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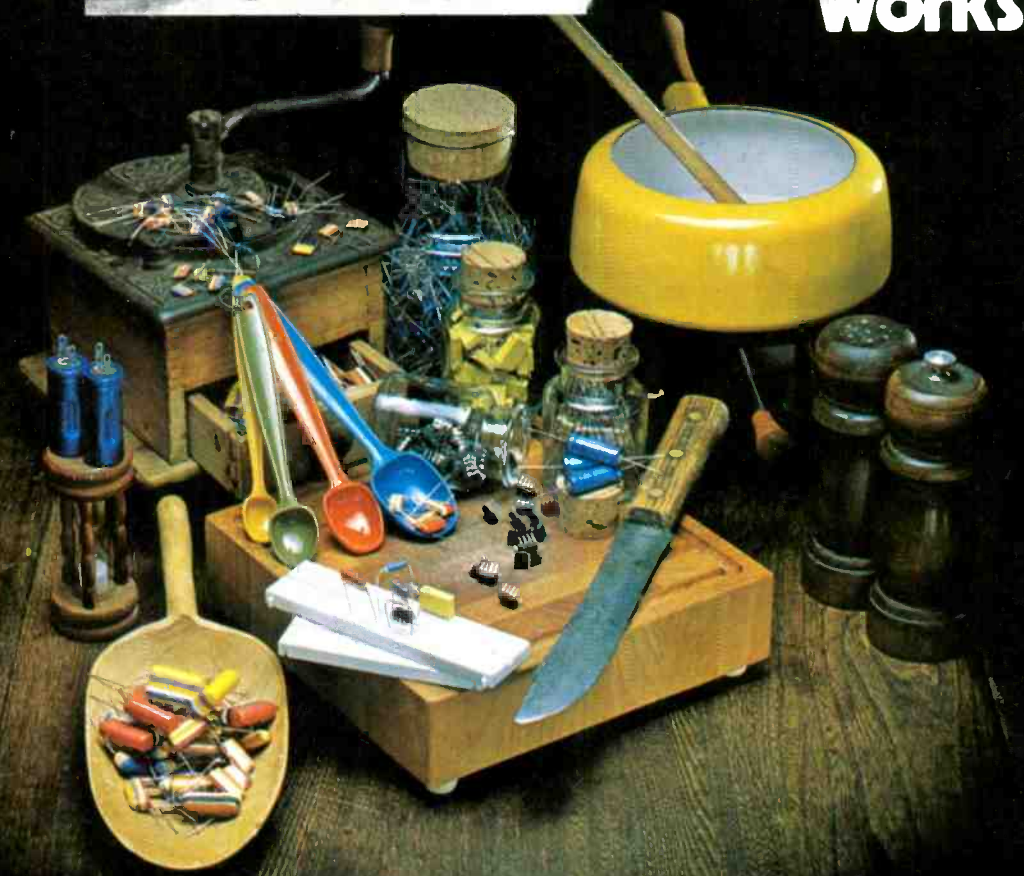

741 COOKBOOK

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FUZZ BOX, BENCH POWER SUPPLY

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3CU3A	2.90
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3DC3	2.60
3DF3	2.80
3DJ3	2.10
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3HQ5	1.90
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4BZ6	1.35
4DT6A	1.55
4EH7	1.55
4EJ7	1.55
4HA5	1.55
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5GH8A	1.85
5GJ7	1.95
5GS7	1.85
5GX7	2.70
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6HS5	4.45

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12BE6	1.05
12BY7A	1.20
12C5	1.55
12DQ6B	2.25
12DW4A	1.90
12GN7	2.00
14GW8	2.00
15DQ8	1.60
17AY3A	1.60
17BE3	1.55
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17DQ6B	2.10
17JN6	2.85
17JZ8	1.85
17KV6A	3.95
17KW6	5.60
18GV8	1.95
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21JZ6	3.20
23Z9	2.65
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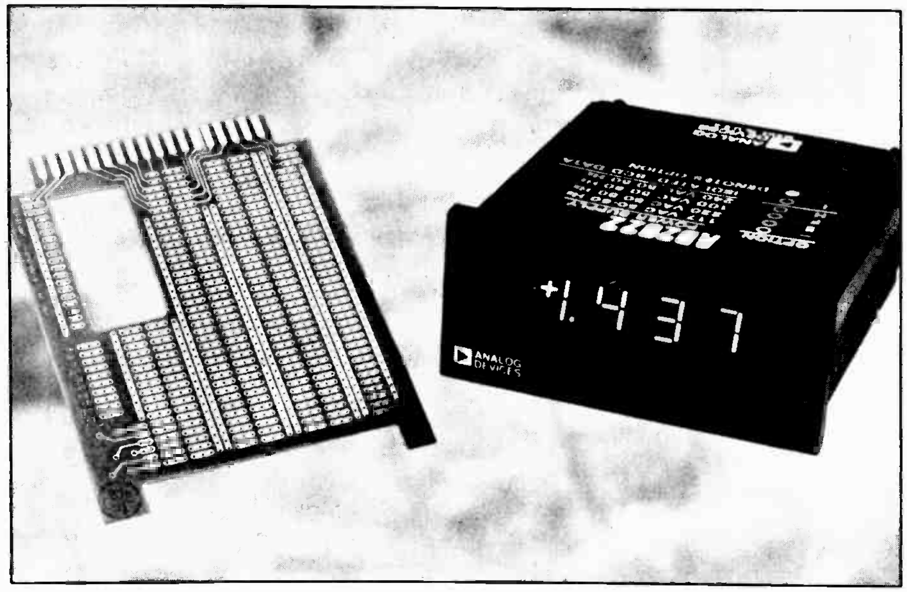
NEWS DIGEST



