have a lowest AC range of about 1 to 5 V FSD. A simple and inexpensive solution to the problem is to add an amplifier, such as the one shown here, ahead of the multimeter. The amplifier has a switched voltage gain of 10 or 100, and would therefore boost the sensitivity of (say) a multimeter switched to the 2.5 V AC range to 250 mV and 25 mV FSD respectively. Measurements down to just a few mV RMS can then be made with reasonable accuracy.

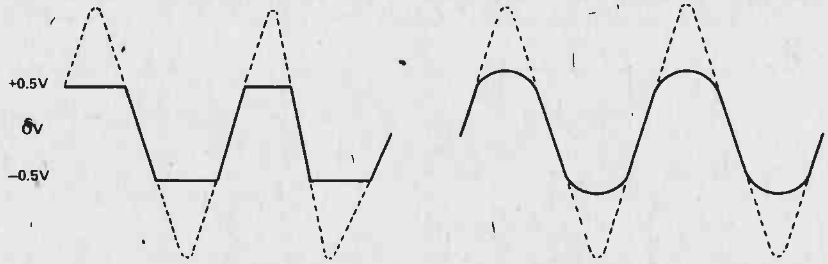
The circuit uses a CA3130T operational amplifier in the non-inverting mode. The non-inverting input is biased to about half the supply voltage by R1 and R2, and the input signal is coupled to this point by C1. The input impedance of the circuit is set at over 1M by R1 and R2, so that the unit places little loading on the circuit under test. R7 biases the inverting input and gives a quiescent output voltage of about half the supply potential. Although IC1 has an extremely high (open loop) voltage gain, the voltage gain of the amplifier as a whole (closed loop) is much lower, and is set by the ratio of two resistances. With SW1 in the 'X 10' position the two resistances are R7, and R3 plus R4. The voltage gain is equal to the sum of the two resistances divided by the shunt resistance (R3 + R4) in this negative-feedback network. This gives almost exactly the required figure of 10 with the specified values. With SW1 in the 'X 100' position the lower shunt resistance of R5 and R6 is switched into circuit, boosting the voltage gain to almost exactly 100.

DC blocking at the output is provided by C4. C5 is a supply decoupling capacitor and should be mounted physically close to IC1. C3 is the compensation capacitor for IC1, and prevents the device from becoming unstable. Note that a carefully designed layout having the input and output well isolated from one another is required, or the circuit as a whole may become unstable. Screened input and output cables should be used to drive the primary winding maximum output of about 3 V RMS. It should therefore be used with the multimeter set to a range of 3 V or less, or if a higher range must be used, the part of the scale above 3 V is ignored. The amplifier has a flat response up to about 30kHz in the 'X 100' mode, and up to about 300kHz in the 'X 10' mode.



R3, R4, R5 AND R7 ARE 2% OR BETTER





CLIPPING AMPLIFIER

Probably the main use for clipping amplifiers these days is in musical effects units to produce the so called "fuzz" effect. This circuit uses two common emitter amplifiers based on Q1 and Q2 to drive a simple clipping circuit using D1 and D2. RV1 is the input attenuator and if this is adjusted for an output level of less than about 1 volt peak to peak at Q2 collector, neither D1 or D2 will be sufficiently forward biased to conduct significantly. These components then have no real effect on the circuit, which in consequence operates as an ordinary amplifier. Assuming SW1 is closed, if RV1 is adjusted for a signal level of more than 1 volt peak to peak at Q2 collector, during positive output excursions when the signal amplitude is greater than 0.5 V D1 will conduct and act like a low voltage zener, preventing the signal from exceeding 0.5 V in amplitude. Similarly, on negative output excursions D2 will limit the signal level to no more than −0.5 V. This causes the signal to be severely disctorted by the clipping action as shown in (a) the distortion products giving the desired "fuzz" effect.

A circuit of this type can be used to produce a form of sustain effect when employed with a guitar. Here RV1 is adjusted so that clipping occurs even when the signal from the guitar has decayed considerably. This results in the output signal remaining at a virtually constant 1 volt peak to peak level for the duration of each note, whereas a guitar signal normally hits a high initial peak and then rapidly decays. In this application the hard clipping produced by the unit will produce the fuzz distortion products whether they are required or not. This problem can be alleviated to some degree by switching SW1 to the "soft" position. R6 is then connected in series with D1 and D2, and this gives the smoother clipping action shown in (b) due to the voltage developed across R6 when D1 and D2 pass a current. This greatly reduces the high frequency distortion products which are the most noticeable and objectionable ones.

The circuit has an input impedance of about 47k and needs an input of less than 1 mV RMS to produce clipping. If the full 1 volt peak to peak output is not required, R7 can be used to attenuate the signal to the required level.

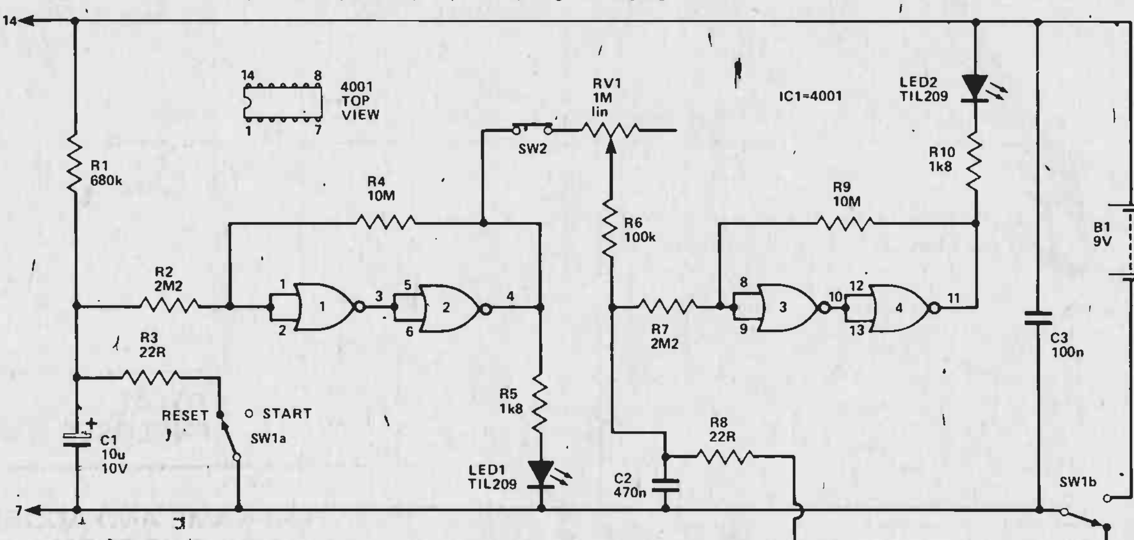
REACTION GAME

This is a simple reaction testing game for one player. The idea of the game is to end up with both LED indicators switched on, and initially only one lamp will come on, followed by the second one shortly afterwards. When this happens a switch must be operated as quickly as possible, and the first LED will switch off if the attempt is too slow.

The circuit uses the four 2 input NOR gates of a 4001 CMOS device, the gates being connected as simple inverters in this application. Gates 1 and 2 are connected to form a Schmitt trigger type circuit, and at switch on C1 will be discharged causing gate 1 input and gate 2 output to be low. After about seven seconds C1 will have charged through R1 to the transition voltage of gate 1, with the coupling between the two gates resulting in gate 2 output swinging positive quite rapidly. Coupling through R4 causes gate 1 input to be taken further positive, and a regnerative action occurs which results in gate 2 output jumping to the high state and switching on D1. This indicates that the player should operate the push button switch SW2.

Until this switch is opened, another trigger/timer circuit will be fed from gate 2 output. D2 is normally on but will be switched off at the end of the second timing period if SW2 is not used to halt the charging of C2 in time. The second delay can be adjusted using RV1, from more than 500mS at maximum resistance to only about 50mS at minimum resistance. This gives a difficulty factor varying from "easy" to "impossible" for anyone with normal reactions.

The circuit is reset using SW1 which disconnects power from the circuit, discharges C2 through current limit resistor R8, and similarly discharges C1 through R3. The unit is then ready to start operation again when SW1 is set back to the "start" position.



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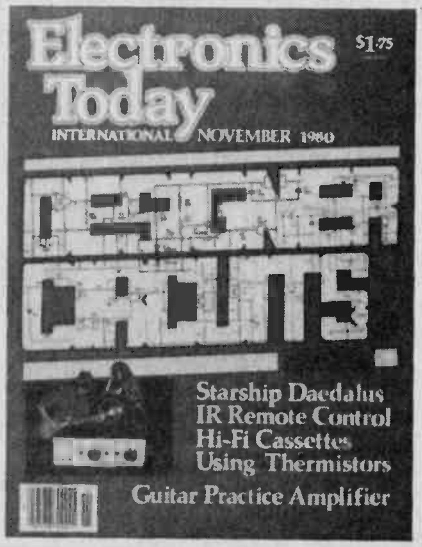

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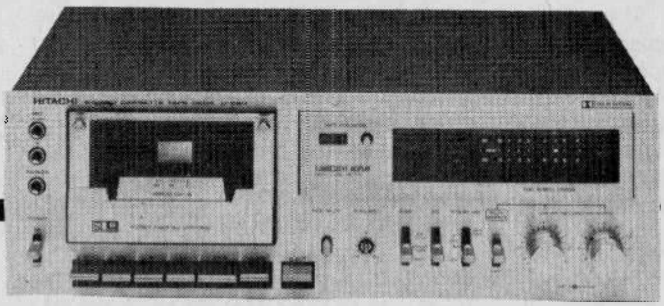
CASSETTE DECKS & TAPE

Gordon King takes a look into the world of the Compact Cassette, the system, now a true entry into the Hi-Fi field, that has developed into a sophisticated audio medium in its own right.



Above the Hitachi D560 cassette deck This piece of Hi-Fi includes a fine bias control and fluorescent display.

ONE AREA OF domestic-based electronics which has attained remarkably high optimization is that associated with the compact cassette medium. Current issue cassette decks partnered with the latest tapes are capable of a frequency response approaching 20 kHz and a net quality of reproduction which is not far short of a prestige record deck or FM tuner. The advantage of the cassette deck over such other programme signal sources is the ease at which programmes can be recorded from radio, disc and other sources in stereo at a cost of around 8¢ per minute.

This tight packing of information is achieved by the use of two pairs of stereo tracks, each a mere 0.6 mm wide, and a tape/head velocity of 4.75 cm/s. One stereo track pair is recorded along one half of the tape width and the other pair along the other half, the cassette as a whole usually being turned over to change from one pair to the other.

These constraints have over the years, since the introduction of the compact cassette medium by Philips way back in the sixties encouraged a good deal of lateral thought by the designers, and it is to their utmost credit that today we are able to enjoy the hi-fi quality that the best machines offer. When the compact cassette was first launched the results were well below hi-fi standards: frequency response was little higher than about 8 kHz, wow and flutter were bad and signal-to-noise ratio and hence dynamic range were abysmal. It was not until the advent of the Dolby B noise reduction system (NRS) that the cassette deck started to take off in 'hi-fi' terms. Designed by Dr Ray Dolby, who also had much to do with early video recording, the system produces an integrated noise reduction of almost 10 dB, thereby putting 10 dB on the effective dynamic range. Other noise reduction systems have since been evolved, but that the Dolby system is a viable one is witnessed by the fact that pretty well every hi-fi deck today is equipped with the system!

The Dolby B NRS sparked off renewed design effort: record/replay heads were vastly improved to define the short wavelengths of the signals recorded on the tape, tapes themselves were improved, and are improving still, and the last traces of subjective W & F (Wow and Flutter) were eliminated from the tape transport mechanisms. On top of all this, the electronic circuits and metering arrangements have been remarkably enhanced, and today we are even seeing the introduction of the microprocessor for machine control.

Recording/Replay Processes

The tape is recorded merely by passing through the winding of the recording head a current corresponding to the amplified input signal. The head pole pieces are styled to form a narrow gap across which the changing magnetic field develops, and it is over this gap that the tape is caused to pass. The oxide layer is thus magnetised to the pattern of the audio signal.

For replay the tape is rewound and again caused to pass over the head pole pieces at the same speed as it was recorded. This time the magnetic lines of force linking the pole pieces induce an electromotive force into the winding which is a close replica of the original signal used to make the recording. This signal is amplified and eventually fed as current to the loudspeaker for reproduction.

The Need for Bias

Although basically straightforward, a number of problems need to be resolved to secure a distortion-free rendering during replay. A primary one concerns the intrinsic non-linearity between the recording current and the output EMF of the magnetic tape itself. When a metal or oxide of metal is magnetised, the magnetism acquired fails to follow the magnetic force (and hence the current through the winding) applied to the material to produce the magnetism. The curious set of curves in Fig. 1 show what happens. Let us suppose that the tape starts in an unmagnetised state at origin 0 and that the magnetising force H is increased in a positive direction by current flowing in one direction through the winding then the magnetism B acquired by the tape increases rather non-linearly according to the broken-line curve OA. At point A the rise in magnetism B halts, even though H may be further increased. This is the saturation point of the tape, meaning that it is unable to accommodate any more magnetism.

If now the current through the winding is reversed H moves in a negative direction and the value B originally acquired by the tape is reduced along curve AB1. At point B1 H is zero, yet B has level B1. This represents the level of magnetism which has been acquired by the tape, called the remanent flux. To pull this flux back to zero and hence demagnetise the tape H needs to be increased further in the negative direction to point C on the curve.

The equivalent things happen to B in the opposite polarity as in curve CD, and a reversal of current in the positive direction brings the remanent flux to level E at zero H (opposite polarity), to the demagnetised state again at F, and up to saturation again over FA. The collection of curves is called the hysteresis diagram of the tape (that shown is not meant to be typical of any tape).

Kinky Distortion

Let us now suppose that a sinewave signal is fed to the recording head and that the tape so recorded is replayed. Fig. 2a shows that, owing to the non-linearity between H and B, the replay signal will suffer bad distortion caused mainly by the 'kink' at the centre of the HB curve. This is

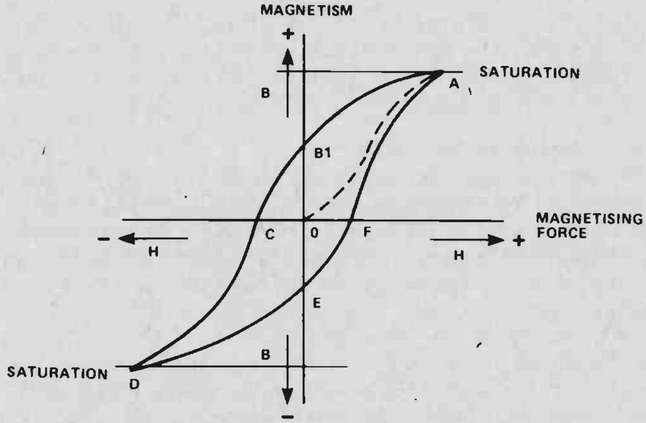


Fig.1. Hysteresis loop of magnetism which is explained in the text.

overcome by superimposing the recording signal on a much higher frequency (100 kHz) signal, called the high-frequency bias. When this is done the audio signal is lifted clear of the centre 'kink' so that it operates on the more linear parts, as shown in Fig. 2b.

The remaining non-linearity of the curve is responsible for third-order distortion which, at normal recording levels at middle frequencies, averages something less than 1%. However, if the recording level is so great that the tape closely approaches or, indeed, enters saturation then the distortion rises dramatically to 20% or more. This is what is likely to happen, especially at the higher frequencies as we shall see, when the recording level meters are running well into the red region.

Different tapes unfortunately require different values of HF bias current for the best results, and for this reason latter-day decks have provision for bias change and sometimes for fine adjustment. Basic ferric (Fe) tape requires less bias than chromium dioxide (Cr) tape. More recent high-energy cobalt-modified Fe tapes need about the same bias as Cr tapes, while the two-layer FeCr (ferrochrome) tapes call for a bias somewhere between the Fe and Cr requirements.

The Need for Equalisation

Each time a half-cycle of signal current flows through the head winding a small magnet is formed on the tape oxide. For simplicity this is illustrated in Fig 3 with a squarewave signal. Thus for the positive half-cycles we get SN poles and for the negative half-cycles NS poles. The length of these magnets, of course, will depend not only on the tape speed, which is fixed, but also on the frequency of the signal. As the frequency is increased, so the length diminishes.

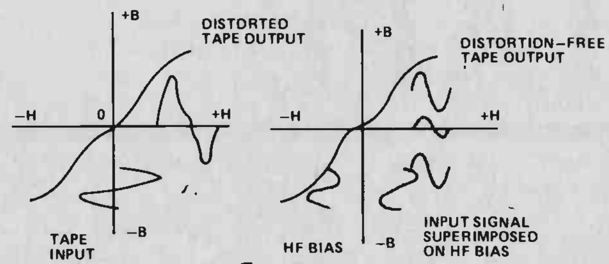


Fig.2. (a) Showing how the 'kinks' at the middle of the BH curve distorts the output signal, and (b) how by superimposing the recording signal on a high-frequency (bias) signal the distortion is eliminated.

During replay the EMF in the head winding increases with the increase in rate of change of the magnetic flux linking the pole pieces. This is on par with a simple dynamo whose output increases with increase in speed of the rotor. It follows, therefore, that the EMF will rise as the frequency of the signal increases. Doubling the frequency doubles the EMF, and since doubling the frequency is an octave and doubling the EMF is a 6dB increase, it is said that the head output rises at the rate of 6dB/octave. This is shown in Fig 4 where it is seen that this natural rate is modified at the LF and HF ends owing to losses.

To provide a 'flat' output during replay it is thus necessary to arrange for the replay amplifier to have a response to inverse of that of Fig 4. That is, for the bass to be boosted at the rate of 6dB/octave. All cassette machines are equipped with this basic equalisation; but additional equalisation is required to compensate for the HF losses in particular, so that the response is boosted at the treble frequencies as it rolls off due to the losses.

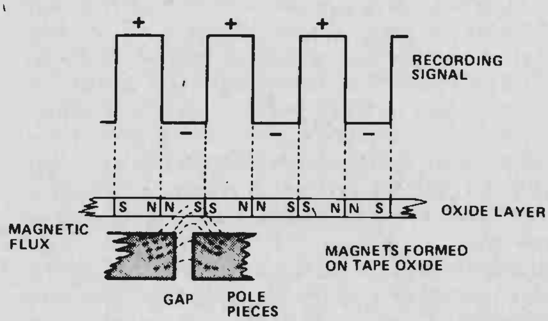


Fig.3. For each half-cycle of recording signal, a small magnet is formed on the tape oxide. The magnet poles alternate with the positive and negative half-cycles as shown.

Flat Response

This is done in two parts: one by arranging for the recording signal to be treble boosted (pre-emphasis), and two, to check the rate of treble roll-off arising from the 6dB/octave bass boost. When these are handled correctly with respect to the tape formulation employed, the result is a response sensibly 'flat' up to, at least, 12 kHz, depending on the length of the gap in the replay head (note: gap length is defined as that distance between the faces of the head pole pieces).

The treble losses are partly attributable to what is called tape compression. If a tape is recorded at a constant level but at an increasing frequency, the magnetism acquired by the tape diminishes with frequency, so the output on replay falls. The compression takes effect earlier in the frequency spectrum as the *level* of the recording is increased. The onset of compression has much to do with the ability of the tape to retain high-frequency signals. This is called tape coercivity. Tapes of high coercivity, such as *Cr*, some *FeCr* formulations and cobalt-modified *Fe* formulations, retain the high-frequency, short wavelength signals more satisfactory than basic *Fe* tapes. They thus require less effective equalisation at the treble end. This equalisation is expressed as a time-constant which for basic *Fe* tape is 120uS and for *Cr, FeCr* and some of the cobalt-doped *Fe* tapes 70uS. Hence most machines are also equipped with an equalisation change switch providing these two time-constants (on many machines the 70uS requirement happens automatically when a *Cr* cassette is inserted).

Signal to Noise Ratio

The time-constant merely refers to the frequency where the boost or arrest in the basic 6dB/octave equalisation takes effect, which is equal to $1/2\pi T$, where the frequency is in Hz and the time-constant (T) is S. Thus 120uS corresponds to a turnover of 1,326 Hz and 70uS to 2,274 Hz. The net result works out to less effective treble boost overall at 70uS than 120uS, which endows *Cr* and other 70uS tapes with a 3 to 4 dB S/N ratio advantage over basic *Fe* tapes. You can discern the drop in noise by switching to *Cr* when running a blank tape *via* an amplifier with its volume control well advanced.

The higher coercivity of the tape, the less tendency there is for it to demagnetise at the higher, very short wavelength signals. Running at 4.75 cm/s, the overall magnet length of a 10 kHz signal is a miniscule 4.7uM (tape speed divided by the frequency in Hz); but each magnet has a length of half this value, or 2.35uM, little wonder, then, that there is a tendency for demagnetisation with the poles so close together! The coercivity of basic *Fe* tape is around 300 *oersteds* (Oe) and *Cr* and high-energy tapes around 500 Oe.

Depending on the coercivity, the compression at HF is governed by the recording level, so when a frequency response plot is made of a cassette machine the level of the swept frequency is deliberately kept low (around 20 to 25 dB below peak recording level — corresponding to approximately —20VU on the meters). As the compression takes effect so the distortion rises, and it rises dramatically when the tape is running well into compression owing to the extremely bad non-linearity then obtaining (there being hardly any increase in output in spite of a large increase in recording current). The distortion is essentially 3rd-order, so the 3rd-harmonic caused by a signal of 333 Hz (a common test frequency) falls at 999 Hz, well within the passband. At higher frequencies the 3rd-harmonic eventually vanishes — for example, at 10 kHz the 3rd-harmonic is 30 kHz, which is too high to be passed by a cassette deck.

Constraints

Nevertheless, compression non-linearity at HF gives rise to intermodulation products which certainly do fall in the passband. A 3rd-order product arising from two signals at, say, 9 and 10kHz falls at (2x9)—10, or 8 kHz, while the 2nd-order falls at 10—9, or 1 kHz, both well in the passband.

Much of the poor quality of cassette decks occurs as the result of over-recording the high-frequency music components, creating in-band intermodulation products which, unlike simple harmonic distortion of low-order, is singularly unmusical!

Some of the more expensive tapes allow recording to a higher level, but even with these tapes care needs to be taken over the recording level. It is a sad fact about ordinary VU meters that the peak value of a swiftly occurring music transient could be as much as 10dB above the indicated level. This is because the inertia of the meter prevents the pointer from accelerating anywhere near as fast as a fast-rising, short-duration signal component. The net result is that the transient has come and gone before the pointer barely has time to move! With complex, wide dynamic range classical music, therefore, it is desirable to peak several VUs below the red section for the best quality results. Some machines are equipped with much faster responding light emitting diodes for peak indication. If these complement the VU meters, it will often be found that the +3dB LED will flash at times when the VU meters are registering —6dB or less.

On the other hand, if the recording level is set too low

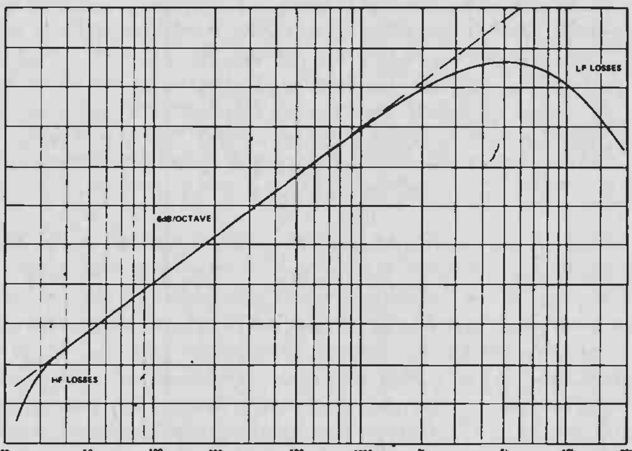
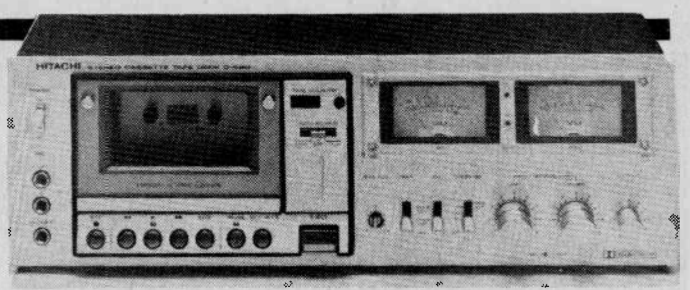


Fig.4. From a constant recorded flux the replay head output rises at the rate of 6dB/ octave. This is equalisation and record pre-emphasis are also used to combat the fall in treble output caused by HF losses.


One of the latest pieces of tape technology from Hitachi, this particular example features an inbuilt memory.

the dynamic range will be impaired because the noise floor relative to the upper recording level will be too high (from first principles, dynamic range refers to the dB distance between the upper recording level and the noise floor). Without Dolby noise reduction, the noise floor is about 50dB (CCIR/ARM-weighted) below peak modulation level (on many machines corresponding to approximately +3VU — Dolby level) using *Fe* tape and about 54.5dB using *Cr, FeCr* and certain cobalt-modified *Fe* tapes requiring 70uS equalisation. With Dolby the effective dynamic range is increased by a further 10dB, yielding the hi-fi dynamic range of around 65dB.

How Dolby Noise Reduction Works

If treble boost is applied to the recording signal the reproduction on replay will be treble heavy, which is fairly obvious. However, if during replay the treble is rolled-off by the same amount as it was boosted, then the frequency response integrity will be restored. The background noise detected by a listener depends on the noise power bandwidth of the replay channel. If the bandwidth is reduced, then the noise level falls. Thus by boosting the recording signal at the treble end, the bandwidth and hence the noise can be reduced during replay without impairing the overall frequency response from recording input replay output.

This scheme is known as pre-emphasis (the treble boost) and de-emphasis (the treble roll-off), and is adopted as a noise reducing artifice for both FM radio and gramophone records. The treble roll-off, of course, is tantamount to a reduction in bandwidth.

The amount of noise reduction possible by this scheme is limited by the amount of boost that can reasonably be applied to the treble. That is, the frequency at which the boost starts to take effect. If the treble boost occurs too early treble overload could well result unless the average recording level is reduced.

Dolby Noise Reduction

The basic principle of DNR is similar to pre- and de-emphasis except that the amount of pre-emphasis is determined by the actual *level* of the recording signal at any instant. At low level where the noise is obviously more troublesome a greater treble boost is given than at higher level where the signal well outweighs the noise, anyway. In fact, at very high level (the Dolby reference level corresponding to a recording level of 200nWb/m and +3VU on most meters) there is no treble boost at all.

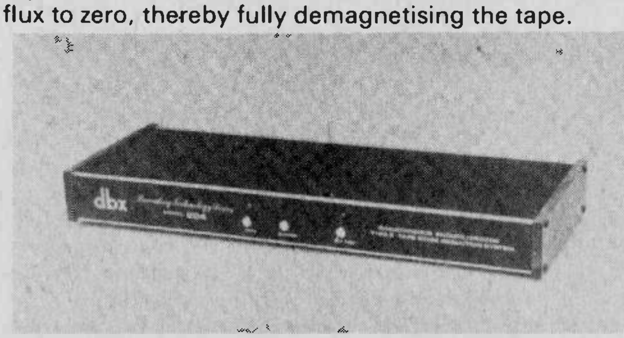
During replay the frequency response integrity is restored by a circuit which again monitors the signal level and sets the treble cut to correspond to the treble boost applied during recording. The encode and decode circuits need to be well matched in gain to avoid aggravation of intrinsic frequency response aberrations, and this requires the circuits to be adjusted for 'balance' on the type of tape which will be used with the machine. If the sensitivity of the tape used differs significantly from that with which the circuits were originally adjusted, then the Dolby circuits will fail to operate correctly — a point well worth bearing in mind!

Metal Particle Tapes

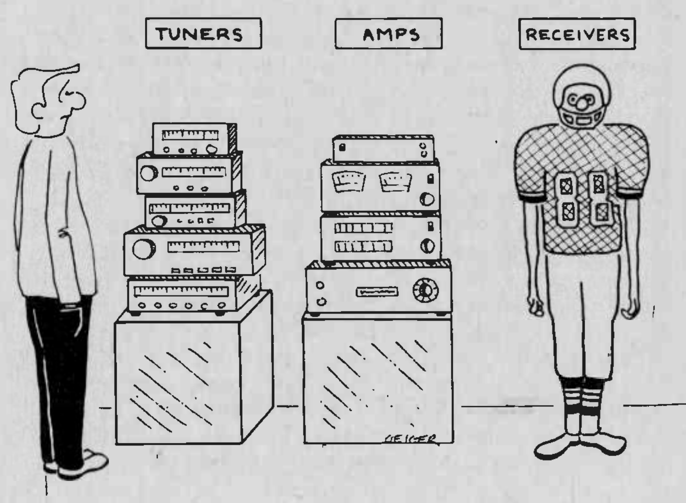
A new tape which will further improve the compact cassette medium is about to be launched. This uses as the coating pure iron particles instead of oxide particles, and as a result exhibits a coercivity (Oe) almost twice as high as *Cr* tape, (1,060 Oe instead of about 540 Oe), and a remanence of 2,600 gauss against about 1,550 gauss of ordinary high-energy tape. For the best results from such tape a greater HF bias current will be needed (also a higher erase field), and the recording amplifier will need to supply a greater recording current without over-loading. The record head, too, will need to deliver the higher magnetic force without running into saturation distortion. Already machines are being made which will do justice to the tape.

Erase

As a final thought, magnetic tape is erased by the machine before recording by passing the erase head which yields a HF magnetic field (working from the HF bias oscillator), and the effect is that the tape coating is subjected to a number of decreasing hysteresis cycles as it passes the erase head, which reduces the remnant flux to zero, thereby fully demagnetising the tape. ●



The dbx Model 224 decreases tape noise by compressing the signal while recording and restoring the original dynamic range on playback.



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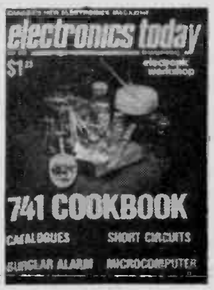

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ATTENUATORS

Ray Marston looks at the rather unglamorous but vital subject of passive attenuators.

ONE OF THE MOST important types of artillery in the design engineer's armoury of 'vital weapons' is the apparently simple passive circuit known as the 'attenuator'. Naturally, these apparently simple weapons are full of nasty little surprises and have a tendency to explode in the face of the unwary designer.

Attenuators

Attenuators are used to reduce an awkward value input or output signal to a lower and more convenient level. The simplest example of a practical attenuator is the 'pot' circuit of Fig. 1, which may be used as a volume control in an audio system or as an output level control in a simple audio generator, etc.

The input signal to the pot attenuator is connected across the total resistance chain and the output is taken from the pot slider. Note that the pot effectively comprises an upper (R1) and lower (R2) resistive arm, thus forming an basic 'L'-type attenuator and that the degree of attenuation is determined by the ratio of lower arm resistance divided by the total resistance.

The precise amount of attenuation provided by a pot is generally of little importance and the contol is usually left uncalibrated. If a precise amount of attenuation is required, a simple switched potential divider network of the type shown in Fig. 2 may be used. It is important to note, however, that this circuit is designed to feed into an *infinite* impedance, or at least one that is very large compared to the total resistance of the divider chain.

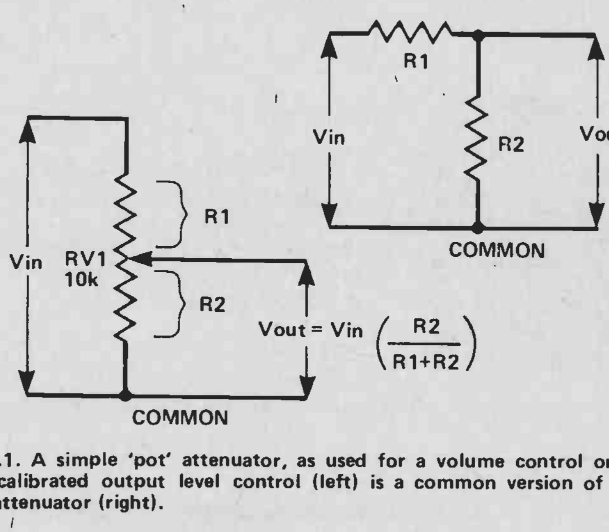


Fig.1. A simple 'pot' attenuator, as used for a volume control or an un-calibrated output level control (left) is a common version of the 'L'attenuator (right).

Design Tips

The first step in designing an attenuator of the Fig. 2 type is to decide what its input impedance or total resistance is to be. Next, the values of the individual resistors are determined. Here the design is carried out in a simple sequence of logical steps, there being as many steps as there are attenuator switched positions. In each of these steps, the circuit is considered to consist of an upper and a lower half only. An example will help clarify matters.

Assume (as in our example) that the total resistance is to be 10k and that two attenuation positions (excluding unity) are required and are ÷ 10 and ÷ 100. The values for the greatest amount of attenuation are always determined first, so for ÷ 100 the lowest arm must contain 1/100th of the total resistance, or 100R. This gives the value of R3 and leaves the remaining 9900R in the 'upper' (R1 + R3, but as R3 is already known to be 100R, R2 must be 1k0 – 100R = 900R. The upper arm, R1, must obviously contain the remaining 9k0 of the 10k chain.

This simple design procedure may be expanded up to give as many attenuator steps as are required for a particular application.

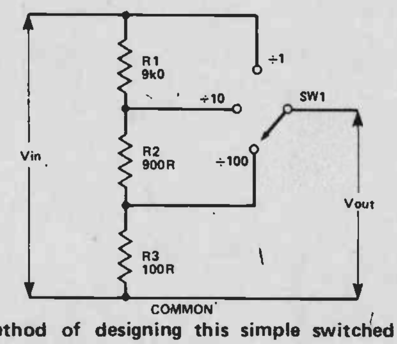


Fig.2. The method of designing this simple switched attenuator is explained in the text.

It should be noted that the simple attenuator circuit of Fig. 2 is only accurate at low frequencies or when moderately low values of resistance are used. At high frequencies, stray capacitance will shunt the values of all resistors and may significantly reduce their values and thus the accuracy of the attenuator. This effect is particularly acute when high value resistors are used: a mere 2pF of stray capacitance represents a reactance of about 800k at 100kHz and will have a very significant shunting effect on any resistor with a value greater than a few tens of kilohms.

Compensation

This problem can readily be overcome by shunting all resistors with correctly chosen values of capacitance, as shown in Fig. 3.

Here, each resistor of the chain is shunted with a fixed capacitor, the reactance values of capacitance being in the same ratios as the resistive arms of the attenuator. The highest reactance (smallest capacitance) is connected to the largest resistor and typically has a value in the range 15 to 50pF, the value being large enough to 'swamp' strays but small enough to present an acceptably high impedance to input signals.

This 'compensated' type of attenuator is invariably used in 'scopes and various other types of high frequency test gear, as shown in the typical circuits of Fig. 4 and Fig. 5. Once again, note that the compensated attentuator is intended to feed into a high impedance load.

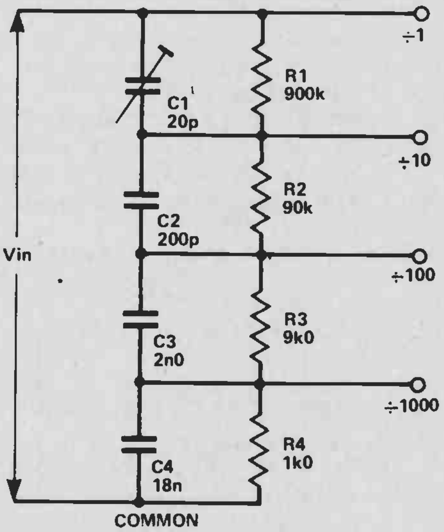


Fig.3. A method of providing frequency compensation (to give a wide frequency response) to a simple attenuator network.

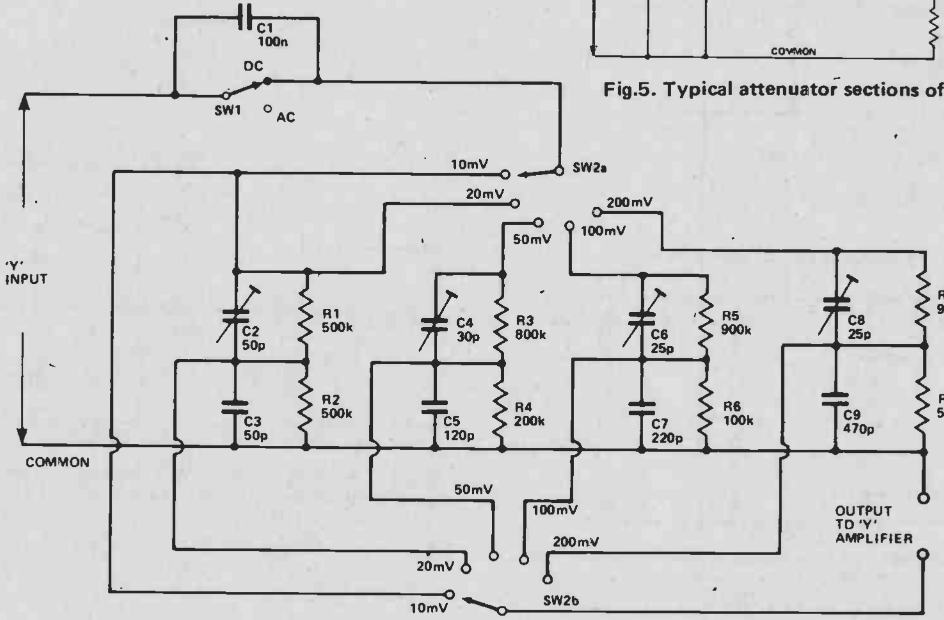


Fig.4. Section of a typical 'scope 'Y' amplifier attenuator.

Pot Pitfalls

At this point in our discussion it may have dawned on you that, because of the effects of stray capacitance, there can be certain pitfalls in using pots in some types of circuit. Suppose, for example, that you have designed an audio amplifier with a beautifully flat frequency response but have, in a moment of madness, fitted it with a 500k volume control. You will (hopefully) not be unduly surprised to consequently find that, at low volume settings, stray capacitance of a few picofarads across the upper arm of the pot causes the amplifiers treble response to be boosted by several dB at 12kHz or so!

Again, suppose that you have designed a superb LF sine/square generator which produces square waves with rise and fall times of a mere 50ns or so, but have fitted the beast with a simple 10k pot as an output level control. Naturally, you will not be surprised to find that the few picofarads of strays across the upper arm of the pot acts as a reactance of only a couple of thousand ohms to your fast rise and fall time signals and consequently causes your square waves to appear incredibly 'spiky' at low amplitude settings.

Both of the above problems can be solved or minimised by using pots with sensible low resistance values, bearing in mind the effects of strays at the operating frequencies in question.

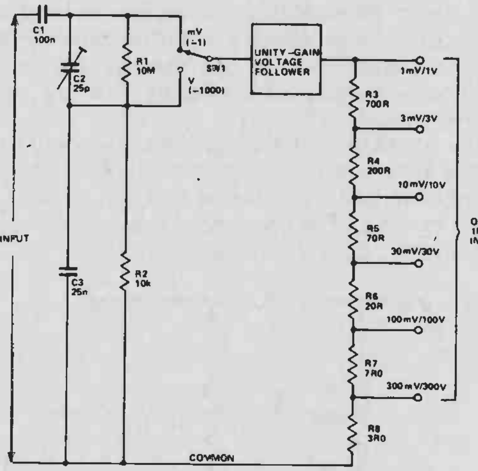


Fig.5. Typical attenuator sections of an AC millivoltmeter;

Matched-Resistance Attenuators

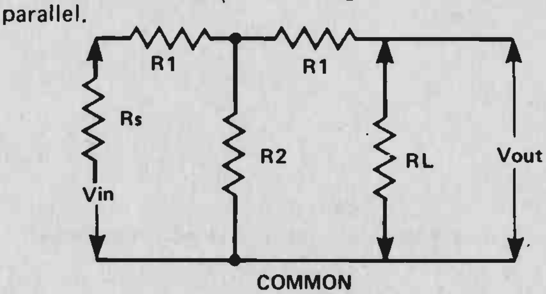
Often, an attenuator is needed to feed into and/or from a fixed load of some kind, in which case the simple potential divider types of circuit discussed above are of little use. Instead, one of the many versions of the so-called matched-resistance attenuator must be used. Two of the most popular attenuators of this type are shown in Fig. 6, together with their basic design formulae. Note that these formulae are valid only when the attenuators are correctly terminated at each end.

The 'T'-type attenuator is a perfectly simple design and several sections can readily be cascaded to form variable attenuator networks, as shown in the practical circuit of Fig. 7. Here, the attenuation can be varied from 0dB to 60dB in 20dB steps by switching individual sections into or out-of the circuit.

The π attenuator sections cannot be directly cascaded, as is made clear in Fig. 8. Nevertheless, sections can be cascaded in modified form to produce a laddered attenuator network, the most popular of all attenuator types.

Looking at Fig. 8, you can see that if three individual π sections are wired in cascade (Fig. 8a) their adjacent R2 sections connect in parallel to give an impedance of P/2 (Fig. 8b) while the two R2 end sections have impedances of P. If an external load, RL, is simply switched to the different outputs of the cascaded π attenuator sections (Fig. 8c) the load will clearly see impedances of roughly half of the correct value and so be severely mismatched. To put things right, the formula for the component values of the ladder network of Fig. 8c are re-jigged as shown.

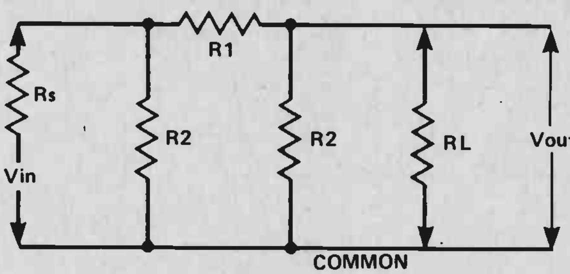
The ladder attenuator of Fig. 8c is very widely used in AF and RF signal generators. Figure 9 shows the practical circuit of a fully variable 600R attenuator that can be used in sine/square generators, etc. The odd resistor values (correct within 2%) can be made up by wiring pairs of resistors in series or parallel. ●



'T' – TYPE ATTENUATOR

$$R1 = R\left(\frac{n-1}{n+1}\right) \quad R2 = R\left(\frac{2n}{n^2-1}\right)$$

Fig.6. Two popular types of matched-resistance attenuator.



'π' – TYPE ATTENUATOR

$$R1 = R\left(\frac{n^2-1}{2n}\right) \quad R2 = R\left(\frac{n+1}{n-1}\right)$$

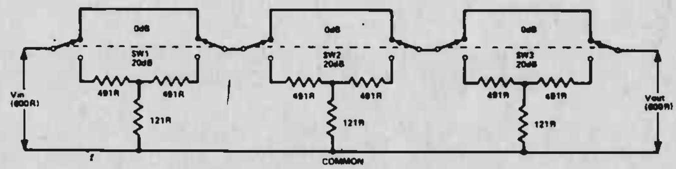


Fig.7. Three identical 20 dB 600R 'T' attenuators cascaded to make a 60-dB switched attenuator unit.

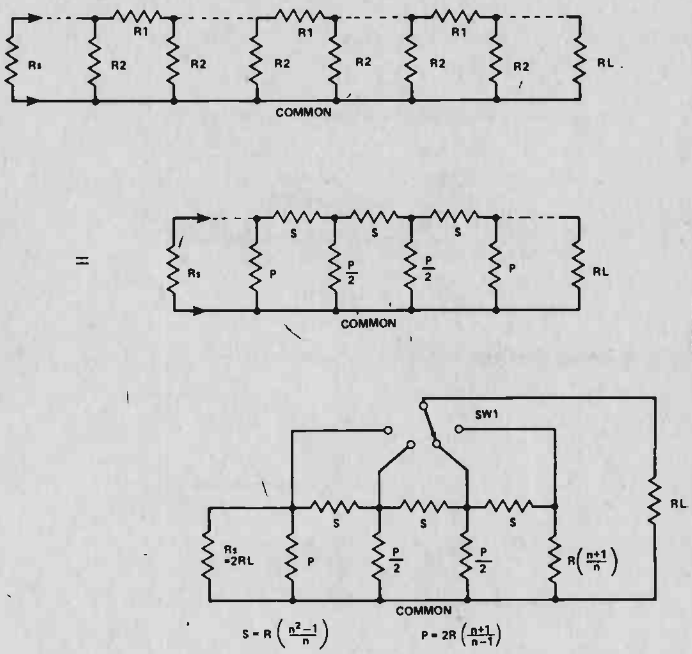


Fig.8. The ladder attenuator (c) is a development of the basic π attenuator (a and b).

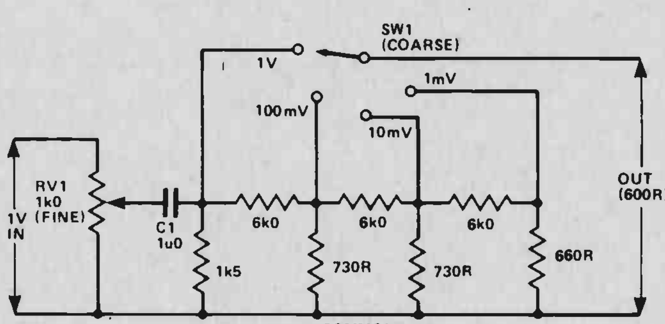


Fig.9. Practical 600R output attenuator, network for a modern sine/square generator. RV1 gives fine control. SW2 gives coarse control.

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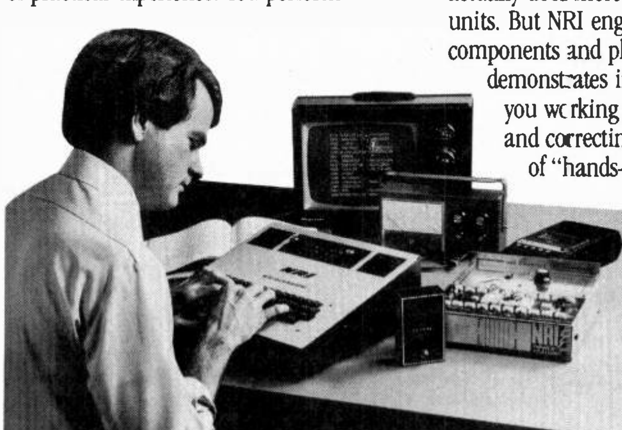

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IDENTIMAT

With so much of commerce and banking being done by computers, there is a major problem with security. The gains, or losses, from fraud can be enormous; Identimat is a Canadian system which is designed to ensure that only an authorised person can use the computer.

"Once you're in through the front door, the computer thinks you're family: you can do what you want."

Dr. Eric Manning,
Canadian computer authority.

IN A WORLD increasingly dependent on the computer as a tool for its well being and maintenance, the axiom that every tool can become a weapon capable of being used against its owner is one that computer security specialists heed with close attention.

But while machines can be made more foolproof and secure, it is the human element that most concerns computer security specialists today: how to control who is to be permitted into the computer room in the first place; and once in, who should be permitted to use a particular computer program?

Secret passwords are not the answer, as computer criminal turned computer security advisor Jerry Schneider showed the gullibility of people when, in 1971, he ripped off the Pacific Telephone and Telegraph Company for $900,000 in equipment deliveries by simply telephoning the computer room and sweet talkingly persuading the personnel that he'd forgotten the password, and was given it without further ado.

Recently, another device for computer security has come on the market with an extremely high degree of accuracy.

Canadian computer industry sources state that it just might be the answer to the computer access problem.

Called Identimat 2000 it operates by simply having a person place either or both hands (the machine instructs as to which) on a glass plate. The machine then photoelectrically determines the person's hand geometry and compares it in less than a second to data inserted into the machine by means of a card constructed along the same design lines as a credit card.

A cardless version of the same machine compares the person's hand geometry with previously stored data.

A person's hand geometry includes the length of a person's fingers, the contours of the hand and the translucency of the skin. It is nearly as unique as a fingerprint.

Unlike an analogous devise, dependent on fingerprints, the Identimat 2000 has never been known to reject a person unneccessarily or, more importantly, has it accepted an unauthorized person in the nine years it has been extensively used in North America for stock room access.

Unauthorized use is impossible, since unlike cards, keys or secret passwords, an individual's hand cannot be lost, stolen, borrowed or forged.

Chances of misidentification are astronomically low. A Stanford Research Institute Report states that the system is effective 99.5% of the time, eg. only 1 in 10,000 hands are sufficiently similar to fool the machine.

With Identimat, the operator places the complete palm on the glass, the system then checks various dimensions and the 'print' to ensure complete security.

Stanley J. Green, Vice-President (Systems Engineering) of Security Information Systems Limited, which holds the Canadian and European patents to the device says that, *"the system will simply not allow an unauthorized person in. While one in ten thousand could use someone elses card, those two people would have to find each other first."*

Forgery of the card is also impossible, he says, due to the secure coding of the card's data.

"The card model cannot be deciphered under any circumstances: there are three levels of security and in fact no one has got past the first level. People have tried for months using a computer to try and break the code and been unsuccessful," he says.

Green further explains that the card's magnetic stripe's first level of security contains a unique employee number, the customer's number, access permission and the individual's hand geometry, all coded and scrambled.

The second level of security consists of one bit of random data for each bit of live data, in no sequence and with the live data looking exactly like the random.

The third level of the card's security consists of the live data in no sequence and scrambled.

Application of this device to the computer security problem is two-fold: access to the computer room itself, and access to the computer terminal or computer program, with the card or cardless models being used depending on the circumstances.

"The card model is a completely stand alone unit that has the capability of being connected directly to a central console as well as the capability of being connected to the computer," says Green.

"The major advantage of the card model is that if the computer should go down for any reason, a cardless model guarding it would go down with it. Power is power: if the power's off, that's it!"

"However, with the card model, in the case of the computer going down, the machine is completely unaffected and continues to protect the doorway or whatever it's being used to protect," says Green.

Using the card model to protect access to the computer room and the cardless model to protect access to the computer terminal or computer program would therefore be the ideal, says Green, as it would cover all security risks.

Further, acceptance or rejection of a person's hand can be hooked up to a recording device providing a written record of when and by whom the device was used.

This last feature is potentially useful in facilitating audit trails, customarily one of the great headaches in computer security when a fraud is known to being perpetrated, but the culprit is lost in the computer's labyrinthine logical intricasy.

A written record of who did what and when would dramatically ease this complexity for auditors who customarily have little knowledge or expertise in tracking a fraud through a computer's software logic.

Costing in the neighbourhood of $6,000 (Can.) depending on the options, this device is currently used by as diverse companies as the Royal Bank of Canada, to protect two sensitive floors at their Toronto headquarters, the US Army to protect their National Defense computer installations, and Bell Northern Research to protect access to their research laboratories. ●

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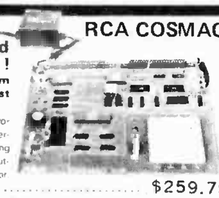

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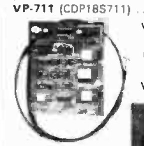

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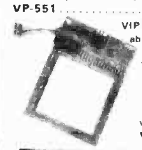

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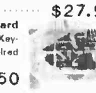

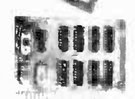

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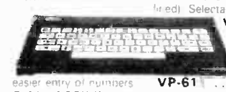

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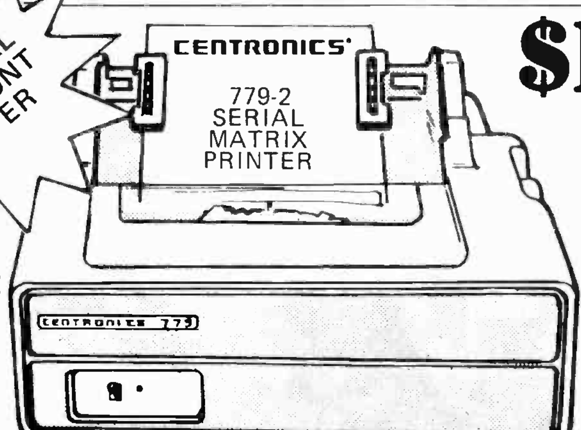

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Forms Handling
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Print Speeds *	60 cps	110 cps
Print Densities	10 cpi	16.5 cpi
Lines Per Minute		
@ 10 char/line	90	130
@ 132 char/line	N/A	21
Max. Print Width	8" (203mm)	
Horizontal Spacing (operator adjustable)	10-16.5 cpi	
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*cps=characters per second

The Model 779-2 is intended to be a basic output device. It uses a single logic board and has simple controls that consist of a power ON/OFF switch and a print switch. Print density is adjustable from 10 to 16.5 characters per inch. This printer offers an alternative to the user who is reluctant to spend additional money for a long list of printer options he doesn't need.

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6 WATT SIREN

A state-of-the-art project to terrify intruders and pussy cats. A police-like "de-dah" alarm that produces a 6-watt output into an 8 ohm speaker when powered from a 12 V battery supply.

THIS NIFTY LITTLE DESIGN uses the very latest advances in semiconductor technology to implement a very compact, inexpensive, yet exceptionally powerful alarm-sound generator unit that can easily be incorporated into an existing burglar alarm system or similar "security" device. The alarm produces a police-like "dee-dah" signal at levels up to 6-watts in an 8 ohm speaker when powered from a 12-volt battery supply and incorporates a number of unusual features.

The alarm circuit incorporates a basic alarm-signal generator, followed by a power amplifier stage. The alarm-signal section of the unit is designed around an inexpensive CMOS integrated circuit that consumes virtually zero "standby" power. The power amplifier stage is a real state-of-the-art device, a low-cost VMOS power FET which also consumes virtually zero current when in the "standby" mode. Consequently, the unit does not need a separate on/off switch and can be left permanently connected to a 12-volt battery supply. The alarm can be activated either by closing push-button switch PB1, or by applying +12 volts to the junction of R1 and R2 (the low end of PB1).

Construction and Use

The unit uses relatively few components and can be built in less than one hour. The components are assembled on a standard 1 inch × 2½ inch strip of Veroboard, as shown in the photos. Start construction by breaking the copper strips as indicated and then solder the nine wire links into place. Next, solder a suitable IC holder into position and then assemble the rest of the components, taking care to observe the polarities of C1, D1, IC1 and Q1.

When construction is complete, double-check all wiring and then connect the unit to a suitable 8R speaker and a 12 volt battery supply, connect PB1 in place and give the unit a functional check by closing the switch. The unit should produce an ear-splitting "dee-

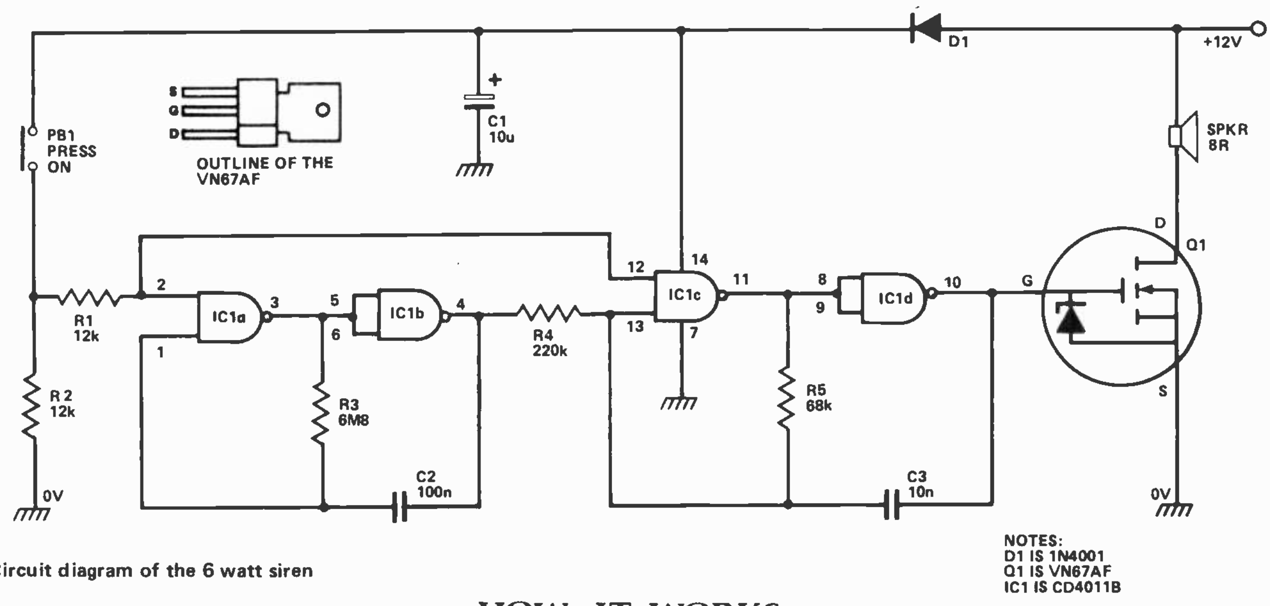


Fig.1. Circuit diagram of the 6 watt siren

HOW IT WORKS

IC1a and IC1b are wired as a slow astable multivibrator and IC1c-IC1d are wired as a fast astable. Both these astables are "gated" types, which can be turned on and off via PB1. The output of the ICa-IB1b slow astable is used to modulate the frequency of the IC1c-IC1d fast astable, and the output of the fast astable is fed to the external speaker via the Q1 VMOS power FET amplifier stage.

Normally, with PB1 open, both astables and Q1 are inoperative and the circuit consumes virtually zero standby current. When PB1 is closed both astables operate and the frequency of the fast astable is modulated by the slow astable to produce a "dee-dah" signal, which is passed to the speaker via the Q1 power amplifier stage. D1 and C1 are used to ensure that the astable actions are not adversely influenced by voltage transients induced into the battery supply leads via the speaker.

dah'' alarm sound. Note that the speaker used in the system must be an type with a power rating greater than 6 watts.

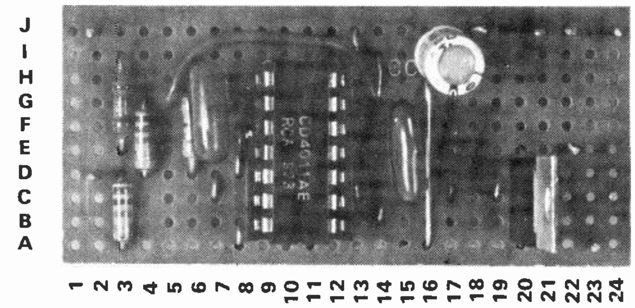
If you want to use this unit in conjunction with an existing burglar alarm system, you can either replace PB1 with a set of relay contacts that are activated via the burglar alarm system, or possibly can use the burglar alarm to activate the generator directly by applying 12 volts to the R1-R2 junction under the ''alarm'' condition. ●

PARTS LIST

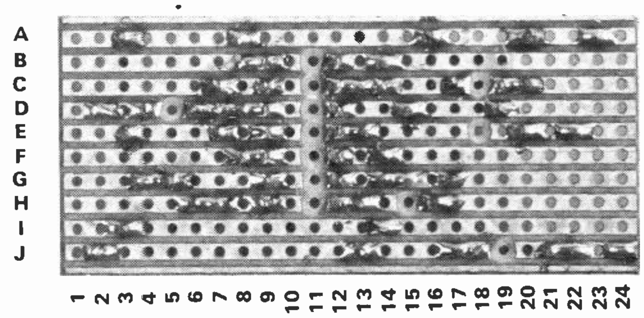
RESISTORS (All ¼w, 5%)	
R1, 2	12k
R3	6M8
R4	220K
R5	68K
CAPACITORS	
C1	10µ 16V Electrolytic
C2	100n Polyester
C3	10n Polyester
SEMI-CONDUCTORS	
D1	1N4001
Q1	VN67AF (Siliconix)
IC1	CD4011B
MISCELLANEOUS	
SPKR	8R, 10 watt
PB1	Push button switch

(note the VN67AF is available from Active Component Sales Corp.),

PROBLEMS? NEED PCBs? Before you write to us, please refer to 'Component Notations' and 'PCB Suppliers' in the Table Of Contents. If you still have problems, please address your letters to 'ETI Query', care of this magazine. A stamped, self addressed envelope will ensure fastest reply. Sorry, we cannot answer queries by telephone.



Above. Component insertion layout. Note the orientation of Q1 Below. Underside of the Miniboard 6 watt siren. Ensure that cuts in the tracks are made in the correct places.



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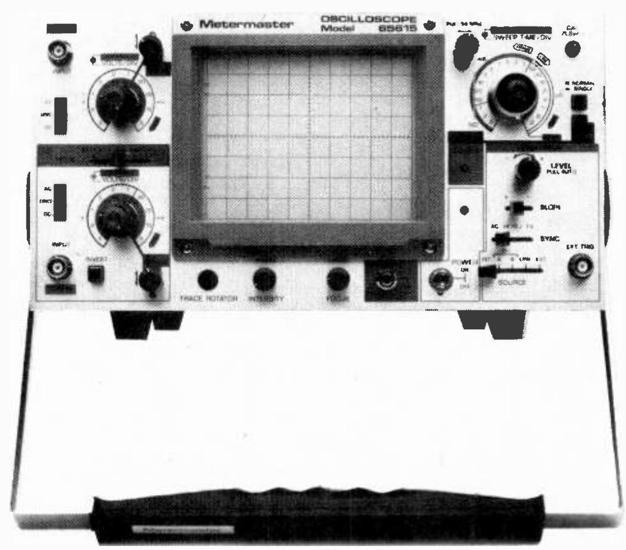

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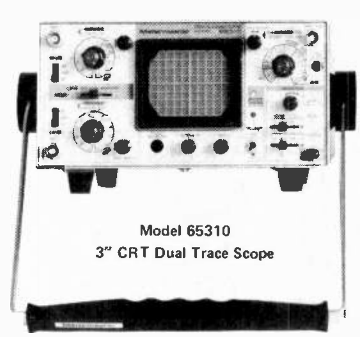

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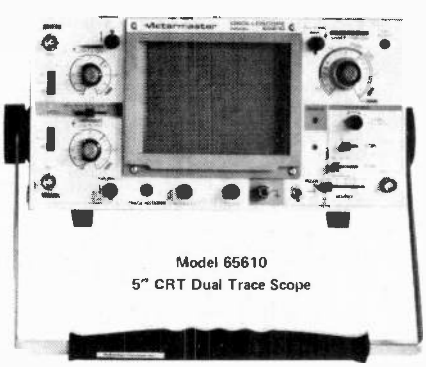

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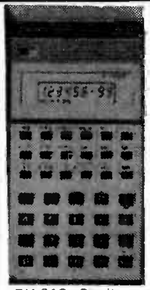

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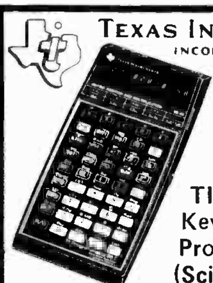

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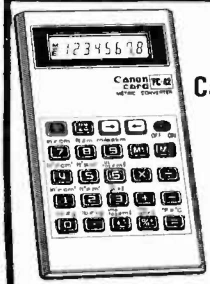

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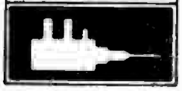

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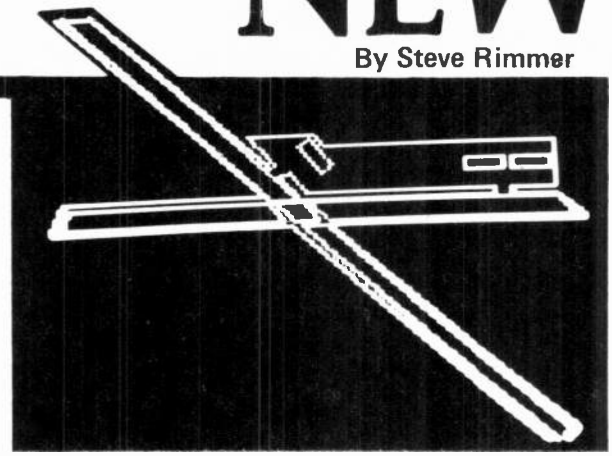
WHAT'S NEW

By Steve Rimmer



This Month our Contributing Editor Steve Rimmer changes his brief. Until now he has confined himself to the subject of video but now, with a minor change in the name of the column, he sets forth to deal with a computer graphics system.

THIS IS A fairy tale. You probably didn't think fairies had them, but here's one anyway.

There once was a Moravian Marsh Gnome named Art. This isn't short for Arthur. He came from a large family, in which all the other gnomes were loathsome little girl trolls. All the girls were named after flowers, like bladderwort, rapeweed, venus flytrap, and so on. His parents were rather at a loss as to what to call him. They were about to put him out with the papers when an idea struck them, breaking his father's left leg in the process. Thus it was that he came to be called Artificial. As it happened they put him out with the papers anyway.

One day Art was skuffling through the woods on his way to the tar pits when what did he come upon but a North American Rockwell DM-551/B computerized aircraft flight simulator. There did not seem to be anyone around. "What a coincidence," said Art, drooling a bit. "Just like in a fairy tale." Then he remembered the popular misconception that fairies haven't got them, and climbed into the simulator. There he saw a video screen.

"RCKWLL 551/B," said the screen, winking its cursor. "DO YOU WANT INSTRUCTIONS? (Y OR N)?"

"N," said Art, who was a bit of a simp.

"LEVEL OF REALISM (0 TO 10)?" said the screen.

"10," said Art.

"CRUISING AT 3500 FEET," said the screen. "AUTO PILOT OFF IN THREE SECONDS."

"What?" said Art, drooling again. Living in a box of old newspapers for the first three years of his life had done nothing for his cerebral development. The screen did not answer.

Instead it said, "ALTIMETER: 3250 FEET. RATE OF DESCENT 100 FEET PER SECOND."

"Oh My, " said Art. "What shall I do?" There was only one thing to do. Run away, and hope nobody beat him up. This was a safe bet; most people didn't like touching Art due to extreme wretchedness. He tried to get out of the simulator.

"DOORLOCKS INOPERATIONAL WHILE AIRCRAFT IS IN FLIGHT," said the screen. "ALTIMETER 2525 FEET. RATE OF DESCENT: 250 FEET PER SECOND," it added.

"Mister Screen, won't you please help me?" cried Art, like a real dolt. "I'm so afraid."

"ALTIMETER: 900 FEET. RATE OF DESCENT: 735 FEET PER SECOND," replied the screen.

"A-WOOOOOO!" howled the imminent disaster alarm.

"Please let me go," wailed Art. "I do so want to go play in the tar pits."

"ALTIMETER: 50 FEET. RATE OF DESCENT: 1845 FEET PER SECOND. CRASH IN TWO SECONDS," said the screen. "YOU'RE DEAD," it added.

Then the flight simulator blew itself into smithereens, and Art along with it. It's simulated gas tank caught fire and touched off the surrounding woods, wiping out whole gnome communities. The survivors applied for relief, but the government doesn't believe in gnomes, so they were turned down.