"DO-IT'YOURSELF"DPM

A 3½-digit panel meter which can internally accommodate 12 square inches of user-build signal conditioning circuitry for measurement and display of a wide variety of electrical and physical functions has been introduced by the Instruments and Systems Group of Analog Devices.

Using either a 3¾" x 4", or a smaller 1.1" x 1.43", printed circuit board which is connected internally to the basic DPM, the new AD2022 allows the user to build in circuitry that will measure and display such variables as temperature, pressure, flow, pH, capacitance, resistance, or decibels. The self-contained "functional DPM" requires about the same amount of space as a typical 3½-digit DPM and uses the industry standard panel cutout size (3.9"W x 1.67"H x 4.5"D).

Available from stock, the AD2022 is unit-priced at $218 inc. duty and FST with its companion AC2615 breadboarding card priced at $25.50 including connector. *Tracan Electronics Corporation, 558 Champagne Drive, Downsview, Ontario M3J 2T9.*

The AC2615 PC card is pre-drilled with 0.100" spacing to accommodate standard components. When populated, the function board connects to the converter board via a 10-conductor ribbon. The flexibility of the connection allows the function board to be "folded" onto the converter board, and the resulting "sandwich" slid back into the AD2022 case.

Al Pollens, Product Marketing Manager, said the extensive use of MOS/LSI circuitry in the "second generation" design of the AD2022 provides the extra space which gives the AD2022 its broad, functional design flexibility. He said that in addition to using Analog Devices' functional breadboard, users could connect their own printed circuit boards up to the capacity of the AD2022.

In addition to providing extra circuit space, the AD2022 offers ±12 @ 20mA to power analog circuitry and +5V @ 100mA of logic power in its standard character serial BCD output configuration, with +5V output @ 30mA if the parallel BCD output option is specified.

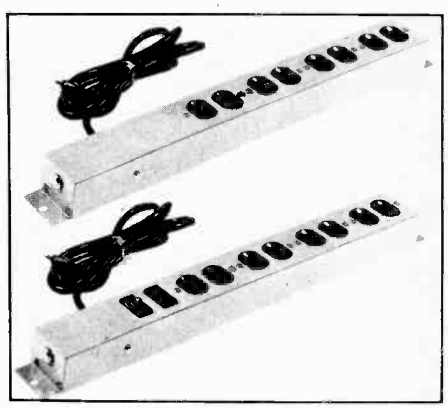
Other advantages of the "second generation" design include large light-emitting-diode (LED) displays, 0.5" high; greater reliability because of the lower components count; lower power requirements, less heat build-up and lower cost.

The AD2022 has a ±1.999V DC full scale range and features auto zero correctiion. Limited differential input is standard on the new DPM, and full floating isolation is optional. The AD2022 can be operated ratiometrically.

With 1975 sales of $30 million, Analog Devices is a leading supplier of electronic components and devices used in measurement and control instrumentation and industrial computer systems.

POWER BAR

A 15 amp circuit breaker is a standard feature on the "Power Bar" by Hammond Manufacturing. CSA industrially certified, this quality unit comes in 4, 6, and 8 receptacle models, with an optional on–off switch, pilot light and choice of 6 or 15 foot U-ground cords. A contemporary beige in colour, it is easily mounted and ideal for residential or industrial use. *Hammond Manufacturing Company Ltd., 394 Edinburgh Road North, Guelph, Ontario N1H 1E5.*



TUBES BEAT ANYTHING IN THE AIR

A Russian MiG-25 Foxbat flown to Japan by a defecting pilot has revealed the use of vacuum tube technology in the Fox Fine radar. The radar has a peak output of 600kW which makes it the most powerful airborne fire-control radar known. USAF experts have concluded that the MiG-25 is unsurpassed as an extremely fast high-altitude intercepter. One wonders what the Russians can do with advanced semiconductor technology!