The moral of this story is simply that computer graphics have made possible more and more realistic flight simulators — and you should always ask for the instructions if you find one in the woods.

Pitch'urs

Computer graphics aren't new; they've been using them in railroad stations for years. The idea is to regard the phosphor screen of the mighty tube as a matrix of parallel lines scanned serially, any of which can be illuminated, but not by the software of the machine. The earliest manifestations of this was in video character generators, as are seen in airports, train stations and on cable TV channels. The software in these things acts as a kind of interpreter for the human hunting and pecking at the typewriter. It knows which dots on the screen want turning on for any given character, so the typist need only specify the actual characters desired. The range of dot patterns that can be placed on the screen by a character generator, however, is quite limited and, as such, the graphics capabilities of such a system are thoroughly abysmal. If Di Vinci had had a computer to work with, Mona Lisa would have had square eyes.

Several of the current "small" computer systems, while being character oriented, have considerably more screen control than would be required just to type error messages and Pong paddles. The Apple for example, can specify any point and, as such, any line on its tube. Thus, with the right software one of these clever little droids could produce actual pictures that are not comprised of strings of a's and X's. The software, is in a much more massive incarnation, simply an interpreter to facilitate a gorilla, or other being equipped with

Continued on page 50

fingers, turning on the desired screen points — without having to specify every one.

We're going to have to peer at one of these software systems, and plumb the limits of the vaulted, stunning technological magnificence that lets us draw *Star Wars* figures on a computer. The millenium has surely come upon us, doowah, doowah.

SubLogics

There a quite a number of graphics packages floating about — at the time of writing, the most advanced of the batch seemed to be one published by SubLOGIC of Illinois. It will run on any Apple having at least 16K of memory, although 24K or more are required to utilize all the features of the system. It can specify lines in two or three dimensional space and, as such, can represent solids, as well as planes on the screen. It deals with almost all the the wretched seven eyed math monsters involved in the geometry of three space, so a second computer will not be required for those of us who bombed out of last year's functions and relations.

Once one has laboriously drawn a box on the screen, the program is capable of two basic manipulations, these being changing the orientation of the solid and changing the orientation of the eye. What eye, dost thou ponder? Well, yours, actually. The program assumes that anyone operating it will be a pirate wearing a patch over one eye. The eye, then, is the point at which the user is allowed to bore a hole in the margin of the computer's internally generated universe and peer in. The stuff inside the universe can be placed anywhere in the space — in fact, it can even be placed outside it. However, in order to keep it from coming out, at least conceptually, through the side of the video monitor, the program is equipped to saw off anything which invades the outer reality beyond its universe. The eye is equally free to move.

The data which specifies the location of planes, solids and the eye in the synthetic space is, of course, alterable. It can be initially specified, resulting in a static presentation, or it can be changed periodically, allowing the program to animate the denizens of its space.

How You Draws a Pitch'ur

The software package contains several routines. The first is called A2-3D1 and is in effect, the nexus of any higher level graphics presentation. When it is running, it consists of two parts, the software, and its data base. The data base consists of a string of memory locations, beginning at decimal 6912, which specifies what the points on the screen are to be and what the software is to do with them, i.e.; display them as pure points, use them as start points of lines, continuing points of lines, and so forth. The data base, then, is a numerical representation of the solids within the machine's space. A2-3D1 comes with a data base already attached to it, specifying a cube 256 units on a side. This can be overwritten by other data, if you get tired of playing the cube.

With A2-3D1 in the Apple's seedy little brain (no we never call this core memory when dealing with an Apple) there are several things that can be done. The first is to mess about with the cube already in place. Very little is required to do this, and exploring the basic transformations that can be wrought upon it will be useful in unravelling the intricacies of the voluminous and at time enigmatic SubLOGIC documentation.

A2-3D1 is capable of rotating a solid in the X plane, the Y plane or about itself. The latter is the easiest to see, as the first two have part of their rotations beyond the margins of the universe. The following program is useful in getting the cube revolving of its own accord.

```
10 FOR B=0TO255
20 POKE6921, B
30 CALL 2048
40 NEXTB
50 END
```

It took years to develop.

1 FORB = 0TO255: POKE6921, B: CALL2048: NEXTB: END will, of course, also work (of some use if you're planning a lot of complex skuttling about the ol' phosphor.)

By running this with A2-3D1 in place, the cube will appear to rotate clockwise, taking about a minute to complete one orbit.

This little gem illustrates a number of the characteristics of the software. First of all, you will notice that there are 255 steps in the loop that turns the cube. In other words, the cube rotates one two hundred and fifty-fifth of a circle each time it shifts. Why two hundred and fifty-five, instead of, say, three hundred and sixty, which would make each step one degree? Well, 255 is the maximum length the Apple's 6502 processor will tolerate for the length of a single string. Thus, everything in the program runs in pseudo-degrees, in which 256^{po} equals one complete spin. A bit confusing at first, but in time it will be entirely baffling.

This statement can also be utilized to control the speed of the rotation. If a STEP instruction is added to the FOR end of the loop, it will march through fractions or multiples of the pseudo-degrees of revolution. 10 FOR B= 0TO255 STEP10 will crank up the revs by a factor of 10, while STEP10 will let it wax glacially slow.

The POKE instruction in 20 loads the degree of revolution into the location of memory that holds the rotation factor. This, in fact, is one of four such locations. There are three others, one for each rotation in the X and Y planes and movement in the Z plane. These are 6920, 6922 and 6918 respectively. If these are POKEed, in place of 6921, the solid will orbit or shift in relation to a central point in space which is outside the universe segment encompassed by the screen — in fact, it is located somewhere inside the viewer's head. As such, much of the X and Y trip will be off the face of the tube, and invisible.

This program loads the memory automatically — in fact, it could be POKEed manually with any fixed rotation value one liked. In this case, software would be called using statement 30 of the small program as a straight command, i.e., CALL2048.

The cube data base will become rather dull after a while because cubes tend to be a mite square, even in the liveliest company. Rotated on its end it can look like two pyramids stuck end to end, but don't let this fool you. It's a cube in disguise, none the less. Thus, step number two is to replace the cube data with something else. At this point, we'll use one of the ones provided on the disc, these being named SKYLINE and WINDMILL. Both are, unfortunately, 2D, but they serve to get into a few useful points. SKYLINE is just that, a symbolic representation of a silhouetted city. Not to exciting. WINDMILL are two blades of a Dutch tulip fan, which look nice when moving. Hence, with A2-3D1 safely in place, we load data file WINDMILL. Actually, load WINDMILL PING-PONG. This is a relatively new sport (the biggest problem in mastering it is ripping the windmill out of the ground to use it as a paddle.)

Hey listen, I didn't make up these dippy names.

By loading a new data base in for A2-3D1, the cube will be removed and replaced by the new solid, or in this case,

Continued from page 48

just a plane. The WINDMILL can be revolved like the cube was.

The PING-PONG part is another feature of the software. The animation, as we've seen it thus far, is a bit choppy as a new image must be drawn right on the screen every time the thing moves. This can be smoothed out considerably if the drawing and figuring out is done on one page while the previous image is displayed from another. Thus, with PING-PONG animation, all the machine is doing is displaying successive pages, instead of redrawing the same one. This increase in speed results in a smoother flow to the movement.

The number of images available on the disc is pretty limited, and the real value of the software is not in using these, but in developing your own. To do this, instead of loading a data base, you load a meta-data base, a program that allows the writing of a new data base, called A DEVELOP. This is yet another interpreter of sorts, translating its own set of commands into synthetic universe points stored in memory locations.

A typical data base is shown in Table I, this being the specifications for file TUT'S PLACE, a pyramid. It requires five points, joined by seven lines. Unlike the images provided on the disc, it is a three dimensional solid. It is loaded into the machine by running A DEVELOP, and selecting the DEVELOP function of the program. This will permit the selection of a new eye location, if desired — usually it's at point 0, 0, 0 in X, Y, Z space. Hopefully, this corresponds to one side or the other of your nose as well. You can also choose the three rotations discussed in the examination of the basic A2-3D1, otherwise known as Pitch, Bank and Heading. These too are usually left at 0, 0, 0. The program has a viewfinder function which will consider the location of the eye and the solid and impose P, B, H limits that will keep you from pointing the eye into completely unoccupied space. Once all this has been taken care of, you have the option of entering your first command. "99" will let you view the solid in memory so far. Keep this in mind, but to date the universe is pretty well unsullied. As can be seen from the data base, the first command is 10, which initializes things. 05 places the eye, and 08 erases and selects page 0. From here on in command 01 specifies points that are to begin lines and 02 specifies points to continue them. There is no line end point command used; if the 02 command is followed by 01 it just leaves off with the line reaching to the point specified by the last 02. When the last line is in place,

SubLOGIC allows you to draw images and then view it from all sides.

command 79 ends the file. At this point command 99 permits viewing the solid — unless your Apple only has 16K of memory, in which case you must be pleased with only the knowledge that it's in there, somewhere, or you'll wipe out the software.

It's a good idea at this point to put the data base on tape or disc, unless you really enjoy loading these things.

A2-3D1 can now be used to move the pyramid around. By POKEing the appropriate locations in memory it can be transported anywhere in the universe.

By combining the various parameters each time the solid is shifted, it can be made to trace fairly complex paths through space. There ought to be a moving pyramid picture around here somewhere.

Applications

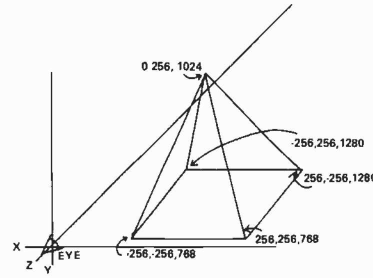
Ye gods, varlet. How speakest thee, that thy don't dig moving yonder pyramids about thine screen? This isn't just an Etch A Sketch you're fooling around with here.

Well, yes, I suppose one can tire of imposing rotations and translations and whatnot on cubes or even, yes, my little pyramid. We must then press on into other applications. Perhaps we could actually do something.

The potential applications of the SubLOGIC package are in fact almost as limitless as those of the machine it runs on. Most of the really interesting ones happen in real time, by using Apple's paddles. One fairly basic thing to try is to write it into a flight simulator (just set the realism counter at 2 or 3.) You can, if you wish, use this to simulate an airplane in flight — I'm afraid I succumbed to it all and decided the life of a space ship pilot was more to my liking. The main hurdle in this is in moving, say, the ground, relative to the plane — no easy problem, if both are to be displayed simultaneously. The solution is to be found back at the WINDMILL PING-PONG match. Instead of using this technique for smoothing up the animation, it can be employed to display to unconnected scenes apparently simultaneously, by rapidly switching on one, and then the other. If one wanted to get really snappy, the scene with the plane could be held on for twice the time of that with the

Table 1

Decimal Address	Command	Location of Specified point & similar stuff
6912	1Ø	
6913	Ø5	Ø,Ø,Ø Ø,Ø,Ø
6923	Ø8	Ø
6925	Ø1	-256,-256,768
6932	Ø2	256,-256,768
6939	Ø2	256,-256,128Ø
6946	Ø2	-256,-256,128Ø
6953	Ø2	-256,-256,768
696Ø	Ø2	Ø,256,.Ø24
6967	Ø1	256,-256,768
6974	Ø2	Ø,256,1Ø24
6981	Ø2	256,-256,128Ø
6988	Ø1	-256,-256,128Ø
6995	Ø2	Ø,256,1Ø24
7002	79	



How to draw a pyramid.

ground so that the plane would appear brighter.

Since the two pages would be stored in consecutive blocks of memory, the A2-3D1 would just be called to start at each alternately. The position of the ground versus plane could be set in two planes by the paddles and by inserting a PDL(0) variable in the sort of control program talked about earlier. The program would be modified with statement 10 reading B=PDL(0) and 40 reading GOTO10.

The games potential of this software alone is enough to keep the computer running, full blast, until the warranty has long since expired.

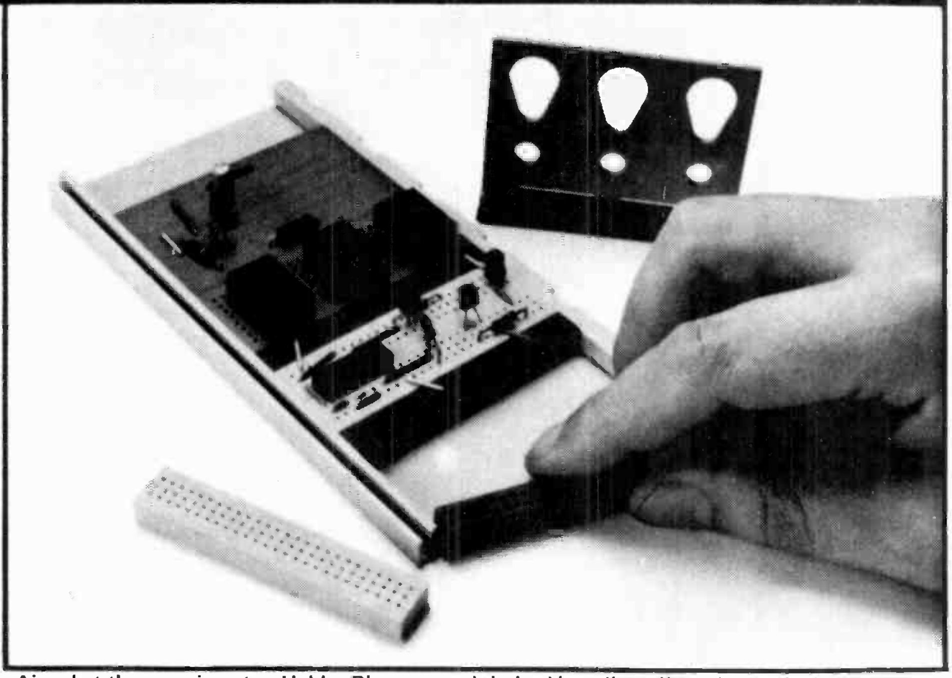
An electronic drafting board is another potential application for the system. There are several ways to approach this, but I think I'd set it up so that the paddles move a cursor around to set points. This would allow real time development of a data base without a lot of prior calculation. As well, there would be some difficulty with curved lines and circles, as the software has no real provision for these little nasties. A routine would have to be developed which specified the points along a curved line segment.

Lastly, there is a whole world of computer generated art tied up in this thing. One can envision attaching the beast to a plotter, there is provision in the software for external display

Continued on page 73

NOVEL NEW BREADBOARD

Have you got a lot of circuits you want to try? Then you should try Hobby Blox. Report by John Van Lierde.



Aimed at the experimenter, Hobby Blox are modularized breadboarding taken to its limit.

ONE OF THE best toys a child can have is a set of building blocks. The ones I recall most vividly were the Lego variety. I had a Campbell's soup box full of them and, in the course of a Saturday morning, I could cover the entire living room floor.

As Lego added more and more accessories (motors, wheels & gears, special windows, etc.), I eventually expanded into the dining room and then the kitchen. Mother became less and less pleased, and I had to leave home at an early age.

Building Blox For Adults

I didn't mean to burden you with my childhood. That last bit was more to explain my fascination with a new product called Hobby Blox. (Fig.1)

Hobby Blox are manufactured by A P Products, the same wonderful people who brought you All-Circuit Evaluators and Superstrip products.

Hobby Blox are easily the most ambitious implementation of the solderless breadboard concept to date. The idea falls into the 'why didn't someone come up with this earlier' category.

Essentially, the system starts out with a simple plastic tray. You then get a number of solderless breadboard strips you can slip into the tray. Unlike standard breadboards, you need two strips to accommodate DIP ICs. Each strip can accommodate 26 nodes of two or three connections each. Additionally, there is another strip designed specifically for laying out discrete components.

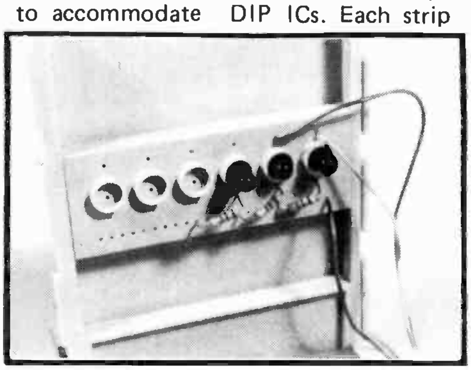


Fig.2. A P has come up with a number of special modules to make breadboarding even easier.

Just like Lego, Hobby Blox come in assorted colours. A built up tray is actually very attractive if not gaudy. The strips appear to be well made and all the holes on all strips can be specified by some sort of coordinate system. Our set didn't seem to fit as easily in the trays as I would hope, but I suspect that this becomes less of a problem with use.

More Blox

Again, like Lego, A P has put out a number of specialty strips. There's a strip designed specifically for holding LEDs for displays (shown in Fig.2). Another strip comes with three 5-way binding posts for easy connection. And, the *piece de resistance* ,you can get a block that holds a standard 9 volt battery to power your projects.

A P also has three vertical panels. One holds up to three switches or pots. Another can accommodate a small speaker, and the third is blank, to allow the user to modify it to suit his own purposes.

Finally, another tray is available that can be mounted vertically from the main one, to make displays more visible, or perhaps to keep your design from sprawling.

As with regular breadboards, all connections are made with No. 22 wire. This covers most components available. You can stuff No. 20 wire in the holes in a pinch, but I suspect this weakens the springs. Also having only three connections per 'node' can be somewhat limiting. This may not be as bad as it seems, since you can run leads from an IC to a discrete strip and build up the passive network of your fourth order high pass filter there.

Fig. 3 shows two strips and a little doodad you may not recognize but is, in fact, one of the retaining conductor springs. This is my only beef about Hobby Blox. A P didn't put anything on the underside of their strips. I had originally intended to build up individual circuits on different strips and then slide

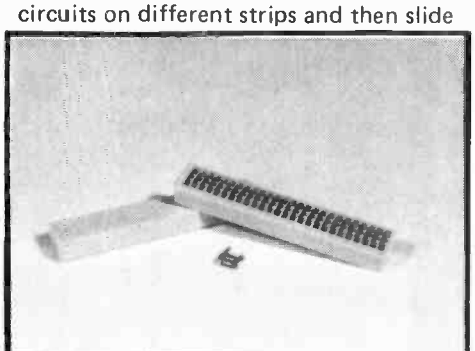


Fig.3. The connecting strips do not have any sort of protective covering on the bottom. This isn't a problem if you keep them in the tray.

Continued on page 74.

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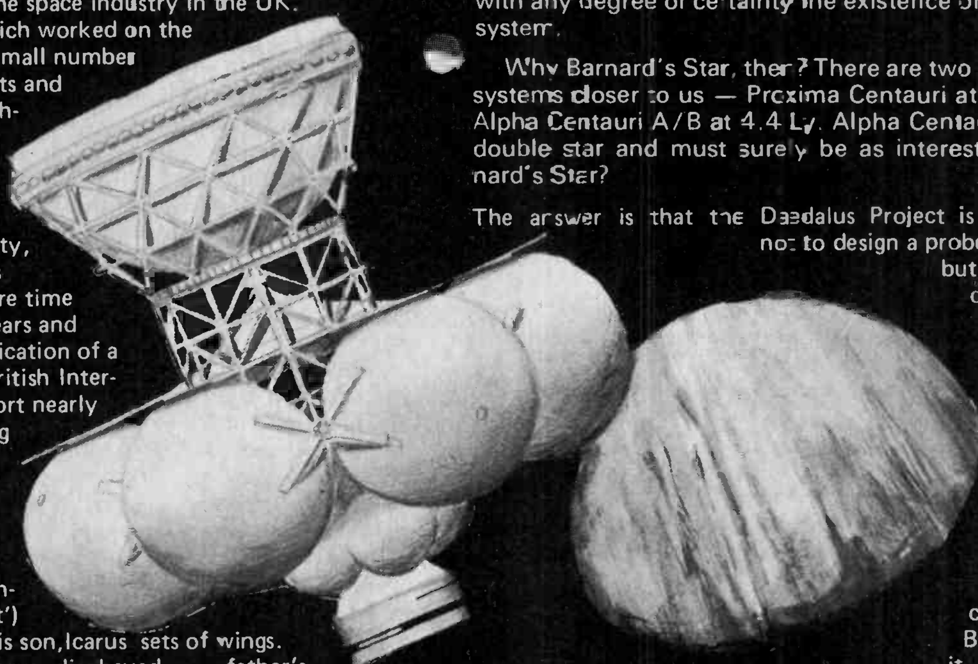
PROJECT DAEDALUS:
Flight of fantasy, or fantastic flight?

Recently the British Interplanetary Society published a report on 'Project Daedalus'. It was nearly 200 pages long and took five years to write. It's packed with detailed calculations for the design of an interstellar craft. These show that the capability is almost within our grasp. Phil Cohen analyses the results of the report.

THE DAEDALUS PROJECT is the brainchild of the British Interplanetary Society, founded in 1933 with the aim of advancing the space industry in the UK.

The 'study group' which worked on the project consisted of a small number or professional scientists and engineers from establishments such as the UK Atomic Energy Authority; British Aircraft Corporation, RAF and City University, London. The work was carried out in their spare time over a period of five years and culminated in the publication of a JBIS (Journal of the British Interplanetary Society) report nearly two hundred pages long which contained a summary of the results of the study!



The name Daedalus is from the Greek . In legend, Daedalus (meaning 'cunningly wrought') built for himself and his son, Icarus sets of wings. During their flight, Icarus disobeyed father's instructions and flew too close to the Sun. The wax holding his wings together melted and he was killed. Daedalus however, reached his destination without mishap!

The Daedalus craft is an unmanned interstellar probe whose purpose is to gain information about nearby stellar systems — and especially to search for planets, which may contain the first alien life we contact.

The Mission

The mission of the probe is to accelerate to about 12% of the speed of light (which works out at 3.6×10^7 m/s, or 20 000 miles per second!) and fly past Barnard's Star (5.91 light years (Ly) away — about 50 years at 20 000 miles per second), dropping probes which will collect data about the star and its (possible) planetary system. This information would then be transmitted back to Earth.

Barnard's Star is not definitely known to have planets. Recent observations have shown that the star 'waltzes' slightly — suggesting that its 'dancing partner' is a massive planet somewhat similar to Jupiter. This 'waltz' is, however, not pronounced enough to prove with any degree of certainty the existence of a planetary system.

Why Barnard's Star, then? There are two other stellar systems closer to us — Proxima Centauri at 4.3 Ly and Alpha Centauri A/B at 4.4 Ly. Alpha Centauri A/B is a double star and must surely be as interesting as Barnard's Star?

The answer is that the Daedalus Project is an attempt not to design a probe completely but to provide a design framework for further studies. The design team considered that if it was possible to use a Daedalus-craft to reach Barnard's Star it should be possible to reach Alpha Proxima Centauri also.

One major consideration in deciding on the actual 'mission' chosen was that it had to yield some sort of results within a human lifetime. This was because it was considered unlikely that any state would under-take a longer-term project!

The first twenty years of the project would be spent designing, building and fuelling the craft in orbit around Jupiter (for reasons which will become apparent later). The craft would then accelerate out of the Solar System for 2 years, at which time the first stage would be dropped to save weight. The second stage would then take over for another 1.8 years, accelerating the craft to its final, awesome speed.

There would then come a 40-year wait, with the craft transmitting only data about the interstellar medium — the dust concentration, for instance, which would be invaluable for the design of later craft.

At the end of this period the craft would be close have to fly past the star itself as well as any planets, which may be at wide orbits. The decisions about which direction to send each probe would be taken by the main computer on board the craft. As radio waves would take about 5 years to reach Earth from the ship by this time (and thus a ten-year wait for a reply!), *all* decisions would have to be taken by the ship's computer.

As the craft reached the outer limits of the system, the probes would begin to send back information to it. It would relay the information back to Earth, the total transmission time being about 3 years — the beginning of the message would still only be half-way home when the craft stopped transmitting!

The Craft

The Daedalus probe has a two-stage engine, the first stage being dropped to save weight when its fuel is finished. These two stages propel the payload of smaller probes, computers for controlling the mission, communications and other equipment.

The first stage weighs over 40 000 tonnes fully fuelled and is about 150 metres long and 190 metres wide. It consists only of a giant motor and six spherical fuel tanks. It 'burns' for about two years continuously at the start of the mission. The designers also took into account which materials would be used for the craft's construction — the materials used for the engine's reaction chamber, for instance, have to stand temperatures from 3°K (3 degrees centrigrade above absolute zero) to 1600°K. This means using an exotic alloy. The one chosen was molybdenum with titanium, zirconium and carbon, internally nitrided — you don't come across alloys much more exotic than that!

The fuel tanks are dropped during the course of the 'burn' to save weight. As they weigh over 16 tonnes each this is quite a saving. Remember, the fuel is being used up also — the first stage itself, without fuel and tanks, weighs only 100 tonnes.

The second stage is almost the same as the first, except that it's about 1/10th of the mass and about ½ the size. It has four fuel tanks which are also disposable and carries the payload bay. This is about 30 metres long and about 50 metres diameter. It holds (starting at the front) an erosion shield to protect the craft from interstellar dust erosion, the eighteen disposable self-propelled probes, the main telescopes, the communications equipment and computers and the 'wardens'.

As the craft will be on its own for some decades, and as only the most optimistic would expect there to be no failures on board during all this time, it is necessary to have some form of automatic repair. This is where the wardens come in. Controlled by the main computers, they are multi-purpose self-propelled robots, flexible enough to perform any repa.. or replacement necessary (within reason). The ship would also carry a large complement of spares — hopefully, the wardens wouldn't have to build anything from scratch.

The ship would be 190 metres long at launch and would weigh over 54 000 tonnes — that's a lot of mass to get moving!

The Propulsion System

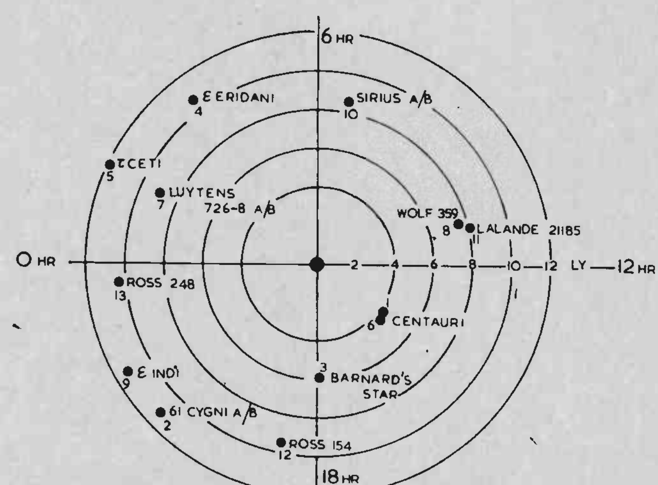
The starship is propelled by a series of very small nuclear fusion explosions, occurring at a rate of 250 per second.

Earlier systems had been proposed by other groups which suggested using conventional atomic bombs ejected from a craft carrying an immense 'pusher plate'. The momentum from the explosions would be transferred from the pusher plate to the craft at a reasonable rate via a pneumatic spring system. This type of system was dropped because of the required size of the vehicle, "the limitations imposed by the nuclear test-ban treaty and the difficulty of testing the system."!

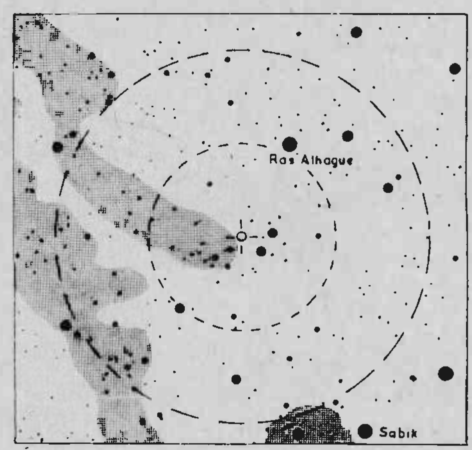
The Daedalus propulsion system contains the energy of the explosions in a very strong magnetic field and releases it between explosions by squirting out the explosion products at an exhaust velocity of about 10^7 m/s.

The fuel for these explosions is a mixture of isotopes of hydrogen and helium in a solid fuel 'pellet' about 10 to 20 mm across. These are stored in fuel tanks at a temperature of 3°K (3°C above absolute zero) to keep them from melting!

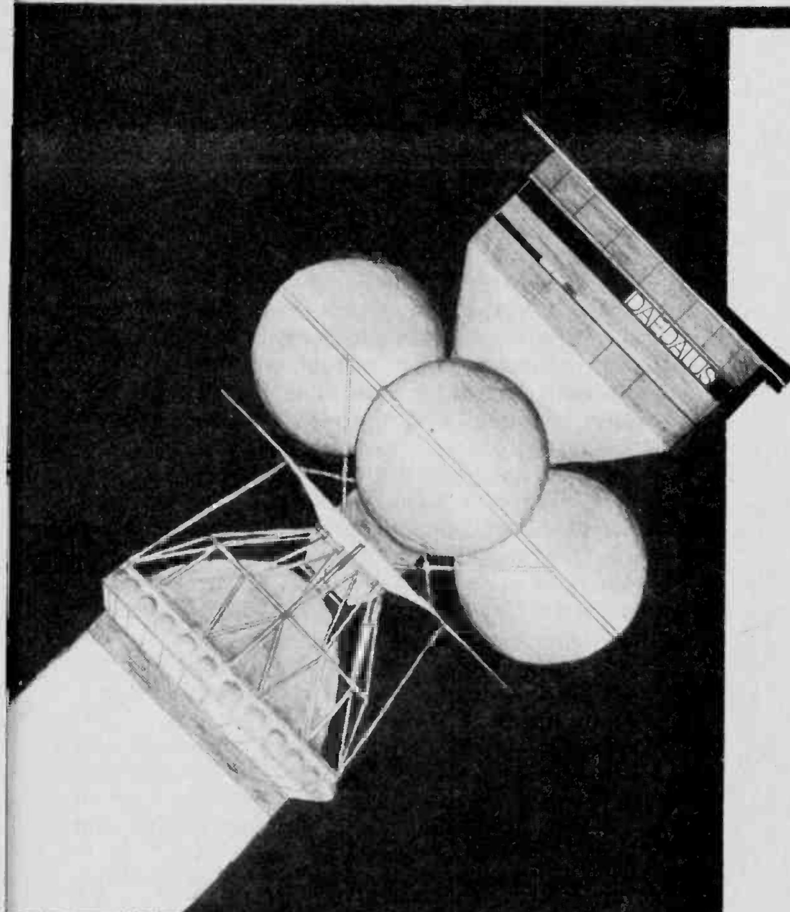
The pellet structure consists of a thin hard coating and a honeycomb centre. The coating is made of a superconducting material. This makes it posible to shoot the pellets into the reaction area by magnetic means at an acceleration of about 10^6g. This phenomenal acceleration is necessary so that they can cross the gap between the pellet ejection system and the ignition point between the time when the



The positions in space of the stars closest to the sun. The figure beside each star is it's 'interest' ranking. These were arrived at by taking into account the distance, the 'uniqueness' of thestar (how frequently similar types occur) and the probability of habitable planets. The obvious choice for a mission would be Alpha Centauri but the probe was designed to reach Barnard's Star for good measure.



Barnard's Star as seem from the Earth. Unfortunately it's not visible to the naked eye. It appears in the constellation of Ophiuchus.



last explosion has died down and the next one is required to start. As this happens 250 times a second, this crossing has to be fairly fast.

Once at the ignition point, beams of high-energy electrons are shot at the pellet. This vaporises the outer shell instantaneously, which increases the pressure and temperature of the centre to the levels required to ignite fusion. The ignition is helped by a 'trigger' particle in the centre.

The expanding plasma is trapped by immensely strong magnetic fields set up by two coils surrounding the engine. The coils generate a peak field intensity of around 14 Tesla and are cooled by liquid helium flowing through the hollow conductors to keep the temperature down to 4°K. The field is deformed by the explosion and (hopefully!) contains it and keeps it within the reaction chamber — exactly like the 'magnetic bottle' which can be used to contain nuclear fusion reactions in terrestrial fusion power generating stations.

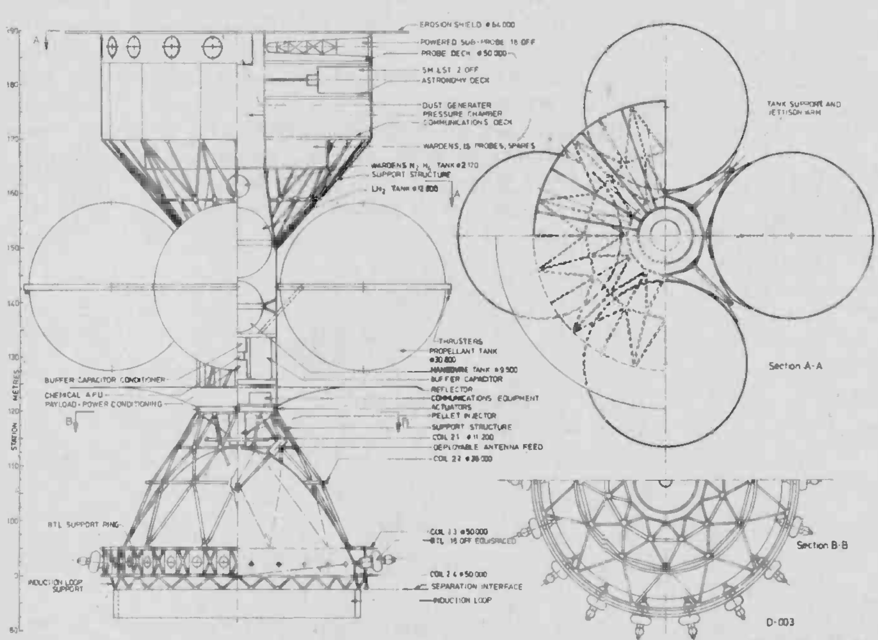
One of the reasons for choosing the particular fuel used is that very little of the reaction energy is released as neutrons. This means that the engine is relatively 'cold' (in radioactive terms only!), as the electrons and protons from the reaction can be trapped magnetically, whereas neutrons cannot. This lack of neutrons means that very little shielding is needed to protect the rest of the ship — a weight saving.