INJECTED

Integrated Injection Logic has taken off and looks set ultimately to display TTL and CMOS. Special frequency control chips for CB use with both analog and digital circuitry on one chip have already been developed and will soon be in production. I^2L is also being looked at by watch manufacturers because of its ability to source high currents from an otherwise micropower chip. If someone introduces a 4000-type series of logic functions in I^2L, we'd better be ready!

1984

In Britain, the Dataskil software subsidiary of ICL is offering an analysis to soccer clubs of their performance. A club can find out what results they need based on other teams' performances, and the effects of variables such as the absence of a key player can be predicted. Since the results can be predicted, why bother to play the games at all? Players would be spared the time-consuming chore of practice sessions and could devote more time to important activities like appearing on TV chat shows, opening boutiques etc.

2K-BYTE STATIC RAM MODULE

Motorola's Microsystems group has introduced Micromodule 6, memory sub system targeted for microcomputer-based OEM products. This provides the user with 2048 bytes of static RAM (type P2102-1 or MK4102 RAMs are used as the memory elements), organized into two groups of eight 1024 x 1 bit RAMs. Typical memory cycle time is 500 nanoseconds.

During manufacture, Micromodule 6 is assigned to base address 7800 (hex) to 7FFF (hex). The user, however, can change this base address by means of jumper wires on the module. The base address can be re-assigned throughout the range of 0000 to F800, in 2K byte increments. The micromodule's address, data and control busses have TTL-compatible buffered inputs; the data bus has three-state TTL outputs. M68MM06 is bus compatible with both the Micromodule Familty and the EXORciser. This adaptability permits the user to utilize the hardware and software features of the EXORciser and its options to aid in system development and production line troubleshooting.

Power requirement for Micromodule 6 is 1.5 A (max) at + t Vdc (± 5%). The unit price is $280.00; the 2 to 9 price is $274.00. Availability from the factory and authorized Motorola distributors, is now.

Also new from Motorola is a modular data acquisition system to the line. The system consists of an 8-channel, differential-input module called Micromodule 5A (MM5A) and a 4-channel analog output module (MM5C).

The analog input voltage range of the MM5A&B is ± 10 mV to ± 10V; the input current range is 4 to 20 mA or 10 to 50 mA (resistor programmable). Input impedance is 100 M; amplifier gain range is 1 to 1000 V/V (resistor programmable).

The MM5A&B both contain an input multiplexer, a high gain instrumentation amplifier, sample/hold circuit, 12 bit A/D converter, timing/control/address decode logic and a + 5 V to ± 15 V dc–dc converter.

Like the MM5A&B, the MM5C is bus compatible with an EXORciser or Micromodule system. The analog output range is strap selectable for ± 10 V, 0 to 10 V, ± 5 V or ± 2.5 V (at 5 mA).

The MM5C contains four 12-bit, hybrid D/A converters, a 12-bit latch, address decode/write control logic and a + 5 V to ± 15 V dc–dc converter. The inputs of the D/A converters are double-buffered to minimize output glitches.

Unit price of each module is $725.00; availability, from the factory and authorized Motorola distributors, is now. For further information on any of these products contact Motorola Microsystems at (602) 244-6815 or the Technical Information Center, Motorola Semiconduct Products, Inc., P.O. Box 20294, Phoenix, Arizona 85036, U.S.A.

COMPUTERS HAVE EARS

EMI Thrshold have introduced a low cost voice-input terminal based on the DEC LSI-11 Microprocessor. This means that data can be input to a computer by speech — a 'hands-off' approach, if you like. The Threshold 500 performs spectral analysis of each spoken word into 32 speech parameters — aspirants, vowels, long and short pauses and other characteristics, and compares these with pre-stored reference patterns. If they match, an output string is generated. With the addition of a speech synthesizer your computer could even mutter to itself under its breath!

MICROCHESS

Microchess, an intelligent chess playing program which will run on any 8080 or Z-80 system with 4K of contiguous memory and an ASCII input/output device has been announced by Micro-Ware Ltd.

The Microchess documentation includes a Player's Manual with a description of the program, and a comprehensive appendix with details for conversion of the I/O routines, or customization programs.

Features include automatic board display, multiple levels of playing skill, castling, and the ability to reverse the board at any time.

Microchess will be available at a price of $15.00 from most major computer stores or direct from:

Microchess (8080), Micro-Ware Limited, 27 Firstbrooke Rd., Toronto, Ont., Canada, M4E 2L2.

SPACE SHUTTLE ON THE TILES

Extremely pure silica glass has been manufactured for at least 40 years - longer than jet aircraft have been around. Now it is to aid and abet the ultimate aircraft - the U.S. Space Shuttle. Made into tiles (composed of 96% silica glass) of which 34,000 are used, the material covers well over 70% of the surface of the Shuttle.

These tiles are incredible heat 'shedding' devices (see photo) and will be expected to withstand temperatures of up to 1260°C for 100 re-entries into the atmosphere. Previous heat shields were destroyed on re-entry.

Each tile is precisely milled to fit exactly against the curvature of the Shuttle body, thus making the composite craft as light as possible, and as aerodynamic as is feasible. This does however mean that no two of those 34,000 tiles are alike! Imagine the little man in a white coat with the job of fitting them to the aircraft - a huge 3-D jigsaw puzzle with only one solution out of 34,000 (i.e. 34,000 x 33,999 x 33,998...x 1) possibilities! Rather him than me.

3-1/2 DIGIT PORTABLE DMM

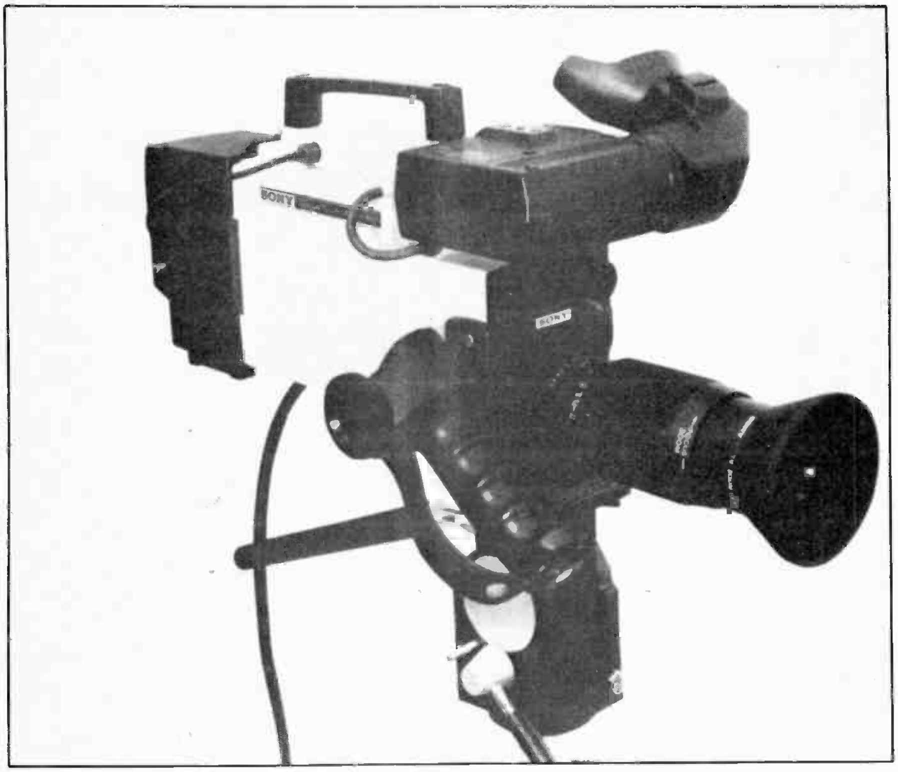
A 3½ digit portable DMM costing only U.S. $99.95 has just been announced by the B&K-PRECISION product group of Dynascan Corporation. The new DMM, Model 2800, is a full-feature instrument that provides a wide range of accurate voltage, current and resistance measurements.

The 2800 features 22 ranges that measure as high as 1000 volts, DC or AC, or up to 40,000 VDC with optional PR-28 probe. Resolution is to 1mV, 1uA or 0.1 ohm. Typical DC accuracy is 1% with an input impedance of 10 megohm. The 2800 also features auto-zeroing and 100% overrange reading on all ranges.

All ranges are well protected against overloads. Ohms circuitry protection ranges from +100V and -450VDC or 300VAC continuously to momentary overloads up to 1000 volts DC or AC. All DC and AC voltage ranges are protected up to +1000 VDC or AC RMS. Decimal point polarity and out-of-range indications are all automatic. The 2800 can be powered by ordinary "C" cells, optional rechargeable batteries, or the optional AC adapter/charger (when rechargeable batteries are used).

The 2800 comes complete with test leads, detailed operating manual and spare fuse. A full range of optional accessories are also available.