Unfortunately, the fuel is rare on Earth and this brings its own problems. For the entire mission, about 3×10^{10} fuel pellets would be required — with a total mass of around 50 000 Tonnes. This would consist mainly of 30 000 Tonnes of helium-3 and 20 000 Tonnes of deuterium. As these are both very rare they have to either be produced artificially on Earth or 'imported' from elsewhere.

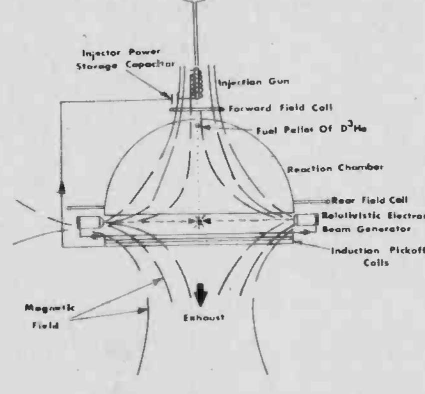
Mining Jupiter

One possible source of suitable fuel — the largest such source in the Solar System — is the atmosphere of the planet Jupiter.

While just *getting* to Jupiter would be a major feat and the prospect of setting up factories around Jupiter to produce 50 000 tonnes of propellant seems daunting the reports points out that once mining' had started, the fuel produced could be used to fuel power station reactors on earth. The mining may well have been



A diagram of the second stage. This is similar to the first stage but carries the payload — a package of smaller probes to be deployed near the end of the journey.



The Daedalus propulsion system. This works by controlled nuclear fusion explosions. Solid pellets of a hydrogen isotope mixture are fired on by electron beams and a magnetic field contains the blast. See the text for full description.

started due to economic pressures by the time a Daedalus-type probe is built.

As Jupiter has no solid surface, the factories could not be built *on* Jupiter but they could be built *in* Jupiter.

One possible design for such a factory would be a giant 'hot air balloon' filled with jovian atmosphere heated by the factory's waste energy.

The skin of the balloon would be woven of carbon fibres or a similar material. It would be 200 odd metres in diameter.

The factory would float in Jupiter at a level which had a pressure equal to the pressure of earth's atmosphere. Unfortunately, this would put it in Jupiter's weather which has been observed to generate 90 m/s winds! Not ideal conditions for a balloon. The *vertical* atmosphere currents are an unknown quantity but may be even worse. The report suggests sending an atmospheric probe to study the conditions — this could probably be done using present technology.

Another little problem is how to inflate the balloon when it is initially dropped into Jupiter. One solution to this would be to fuel it with about twelve tonnes of liquid oxygen — which would burn nicely in the hydrogen-rich jovian atmosphere.

The factory itself would hang free of the balloon, with it's waste heat directed through a funnel into the neck of the balloon. It would weigh over 100 tonnes. About 128 complete factories would be used in total. These would probably be unmanned. With a 12-second communications gap between the factory and an orbiting platform there would probably have to be a fair degree of autonomy in the factory computer's operation.

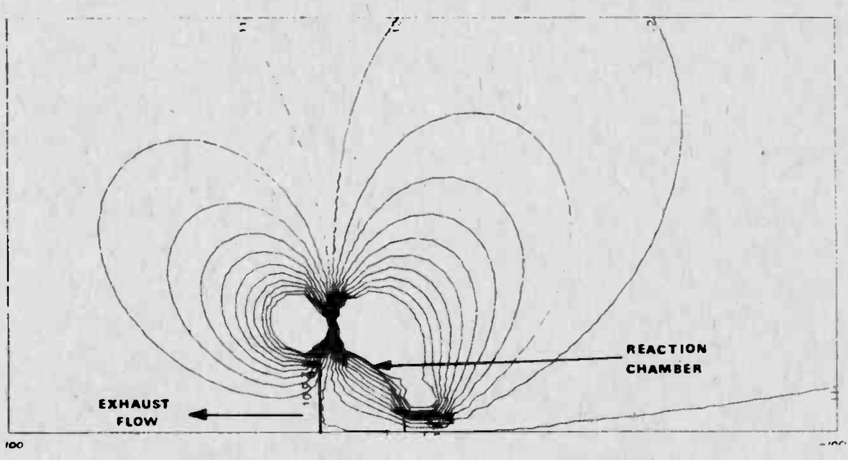
The alternative—manning the factories—may, if it proves necessary, be the future equivalent of North Sea Oil drilling, with massive wages and long, dangerous shifts. It wouldn't be possible to fish someone out of Jupiter, though, if the factory collapsed!

The conditions encountered in space would provide problems for the Daedalus probe also, as it sped through space at 12% of light speed.

Probe Debris Protection

The chunks of rock which plague Han Solo and his ilk by ploughing through the walls of spacecraft during gaps in the plot are not as numerous in interstellar space as was once imagined.

The fuel pellet structure. The superconducting shell enables the pellet handling system to fire the pellet into the reaction area, where the boiling of the deuterium coat generates enough pressure to detonate the 'trigger' pellet. Each fuel pellet is 1 to 2 cm in diameter.



In the main, the matter which will be encountered between stars consists of ionised and neutral hydrogen clouds and very fine dust grains.

The average mass of the grains is thought to be about 0.1 pg (or 10^{-16}kg). While this is not exactly enormous, the craft will hit quite a large number of them, all at a velocity of 20 000 miles/second!

There are two problems to be countered — the heating effect of the ionised gasses (as large numbers of high energy protons and electrons hit the vehicle) and the erosion caused by the impact of the dust. The designers predict that the erosion shield of the probe will reach a temperature of 193°K — well within reasonable limits.

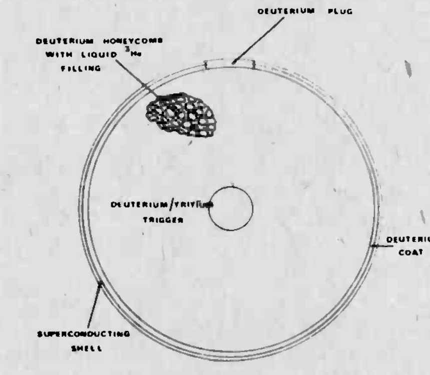
The material used for the shield will probably be boron and the report concludes that a thickness of 9mm of boron will survive dust erosion long enough to protect the vehicle from the X-rays produced by the impact of protons and electrons (and of course the protons and electrons themselves) during the course of the entire coast period.

When the probe reaches the Barnard's Star System, however, it will encounter the same problem again, but on an entirely different scale.

The target system, if it's anything like our own, will be full of all manner of junk — ranging from material the same size as the interstellar dust all the way up to asteroids weighing up to 10^{12} tonnes! Of course, the likelihood of meeting something large is small, so to speak. The designers of the probe took as a target protection against a 0.5 tonne object.

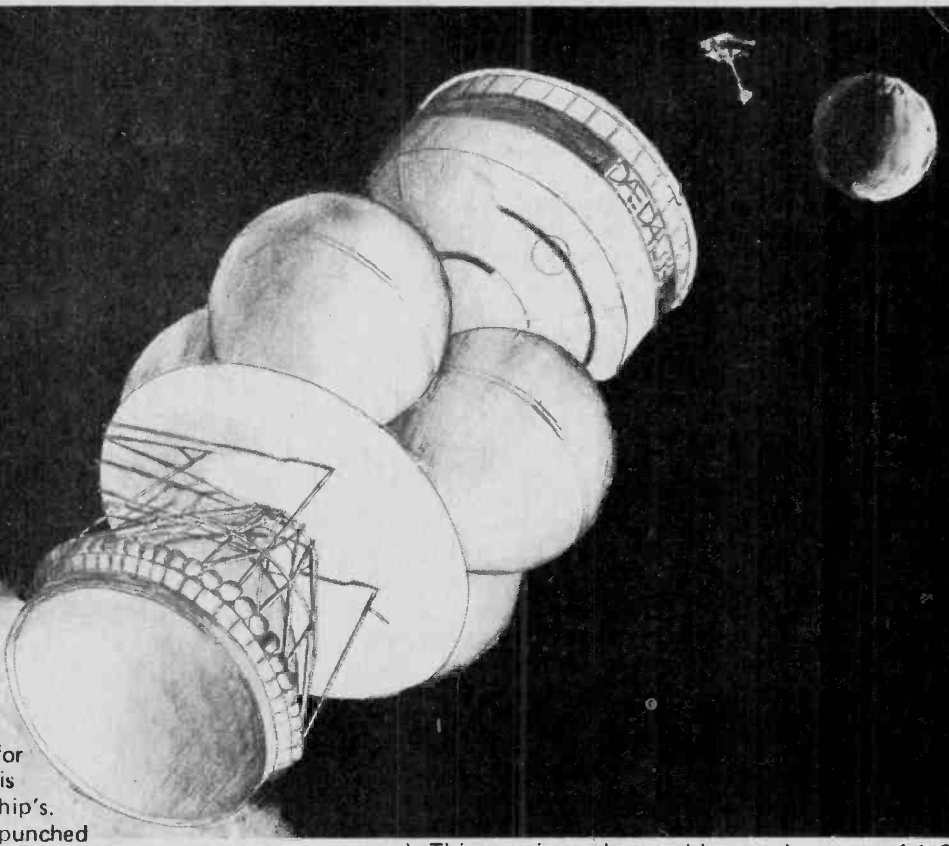
To protect the vehicle against half-tonne rocks coming towards it at 20 000 miles per second is not as difficult as it sounds, luckily! The system used is to fly a small chemically-propelled vehicle about 200 km ahead of the main probe and use it to deploy a smoke cloud about 100m thick and with a total mass of 6 kg. While this seems rather insubstantial, the calculations show that anything under 500 kg will be totally vaporised on meeting this cloud and that the expanding vapor will be too thin to harm the vehicle when it passes through it, 200km behind the smoke cloud and 0.005 seconds later. It seems that you can stop anything if only it's moving fast enough!

A similar method would be used to protect the smaller probes which are shot into other parts of the target system. The probe couldn't really be said to fly past the Barnard system — it punches several holes in it and flies *through* it!



A computer-generated cross-section of the area around the reaction chamber, showing the magnetic field profile. The peak field generated in the coils would be about 14 Tesla

GAVIN ROBERTS



Subprobes

Most of the information to be gained about the target system will be via the 220 tonnes of smaller probes the mother ship will carry. These will be 'launched' some distance from Barnard's Star and will follow carefully-planned trajectories through the system, transmitting information back to the main vehicle.

The probes (18 in all) would be designed' 5 for stellar physics etc. terrestial plants, for specific tasks — 3 for They would each contain a debris protection system similar to the main ship's. In fact, there would be nineteen holes punched in the target systems detritus! There is an important principle in physics which states that you can't study anything without changing it — that's certainly true here.

The Daedalus craft would also carry five 'interstellar medium probes' for finding the shape of variations in dust concentrations, for example. These would be spread around the mother craft (three at a time, with two in reserve) at a distance of 1000 to 10 000 km. When the craft flies through the edge of a cloud of dust, the information from all four sources (including the main vehicle) would give information about the shape of the edge and how the dust varied throughout the cloud.

Communications

Naturally, it will be useful for the probe to be in contact with the earth at all times — it should be capable of sending information back and receiving major 'policy change' messages.

During the boost phase, a large plume of plasma (dissociated sub-atomic particles) will trail the vehicle, making microwave communications impossible. For this reason the probe will carry a communications laser for use during the early period of the mission. This system will have a bandwidth (frequency response) of 20 kHz and a range of one light year (20 000 miles / second over one year). This requires a laser with a peak power of 1.3 MW, operating in the infra-red (which the plasma would be transparent to).

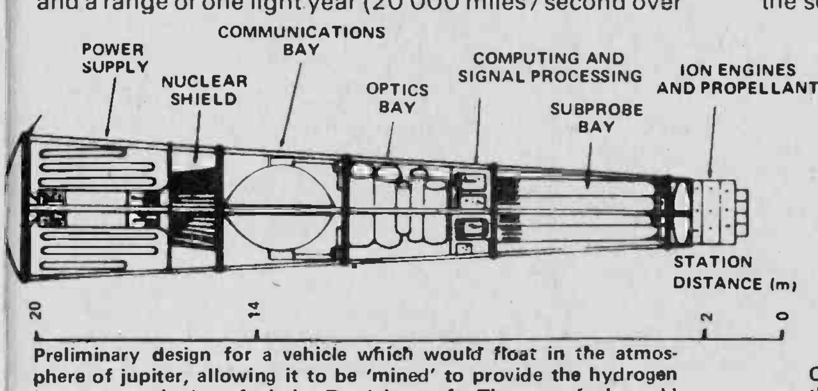
When the boost phase finishes, the craft will deploy a microwave transmitter / receiver which will be mounted in what was previously the reaction chamber, using the chamber to focus the microwaves. This would operate at 2.24 — 3.02 GHz and would have a data rate of 864 k baud (864 000 bits / second). The range would be about seven light years — sufficient for the 'Post-encounter' transmissions of data about the interstellar medium on the far side of the targer system. One thing which had to be taken into account in designing the system was that transmissions would be received at a lower frequency due to the Doppler effect!

Less powerful transmitters and receivers would also be required for communication with the disposable probes and the wardens.

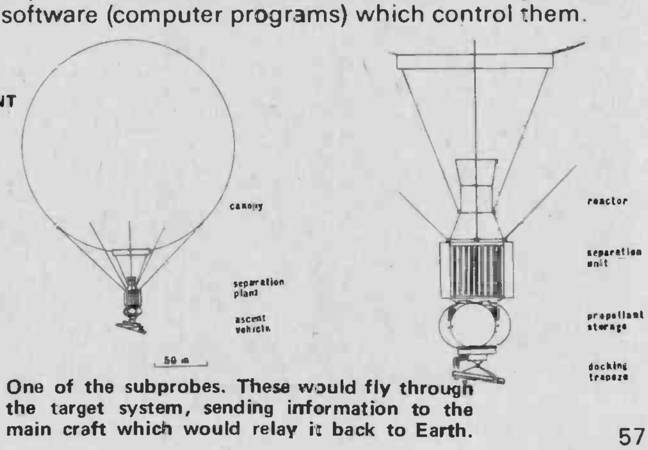
The Computers

Perhaps the one aspect of the Daedalus project which will require the greatest extension of present-day capabilities is the self-repair function.

The concept of the multi-purpose 'warden' robots is all very well but these are, after all, only as intelligent as the software (computer programs) which control them.



Preliminary design for a vehicle which would float in the atmosphere of jupiter, allowing it to be 'mined' to provide the hydrogen isotopes required to fuel the Daedalus craft. The same fuel would be ideal for the production of 'clean' fusion energy for use on Earth.



One of the subprobes. These would fly through the target system, sending information to the main craft which would relay it back to Earth.

All the way through the report the wardens crop up as a sort of *deus ex machina* for repair and even improvement of the craft.

As was mentioned before, the speed of radio waves limits the amount of control from the earth to an absolute minimum. The report shows, by extrapolating data from military and commercial aircraft, that a long flight without on-board repair is not feasible.

This means, in effect, that before the project is undertaken there must be a major advance in the state of what is known as 'artificial intellegence'.

The ability of modern computers to deal with predictable repairs — items which will inevitably wear out in a certain way — and such other tasks as will be known in advance is probably adequate when projected to the mission date. However, the complete inability of software as it stands at present to deal with a) un-predictable events and failures and b) failures *in the software itself* is discouraging.

Then again, looking back at the advances in computing in the last few years . . . who knows?

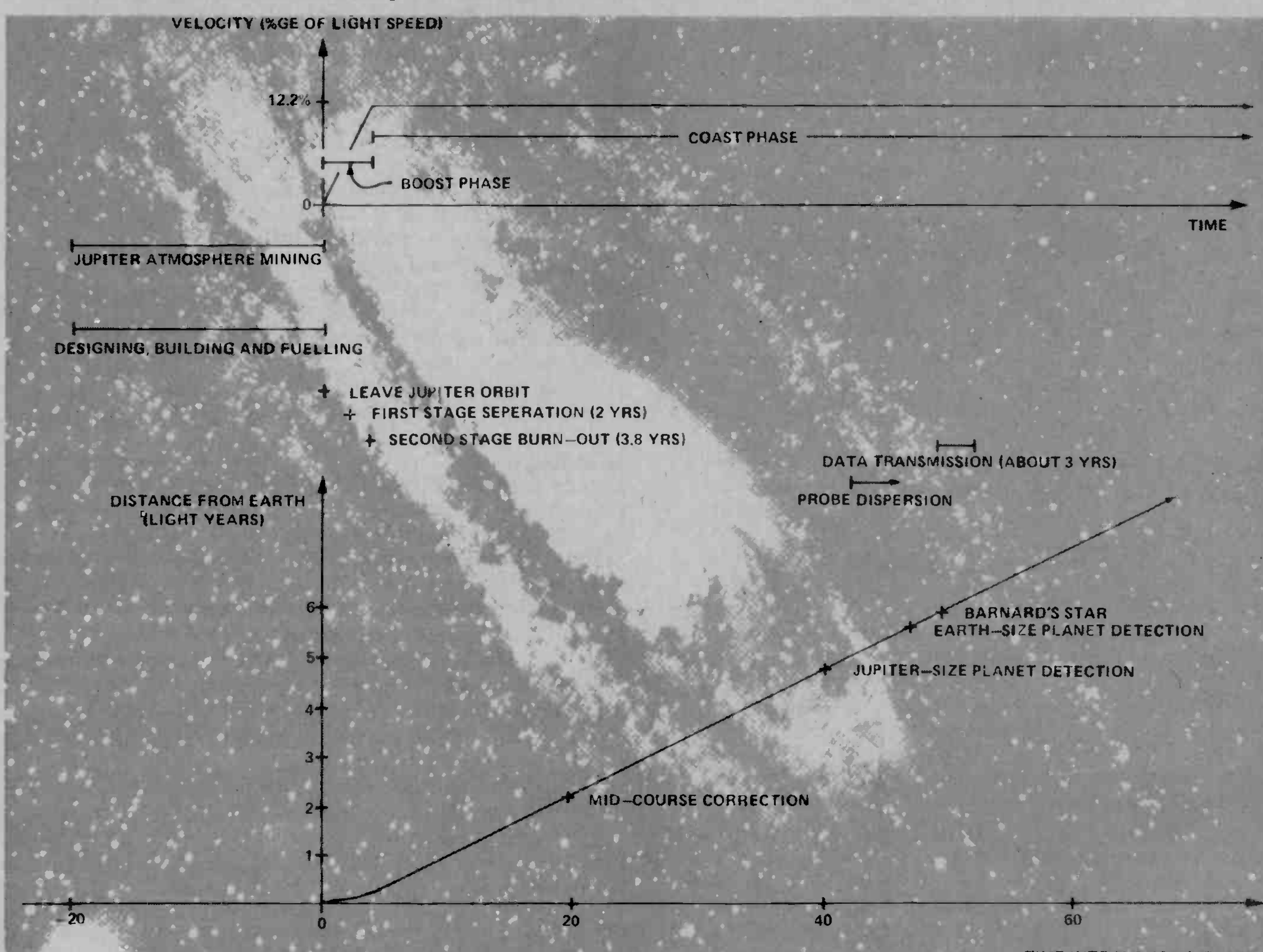
The memory capacity of the system, calculated from the amount of information to be stored during flypast for transmission back to earth, is about 3 x 10^{10} bits. Using the latest in high density information storage — the magnetic bubble memory — this would require about 200 000 integrated circuits, weighing 1½ tonnes!

Summary

The Daedalus Project report makes fascinating reading. What is most impressive is the level of *detail* to which everything has been thought out. For instance, the material used for the insulators in the electron beam generators (part of the engine) was chosen to be Berylia, which has the required mechanical and electrical properties. The mere fact that the designers have gone into such detail lends the report much credibility.

The whole thing is written in a clear (if highly technical) manner with references to all sources of data — all in all a very impressive work — but what use is it?

The report will have several effects. One will be to swell the ranks of the British Interplanetary Society — not a bad thing. Another may be the serious consideration at some time in the future of a Daedalus-type project. It's worth noting that the same society produced a feasibility study on a lunar mission some *thirty years* before Appollo 11! ●



INFRA RED REMOTE CONTROL

Just a few suggestions. Applications are limited only by imagination

A state-of-the-art project that lets you turn any electrically powered device on and off via a remote control transmitter. The device uses an infra-red data link and has a useful range of around 30 feet.

THIS REMOTE-CONTROL PROJECT can be used to turn any electrically powered device, such as a radio, TV, heater, etc., on and off from ranges up to 30 feet, provided that the remote device is in the line-of-sight of the operator. The project uses an infra-red remote control 'link' and, unlike most other types of remote control system, does not need an operating license, has no trailing wires to trip the unwary, is not susceptible to acoustic interference and does not generate radio or TV interference.

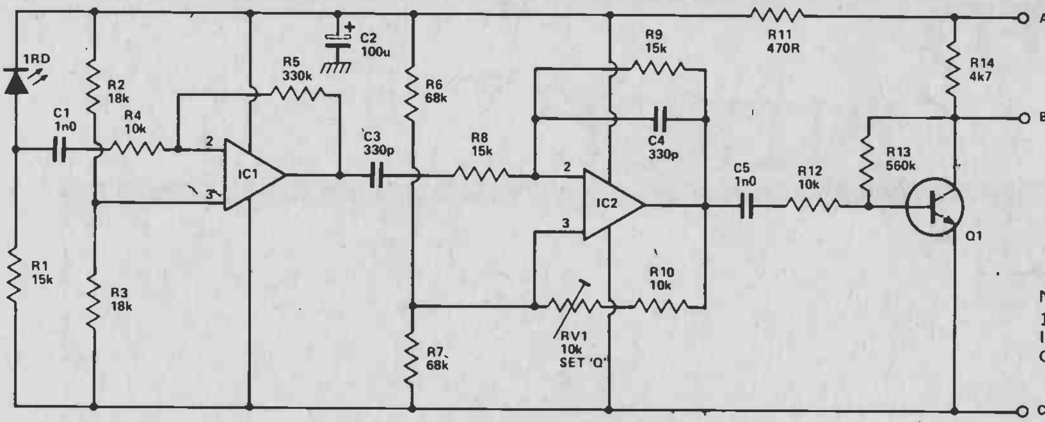
The control system consists of two separate units, a hand-held infra-red transmitter and a remotely-located line powered infra-red transmitter and a remotely-located relay output. The relay output terminals are used as a 'switch' that makes or breaks the power feed to the device (radio, TV, etc) that is being controlled. The transmitter unit contains only one control, a press-button switch, which connects battery power to the circuit which causes a coded high-efficiency infra-red beam to be generated. This invisible beam is aimed at the receiver and causes its output relay to change state, thereby giving an alternate ON-OFF-ON relay switching action via the transmitter.

We've taken a lot of trouble with this project to ensure that the system has both good range and high reliability, ie, high sensitivity but excellent rejection of spurious and unwanted electrical and optical signals. This has resulted in fairly complex circuitry in both the transmitter and the receiver. Consequently, the project is not suitable for the absolute beginner, but can be tackled with reasonable confidence by the novice with a moderate amount of constructional experience. The complete system uses only two pre-set controls, and can be set up without the use of test gear.

Construction: The Transmitter

All components except the two infra-red LEDs and PB1 and the battery are mounted on a single PCB. Take special care to observe the polarities of all semiconductor devices and the electrolytic capacitors when assembling the components on the PCB. The two ICs should be mounted in low-level holders and all components should be mounted close to the board.

When construction of the PCB is complete, drill two ¼ inch holes in the hinge-end of the flip-top Vero case, with each hole roughly ⅜ inch from a corner of the case. Now fit the two IR LEDs into place in the holes using standard 0.2 inch LED mounting clips and connect the cathode of LED 1 to the anode of LED 2. Fit the PCB and the battery into the case, after carefully double-checking all PCB connections, using sticky fixers. Complete the two connections to the IR LED's and the connections to the battery and the PB1 push-button switch.



NOTES:
1RD is SFH 205
IC1,IC2 are CA3140
Q1 is 2N3904

Fig.1. Circuit diagram of the IR receiver section.

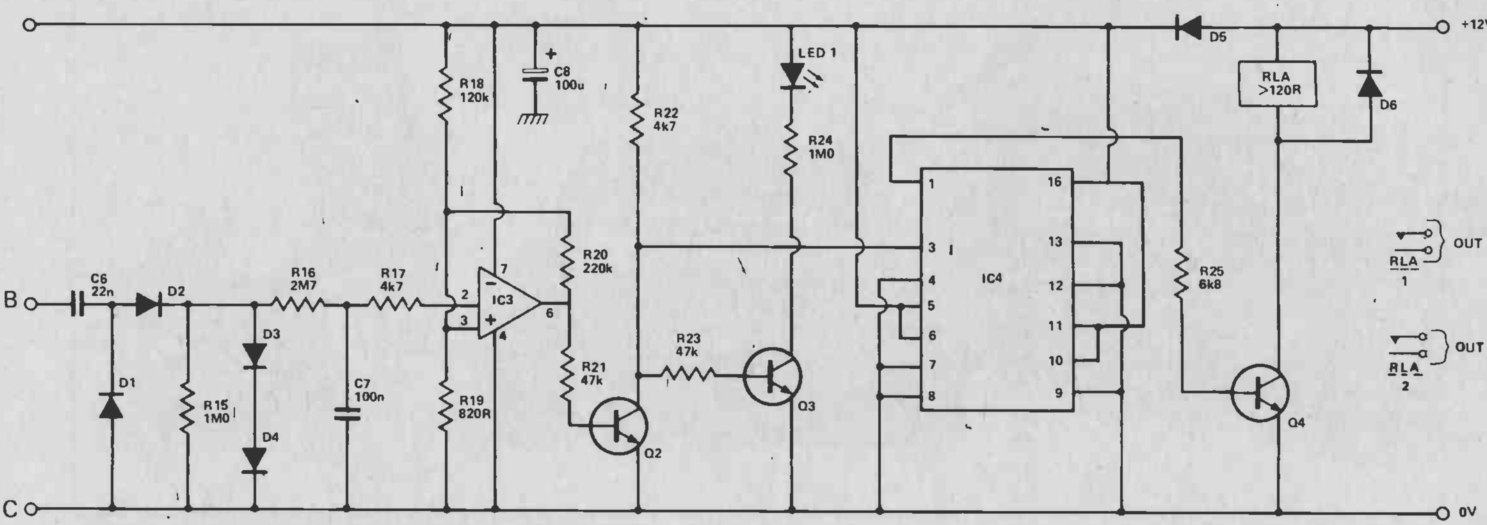
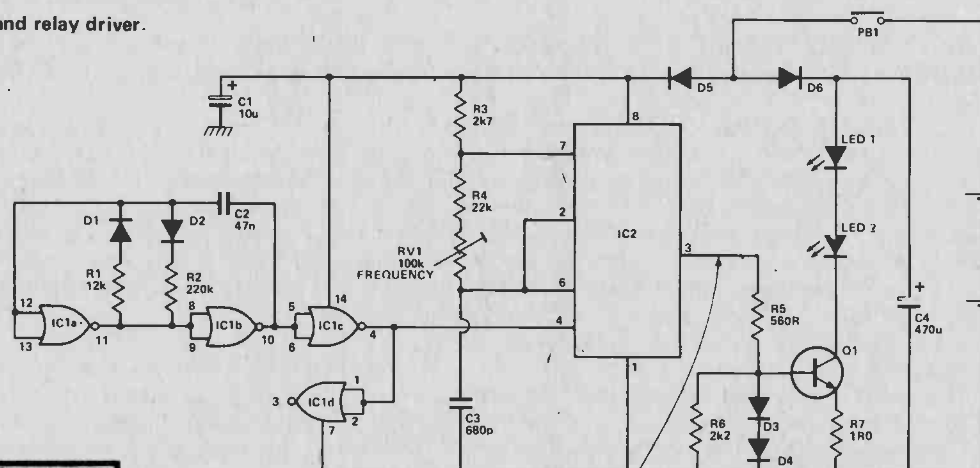
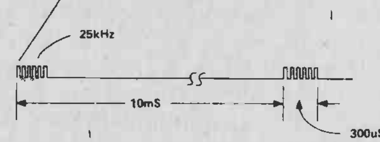


Fig.2. Circuit diagram of the receiver decoder and relay driver.

NOTES:
D1—D4 are 1N4148
D5—D6 are 1N4001
Q2—Q4 are 2N3904
IC3 is CA3140
IC4 is CD4027B

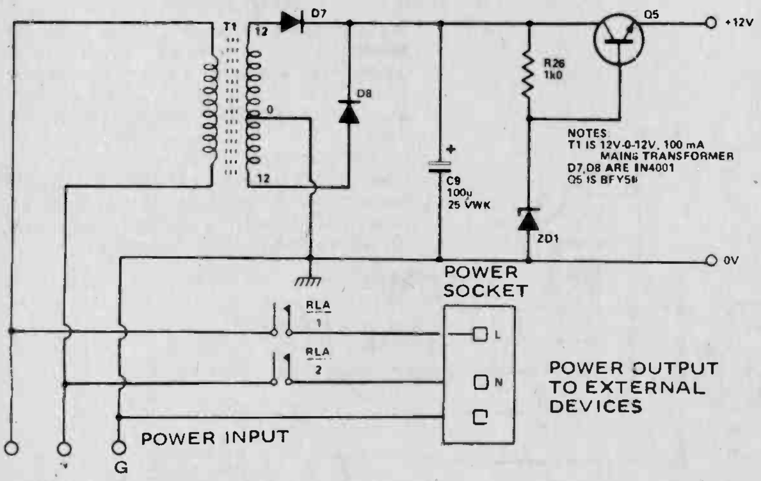
Fig.3. Right. Circuit diagram for the Intra Red control transmitter.

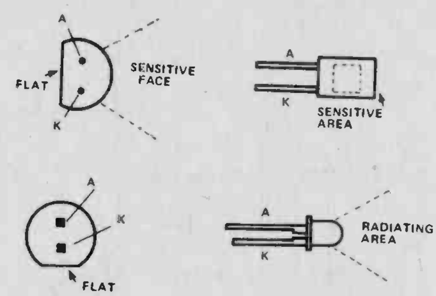




NOTES:
D1—D4 are 1N4148
D5—D6 are 1N4001
Q1 is 2N1893
IC1 is CD40018
IC2 is 555
LED1 — LED2 are LD271

Try connecting the IR control unit up to a cassette player.





NOTES:
T1 Is 12V-0-12V, 100mA Transformer
D7,D8 are 1N4001
Q5 Is 2N1893

Fig.4. Above. Connection diagram for the PSU and relay switching circuitry.

HOW IT WORKS

THE RECEIVER

The receiver circuit can be broken down into three distinct sections, a high-gain non-inductive selective pre-amplifier, a signal detector and a bistable relay driver. The coded infra-red signal beam is initially picked up by a detector diode IRD and appears as a very small signal voltage across R1. The high frequency (greater than several kHz) components of this signal are passed through the IC1x33 voltage amplifier and then fed to IC2.

IC2 is a Wein selective amplifier that is fixed-tuned (via C3-R8 and C4-R9) to approximately 25-30 kHz. The transmitter circuit is also tuned to this frequency, so IC2 enables the receiver to discriminate between wanted and unwanted signals. The 'Q' or tuning sharpness of the circuit is adjustable via RV1:R6 and R7 form part of the Q-adjustment circuitry and must have the values shown. Note that, unlike most inductivity-tuned selective amplifiers, this circuit is not susceptible to interference from radiated electrical signals. The output signals from IC2 are passed on to Q1, where they are further amplified and made available at terminal 'B' of the pre-amplifier.

The output signals from the 'B' terminal of the pre-amplifier are rectified by D1-D2 and amplitude-limited by D3-D4. The resulting DC voltage is passed on, via integrating network R16-C7, to the input of regenerative voltage comparator IC3, which switches low when its input signal exceeds a hundred millivolts or so. Because of the integrating action of R16-C7, however, the input of IC3 goes adequately high only when the 'B' output of the pre-amplifier is continuously present for a period in excess of 200 mS or so, thereby ensuring that the circuit rejects spurious or transient signals.

As the output of IC3 switches low it turns Q2 off and causes Q2 collector to switch high. As the collector switches high it drives Q3 and LED 1 on (thus giving a visual indication of the switching action) and simultaneously feeds a single 'clock' pulse (a rising edge) to bistable IC4, which then changes state and in turn changes the state of the relay via Q4. Thus, the relay switches from the OFF to the ON state, or visa versa, each time a coded transmission signal is received, provided that the transmission signal is of adequate strength and has a duration greater than 200 mS or so.

The complete receiver circuit is powered from a 12 volt supply derived from a simple power pack. The circuit draws 100mA or less when the relay is on The relay contacts are used to make or break the line connections to external devices such as radios, TVs, etc.

HOW IT WORKS

THE TRANSMITTER

An invisible infra-red beam can be generated by passing a current through a suitable infra-red light emitting diode (IR LED). The strength of the beam is proportional to the magnitude of the energising current and to the number of LEDs used. To produce a beam adequate to cover our specified 30 foot range it is necessary to pass peak currents of about 500 mA through two series connected LEDs as shown in our transmitter circuit.

An important point to note here is that it is possible to produce these high peak currents while drawing only a low mean current from the supply battery. In our circuit we achieve this by rapidly pulsing the IR LED current on and off at a 25 kHz rate for a brief 300 uS period once in every 10 mS, thereby giving a total on time of only 150 uS in every 10 mS period. This technique has two useful effects. First it reduces the mean current consumption of the IR LEDs to 500 mA x (150uS/1000uS) = 7.5mA while still giving the required 500 mA peak current. Second, it enables the infra-red beam to be frequency coded, so that the receiver can distinguish it from other (unwanted) sources of infra-red radiation.

The transmitter circuit comprises two distinct sections, with IC1 and IC2 acting as a waveform generator and Q1 and its associated components acting as a high-current IR LED driver. When PB1 is closed, the battery supply is independently connected to the waveform generator circuit via D6-C4 this form of connection prevents undesirable intereaction between the two circuit sections.

In the waveform generator section, IC1a to IC1c are wired as a buffered-output non-symmetrical astable multivibrator that produces ON and OFF times of 300 uS and 10 mS respectively. IC1d is unused. The output of IC1 is used to gate IC2, which is wired as a 25kHz (nominal) astable: the frequency of this astable is variable over a limited range via RV1. The circuit diagram shows the waveform that is produced at the output of IC2. This waveform is used to drive constant-current generator Q1 via the R5-R6-D3-D4-R7 network. The IR LEDs (LED1 and LED 2) are wired in series with the collector of Q1 and derive their high peak currents from storage capacitor C4.

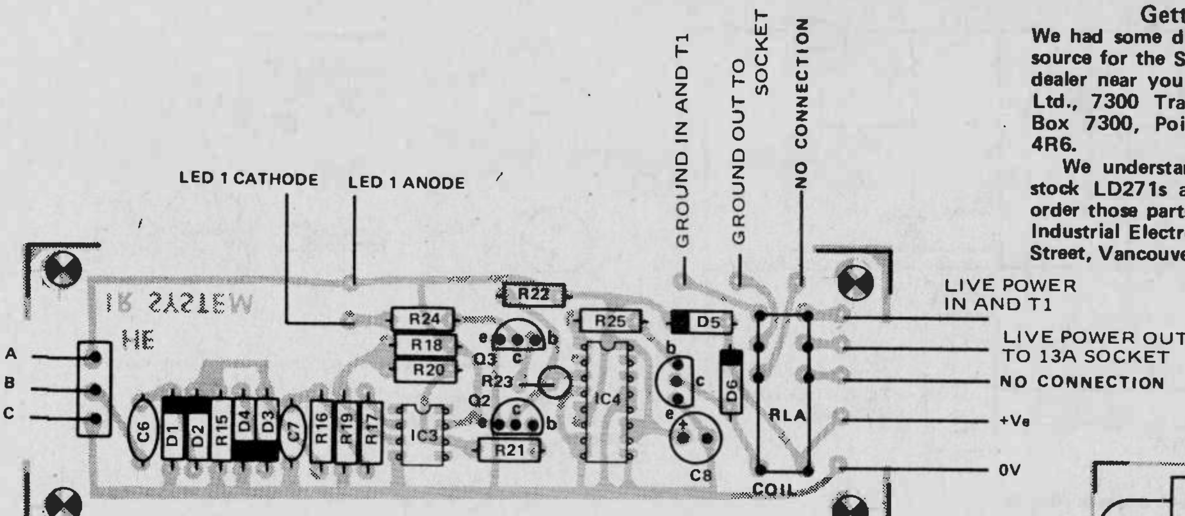


Fig.5. Overlay for the decoder, relay driver.

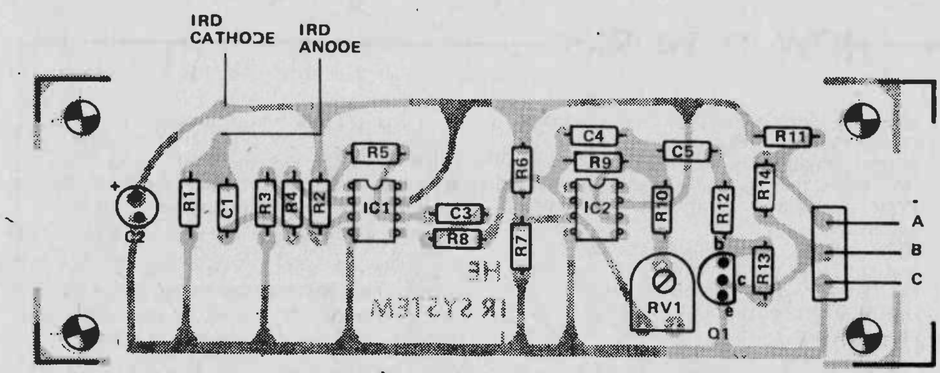


Fig.6. Overlay for the IR receiver section

Getting the LEDs

We had some difficulty finding a reliable source for the Siemens components. For a dealer near you write to Siemens Electric Ltd., 7300 Trans-Canada Highway, P.O. Box 7300, Pointe Claire, Quebec H9R 4R6.

We understand that while they don't stock LD271s and SFH205s, R-A-E will order those parts for you. Write to R-A-E Industrial Electronics Limited, 1629 Main Street, Vancouver, B.C. V6A 2W5.

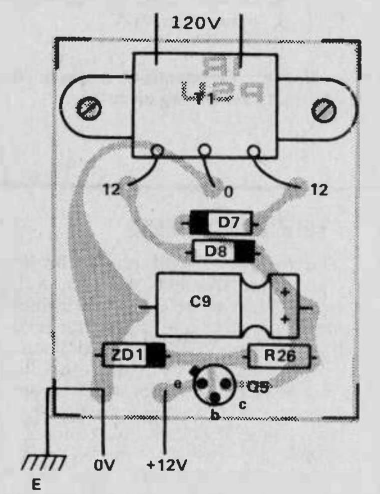


Fig.8. PCB foil pattern for the receiver PSU

PARTS LIST

IR Remote Control Switch
RESISTORS (all ¼W 5%)

R1	12k
R2	220k
R3	2k7
R4	22k
R5	560R
R6	2k2
R7	1R0

POTENTIONMETERS

RV1	100k sub-min preset, horizontal mounting

CAPACITORS

C1	10u 35V tantalum
C2	47n polycarbonate
C3	680p polystyrene
C4	470u 10V electrolytic

SEMICONDUCTORS

IC1	4001B
IC2	555
Q1	2N1893
D1 -D4	1N4148
D5–D6	1N4001
LED 1,LED 2	LD271 (Siemens)

MISCELLANEOUS
PB1, push button (momentary action)
9V Battery
Vero flip top case, order No. 202-21317D

Receiver Preamplifier
RESISTORS (all ¼W 5%)

R1, 8, 9	15k
R2, 3	18k
R4, 10, 12	10k
R5	330k
R6, 7	68k
R11	470R
R13	560k
R14	4k7

POTENTIONMETER

RV1	10k Sub min. Horizontal preset

CAPACITORS

C1, 5	1n0 polystyrene
C2	100u 25V PCB type electrolytic
C3, 4	330p Polystyrene

SEMICONDUCTORS

IC1, IC2	CA3140
Q1	2N3904
IRD	SFH205 (Siemens)

MISCELLANEOUS
1, 3 way plug
1, 3 way socket

Detector and Bi-stable Relay Driver
RESISTORS

R15	1M0
R16	2M7
R17, 22	4k7
R18	120k
R19	820R
R20	220k
R21, 23	47k
R24	1k0
R25	6k8

CAPACITORS

C6	22n polyester
C7	100n polyester
C8	100u 25V PCB type electrolytic

SEMICONDUCTORS

IC3	CA3140
IC4	CD4027B
Q1, 4	2N3904
D1–D4	1N4148
D5–D6	1N4001

MISCELLANEOUS
1, 3 way plug
1, 3 way socket
Relay 12V coil greater than 120R DPST PCB type 15A contacts
Case

Power Supply
RESISTORS

R26	1k0

CAPACITORS

C9	100u 25V axial electrolytic

SEMICONDUCTORS

Q5	2N1893
D7–D8	1N4001
ZD1	12V 400 mW

MISCELLANEOUS
T1, 12-012 @ 100mA

The receiver in its aluminum case. A simple design like this looks unobtrusive.

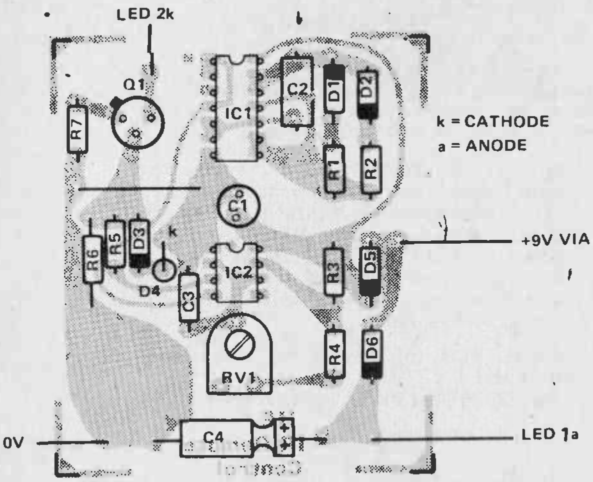


Fig.7. Overlay for the IR transmitter

The transmitter. The panel has been removed to show the electronics

On our prototype, PB1 is a low-profile PCB-mounting keyboard switch and is fixed to the Verocase front panel with contact adhesive after first drilling two switch-contact clearance holes in the panel. Take care when positioning this switch to ensure that it is not inadvertently activated by closure of the flip-top of the case: alternatively, cut a switch-clearance hole in the flip-top. Do not finally fix the front panel into place until the receiver circuit has been built and the complete system has been adjusted for maximum sensitivity.

Construction: The Receiver

The receiver unit is built up on three separate PCBs, all fitted into an 8″ × 5″ × 2″ case. Start construction by building the small power supply board, taking care to fit all components in the polarity shown. When construction is complete, double-check all wiring and then temporarily make a line connection to the primary of T1 and check that approximately 12 volts DC is available at the output of the board. Switch off and remove the temporary power connection.

Next, wire up the DETECTOR/BISTABLE-RELAY-DRIVER board, taking great care to ensure that all components are assembled in the polarity shown. The two ICs should be mounted in suitable sockets. When construction of this board is complete, carefully re-check all wiring.

At this stage you can fit the two complete boards into a suitable case. Drill two ¼″ holes in the case front panel as shown in the photo's. One hole is intended to accept LED 1 and the other acts as a window for IRD. Drill two holes in the rear panel, of sufficient size to accept power cable grommets. Next fix the two PCBs in place, leaving sufficient space for the preamplifier board. Now refer to the PCB overlays and the power supply circuit diagram and interwire the two boards, noting the following specific points.

(1) The neutrals of the power input and output cables and the 0 V lead of the power supply must be connected to chassis.

(2) The LIVE power input lead goes to the COMMON terminal of one set of relay contacts and also to one side of T1 primary. The NEUTRAL power input lead goes to the COMMON terminal of the other set of relay contacts and to the other side of T1 primary.

(3) The line output connections to the external 15A socket can be taken from either the two relay connections shown in the diagram or from the two unmarked relay output terminals (the relay actually used on the board is a 2-pole changeover type).

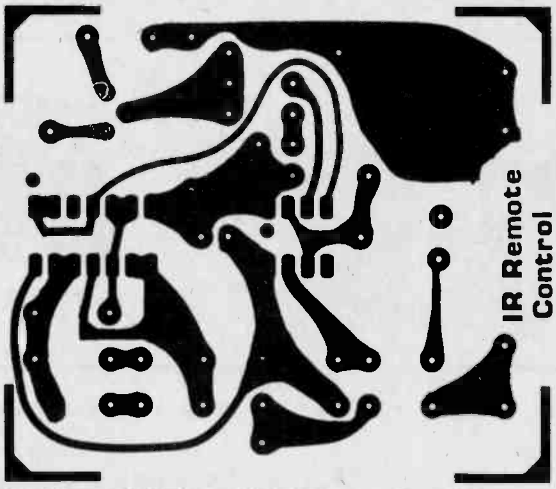
When the circuit has been constructed as described above, complete the power supply connections between the two boards, fit LED 1 to the front panel and wire it to the board. Now plug a lamp or some other 120V load into the external 15A socket, switch the power on and check the functional performance of the unit by momentarily connecting a 47k resistor between D5 cathode and the top of R15. As the resistor is connected, LED 1 should turn on and the relay should change state, making or breaking the power connection to the external lamp. When the resistor is disconnected, LED 1 should turn off but the relay should not change state. The external lamp can be turned on and off the alternately connecting and disconnecting this resistor.

When the above check is complete, switch off the power and proceed with the final stage of construction, the assembly of the pre-amplifier components. When construction is complete, fit the board into the case, interconnect the pre-amplifier to the detector/B-R-D board and, finally, tape infra-red detector IRD into place behind the front-panel 'window' (with its sensitive surface facing outwards) and complete its connection to the pre-amplifier board.

Now switch the circuit on and adjust sensitivity control RV1 so that LED 1 turns on and then turn RV1 back so that LED 1 *just* turns off again. Next, take a deep breath, cross your fingers, aim the IR transmitter at the receiver unit and briefly press the transmit button. If all is well, LED 1 will illuminate and the relay will change state. If this action is not obtained, either the pre-amplifier or the transmitter is defective.

When you are satisfied that the IR system is functioning correctly, you can set it for maximum sensitivity by simply adjusting frequency control RV1 in the transmitter to give the maximum possible operating range. When the transmitter and receiver pre-sets are correctly adjusted the system should have an effective range of about 30 feet. Finally, fix the transmitter front panel firmly into place. ●

Fig.9. PCB for the transmitter close



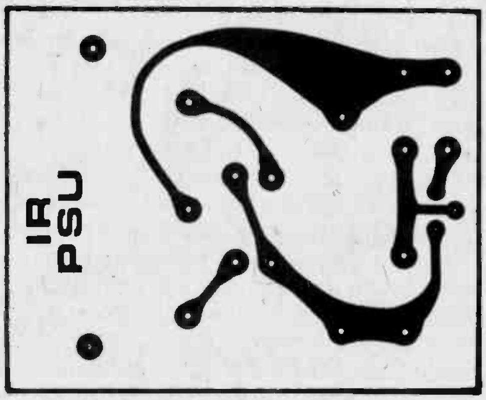
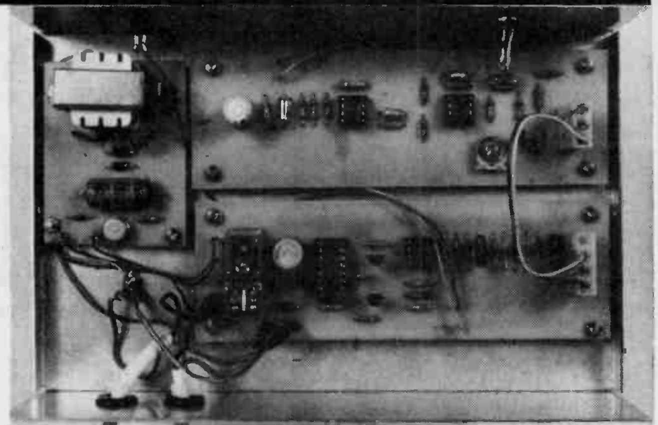


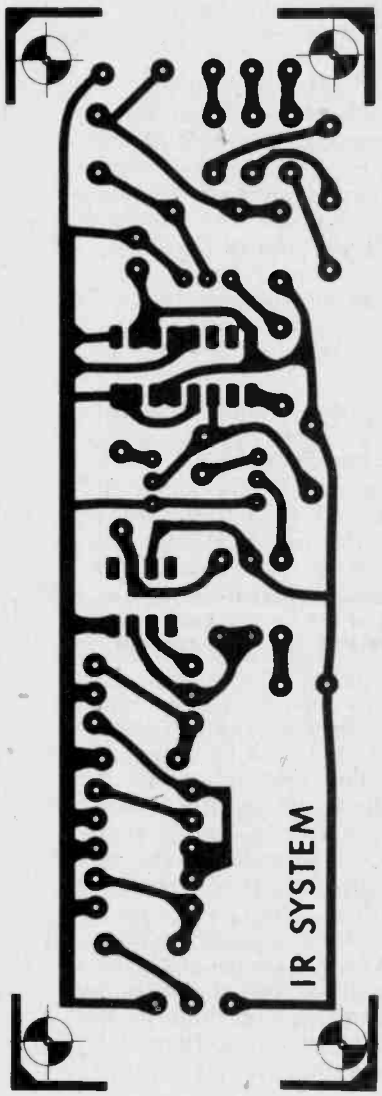
Fig.10. Overlay for the receiver PSU

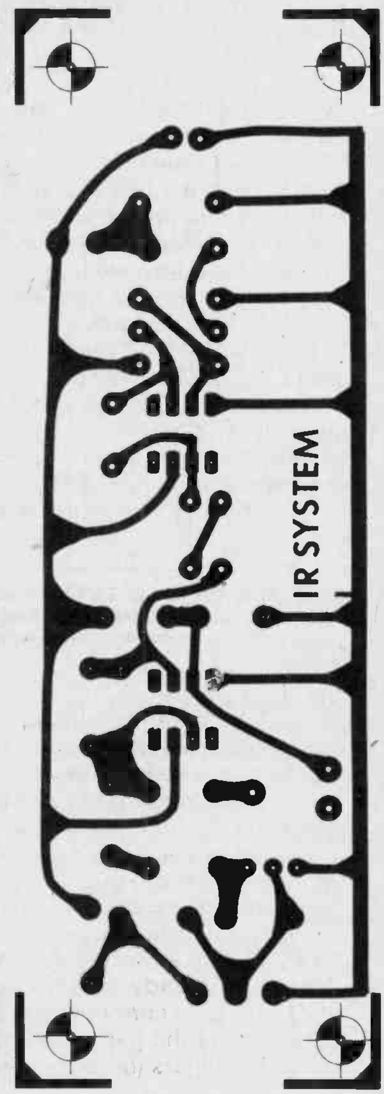


Close up of the receiver boards. The relay current handling must be within limits for the load to be switched.

PROBLEMS? NEED PCBs? Before you write to us, please refer to 'Component Notations' and 'PCB Suppliers' in the Table Of Contents. If you still have problems, please address your letters to 'ETI Query', care of this magazine. A stamped, self addressed envelope will ensure fastest reply. Sorry, we cannot answer queries by telephone.

Fig.11. PCB foil pattern for the receiver front-end
Fig. 12. PCB for the IR receiver decoder.





INTO ELECTRONICS (PART 2)

In this second part we look at passive components and how they behave in electronic circuits. by Ian Sinclair

IN A COMPLETE circuit, DC current in the form of moving electrons can flow around the circuit, pushed by the EMF (electro-motive force). If the current is AC, the electrons never flow right round the circuit, but only dance to and fro, moving in one direction when one end of the circuit is positive, and in the other direction when the EMF reverses. As we've seen, it doesn't matter to a resistor whether the electrons move steadily or to-and-fro, the power is converted into heat anyway. For some other components, though, it matters a lot. For example, moving-coil meter simply cannot cope. The coil and needle cannot reverse direction more than a few times per second, so that for AC of 10Hz or more, the reading is effectively shown as zero.

Other components behave differently; think of a circuit with a break in it. Because electrons won't move across the gap, there is no steady current. When the EMF is alternating, there is still some movement of electrons in the rest of the circuit. With the EMF in one direction one end of the gap is positive, the other end negative. When the EMF reverses, the polarity across the gap must also reverse.

Now for this to happen, some electrons have to

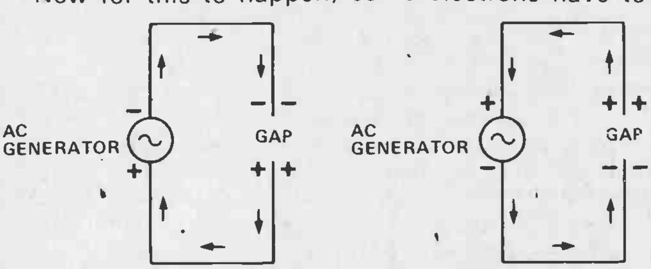


Fig.1. An alternating EMF will cause a to-and-fro movement of electrons even if there is a break in the circuit. Each time the EMF reverses, electrons must move along the wires as for as the break.

move. For one end of the gap to be positive and the other end negative, electrons have had to move from the positive end to the negative end (remember that the electron is negatively charged). When the voltage reverses, the electrons have to shuffle around in the opposite direction. Even with a gap in the circuit, then, there can be some to-and-fro movement of electrons, the type of current we call alternating current.

You could call a capacitor a carefully designed gap in a circuit. Like any other gap in a circuit, a capacitor does not allow steady current to flow, but it will allow electrons to accumulate on one side and drain on the other side of the gap. The first capacitors were made in the shape of jars (because it was thought that electricity

Capacitors come in all shapes and sizes. Here are a few, but there are many more to choose from.

was a liquid!) with gold leaf on the inside and also (but not electrically connected) on the outside. Later, metal plates separated by an insulator (known as the **dielectric**) were used. Nowadays, we use paper or plastic insulators coated with metal film each side but we still talk of "plates", and the symbol for a capacitor (Fig. 2) shows two plates separated by a gap.

Fig.2. Symbol for capacitor. This symbol is used for a fixed capacitor, meaning a capacitor whose value is not deliberately changed (as for tuning a radio). A slightly different symbol is used for an electrolytic capacitor.

It's not so simple as a gap in the circuit, though. The greater the area of these plates, and the closer they are to each other, the greater the number of electrons that have to be shifted from one side to the other to create a voltage across the plates. Even the type of material that lies between the plates can affect this number of electrons. In electronics language (parliamo electronico?) a lot of charge has to be shifted to get a voltage across the plates. The ratio

$$\frac{\text{amount of charge}}{\text{amount of voltage}}$$

is called **capacitance** and is measured in units called **farads** (abbreviated F). A large amount of capacitance means that a lot of charge has to move to give one volt between the plates, a small capacitance means that only a small amount of charge needs to move to obtain the same one volt between the plates of this device, called a capacitor.

We boobed a bit with the unit, though. Using the definition:

$$\text{capacitance} = \frac{\text{charge}}{\textbf{voltage}}$$

and using the units of coulombs for charge (the coulomb is the amount of charge that moves when one ampere flows for one second) and volts for voltage, the unit of capacitance, the farad, is the coulomb per volt, and it's miles too big for practical purposes. We have to make use of the sub-multiples micro-, nano- and pico- when we work with capacitors, so that values such as 10uF, 2.2nF (written as 2n2) and 100pF are the sort of values we are likely to see and use.

The way we make capacitors depends on the sort of values we need. For the smallest pF (picofarad) sizes, we can use small discs or rectangles of insulators, such as silver-mica, coat each side with metal, then make contacts to the two separate metal layers. For larger values, a few nF perhaps, we can pile these plates on top of each other, separated by uncoated plates for insulation, and connect alternate sides together (Fig. 3b).

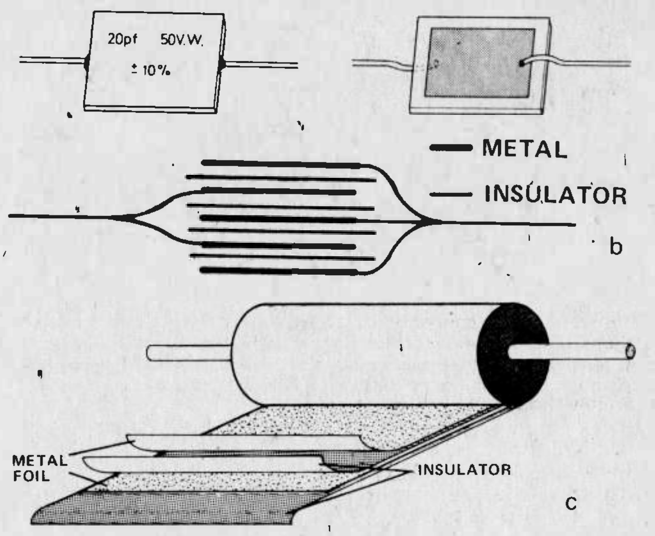


Fig.3. Some practical methods of construction. a) Single metallised plate. b) Multiple plates — showing plates separated, with interconnections, befor pressing together and covering with plastic coating. c) Rolled paper of plastic construction.

When we get to values of 10nF or more, an easier construction is to use a ribbon of paper or plastic, metallise each side, then roll the ribbon up along with an unmetallised ribbon to make sure that the metal surfaces do not touch; this gives the tubular capacitor. For values of 1uF upward, even this construction is too bulky, and electrolytic capacitors, constructed like dry cells, are used. The insulator here is a thin film of hydrogen gas, so thin that it will be damaged by having too great a voltage across it. Electrolytic capacitors can have very large capacitance values in a very small size, but work only at comparatively low voltages, and must be polarised.

Polarised? Yes, like a battery there's a + and a — connection to an electrolytic, and the markings must be observed, with the + lead always connected to a higher positive voltage than the — lead. Get these reversed and, at best your circuit will not work, at worst you will have the corrosive paste from inside the capacitor sprayed all over you!

Inductors and Transformers

If a gap in a circuit can become a circuit component for AC signals, what else is in store? Watch this space for the curly wire trick. Take a length of wire, connect it up in a DC circuit, find its resistance. A few ohms, perhaps? Fine, now coil the wire up, and find the resistance. Just the same, you find. Do all this with an AC circuit, working at high frequency, and you find that coiling the wire up has a very great effect on the current, just as if the resistance had increased.

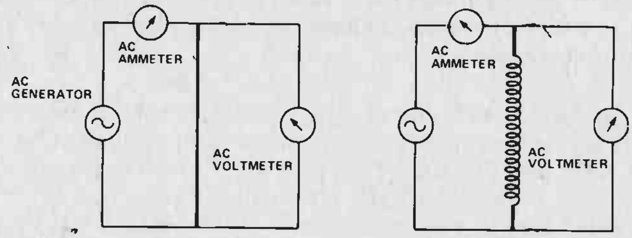


Fig.4. The curly-wire trick a) in an AC circuit a straight wire with low resistance has only a small voltage across it. b) Coilling the wire has the effect of making it behave like a higher resistance, so that the voltage across the wire is greater. This would be noticeable only when the supply frequency was fairly high.

It's no mystery, really. Coiling the wire up makes it an electromagnet when a current flows, and when the current reverses, the direction of the magnetism has to reverse also. It needs a bit of energy to do this though, so that passing an alternating current through such a coil, called an **inductor,** is not so easy as passing the same current through a straight wire or passing DC through the coil. The size of this effect is measured by a quantity called **inductance,** measured in units called **henries** (Mr Henry was an American physicist who died in 1878). As usual, we make use of submultiples like millihenries (mH) and microhenries (uH), though it is possible to make coils of several henries of inductance.

Because inductance is caused by magnetism, winding a coil of wire around a magnetic material, such as soft iron, makes the amount of inductance very much greater than that of the coil alone. Materials like soft iron concentrate magnetism, and it's this effect, called **permeability,** that makes a coil with an iron core have so much more inductance than a similar coil with an air core. For two similar coils, the addition of a magnetic core can make the inductance value many *thousands* of times greater.

Iron cores are less useful, though, when the currents through the wire in a coil are high-frequency signals, because then too much energy is wasted in magnetising and demagnetising the iron. Inductors intended for use with high frequency signals must use air cores or special materials called ferrites.

That's not the end of the tricks we can play with coils, though. Suppose we wind two separate coils, insulated from each other, on to the same magnetic core. Connect one coil to an AC circuit and pass AC current through the coil. This will magnetise the core, but the magnetism will be alternating, changing direction as the current changes direction. Now for the crunch — the alternating magnetism will generate alternating EMF in the other coil. We can use this other coil as if it were a generator of alternating EMF — which it is. This arrangement is called a **transformer.** The coil which is used to create the alternating magnetism is called the primary coil, and the coil which has the EMF generated in it is called the secondary coil.

The reason for the name, transformer, is that the voltage that comes out of the secondary coil isn't necessarily the same as the voltage across the primary coil. We put an alternating voltage, a sine wave, across the primary winding, and we get an alternating voltage, a sine wave with the same frequency from the secondary winding, but the voltages don't have to be the same. In fact the voltage at the secondary depends on the number of turns in each of the two coils as well as on the primary voltage. The law of the transformer is $Vs/Vp = ns/np$; where ns is the number of secondary turns, np is the number of primary turns, Vs is the secondary voltage, Vp is the primary voltage

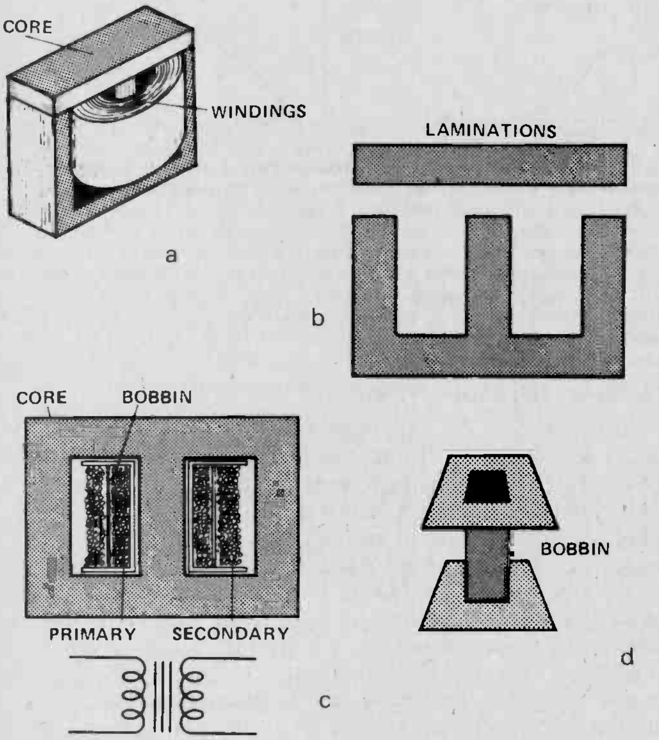


Fig.5. The transformer. a) General appearance, b) Core and bobbin, c) Sectioned view, d) Symbol.

For example, if we have a transformer with 5 000 turns of wire for a primary winding, and a 250V AC supply, what voltage can we expect across a 500 turn secondary winding? The equation is $Vs/Vp = ns/np$, and filling in values we get $Vs/250 = 500/5\,000$; so that $Vs = 25V$.

This we would call a **step-down** transformer, because the secondary voltage is less than the primary voltage. We could just as easily make the secondary winding have a greater number of turns, so that the transformer is a **step-up** transformer.

None of this happens when DC is used. Slap some DC through a transformer and all you get is a hot transformer, a smell of burning and a few blown fuses. DC will magnetise the iron core all right, but it won't cause the alternating magnetism that makes the thing work. Worse still, because the resistance of the wire used for transformer windings is low, far too much current will flow through the wire if DC is used. Transformers are strictly AC devices.

Joining them Up

In a circuit, components like resistors, capacitors and inductors can be connected together. Before we look at what happens in such circuits, let's see what the effect is of joining similar components together. There are two ways of connecting components, in series and in parallel. In a series circuit, the same current flows through the components, one after the other. In a parallel circuit, the same voltage is across each component, though the currents can be different.

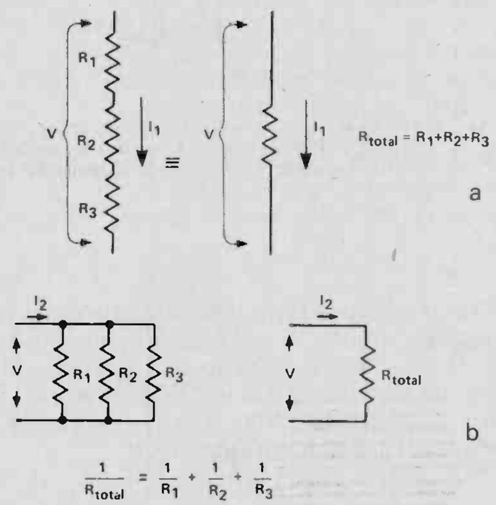


Fig.6. Resistor circuit connections. a) In series. Total resistance means the resistance value which would have the same voltage across its terminals for the same amount of current passing through it b) In parallel. Using the same definition of total resistance leads to the formula shown.

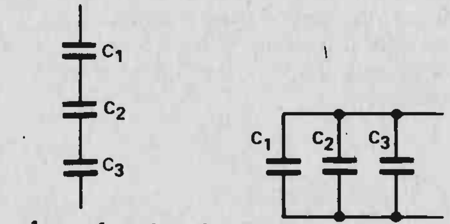
Connecting resistors in series has the effect of increasing the total resistance, as we might expect. Formula: $R_{total} = R_1 + R + R_3$ . . . for as many resistors as we have connected in one series circuit with the same current flowing. For example, a 6k8 resistor in series with a 2k2 resistor gives a total of $6.8 + 2.2 = 9k$. This is a value we can't obtain in the usual 10% series and this is one use of series connections. A more valuable application is the potential divider shown in Part 1 of this series.