The B&K-PRECISION Model 2800 is sold through electronic distributors and will be available in April. For additional information contact: **B&K-PRECISION, Dynascan Corporation, 6460 W. Cortland Avenue, Chicago, Illinois 60635.**



COLOUR CAMERA

Sony of Canada Ltd.'s new DXC-1610 Trinicon colour video camera was designed to complement the VO-3800 portable videocassette recorder/player and the newly-introduced BVU-100.
introduced BVU-100. Available from Sony video products dealers across Canada, the self-contained camera unit has a four-way power capability making it ideal for field or mobile operation. In field operations, the DXC-1610 may be powered by either the portable videocassette recorder or for up to three hours using the optional BP-60 battery pack which may be attached to the back of the camera head. Sony's DCC-3000 car battery adaptor or the CMA-5 AC operated camera adaptor are available for mobile use.

Features include: adjustable electronic detachable viewfinder, F2:1, 17-102mm one touch zoom and focus lens, built-in electret condenser mic and colour temperature compensation filters, flip-open side panels to facilitate maintenance, Sony's registered MF (mixed field) Trinicon tube system in which the chrominance and luminance information is sensed by a single pick-up tube, external mic input.

This lightweight camera (inc. batteries, lens, viewfinder) provides faithful colour reproduction, reliable performance and high resolution with no misregistration problems. It is packaged in an easy-to-carry aluminum case. **Sony of Canada Ltd., Industrial Products Div., 88 Horner Ave., Toronto, Ontario.**

SINCLAIR STRIKES AGAIN

The original Sinclair Programmable calculator was a bit quirky in operation and limited as a scientific calculator; this was often a characteristic of Sinclair's calculator advances. Some readers may recall the original Sinclair Scientific, which used to cause users headaches through its lack of 1/x key. These calculators were great value for money though, and now Sinclair has done it again, but this time, the calculator appears to be idiosyncracy-free.

The new Sinclair Cambridge Programmable is only 4½" x 2" and weighs 2 oz. (HP67 is 11 oz.), yet it has 36 steps of program memory, parentheses, line numbering and even conditional and unconditional branching. Programs may be single-stepped and edited, with step and line number being displayed. Available for this calculator is a library of 294 programs for only $10. It looks like Sinclair have definitely got it right this time — especially at only U.S. $29.95.

IGNITION TRANSISTOR

A new monolithic Darlington transistor circuit — type number MJ10012 — designed specifically for the high-voltage, high-current and harsh environmental requirements encountered in automotive ignition systems has been introduced by Motorola.

Despite their improved specifications, the new automotive Darlingtoniced competitively, at U.S. $2.75 in quantities of 100 to 999. The devices are available in quantity from factory and distributor stock.

For further information, contact the Technical Information Center, Motorola Semiconductor Products, Inc., P.O. Box 20924, Phoenix, Arizona 85036.

Number One ETI CIRCUITS

The first in a new series of 'ideas books' for the experimenter

Contents

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Intruder Alarm
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Coolant level
Water Level
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Car Battery Watchdog
Simple Car Alarm
Simple Lock

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Wide Band Amplifier
Video Power Amp
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Guitar Fuzz
Fuzz Box
Waa Waa
Disco Autofade
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FET-Radio
Op-Amp Radio

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Audio Mixer
Virtual Earth Mixer
Plop Eliminator
Loudspeaker Protection
Digital Capacitance Probe
Digital Tape Recorder Adaptor
Breakdown Diode Substitution
Dual Function Charger
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NEWS DIGEST

MICROCOMPUTER KIT

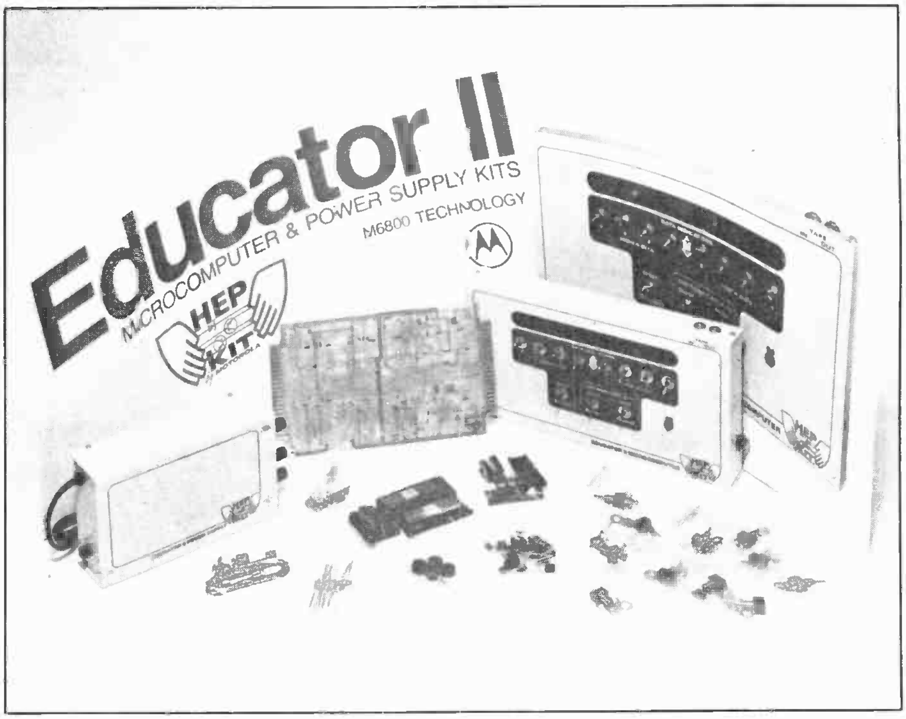
An 8-bit microcomputer system in kit form, has been introduced by Motorola's HEP/MRO Operations Group. Called the Educator II, the kit contains an NMOS 8-bit, MPU, PIA, 128x8-bit static RAM; two TTL 512-4-bit ROMs and a TTL clock circuit. The NMOS components are the HEP versions of the popular M6800 microcomputer products. Educator II utilizes the full instruction set and address modes of the MC6800 MPU. The clock frequency is approximately 625KHz.