Connecting resistors in parallel makes the flow of current easier because there are several paths for current now. Formally, $1/R_{total} = 1/R_1 + 1/R_2 + 1/R_3$ for as many resistors as are connected in parallel across the same voltage. For example, a 30R resistor connected in parallel with a 20R will give

$$1/R_{total} = 1/20 + 1/30 = 5/60$$

$$\text{so that } R_{total} = 60/5 = 12R.$$

This is the value of the resistor which could replace the 20R and 30R in parallel. Note that two identical resistors in parallel produce a total resistance equal to half the value of each resistor, three in parallel are equivalent to a resistor of one third of each resistor value and so on; for example, three 3k3 resistors in parallel give 1k1. Parallel connections are very useful for reducing or trimming resistance values down to the size we want. For example, if we want to use 6k and we have 6k8, we must add a resistance R so that $1/6 = 1/6.8 + 1/R$. Producing the old calculator and going through the steps we find $R = 51k$. (The nearest preferred value is 47k.)



$$\frac{1}{C_{total}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} \qquad C_{total} = C_1 + C_2 + C_3$$

Fig.7. Capacitor connections — the same formulae apply, but they apply to the opposite connections. The simple addition formula applies to parallel capacitors, the inverse formula to the series connection.

Inductors obey the same laws — adding the value for series connections, and using the reciprocal rule for inductors in parallel. Capacitors, just to be awkward combine the other way round. Connecting capacitors in parallel is like adding their plate areas, so creating a larger capacitance. For capacitors in parallel

$$C_{total} = C_1 + C_2 + C_3 \ldots$$

Capacitors in series behave like resistors in parallel, so that

$$1/C_{total} = 1/C_1 + 1/C_2 + 1/C_3 \ldots$$

Time Constants

All a resistor can do is to dissipate power, converting it to heat. Capacitors and inductors can store energy and give the stored energy back again, but both need some time to act. The thing to remember is that we can't *instantly* change either (a) the voltage across a capacitor or (b) the current through an inductor. Take for example, the capacitor and resistor in Fig. 8. Switching on causes the voltage of plate (1) of the capacitor to rise from 0 to +9V. Because of the instant change rule, the voltage of the other plate (2) is also 9V at switch-on. It can't stay at the voltage, though, because current will now flow through the resistor — this is the movement of charge that is needed to charge the capacitor. When the charge has stopped moving, plate (2) voltage is zero and the capacitor is fully charged. The time constant for this arrangement is given by C (in farads)×R (in ohms), result in seconds. Because of the shape of the graph of voltage plotted against time, the figure of time constant is not the time for the voltage to each zero but to fall to 37% of its starting value. In this example, the time constant is the time taken for the voltage to reach 37% of 9V, which is 3.3V. The point is that the greater the value of this time constant (great capacitance, greater resistance, or both) the longer it takes for charging to be complete.

The same applies to current in an inductor. Switching on a voltage across a large inductor does not cause instant current. Instead, the current grows gradually with a time constant of L/R seconds (L in henries, R in ohms). In this case, because current is growing, the time constant is the time to reach 63% of the final current (which is V/R amps).

We usually reckon that for practical purposes that the currents have stopped changing after a time equal to four times the time constant.

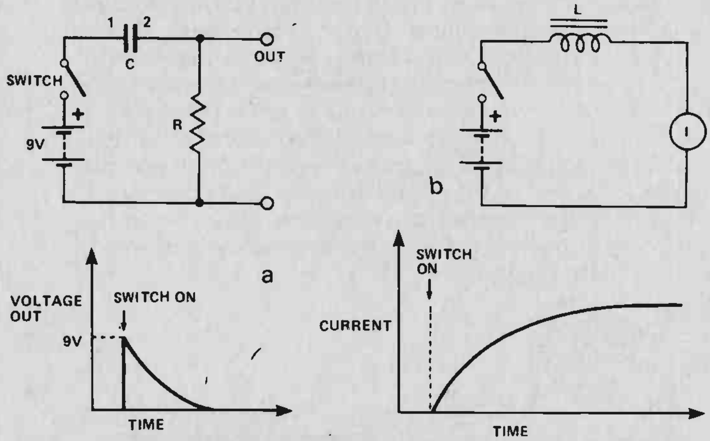


Fig.8. Time constants. a) A capacitor and a resistor connected together have a natural time constant equal to CR seconds. In the graph of voltage against time that is shown here, the time constant is the time after switch on for the voltage to reach 37% of the battery voltage. b) An inductor has resistance R (because of the wire it's made from), and its time constant is L/R. The time constant of an inductor causes a delay in reaching a steady value of current when a voltage is applied across the capacitor. The time constant in this circuit is equal to the time taken, after switch on, to reach 63% of the final current.

Reactance, Impedance, Resonance

In an AC circuit we can have resistors, inductors and capacitors. Any circuit that has capacitors connected in series with the other components must be a circuit for AC only, because capacitors do not pass steady current. Any inductors in a DC circuit will act only as resistors, their inductance has no effect once the current has settled down to its final value. For an AC circuit, however, both capacitors and inductors pass current and will have alternating voltages across them. For a capacitor or inductor, the ratio $\tilde{V}/\tilde{I}$ meaning the ratio of signal voltage to signal current, is called the **reactance** of the capacitor or inductor, symbol X, and is measured in ohms. It's measured in ohms because resistance is the ratio of V/I, using DC values that also result in the unit, ohm.

Why use a different name for these 'AC' ohms? Well, for a start, DC doesn't flow through a capacitor at all, and the resistance of an inductor is only the resistance of the wire it's made from. For an encore, there's another big difference. When an alternating current flows through a resistor, there is, of course, an alternating voltage across the resistor. This voltage is exactly in step with the current — when the current is zero, the voltage is zero, when the current is at its positive peak, the voltage is at its positive peak, and so on. Reactances don't behave like this. Instead, the voltage wave is shifted compared to the current wave, so that we have maximum voltage when the current is zero and zero voltage when the current is maximum. This effect is called a 90° phase shift. The reason for the 90° label is that the shift is one quarter of a cycle, and an alternator generates one cycle of AC by 360° of rotation, hence a quarter cycle is 90°

Capacitors cause the voltage peak to be a quarter cycle later than the current peak; inductors cause the current peak to be a quarter cycle later than the voltage

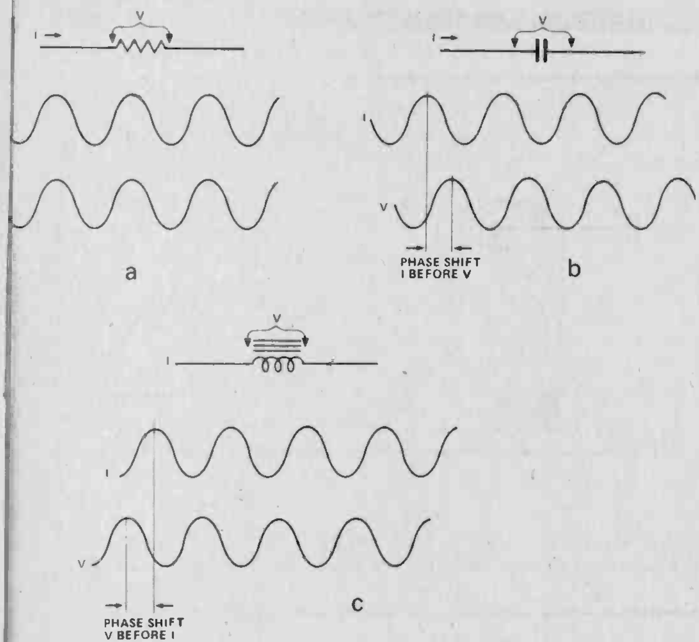


Fig.9. Phase shifts. a) When alternating current passes through a resistor, the waves of voltage and of current are in step. b) When AC is applied to a capacitor, the current wave is a quarter cycle (90°) before the voltage wave. c) When AC passes through an inductor, the current wave is a quarter cycle (90°) after the voltage wave.

peak. One simple way to remember which way round it is is the word **C-I-V-I-L** C (for capacitor), I before V; V before I in L (inductor).

The most noticable difference between reactance and resistance, though, becomes obvious when we change the frequency of the AC supply. Inductors have more reactance at high frequencies than at low frequencies. Capacitors have less reactance at high frequencies than at low frequencies. Graphs showing reactance size plotted against frequency look as shown in Fig. 10. For an inductor, the size of reactance is given by
$X_L = 6.3 \times f \times L$, with f in hertz, L in henries.

For example, a 0.1 H inductor at a frequency of 400 Hz has a reactance of 252 ohms.

For a capacitor, the size of reactance is given by

$$X_c = \frac{1}{6.3 \times f \times C}$$

Now we have to be careful here. C has to be in units of farads, and we usually use microfarads or smaller units. For example, the reactance of a 0.1uF capacitor at 5 kHz is:

$$X_c = \frac{1}{6.3 \times 5000 \times 0.1 \times 10^{-6}} = 317 \text{ ohms}$$

Because reactance is different in value at each different frequency, we have to calculate the amount of reactance from the fixed values of inductance or capacitance.

When a circuit contains a resistance and a reactance, the whole circuit is neither perfectly resistive nor perfectly reactive, but a mixture of the two is called **impedance,** symbol Z. The simple laws for adding series or parallel components don't apply to reactances because of the phase shift, and the phase shift of an impedance is somewhere between 0 and 90.

One type of impedance is rather special. When a circuit contains a resistor, a capacitor and an inductor all

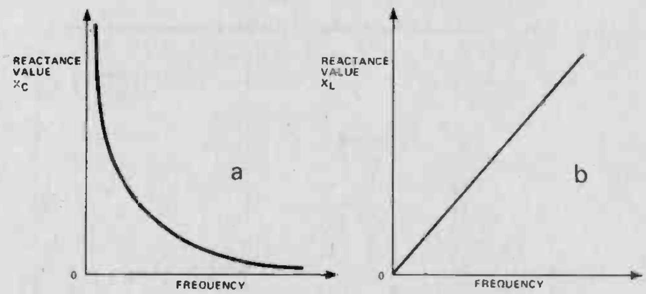


Fig.10. Reactance is not constant. a) The reactance of a capacitor is very high for low-frequency signals, very low for high frequency signals. b) The reactance of an inductor is very low for low-frequency signals, very high for high-frequency signals.

in series, or all in parallel, it doesn't behave like any other circuit we have met so far. At low frequencies, this circuit behaves like an inductor, at high frequencies, it behaves like a capacitor. At one frequency in between, called the **resonant frequency,** or frequency of resonance, the circuit behaves like a resistance. At this frequency, the reactances of the capacitor and of the inductor have balanced each other out, leaving only resistance. How much resistance?

If the capacitor and inductor are in series, making this a series resonant circuit, then the resistance at the frequency of resonance is very low, just the resistance of the wire in the inductor unless other resistance has been added. If the inductor and the capacitor have been connected in parallel, making a parallel resonant circuit, then the resistance at resonant frequency is very high, unless other resistances have been added in parallel. The effect is shown in Fig. 11. We use resonant circuits for tuning a frequency we want. If a parallel resonant circuit is used as a load, then a signal current will produce a large voltage across the load, but only at and around the frequency of resonance. Radio wave tuning, whether of radio, TV or radar signals depends on this resonance effect which lets us select the frequency we want from all the possible frequencies which can be picked up or generated. *To be continued next month.*

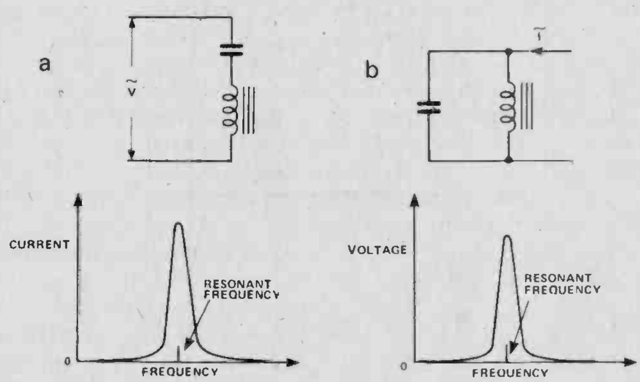
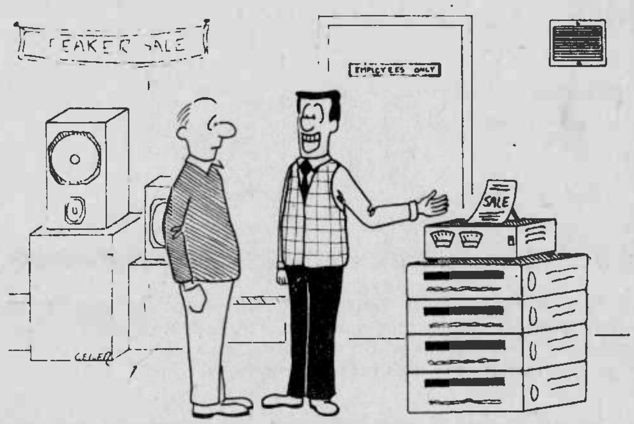
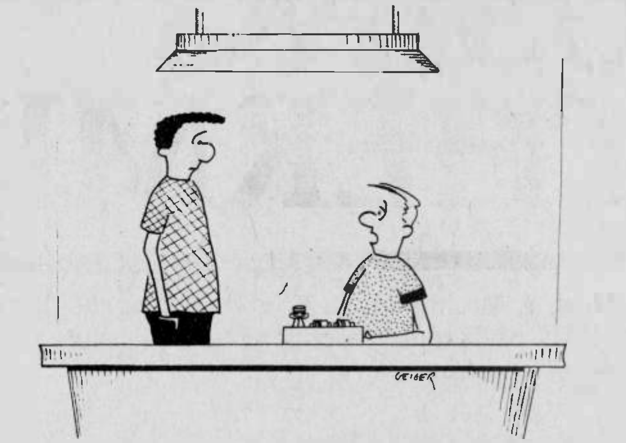


Fig.11. Resonance. a) Series-resonant circuit; the resistance in the circuit is the resistance of the wire of the inductor. The current is maximum at the resonant frequency, when the circuit has only resistance, no reactance. b) Parallel-resonant circuit. The voltage (and the resistance) is a maximum at the resonant frequency.

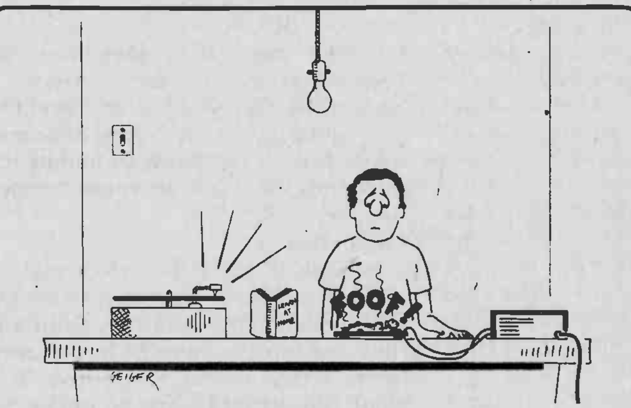
The Fun of Electronics — Geiger



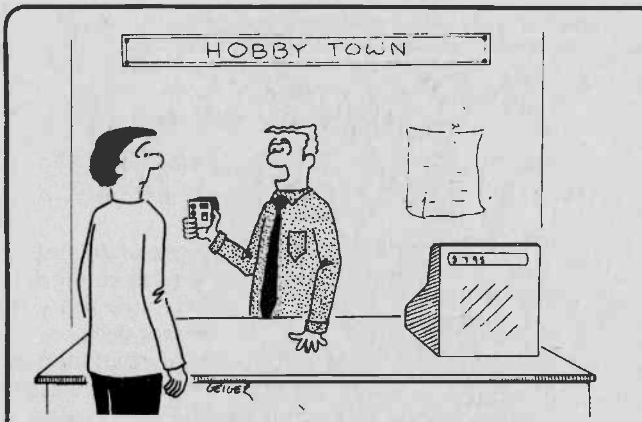
For that empty space on your stereo rack, we have the all new, fully metered quadrophonic, $2,000 'Audiophile Placebo'. It does absolutely nothing, but does it with perfect fidelity!



The transistor I used in this circuit is light sensitive, so I had to look all over town for a tiny pair of sunglasses.

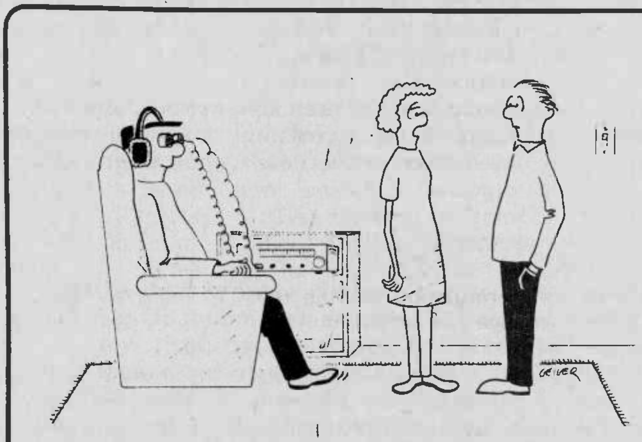


Congratulations! You have just completed Lesson 6 in which you built your first working prototype electronic circuit! Lesson 7, on the other side of this record will introduce you to the idea of polarity.



This is the latest device for making your model train set more realistic: it's a tiny time delay circuit that ensures that your trains are always late.

I don't care if you do think it's stupid that we disguise our real alarms as books and make our phoney alarms look like real alarms. That's the way we do things around here.



It's Harold's latest invention — to go along with his headphones, he built a set of 'eyephones' for his colour organ.

USING THERMISTORS

W. Thiel, J. Machin and J. Kornatowski of the Department of Zoology of University of Toronto describe simplified calibration and more convenient use for thermistors.

Introduction

Thermistors are temperature sensitive resistors usually with a negative temperature coefficient. One of the advantages of using thermistors for temperature measurement is their small size; another is that small temperature changes cause considerable changes in their electrical resistance. Apart from the direct measurement of temperature they may be incorporated into electronic circuits as temperature compensating devices as well as forming the sensitive elements in hygrometers, vacuum gauges, conductivity cells and anemometers. Manufacturers typically supply precalibrated thermistors as well as less expensive types which have much wider tolerances (to within 20% of nominal calibration). The idea has grown up, that inexpensive thermistors are unreliable and require frequent and laborious calibration. Our experience with the calibration and use of inexpensive thermistors in biological research has removed much of this doubt and has lead to greater confidence in a simplified calibration procedure. This calibration technique together with some practical consequences of a mathematical formulation for the temperature-resistance relationship are described below. It is hoped that this information will encourage the design and use of inexpensive thermistor instrumentation by the individual experimenter. Those who employ multiple, readily portable remote reading temperature measuring devices with a sensitivity in the order of 0.5°C would benefit most from the type of instrument described.

Thermistor Temperature Characteristics

The general relationship between temperature and resistance for a thermistor is given by the following exponential equation (Philips Electron Devices 1963)

$$R = Ae^{(B)T} \qquad (1)$$

where R is resistance in ohms at temperature T. T is the temperature in °C and e the base of natural logarithms. Since R equals A at zero degrees Celsius, A is the intercept and B is the slope in a semi-log plot given by

$$B = \ln(R) - \ln(A)/T \qquad (2)$$

We had thought that inexpensive wide tolerance thermistors would follow this exponential relationship less closely. This was found not to be true. When comparing a large number of conventionally obtained calibration curves from Philips thermistors (type 205-CE/P2K2), we found that values for B were remarkably consistent. It was only coefficient A that varied considerably between individual thermistors. It appears that B is related to the composition of the temperature sensitive material used in the thermistor, differing only slightly within each type and even less within one batch. Since B represents the slope, it is also an indication of the sensitivity of the thermistor. The value of A is a characteristic of each individual thermistor and is therefore related to the nominal values stated by the manufacturer. The spread in A for inexpensive thermistors may be as high as 20% but more recent production technique or quality controls have resulted in generally closer tolerances. It is now frequently possible to find matching pairs in a sample of ten. Thermistors of the same material in many different physical configurations are available in a wide range of nominal values from a few ohms to hundreds of thousands of ohms at room temperature.

Calibration

Thermistors may be calibrated by mounting them in contact with the bulb of an accurate thermometer. Calibration runs are most conveniently performed by first packing the thermistors in ice chips and distilled water to obtain zero degrees. Higher temperatures are then obtained by stirring various amounts of warm water. For the present purpose thermistor resistances were conveniently measured with a digitial ohmmeter to the nearest ohm and temperatures were measured to 0.1°C. We have found that satisfactory calibration curves for thermistors can be obtained by simply determining thermistor resistance at zero °C and at one other temperature preferably at the other end of the temperature range of interest and by using Eq. (1) and Eq. (2). In this manner it is possible to derive calibration curves for any unknown thermistor. Limited extrapolation to temperatures outside the calibrated range can be made but possibly with increased error. Comparisons of single resistance measurements can be confidently used to check for damage. We have found that undamaged thermistors used at biological temperatures do not change their calibration with time. Since coefficient B varies slightly over wide temperature ranges, more accurate calibrations may be performed at several temperatures. In

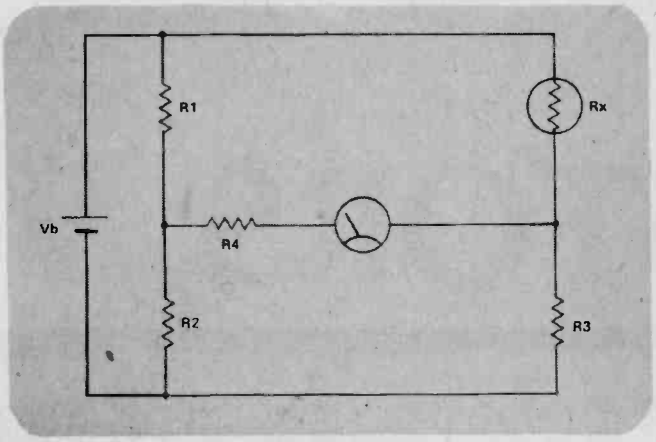


Fig. 1. Wheatstone Bridge circuit modified as a thermistor thermometer.

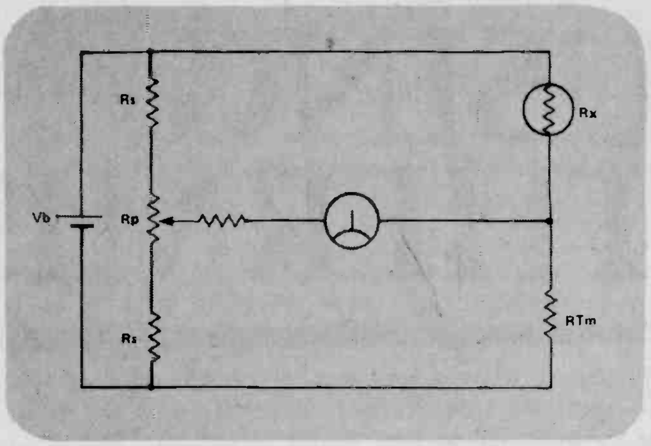


Fig. 3. Slidewire bridge modified for potentiometer readout and range limiting resistor.

this case a somewhat better overall fit to the calibration data can be obtained with a computer least squares curve fitting program which computes the best fit for an exponential equation to all the observed values. Table 1 compares observed resistance with those predicted from a computer determined curve equation based on calibration measurements made at 10°C intervals and with those predicted from a regression line between points for zero and 50°C. In the latter the log-linear calculations were performed on an electronic pocket calculator. It can be seen that the errors in calculated resistance do not exceed 0.9% in either case. This is equivalent to a maximum error of about 0.4°C.

Portable, Linear Thermistor Thermometers

Accurately known temperature characteristics of a given thermistor permit the design of specific measuring bridges (Fig. 1) which because of their simplicity, greatly add to the convenience of actual temperature measurement. It is possible to use a microammeter as a temperature indicator if we replace Rx by a calibrated thermistor (RT). By the choice of appropriate resistance values, of the bridge and thermistor can be matched to give an almost linear response to temperature. The thermistor exponential curve closely approximates the hyperbolic curve of the bridge (Fig. 2). The closest agreement between the two curves can be obtained by using a geometric mean calculation to determine values for R2 and R3. RTc is the thermistor resistance at the lowest temperature to be measured and RTw is the thermistor resistance at the highest temperature to be measured. The values RTc and RTw are obtained from manufacturers data, previous calibration or calculations using Eq. (1).

The best values for R2 and R3 are given by

$$R2=R3=\sqrt{(RTc)RTw}$$

This value corresponds to the thermistor resistance at midscale temperature, RTm. Since the meter should read zero at the lowest temperature, R1 must equal RTc. The voltage V1 which sets the meter to zero is given by

$$V1=(Vb)R1/(R1+R2)$$

where Vb equals the voltage of the battery. The voltage V2, full scale meter reading is given by

$$V2=(Vb)RTw/(R3+RTw)$$

The calculation of the resistance R4, in series with the meter is according to Ohms Law, when

$$R4=[(V1-V2)/Im]-Ri$$

where Im is the full scale deflection current in Amps of the meter, and Ri is the internal resistance in Ohms of the meter movement.

Since calculated values rarely fit standard values the use of trimpots for R1 and R4 allow accurate alignment of the instrument. The type of battery to supply the bridge and the value of Vb must be chosen with some care to reduce errors due to thermistor self-heating to a reasonable level. Maximum battery voltage may be calculated as follows

$$Vb=2\sqrt{(P)RTm}$$

where P is the power dissipation constant of the thermistor in watts. Miniature thermistors have a dissipation constant of 0.25 milliwatts at 25°C ambient in still air. This value increases if the thermistor is dissipating in flowing air, water or in physical contact with a heat conducting object. The power dissipated is best chosen to be one tenth of the still air dissipation constant given by the manufacturer. With battery voltages of under 3V, self-heating errors are not significant. Mercury batteries should be chosen over other types because of their constant voltage over long periods of time. The meter should be as sensitive as possible to avoid loading the bridge. This means that the series resistance R4 is large compared with other resistance in the bridge. (At least ten times RTw).

Thermistor Thermometer with Multiturn Potentiometer & Center Zero Meter

The traditional form of the Wheatstone Bridge for measuring resistance employs a slidewire replacing R1 and R2. The ratio of the R1 and R2 portions of the slidewire for a zero reading of the microammeter is directly proportional to the ratio of Rx to R3 where Rx is the unknown resistance and R3 is the standard resistance. Since the ratio of R1 to R2 theoretically ranges from zero to infinity at the extreme settings of the slide wire, it is useful to limit the ratio by inserting a series resistor (Rs) at each side of the slide wire potentiometer. In a practical circuit it is convenient to use a multiturn potentiometer in place of the slidewire. When the multiturn potentiometer is equipped with a turns counting dial, a three digit reading is possible. The circuit for a thermistor thermometer is given in Fig. 3. In comparison to the circuit in Fig. 1, the circuit in Fig. 3 has the advantages of both increasing the resolution of the thermometer and making it less dependent on the battery voltage. The absolute accuracy of the thermometer will depend on the precision with which the components can be selected and calibrated. The resistance RTm is determined as before by

$$RTm=\sqrt{(RTw)RTc}$$

Since the potentiometer is to read null balance over this range, the bridge ratio (Br) to set the span for the range, is

$$Br=RTc/RTm=RTm/RTw$$

The value of the series resistors (Rs) for the potentiometer which set the range are given by

$$Rs=Rp/(Br-1)$$

where Rp is the resistance of the potentiometer. The resistance of the potentiometer should be within 100% of RTm. The considerations for power dissipation are as outlined previously. The meter used in this circuit can be any center zero meter of sufficient sensitivity. Usually a 50 microamp meter is a good choice. The final calibration of the thermometer is done by using a decade resistance in place of the thermistor. This results in a table of potentiometer reading versus resistance. ●

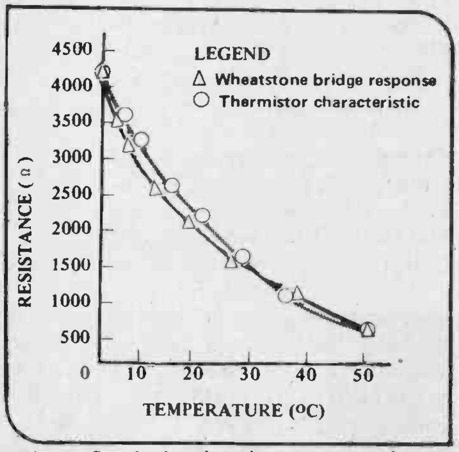


Fig. 2. Graph showing close correspondence between thermistor temperature characteristics (○) and Wheatstone bridge response (Δ). The Wheatstone bridge response represents the voltage across the meter for the change in the resistance of Rx.

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Appendix

To calculate the parameters of a thermistor that was measured at two points — zero degree and 50 degrees. The resistance at zero was 4036 Ohms and the resistance at 50 degrees was 545 Ohms.

First to calculate B

enter R	545
press ln x	6.30079
press minus	
enter A	4036
press ln x	8.303
press equal	–2.00222
press divide	
enter T	50
press equal	–.0400445 answer

Calculate resistance for 10 degrees

enter B	–.0400445
press multiply	
enter T	10
press equal	–.4004447
press e^x (inverse ln x)	.670022
press multiply	
enter A	4036
press equal	2704 answer

TABLE I

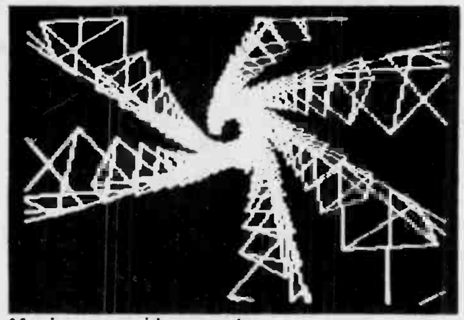
Discrepancies between observed and calculated resistances predicted from Eq. (1) comparing the results from a computer program using all temperature values and those from an electronic pocket calculator using only two points (zero and 50°C).

Temperature °C	Actual Resistance	Computer Best Fit	Error %	Pocket Calculator	Error %
0	4036	4013.93	+0.6	4036	+0.0
10	2689	2689.20	+0.0	2704	+0.5
20	1792	1800.82	–0.4	1811	+1.0
30	1201	1207.12	–0.5	1214	+1.0
40	808	808.35	+0.0	813	+0.6
50	545	541.85	+0.6	545	+0.0

What's New

Continued from page 50

devices, and producing wallpaper. The intricacy possible by utilizing the computer's eye for precision rivals that of even the sober human hand. While specifying precise shapes is time consuming, the system is adept at dealing with form, and large forms emerging out of small shapes are really where its cybernetic head is at. It's so happy working out the beasties of perspective in three dimensional to two dimensional conversion that it can produce what seem to be extra-real looking line drawings, because of the detail it can render.



Moving pyramids around.

All of this happens in real time, on the screen, which, finally, returns to video. The potential of the system in TV graphics is really wild. Psychadellic headspace features come quickly to mind — put some John Cage on the turntable and move that pyramid boys. However, even if your taste does not run to such esoteric and possible irrelevant fare, the computer images can be combined with regular, televised pictures for titles and effects. It's more fun than a laser show with a burnt out tube.

I should definitely mention that M&W Computers, 407 Queen Street West, Toronto, Ontario kindly loaned me the Apple computer and subLOGIC software package to write this month's column, saying in the process that it's a wonderful little store that has all sorts of fascinating things inside, and recommend that you all go down there and buy some of their stuff — but I'm sure I'll forget to.

Stay Tuned.

Next month the topic will be Vocoders.

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WHAT DO WE DO?
We typeset your words (and put the first word and your company name in BOLD capital letters). If we get your message by the 14th of the month, it will appear in ETI 1½ months later. For example if we receive it by October 14th you (and thousands more) will see it in the December issue.

Novel New Breadboard

Continued from page 51.

them into the trays and interconnect them. In the process of fitting a L.E.D., I popped a spring on the shag carpet I was working on. If you keep the strips in the trays, this shouldn't be a problem.

Further Notes

Compared to other breadboarding systems, Hobby Blox are much more versatile and probably offers more value or use for your money. You can have a number of projects going at once, instead of trying to fit two or three circuits on a single breadboard. It would be possible to keep the various strips in one of those compartmented 'tidy' boxes, and glue the trays to the top of the lid. As you build up a circuit, you just pull out more strips as required.

As the name suggests, Hobby Blox represents a strong commitment on A P Products' part to the Hobbyist market. A project booklet (Fig. 4) is available with a starter kit that details 10 simple projects such as an astable multivibrator and a liquid level detector. There is also a good section on components and how to use them. Incidentally, Fig. 4 may be a bit misleading. The starting kit consists of a tray and two different pairs of connecting strips. The LED Strip, Binding Post Strip, Battery Holder Pack and the others are available separately.

Aside from being very useful to the hobbyist, Hobby Blox would be ideal in schools and colleges. A set of strips for 25 students can easily stretch to 30 or 40. How's that for a way to handle overcrowding in classrooms?

Fig.4. A P Products also produces an excellent project booklet. Note that these are the parts we had, the starter kit does not have all these components.

If you're in the market for a breadboarding system, you can write to Weber Electronics, 105 Brisbane Rd., Downsview, Ontario M3J 2K6, or phone (416) 663-5670. They'll give you infomation on a dealer near you.

Audio Today

AM Stereo is fast becoming a reality. For those readers who believe AM is incapable of Hi-Fi, Wally Parsons presents this month's discussion.

I JUST SPENT a few hours glancing through back issues of ETI, with special attention of "Audio Today" (and, in answer to a reader's enquiry, yes, I do read my own stuff, just as when I worked in radio I listened to my own air checks).

In the process I made a most startling discovery: in almost three years writing on a variety of audio topics, I have not yet written on one of my favourites. And to think that when I started this department I feared that I might run out of material!

Anyway, a little background material, maestro. As it happens, although my taste in television runs more along the lines of drama and films, in radio it tends more towards news and public affairs, including some attraction to phone-in-shows. I don't generally bother with FM Muzak, and about the only disc jockeys for whom I have any use are Johnny Fever and Venus Flytrap, especially when well seasoned with Luscious Loni. I prefer my music either from my own records, live, or via live broadcast.

Consequently, most of my radio listening consists of CBC-AM, with a smattering of DX'd American stations.

AM Comes of Age

Over the past five years, studies have been underway to develop a system of transmitting stereophonic sound on the Medium Wave AM Band, and several proposed systems were outlined in ETI in December 1977. Finally, a system was adopted and approved by the FCC for implementation in the United with approval likely to follow in other countries, including Canada.

This is all very good, but before considering the new system it might be a good idea to look at the whole question of why anyone bothered.

The reasons for giving high priority to AM Stereo rather than, say, stereo sound for television seem to be a great mystery to many people. As a matter of fact, I first heard the announcement one night on the Larry King Show, broadcast on Mutual from Las Vegas at the time of the Engineering Convention of the National Association of Broadcasters. To my utter amazement, Larry King, a veteran broadcaster, hadn't the foggiest idea what use stereo would be on AM, and none of his Convention guests or telephone callers were able to offer any enlightenment.

Herewith, then, this column, dedicated to the Larry Kings and other Big Movers of radio, that they may be as informed about their own industry as are members of the ETI elite.

Some History

Back around 1962, FM radio had gone through a period of growth thanks to an increased public awareness of High Fidelity sound. However, there was also a great public awareness of stereo disc recordings. FM had fallen behind in at least one aspect of its prime reason for existence, and no amount of snob appeal in the form of "quality programming" could help.

Consequently, the development of FM Stereo assumed a high priority and was realized in 1962.

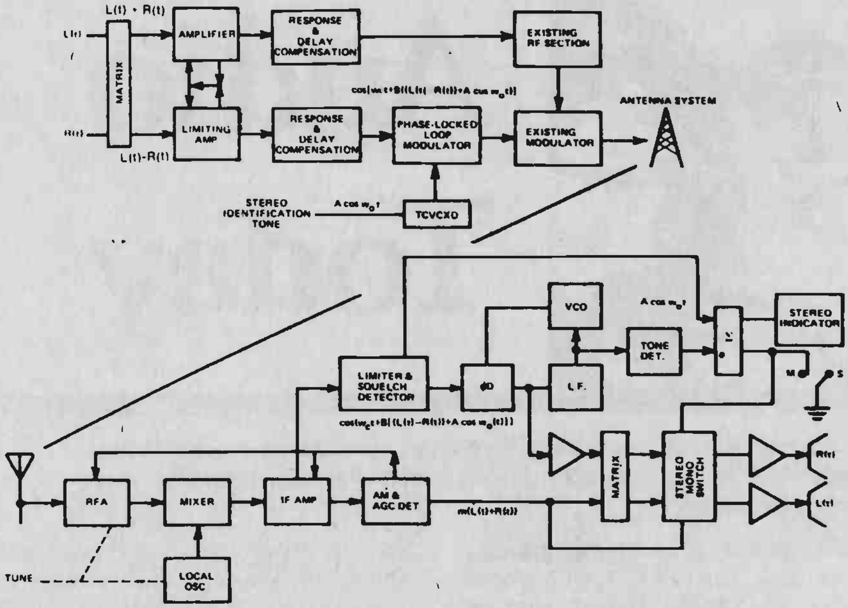
This helped spur quality sound as a consumer commodity, but as a side effect established firmly in the minds of the public the myth that FM stood for "Fine Music" and quality sound, while AM stood for "Abysmal Mediocrity" and equally abysmal sound. To this day, most people seem to believe that good quality sound on the AM band is impossible, a belief reinforced by the miserable performance from the AM sections of many otherwise respectable receivers.

AM radio does, indeed, have a couple of limitations. The best known of these is bandwidth limitations. Many people believe that the muffled quality they associate with AM is due to the 5kHz cutoff characteristic of the medium. Well, long time members of the Audio Today Show and Tell Club know this to be just a lot of ether dust. We've discussed bandwidth and balance in these pages in the past, so there's no need to go into it here. Suffice to say that, although a bandwidth limitation of 5kHz does not contribute to the ultimate in realism, it still allows a high degree of naturalness, clarity, and intelligibility, as any collector and restorer of vintage 78's can attest. What is *not* beneficial is the intentional rolloff above about 2kHz frequently built into many receivers.

This rolloff is used to cover up the other basic problem of AM reception, and is a lot cheaper than actually dealing with the problem.

The problem is one of noise sensitivity, specifically, man-made and atmospheric noise.

All broadcasting systems use a transmitted carrier of some fixed frequency. With the exception of code transmission, information (sometimes called "intelligence", a somewhat ironic term in this context) is transmitted by modulating the carrier, either amplitude, frequency, or phase. This produces sidebands, signals whose frequencies lie above and below that of the carrier. In the case of amplitude modulation, these sidebands consist of the sum of the carrier and the modulating signal, and the difference between the carrier and the modulating signal. It doesn't take a mental giant with access to IBM to figure out that the greater the audio bandwidth, the wider the passband requirements of the tuner, and in fact to accommodate the sum and difference sidebands requires twice the



audio bandwidth. Moreover, the tuner must pass them all at equal level. Loss of sidebands means loss of high frequencies. Loss of one sideband and not the other results in distortion at the frequency generating the sideband.

Obviously, to achieve this response, the RF and IF sections must have a flat response across their pass-bands.

At the same time, the RF and IF sections must reject signals outside the desired passband because such signals would constitute interference from an adjacent station.

To achieve this adjacent channel rejection most manufacturers cheat, by tuning sharply to the centre frequency, resulting in severe high frequency loss and/or distortion.

Reluctant Audiences

It should come as no surprise, then, that most people prefer FM with its wider practical bandwidth, freedom from atmospheric and man-made noise, and, of course, stereo.

But FM too, has its problems. The first of these is range. FM reception is limited roughly to line of sight. This means, literally, the ability to see the transmitting antenna from the receiving antenna. To achieve long transmission range requires that either or both be raised high off the ground. This is why most Toronto stations transmit from the CN tower, and accounts for the better reception experienced in cities with MATV Cable systems, whose operators place their systems on high towers, often on a mountain. AM, on the otter hand, suffers from no such difficulties. At the frequencies involved (and it should be pointed out that this is a function of frequency rather than system of modulation) signals are often received by reflection off the ionosphere and re-transmitted back to earth for distant reception. At FM frequencies the ionosphere simply passes the signal. Although Medium Wave AM signals are deflected by large steel structures in the vicinity of the receiver, this can usually be overcome by either increasing receiver sensitivity or transmitter power or both. But no increase in either power or sensitivity can overcome the line-of-sight limitation of VHF FM signals.

So, what is the significance of this? Over the past few years, the public has become so accustomed to the technical superiority of FM that they have taken it on the road. Automotive sound is now big business, with AM stations losing audiences to FM not only in the home but in the car as well.

From the listener's viewpoint this is of more than academic interest. One reason for going mobile FM is the desire for quality, along with the belief that the difference was inherent in the system. In addition, FM provided one thing unobtainable from even the best AM receivers: stereo.

You might think that this wouldn't matter to the talk show host, but an examination of listening habits reveals that most people do not listen to programmes, but rather they tune into *stations*. With all the FM sations on the air operating all day and night listeners are more inclined, if not to stay with one station, at least to stay on one band. This is especially so when driving.

Thus, the listener accustomed to quality stereo sound is literally captive to whatever programming is available locally on FM. It's one thing for me to drive to Kingston, literally from one end of Lake Ontario to the other with the radio tuned to CBC's Toronto station, but most people just don't behave this way.

The other problem with FM is particularly common in cities, and affects FM's most desireable characteristic, stereo reception.

VHF signals have a most disconcerting tendency to bounce off things; buildings, trees, people. I recall parking in a shopping plaza one evening and noting the changes in reception as people walked by my car.

Even the best of receivers is not always too bright. It doesn't *know* whether a signal came directly from a transmitter, or reflected off the gold-tinted windows of the Royal Bank's megastorey monument to usury. It will pick up either one. Or both. And at the same time. This wouldn't matter too much on the AM band but at the frequencies involved in FM (and TV) it matters a great deal.

Radio waves travel at a rate of about 186,000 miles per second, give or take a bit. This is true no matter what the frequency is. Since frequency, time, and phase are each different expressions of each other, and since for a given velocity, the wavelength of any transmitted frequency varies inversely as the frequency, then the higher the frequency, the shorter the wavelength. If a signal is delayed in time, it will be shifted in phase. And since the higher the frequency the more cycles there are in a given period, it follows that for a given time delay, phase shift increases with frequency.

If a receiving antenna receives a signal directly from the transmitter and by reflection from another object, the reflected signal will have travelled a slightly longer path than the direct signal, and will arrive slightly delayed in time and shifted in phase. We often see this on the television screen as a ghost image, which is simply the image produced by a reflected signal received slightly later than the direct signal.

FM stereo is transmitted in matrix form, similar to the matrices described in this corner last summer. This sum signal modulates the frequency of the main carrier. The difference signal amplitude modulates a 38kHz subcarrier which is removed at the transmitter, so that only the sidebands are transmitted. This sub-carrier is reconstructed in the receiver using a 19kHz pilot tone as a reference. In order that the demodulated sum and difference signals may be combined accurately to produce a left and right signal, they must retain the same phase and amplitude relationship which existed before they were matrixed. Reception of "ghost" signals upsets this relationship, and screws up the recovery of the stereo information. Even in mono, if the distances (that is signal path lengths) are right, the reflected signal can completely cancel the direct signal, resulting in signal loss or distortion.

Needless to say, if things are that tough with a fixed installation, imagine what happens in a moving automobile!

There are areas in large cities where FM reception in the car is absolutely hopeless.

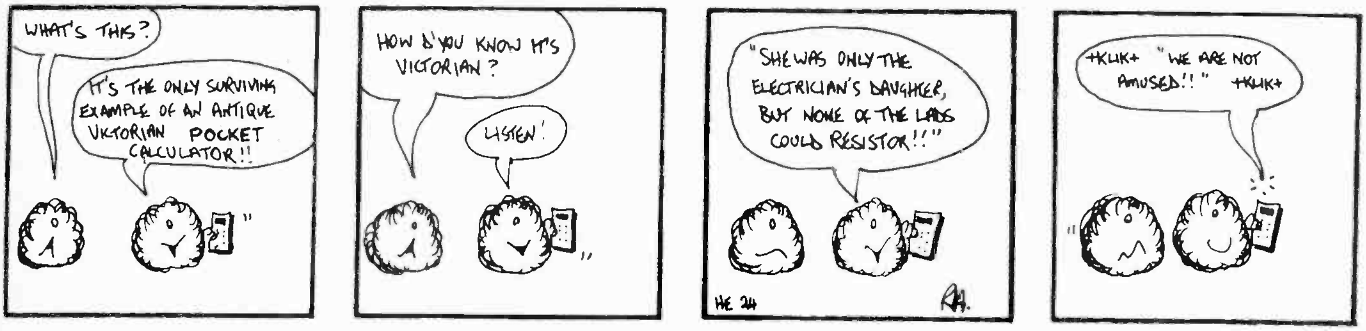
The AM Solution

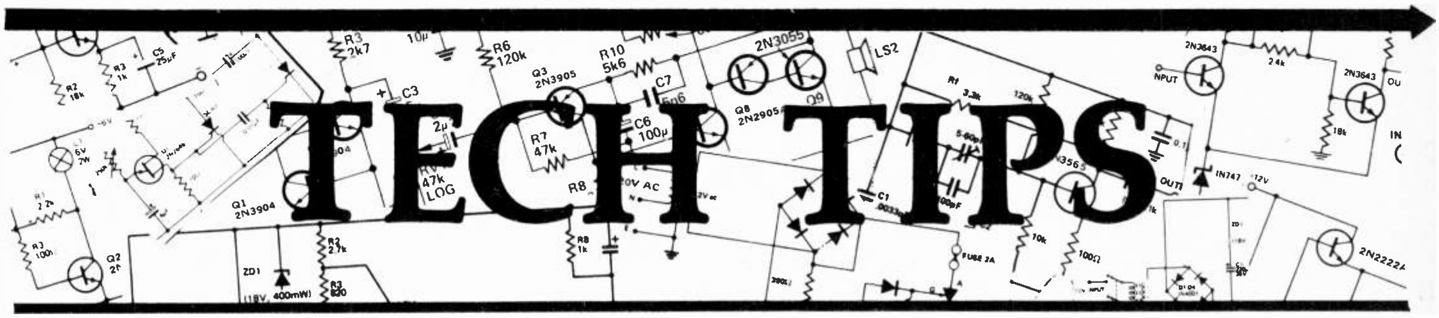
The wavelengths involved in the Medium Band occupied by AM broadcasting stations is about a hundred times as great, and the resulting phase shift effects are less by the same magnitude, if they occur at all. Remember, Medium Band signals pass *through* objects which reflect VHF signals. Indeed, the only likelihood of such a problem is a "skip" from the ionosphere involving a relatively close powerful station, and such an event is quite rare.

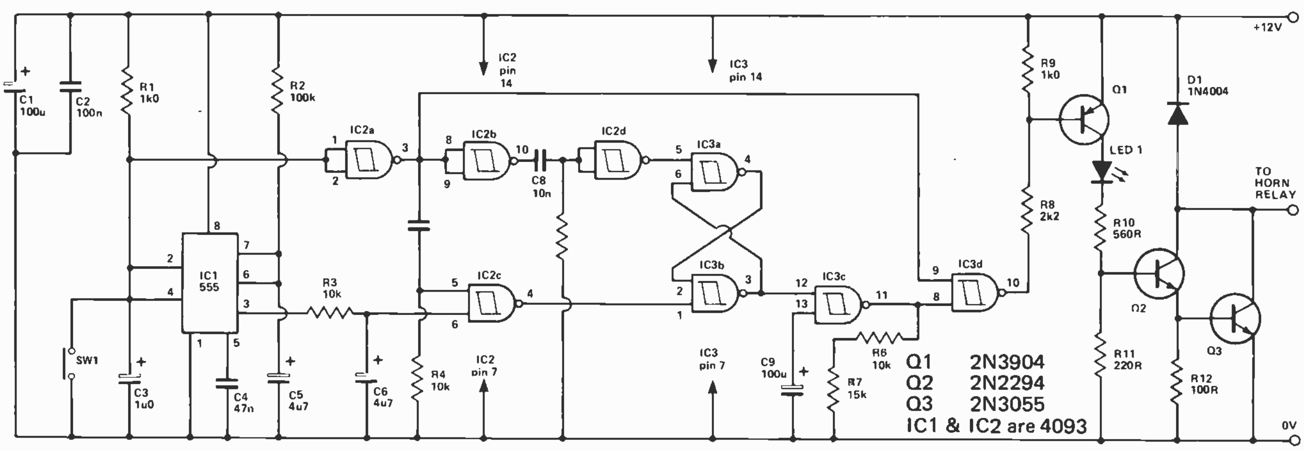
In other words, mobile AM reception is generally far superior than FM. Quality can be almost a good. All that's needed is stereo.

An next month we'll take a look at the approved system and see how it works.

And if you want to look up December 1977 ETI and do some homework, the system approved is the one by Magnavox. ●







Car Horn Repeater

I. Hopkins

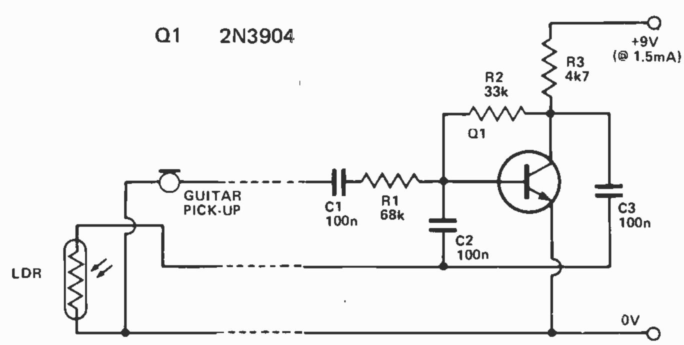
This circuit allows the horn to sound either continuously or repetitively while the horn switch is pressed. The second option is activated by pressing the horn button twice in quick sucession.

When SW1 is pressed initially, gates IC2a and IC3d propagate the signal, turning on transistors Q1 -Q3 and sounding the horn in the conventional manner. Releasing SW1 triggers the monostable IC1 (a 555 timer). If SW1 is pressed again while IC1 is active, flip-flop IC3a/b is set, enabling oscillator IC3c and causing the horn to operate intermittently as long as the switch is closed.

LED 1 is optional and monitors the operation of the horn — very useful during testing. The oscillator frequency can be varied by altering C9, while the monostable period is adjusted using R2 and C5. C3 and C6 suppress the effects of switch bounce and R7 sets the mark/space ratio of the oscillator to approx 3 1.

Autowah Without Tears

S. N. Goodwin



The main disadvantage of a simple wah-wah circuit is that it requires a manual trigger for the effect, usually provided by a foot-pedal, which needs solid (and often expensive) mechanical construction and also prevents the guitarist from moving freely about the stage. After a couple of hand-made pedal systems collapsed in use, the standard wah-wah circuit was modified as follows A light dependent resistor was mounted on the soundboard of the guitar about 2 cms from the highest string, pointing out about 1 cm from the front of the instrument. The shadow of the player's hand moving across the guitar triggers the effect — the more light shining on the LDR, the higher the frequency-range boosted by the circuit.

It is tolerant of quite a wide range of light levels and if the range is found to be incorrect this can be rectified in two ways. Lenses or filters can be put across the LDR, or resistors can be connected in series/parallel with it. Fluorescent lights could give problems with mains hum, but, under normal incandescent lighting, none were experienced. The wire to the LDR should ideally be screened, but over short distances this is not vital. Avoid bending its leads close to the body, as they can be snapped off very easily.

Babani Books from ETI

BP1: First Book of Transistor Equivalents & Substitutes — $2.80

More than 25,000 transistors with alternatives and equivalents make up this most complete guide. Covers transistors made in Great Britain, USA, Japan, Germany, France, Europe, Hong Kong, and includes types produced by more than 120 different manufacturers.

BP14: Second Book of Transistor Equivalents & Substitutes — $4.80

This handbook contains entirely new material, written in the same style as the "First Book of Transistor Equivalents & Substitutes". The two complement each other and make available some of the most complete and extensive information in this field.

BP24: Projects Using IC741 — $4.25

The popularity of this inexpensive integrated circuit has made this book highly successful. Translated from the original German with copious notes, data and circuitry, a 'must' for everyone, whatever their interest in electronics.

BP33: Electronic Calculator Users Handbook — $4.25

An invaluable book for all calculator users whatever their age or occupation, or whether they have the simplest or most sophisticated of calculators. Presents formulae, data, methods of calculation, conversion factors, etc., with the calculator user especially in mind, often illustrated with simple examples.

BP35: Handbook of IC Audio Pre-amplifier & Power Amplifier Construction — $5.50

This book is divided into three parts: Part I, Understanding Audio ICs, Part II, Pre-amplifiers, Mixers and Tone Controls, Part III, Power Amplifiers and Supplies. Includes practical constructional details of pure IC and Hybrid IC and Transistor designs from about 250mW to 100W output. An ideal book for both beginner and advanced enthusiasts alike.

NO.205: First Book of HI-FI Loudspeaker Enclosures — $3.55

The only book giving all data for building every type of loudspeaker enclosure. Includes corner reflex, bass reflex, exponential horn, folded horn, tuned port, klipschorn labyrinth, tuned column, loaded port and multi speaker panoramic. Many clear diagrams are provided showing all dimensions necessary.

BP47: Mobile Discotheque Handbook — $5.90

The aim of this book is to give you enough information to enable you to have a better understanding of many aspects of "disco gear". The approach adopted is to assume the reader has no knowledge and starts with the fundamentals. The explanations given are simplified enough for almost anyone to understand.

BP48: Electronic Projects For Beginners — $5.90

The newcomer to electronics, will find a wide range of easily made projects and a considerable number of actual component and wiring layouts. Many projects are constructed so as to eliminate the need for soldering. The book is divided into four sections: "No Soldering" Projects, Miscellaneous Devices, Radio and Audio Frequency Projects and Power Supplies.

BP49: Popular Electronic Projects — $6.25

A collection of the most popular types of circuits and projects which will provide a number of designs to interest the electronics constructor. The projects selected cover a very wide range. The four basic types covered are: Radio Projects, Audio Projects, Household Projects and Test Equipment.

BP50: IC LM3900 Projects — $5.90

The purpose of this book is to introduce the LM3900, one of the most versatile, freely obtainable and inexpensive devices available to the Technician, Experimenter and the Hobbyist. It provides the groundwork for both simple and more advanced uses.

Simple basic working circuits are used to introduce this IC. The reader should set up each of these for himself. Familiarity with these simple circuits is essential in order to understand many more complicated circuits and advanced uses.

BP51: Electronic Music and Creative Tape Recording — $5.50

This book sets out to show how electronic music can be made at home with the simplest and most inexpensive of equipment. It then describes how the sounds are generated and how these may be recorded to build up the final composition.

For the constructor, several ideas are given to enable him to build up a small studio including a mixer and various sound effects units. All the circuits shown in full have been built by the author. Most of the projects can be built by the beginner.

BP69: Electronic Games — $7.55

The author has designed and developed a number of interesting electronic game projects using modern integrated circuits. The book is divided into two sections, one dealing with simple games and the latter dealing with more complex circuits. Ideal for both beginner and enthusiast.

BP70: Transistor Radio Fault-Finding Chart — $2.40

Author Mr. Chas. Miller has drawn on extensive experience in repairing transistor radios to design this book. The reader should be able to trace most of the common faults quickly using the concise chart.

BP71: Electronic Household Projects — $7.70

Some of the most useful and popular electronic construction projects are those that can be used in or around the home. These circuits range from such things as '2 Tone Door Buzzer' and Intercom through Smoke or Gas Detectors to Baby and Freezer Alarms.

BP72: A Microprocessor Primer — $7.70

A newcomer tends to be overwhelmed when first confronted with articles or books on microprocessors. In an attempt to give a painless approach to computing, this small book will start by designing a simple computer that is easy to learn and understand. Such ideas as Relative Addressing, Index Registers, etc. will be developed and will be seen as logical progressions rather than arbitrary things to be accepted but not understood.

BP 73: Remote Control Projects — $8.58

This book is aimed primarily at the electronics enthusiast who wishes to experiment with remote control and many of the designs are suitable for adaptation to the control of other circuits published elsewhere. Full explanations have been given so that the reader can fully understand how the circuits work and see how to modify them. Not only are Radio control systems considered but also Infra red, Visible light and Ultrasonic systems as are the use of Logic ICs and Pulse position modulation etc.

BP74: Electronic Music Projects — $7.70

Although one of the more recent branches of amateur electronics, electronic music has now become extremely popular and there are many projects which fall into this category, ranging in complexity from a simple guitar effects unit to a sophisticated organ or synthesiser.

The purpose of this book is to provide the constructor with a number of practical circuits for the less complex items of electronic music equipment, including such things as Fuzz Box, Waa Waa Pedal, Sustain Unit, Reverberation and Phaser Units, Tremelo Generator etc.

BP75: Electronic Test Equipment Construction — $7.30

This book covers in detail the construction of a wide range of test equipment for both the hobbyist and radio amateurs. Included are projects ranging from a FET Amplified Voltmeter and Resistance Bridge to a Field Strength Meter and Heterodyne Frequency Meter.

Not only can the home constructor enjoy building the equipment but the finished project can also be usefully utilised in the furtherance of his hobby.

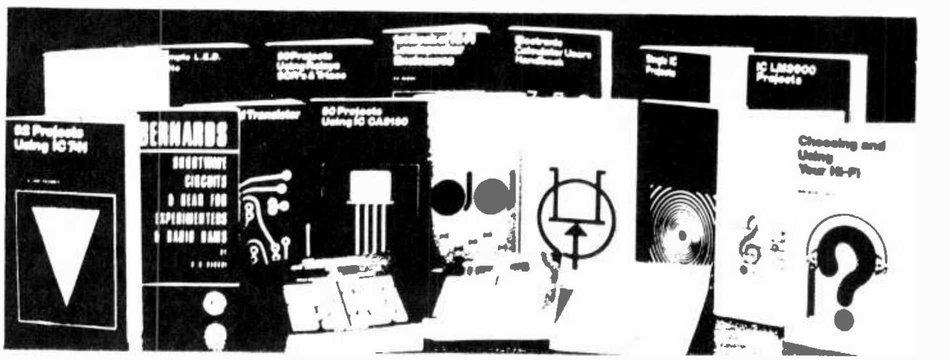
An ideal book for both beginner and advanced enthusiast alike.

BP76: Power Supply Projects — $7.30

Power supplies are an essential part of any electronic project.

The purpose of this book is to give a number of power supply designs, including simple unstabilised types, fixed voltage regulated types, and variable voltage stabilised types, the latter being primarily intended for use as bench supplies for the electronic workshop. The designs are all low voltage types for use with semiconductor circuits.

There are other types of power supplies and a number are dealt with in the final chapter, including a cassette supply, Nicad battery charger, voltage step up circuit and a simple inverter.



These books are specially imported from England by us. If someone has already used the form in this issue, please write to: ETI Magazine, Unit 6, 25 Overlea Boulevard, Toronto, Ontario M4H 1B1.

BP37: 50 Projects Using Relays, SCR's & Triacs — $5.50

Relays, silicon controlled rectifiers (SCR's) and bi-directional triodes (TRIACs) have a wide range of application in electronics today. These may extend over the whole field of motor control, dimming and heating control, delayed, timing and light sensitive circuits and include warning devices, various novelties, light modulators, priority indicators, excess voltage breakers, etc.

The enthusiast should be able to construct the tried and practical working circuits in this book with a minimum of difficulty. There is a wide latitude in component values and types, allowing easy modification of circuits or ready adaptation of them to individual needs.

BP39: 50 (FET) Field Effect Transistor Projects — $5.50

The projects described in this book include radio frequency amplifiers and converters, test equipment and receiver aids, tuners, receivers, mixers and tone controls, as well as various miscellaneous devices which are useful in the home. This book contains something of particular interest for every class of enthusiast – short wave listener, radio amateur, experimenter or audio devotee.

BP42: 50 Simple L.E.D. Circuits — $3.55

50 interesting and useful circuits and applications, covering many different branches of electronics, using one of the most expensive and freely available components – the Light Emitting Diode (L.E.D.). Also includes circuits for the 707 Common Anode Display. A useful book for the library of both beginner and more advanced enthusiast alike.

BP44: IC 555 Projects — $7.55

Every so often a device appears that is so useful that one wonders how life went on before without it. The 555 timer is such a device. It is manufactured by almost every semiconductor manufacturer and is inexpensive and very easily obtainable.

Included in this book are Basic and General Circuits, Motor Car and Model Railway Circuits, Alarms and Noise Makers as well as a section on the 556, 558 and 559 timers.

BP46: Radio Circuits Using ICs — $5.90

This book describes integrated circuits and how they can be employed in receivers for the reception of either amplitude or frequency modulated signals. Chapters on amplitude modulated (a.m.) receivers and frequency modulation (f.m.) receivers. Discussion on the subjects of stereo decoder circuits; the devices available at present for quadrophonic circuits and the convenience and versatility of voltage regulator devices. An extremely valuable addition to the library of all electronics enthusiasts.

BP62: BOOK 1. The Simple Electronic Circuit & Components — $8.95
BP63: BOOK 2. Alternating Current Theory — $8.95
BP64: BOOK 3. Semiconductor Technology — $8.95

Simply stated the aim of these books is to provide an inexpensive introduction to modern electronics. The reader will start on the right road by thoroughly understanding the fundamental principles involved.

Although written especially for readers with no more than ordinary mathematical skills, the use of mathematics is not avoided, and all the mathematics required is taught as the reader progresses.

The course concentrates on the understanding of the important concepts central to electronics. Each book is a complete treatise of a particular branch of the subject and, therefore, can be used on its own. However, latter books assume a working knowledge of the subjects covered in earlier books.

BOOK 1: This book contains fundamental theory necessary to a develop a full understanding of the simple electronic circuit and its main components.
BOOK 2: This book continues with alternating current theory.
BOOK 3: Follows on semiconductor technology, leading up to transistors and integrated circuits.

BP65: Single IC Projects — $6.55

All the projects contained in this book are simple to construct and are based on a single IC. A strip board layout is provided for each project, together with any special constructional points and setting up information, making this book suitable for beginners as well as more advanced constructors.

BP66: Beginners Guide To Microprocessors & Computing — $7.55

This book is intended as an introduction to the basic theory and concepts of binary arithmetic, microprocessor operation and machine language programming. The only prior knowledge which has been assumed is very basic arithmetic and an understanding of indicies. A helpful Glossary is included. A most useful book for students of electronics, technicians, engineers and hobbyists.

BP67: Counter Driver & Numeral Display Projects — $7.55

The author discusses and features many applications and projects using various types of numeral displays, popular counter and driver IC's, etc.

BP68: Choosing & Using Your HI-FI — $7.25

The reader is provided with the fundamental information necessary to enable him to make a satisfactory choice from the extensive range of stereo equipment currently on the market. This should aid him in understanding the technical specifications of the equipment he is interested in buying. Full of helpful advice on how to use your stereo system properly so as to realise its potential to the fullest and also on buying your equipment. A Glossary of terms is included.

NO.213: Electronic Circuits For Model Railways — $4.50

The reader is given constructional details of how to build a simple model train controller, controller with simulated inertia and a high power controller. A signal system and lighting for model trains is discussed as is the suppression of RF interference from model railways. The construction of an electronic steam whistle and a model train chuffer is also covered.

NO.215: Shortwave Circuits & Gear For Experimenters & Radio Hams — $3.70

Covers constructional details of a number of projects for the shortwave enthusiast and radio "Ham". Included are: an add in crystal filter, adding an "S" meter in your receiver, crystal locked H.F. Receiver, AM tuner using phase locked loop, converter for 2MHz to 6MHz, 40 to 800MHz RF amplifier, Aerials for the 52, 144MHz bands, Solid State Crystal Frequency Calibrator, etc.

NO.221: Tested Transistor Projects — $5.50

Author Mr. Richard Torrens has used his experience as an electronics development engineer to design, develop, build and test the many useful and interesting circuits in this book. Contains new and innovative circuits as well as some which may bear resemblance to familiar designs.

NO. 223: 50 Projects Using IC CA3130 — $5.50

In this book, the author has designed and developed a number of interesting and useful projects using the CA3130, one of the more advanced operational amplifiers that is available to the home constructor. Five general categories are covered: Audio Projects, R.F. Projects, Test Equipment, Household Projects and Miscellaneous Projects.

NO.224: 50 CMOS IC Projects — $4.25

CMOS IC's are suitable for an extraordinary wide range of applications and are now also some of the most inexpensive and easily available types of ICs. The author has designed and developed a number of interesting and useful projects. The four general categories discussed in the book are: Multivibrators, Amplifiers and Oscillators, Trigger Devices and Special Devices.

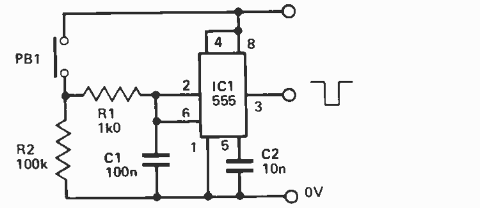
ALL PRICES INCLUDE POSTAGE & HANDLING

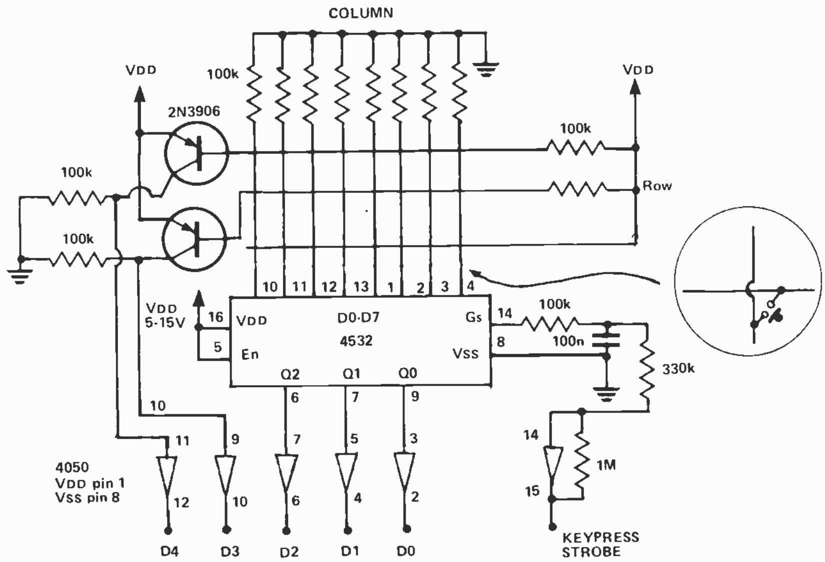
Prices subject to change without notice.

555 Input Reset

P. Davidson

When dealing with a microprocessor system, there are several features which place requirements on the duration of their input leg reset. These signals are usually negative (in the author's experience) and so, with the use of a 555, these requirements can be filled reliably (as opposed to the normal flip-flop debounce circuit). The circuit saves on logic used to invert the normal 555 monostable action.





Simple Keyboard Encoder

Malcolm Coyne

This simple circuit provides decoding for up to twenty-four cross-point or momentary contact switches arranged in the matrix pattern shown. The outputs are buffered to drive a single TTL load and key decoding is static. An added attraction of this circuit is its low current drain, approximately 50uA on standby and 90uA with a single key pressed.