An executive program, residing in the ROMs, contains routines for examining and modifying memory locations and MPU registers, servicing interrupts, transferring programs to and from cassette tapes, searching tapes for specific programs and a routine to test the finished kit. The executive uses 14 bytes of RAM for a scratchpad; the remaining 114 bytes are for user programs. An optional 128x8-bit RAM can be added to the p.c. board for larger user programs.

The p.c. board layout is quite simple; kit construction could be accomplished in one evening. All components necessary to get the microcomputer "up and running" are supplied, even the solder. A separate power supply is required, for which a kit is available. A Test-As-You-Build feature provides for accurate, minimum error construction.

A comprehensive construction/instruction manual is included with the kit. Nothing is left to chance in the manual, construction steps are explicitly detailed. Theory of operation of the kit's NMOS microcomputer components are described in an articulate manner. The user is "stepped through" increasingly complex demonstration programs, shown the basics of debugging and how to use the cassette operation. Applications programs are described and listed, along with a listing of the resident firmware.

Educator II retails for $169.95 and is available from selected Motorola HEP and MRO distributors and other distributors, nationally. The additional 128x8-bit RAM is also available at the same locations; the retail price is $19.04.



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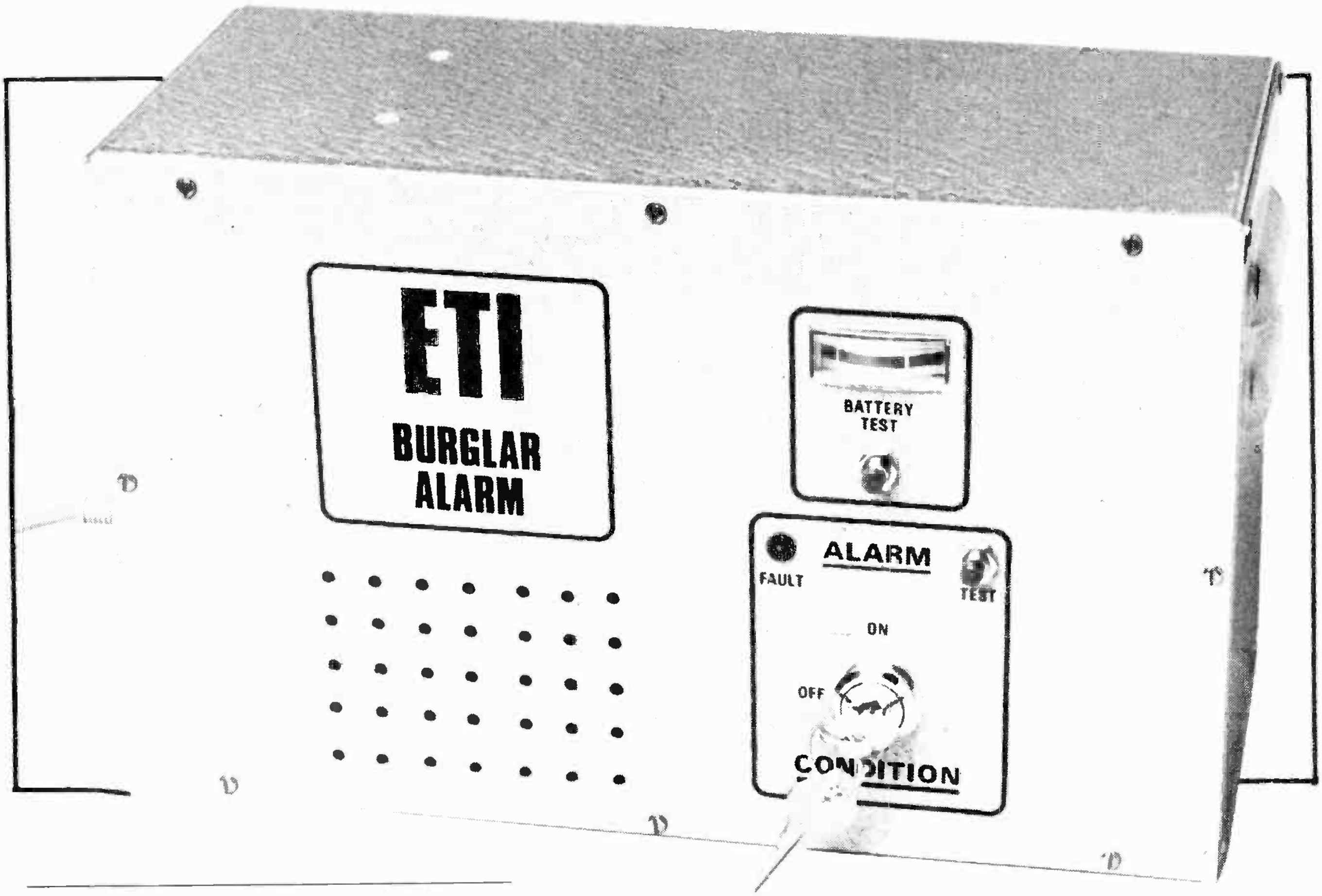
ETI Project