Circuit operation is relatively straight forward. The 100K resistors at the head of the columns normally hold all the inputs to the 4532 CMOS priority encoder at ground and the row resistors hold the bases of the PNP transistors at the positive supply and hence the transistors off. When a key is pressed, shorting a column to a row, one one of the inputs to the 4532 is taken high and its output will be the octal number for the column. If the key number is greater than seven then the keypress allows current to flow out of the base of one of the PNP transistors turning it on. This provides the row decoding.

It is also necessary to detect the keypress to distinguish between no input and zero. This is done using the group select (GS) output of the priority encoder which will go high if any of its inputs go high. The integrator formed by the 100K resistor and the 100n capacitor coupled with the Schmidt trigger formed from the two resistors and the buffer are used to remove contact bounce and eliminate false triggering. The outputs are buffered by the 4050 to provide adequate drive capability.

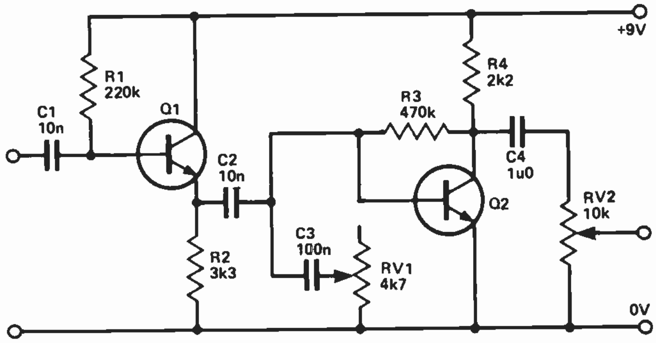
Tech-Tips is an ideas forum and is not aimed at the beginner; we regret that we cannot answer queries on these items. We do not build up these circuits prior to publication.

ETI is happy to consider circuits or ideas submitted by readers; all items used will be paid for. Drawings should be as clear as possible and the text should be preferrably typed. Anything submitted should not be subject to copyright. Items for consideration should be sent to the Editor.

Guitar Treble Boost

J.R. Spink

Q1 is connected as an emitter follower in order to present a high input impedance to the guitar. C2, being a relatively low capacitance, cuts out most of the bass and C3 with RV1 acts as a simple tone control to cut the treble and hence the amount of treble boost can be altered. Q2 is a simple preamp to recover signal losses in C2, C3 and RV1.



Train Chuffer

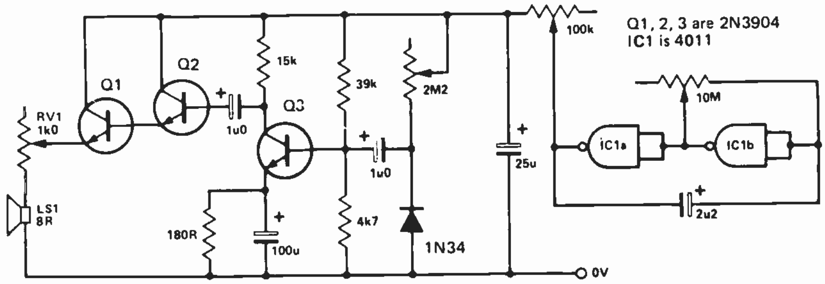
C.S. Histed

This circuit will produce a train chuffing noise and should prove interesting to anybody with their own layout.

The circuit consists of a white noise generator, which only switches on with the high part of the square wave output from the clock circuit. The frequency of the clock is adjusted with the 10M pot and the output voltage of the clock is adjusted by the 100k pot (rate and volume of chuff respectively).

The 2M2 pot controls the amount of noise produced and the 1k pot on the speaker controls the pitch of the average noise.

The circuit works by by amplifying the noise through the seemingly wrong way around diode and only letting the circuit on when the clock is at logic '1'.

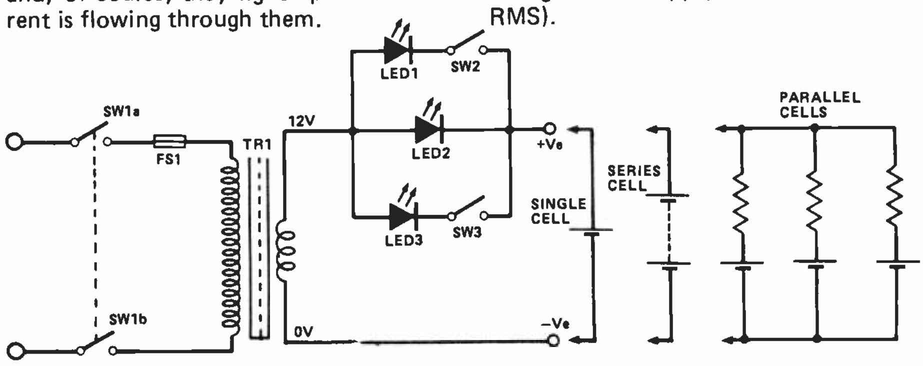


Ni-Cad Charger

J. Grainger

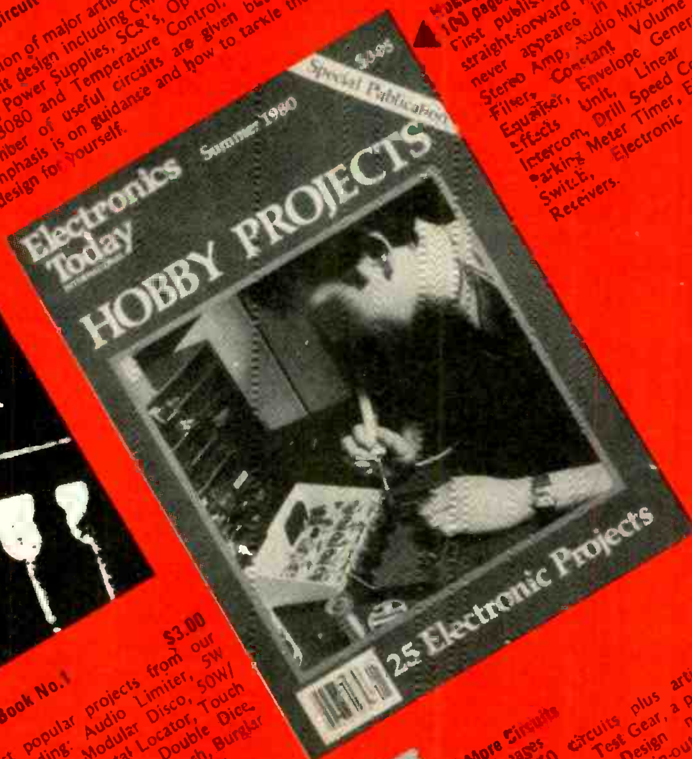
This circuit makes use of constant current LEDs now available for around 80¢ each. These devices pass a constant current of about 15ma for an applied voltage range of 2-18V and will also block voltage peaks of up to 18V in the reverse direction. Furthermore they can be paralled to give any multiple of 15ma and, of course, they light up when current is flowing through them.

The circuit shown will charge a single cell at 15, 30 or 45ma or cells in series up to the rated supply voltage limit (about 14V). If it is desired to charge the cells at less than 15ma, several cells may be paralled using suitable sharing resistors, which should drop about 10V at the cell current. The LEDs will be damaged if the peak voltage of the supply exceeds 18V (13V RMS).



ETI SPECIALS

Electronic Circuit Design $3.95
92 pages
A collection of major articles on various aspects of circuit design including CMOS, Audio Amplifiers, Power Supplies, SCR's, Op-Amps, Using the 3080 and Temperature Control. A large number of useful circuits are given but the emphasis is on guidance and how to tackle the design for yourself.



Hobby Projects $3.95
100 pages
First published Summer 1980. Contains 25 straight-forward projects most of which have never appeared in the magazine including: Stereo Amp, Audio Mixer, Scratch and Rumble Filter, Constant Volume Amp, Graphic Equaliser, Envelope Generator, White Noise Effects Unit, Linear Scale Ohmmeter, Intercom, Drill Speed Controller, LED Tacho, Parking Meter Timer, Electronic Organ, Touch Switch, Electronic Dice, Siren, Simple Receivers.

Canadian Projects Book No.1 $3.00
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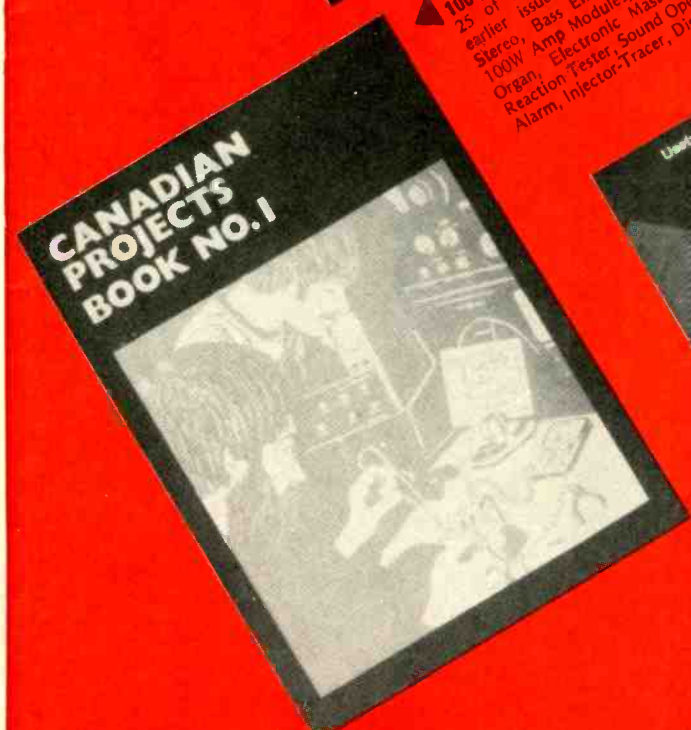
25 of our most popular projects from our earlier issues including: Audio Limiter, 5W Stereo, Bass Enhancer, Modular Disco, 50W/100W Amp Modules, IB Metal Locator, Touch Organ, Electronic Mastermind, Double Dice, Reaction Tester, Sound Operated Flash, Burglar Alarm, Injector-Tracer, Digital Voltmeter.



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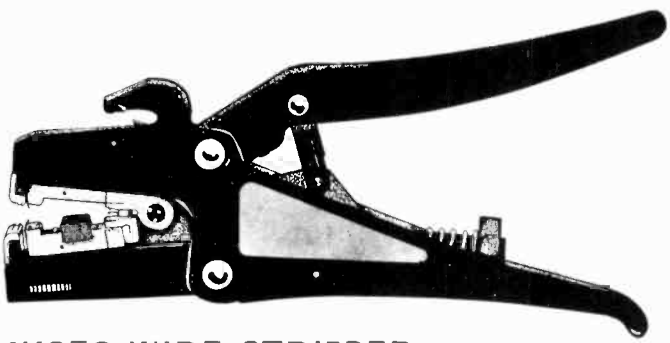
UNIQUE TOOLS FOR ELECTRONICS

STRIPPERS & CUTTERS



MK2FC WIRE STRIPPER

Self adjusting wire stripper with built in wire cutter strips. Single or multi conductor cables. Lightweight and effortless to use. Replaceable metal gripping jaw.

Stripping blades are flat and they adjust themselves around the diameter of wire. You can, therefore, strip with the same ease single or multiple wires, round or flat conductors.

NEW

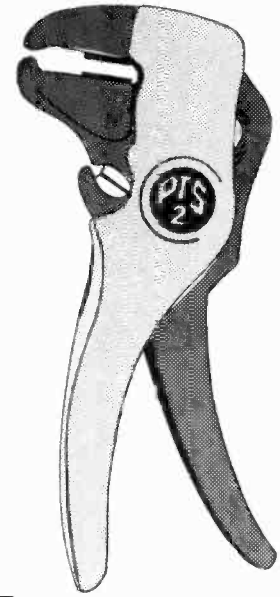
TYPE PTS2

This new tool functions as both a cutter and a stripper for electrical cables of Section 0.2 to 6 mm without adjustment. It can also be employed for multiple cables as the outside main insulation and the internal single cables can be stripped without readjusting the tool.

PTS2 has the functional characteristics of two separate tools.

The operations of cutting and stripping are here perfectly executed by one single device.

Suitable for cutting/stripping cables of Section 0.2 to 6 mm



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THE BEST FROM SWEDEN

OBLIQUE-CUTTING NIPPERS

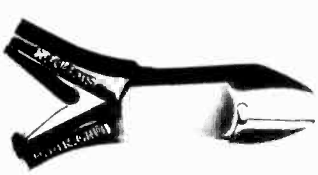
575 (Semi-flush)
576 (Full-flush)

With edges set at 75°
Length of cut 15.5 mm
Total length 108 mm (4")

OBLIQUE-CUTTING NIPPERS, SHORT

577 (Semi-flush)
578 (Full-flush)

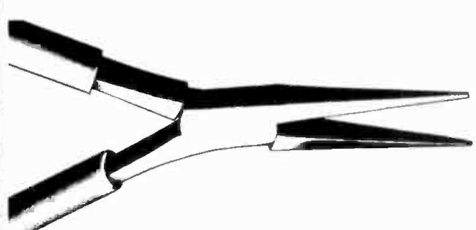
With edges set at 75°
Length of cut 8 mm
Total length 108 mm (4")



DIAGONAL CUTTING NIPPERS

670 (Semi-flush)
671 (Full-flush and relieved back)

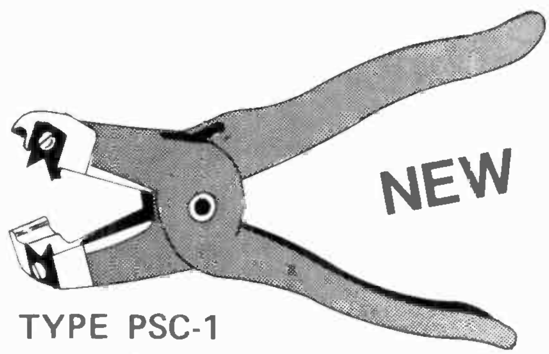
With edges set at 15°
Length of cut 9 mm
Total length 110 mm (4½")



SNIPE-NOSE PLIERS, LONG JAWS

890 (Smooth jaws)
892 (Cut jaws)

Width of tips 1 mm
Length of jaws 32 mm
Total length 132 mm (5")



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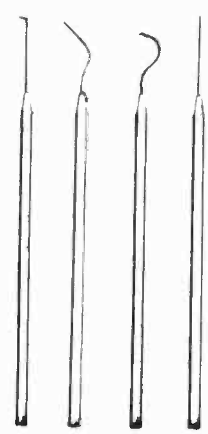
Our new Cable Stripper PCS-1 is simple to use and it is suitable for cables of varied diameter without needing adjustment. An indespensible tool when working with heavy duty cables, (6 to 18 mm).

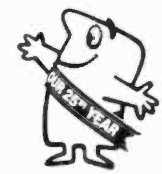
Made of rugged pressed steel, cutting blades are tempered and are easily removed for resharpening. Specially designed to allow any length to be stripped at any point in the cable.

PROBE KIT

For probing, picking and poking solder joints. Use in inspection and production. Stainless steel, tempered spring wire steel tips for flexibility.

70-180





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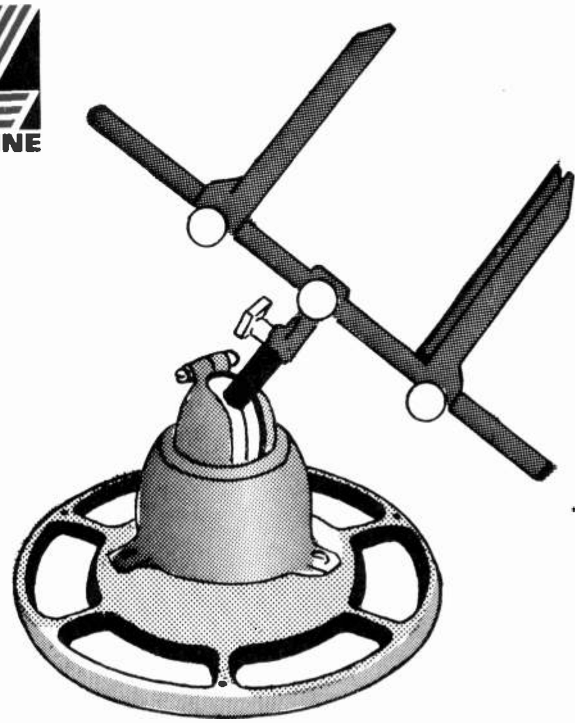

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Holds boards of any shape, up to 12 wide, in any position . . . flat, vertically, at any angle. It is easily rotated, tipped, tilted, elevated, lowered, moved left or right, or turned over. New model 312 Tray base mount has 6 convenient trays moulded into the base for neatly holding small parts and tools.

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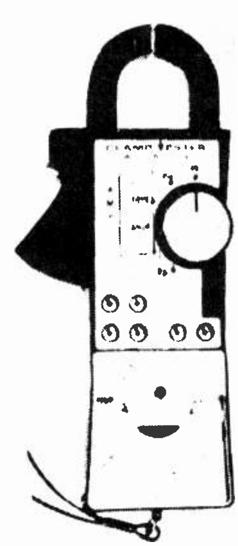


MCP-3

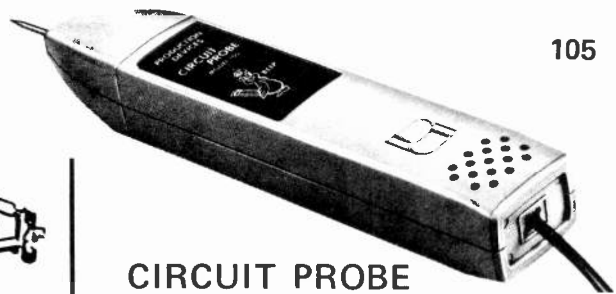
CLAMP-ON TESTER

The tester is capable of wice-range measurement: Amperage can be measured in 5 ranges from 6A to 300A; Voltage in 3 ranges from 150 to 600 Volts; and Resistance up to 1K . The Clamp-On tester is supplied with a carrying case. (Supersedes CT-300)

JW79-1 SPADE AND PICK

Electronic Service Aid with insulated handle for solid state electronic equipment.

Both ends of this tool are heat treated, hardened, and plated to assure you of long and trouble free use

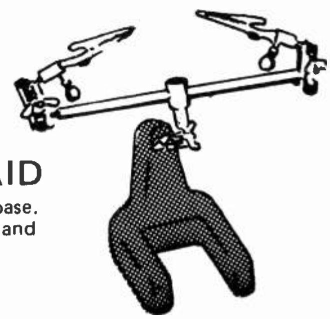


105

CIRCUIT PROBE

Circuit Probe produces a tone that varies with resistance, capacitance, or voltage. With a little practise the Circuit Probe may be used to compare circuit resistances, check many types of components, trace audio signals (up to 1khz), and check live circuits up to 130 VAC or DC. Because the probe is current limited, it will not harm any circuit.

Weight: 4 oz. Size: 7"x 1.2"x .9"
Warranty: 1 year



"THIRD-HAND" SOLDERING AID

Two adjustable arms with alligator jaws set in a heavy base. A versatile tool, it can be adjusted to any position and firmly hold small items of any shape.

70-490 — Shipping Weight 1 lb.
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130

MINIGEN AUDIO GENERATOR

The model 130 is a quality generator in a "mini" package. This instrument is an excellent source for testing amplifier frequency response, speaker enclosures, and tape recorder head alignment. An internal voltage regulator permits the unit to always remain within specifications. Once set, the output amplitude and frequency are constant. The frequency is variable from 20 Hz to 20 Khz. The generator can be modified to other frequency ranges by changing one internal capaciter.

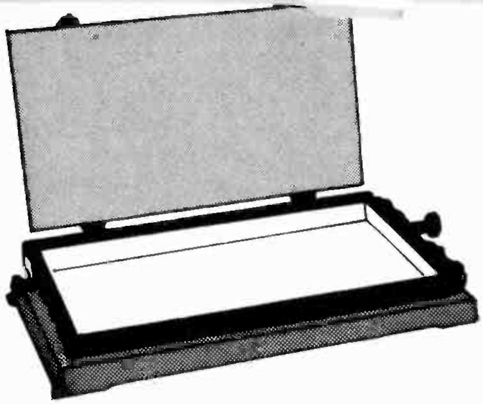
110

A/V LOGIC PROBE

The Audio/Visual Logic Probe has eliminated the need to continually watch for pulses, + or - transitions, or high speed pulse trains. A new concept in logic testing. The model 110 is a complete tester compatible with DTL, TTL, and CMOS logic. Threshold levels are automatically set. Ideal for analyzing logic circuits in computers, telephone systems, digital test equipment and desk calculators.

Size: 6.8" x 1.2" x 9" Weight: 2.5 oz.

PCB HOLDERS



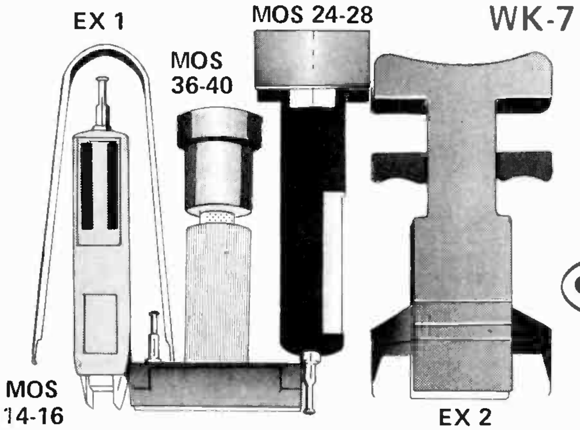
The practical and elegant design is particularly suited to shorten the time in mounting components, parts, etc. in printed circuit boards. They are 3 piece units; a frame base, printed circuit holder, and foam rubber component pressing or holding lid. Larger models are available.

LENLINE

Board Sizes:

PCSS 0	210 x 180 mm
PCSS 1	270 x 220 mm (with Mid Rail) 270 x 110 + 270 x 100 mm
PCSS 2	500 x 220 mm (with Mid Rail) 500 x 100 + 500 x 100 mm
PCSS 3	750 x 220 mm (with Mid Rail) 750 x 110 + 750 x 100 mm
PCSS 4	500 x 350 mm (with Mid Rail) 500 x 175 + 500 x 165 mm

INSERTION/EXTRACTION KIT



WK—7 Kit items may be purchased separately.

CONTAINS:

MOS-1416 14-16 Pin, MOS, CMOS Safe Inserter MOS-2428 24 - 28 Pin, MOS, CMOS Safe Inserter

For highly sensitive MOS & CMOS IC's. Ground strap may be easily attached.

36-40 Pin CMOS Safe IC Insertion Tool. Unique new insertion tool. Also aligns bent-out pins.

Dip IC Extractor Tool. The EX-1 Extractor is ideally suited for hobbyist or lab engineer. Featuring one piece spring steel construction. It will extract all LSI, MSI and SSI devices of from 8 to 24 pins.

CMOS Safe Dip IC Extractor Tool. Extracts all 28-40 pin DIP IC's having standard .600 widths, including MOS and CMOS devices. Easy one-handed operation.

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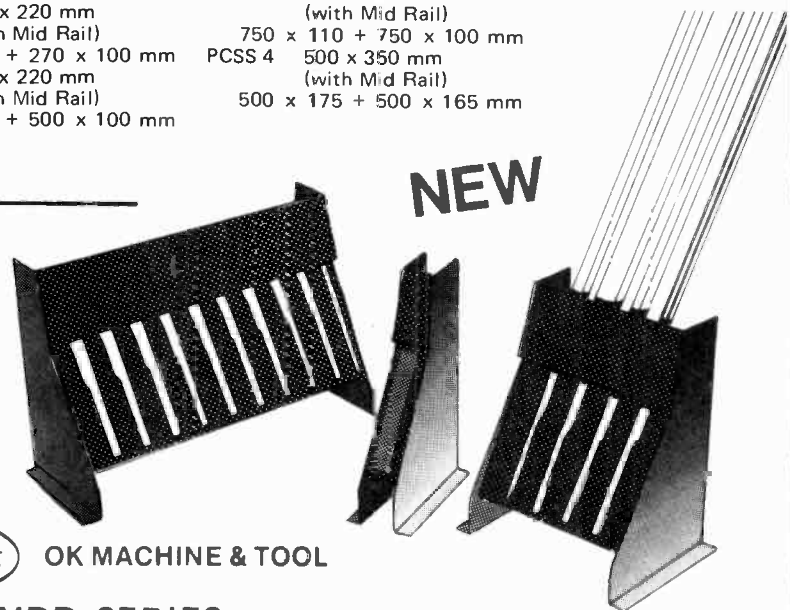

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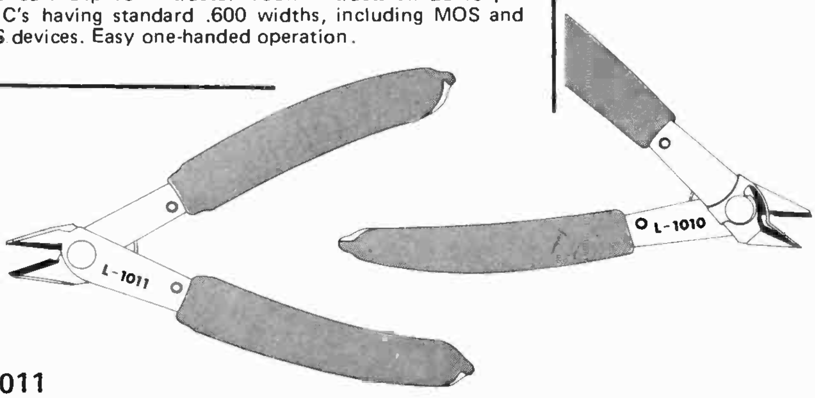
CMOS, MOS I.C. DISPENSERS

FEATURES:

Simple yet very effective design and capable to handle all known I.C. carrying tubes. Dispenses I.C.'s of 0.3, 0.4 & 0.6 pitch up to 42 pins. MOS, CMOS protected — material is carbon filled. Dispenser clamp to hold tube firmly in position and adjustable stop to suit length of I.C., empty tubes can be removed with ease. I.C.'s cannot "piggyback" and automatically release one at a time. Grounding lug fitted and is available in 1, 5 & 10 channel versions as standard.

BENDING TOOL



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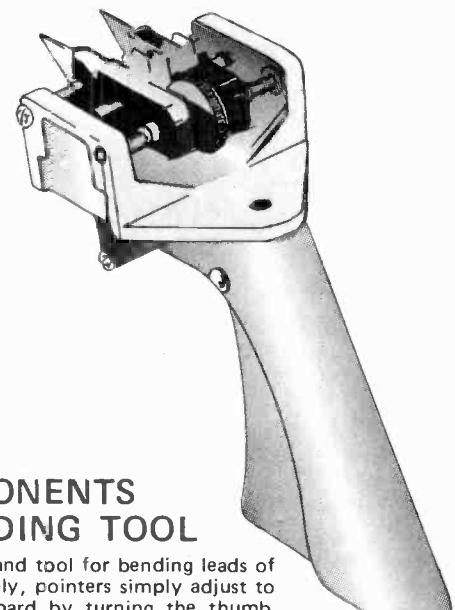
THIN PROFILE WIRE CUTTERS

5" angled flushcutters with patented shearing action for soft wire to 20 gauge. This is a U.S. made, quality tool of high carbon steel fabrication with significantly longer life. Its double-coil spring return and thin profile tips give you a smooth effortless flush cut with lower stress and operator fatigue. Unique vinyl foam non-slip handles allow you a comfortable cushion grip. Distinctive green colour.

L 1010
THIN PROFILE SAFETY WIRE CUTTER

Same as above cutter but with a built-in lead catcher that retains cutoff wire, eliminating flying ends.



TP-8 COMPONENTS LEAD BENDING TOOL

Simple to operate hand tool for bending leads of components accurately, pointers simply adjust to pitch of holes in board by turning the thumb wheel, components are then inserted and bent to the exact pitch by light squeeze of handles. Made to very high standards of quality, with built-in compensator for varying wire diameters. This tool will produce perfect scratch free bends. Technical Data: Capacity: 0.25 mm to 1 mm. Max. length of bend: 35 mm. Min. length of bend 9.5 mm. Component dia: max. 12.5 mm.

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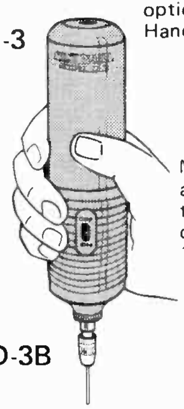
This is a simple and convenient mini-drill suitable for drilling PC boards with ease and reliability. Also applicable for making panels, name plates, aluminum plates, handicrafts, home carpentry, etc. 186mm long, lightweight, with speed of 2,500 r.p.m. Battery operated (batteries not included) or can be used with optional AC adapter (see part number AD-660 below). Handles drill sizes 0.6mm to 1.5mm.

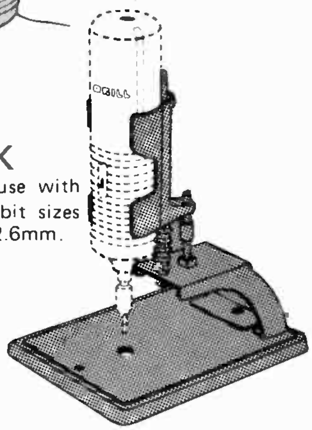
D-3



D-3B

MINI-DRILL STAND

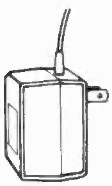
Mini-drill is easily installed in this stand giving you an ultra-compacting drilling machine. Enables you to drill printed circuit boards more easily and precisely. Stop moves easily for fine adjustments. Measures 157mm high x 120mm wide x 70mm deep.



STD-50

CHUCK

Chuck for use with larger drill bit sizes 1.6mm to 2.6mm.

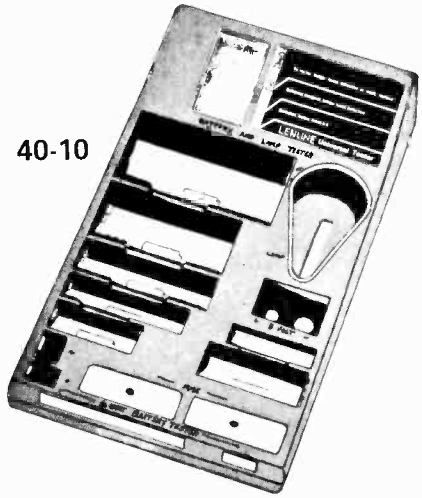


AD-660

AC ADAPTER

Special 6 volt AC adapter for use with D-3 mini-drill.

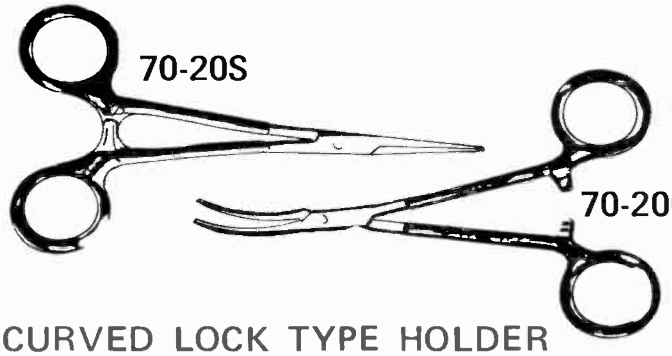
40-10



STRAIGHT LOCK HOLDER

6" O.A.L. stainless steel, slim serrated jaws. Has two position snap-lock. Excellent heat sink and clamp. Allows quick disconnect and reconnect for temporary connections.

70-20S



70-20C

CURVED LOCK TYPE HOLDER

6" O.A.L. Same as 20S except with a slight curve in the jaws to afford easy access to hard to get to places.

BATTERY/BULB/FUSE TESTER

At last, a home-type electrical tester that anyone can use! Solves all common household electrical problems, Tests standard zinc-carbon batteries, Checks automotive fuses, Checks round or cylindrical cartridge fuses, Checks miniature lamps, and Checks standard household lamps up to 200 w size.

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With all the same features as the original Vise-Grip but with Gator-Grip

It can do more jobs, faster and easier than any other long nose pliers.

Get fingertip control.
Cut heavy wire.
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Use as wrench.
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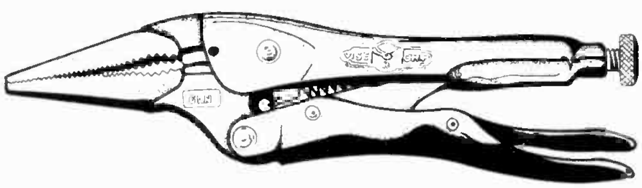
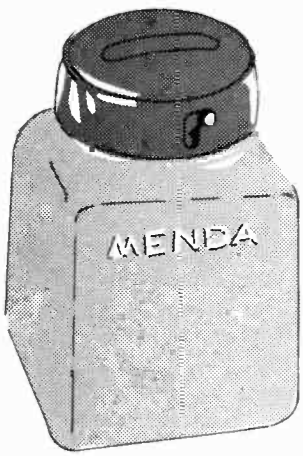


SOLVENT DISPENSERS



Precision instruments in every respect. Pump units are constructed of the finest stainless steel obtainable to give a lifetime of satisfactory service. Airtight check valve eliminates evaporation over long periods. Yet the light pressure of an applicator or sponge on dispenser dish pumps solvent to surface the instant you need it. Bottles are molded linear polyethylene. Ideal for dispensing: Methyl Ethyl Ketone, Alcohol, Carbon Tetrachloride, Acetone, Ether, Perchloroethylene, Trichloroethylene and any other solvents.

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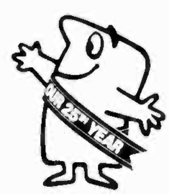

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