BURGLAR ALARM



A simple and versatile control unit, with internal siren and battery.

FOLLOWING ON from last month's Burglarproof Your Home article, we present the ETI burglar alarm. The circuit is simple, reliable and versatile. Based on a single CMOS chip, the standby current is very low, making a line power supply non essential. Several versions are possible, depending on the particular circumstances where it will be used. We built the simplest version, and will describe it fully, with details of possible modifications and additions.

BASIC UNIT

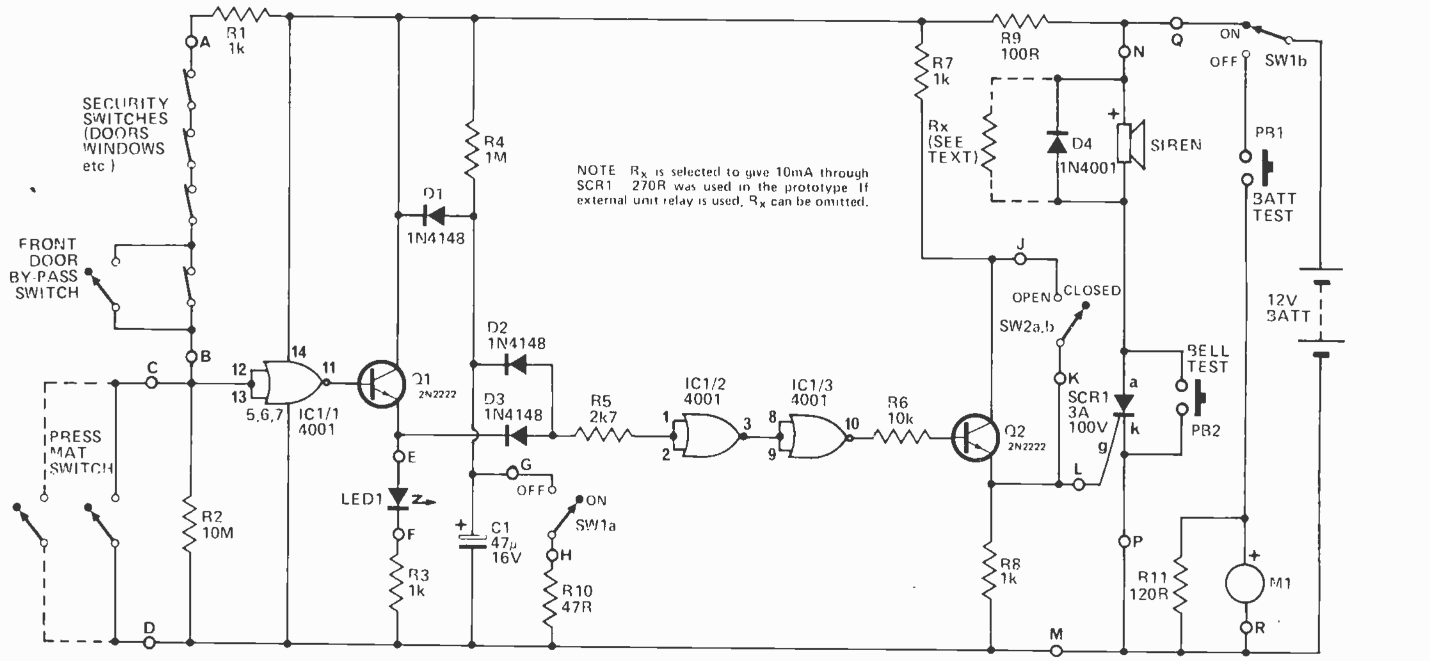
The basic unit is self-contained, apart from sensor switches. A 12V battery is used as the power supply, this battery is capable of powering the system for about a year, if the siren is not activated! When in the alarm condition the battery will power the siren for about 6 hours continuously. A battery test facility is included in the design, which displays the on load voltage. We used a 12V siren similar to the well known "Sonalert", mounted inside the case. Our siren has a sound output of about 93dB meters — quite loud!

Other features of the basic unit are, on/off keyswitch on front panel, bell test button and LED fault indication. The box itself is fitted with anti-tamper microswitches, so that it can only be opened in the off position, without sounding the alarm.

Another important feature is the 30 second delay facility. This ensures that when you switch the unit on — the alarm will not sound for 30 seconds but any fault will light the front panel LED. Also if you have to walk over a pressure mat or open an alarmed door, to leave, you have the delay to do it in.

SENSORS AND SIRENS

Three types of sensor can be used with the system. Normally open circuit types, such as pressure mats; and normally closed types such as reed switches biased by magnets. Changeover contacts can also be used, wired to break the normally closed circuit and short the open circuit when operated, this is possible as one wire is common to both circuits. Connection to the unit is via a standard 180 5 pin DIN plug and socket, all the pins are not used, and external bell



Circuit diagram of basic alarm

units can be wired via this connector if required.

As shown the unit is suitable for shop display protection, trailer protection or even as a tent alarm — a pressure mat under your ground sheet! For some homes the internal siren will be all that is needed, however, the only way to find out is to try it. If you get lots of complaints from your neighbours or a rapid visit by men dressed in blue — it's loud enough! Obviously it is best to try it out at a civilised time — not 4 am. If the internal siren is not loud enough, you will need an external alarm. This will be described further on.

If a shunt switch is not fitted to the main exit, the alarm will sound on entry, this can be unpopular with neighbours. So a shunt switch is strongly recommended.

OPERATION

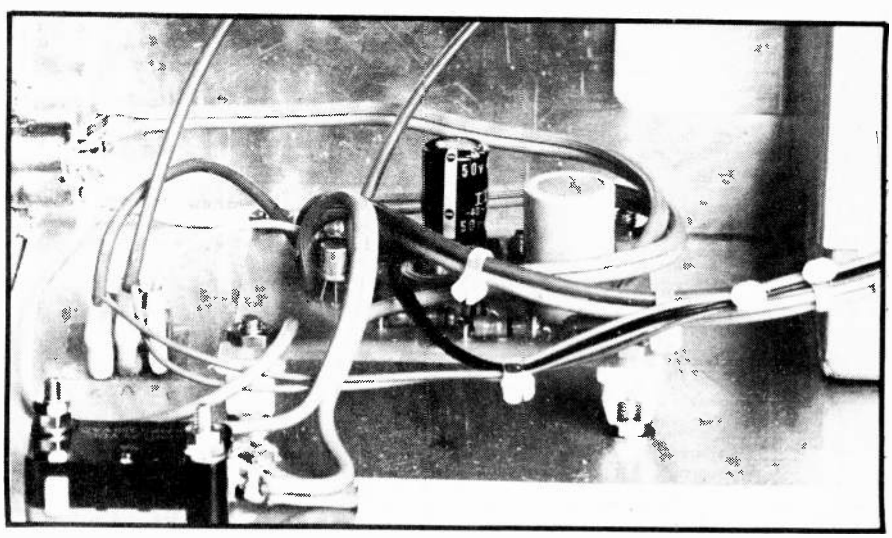
In operation the unit is turned on, by the front panel keyswitch. If the LED lights it means that part of the circuit is either open or closed incorrectly, if this happens switch off and find the open door, or chair on pressure mat etc. To check if you have found the fault switch on again — the LED should remain unlit. A point to note is that you can only test the battery with the unit switched off — this is to prevent the battery being flattened by a burglar keeping the test button depressed (if he managed to get up to the box without setting off the alarm).

Assuming that you have fitted a shunt switch to the exit, you can now leave and lock the door behind you. This is why a shunt switch inside the main lock is preferred to a separate shunt switch; if you forget to operate a separate switch the door is unprotected.

INSTALLATION

Bearing in mind the general guide lines given last month, the installation can be worked out. Points to remember are, cover all external doors, and if uneconomical to protect all windows — to cover the internal doors as well, with the odd pressure mat in hallways and on stairs to complete the protection.

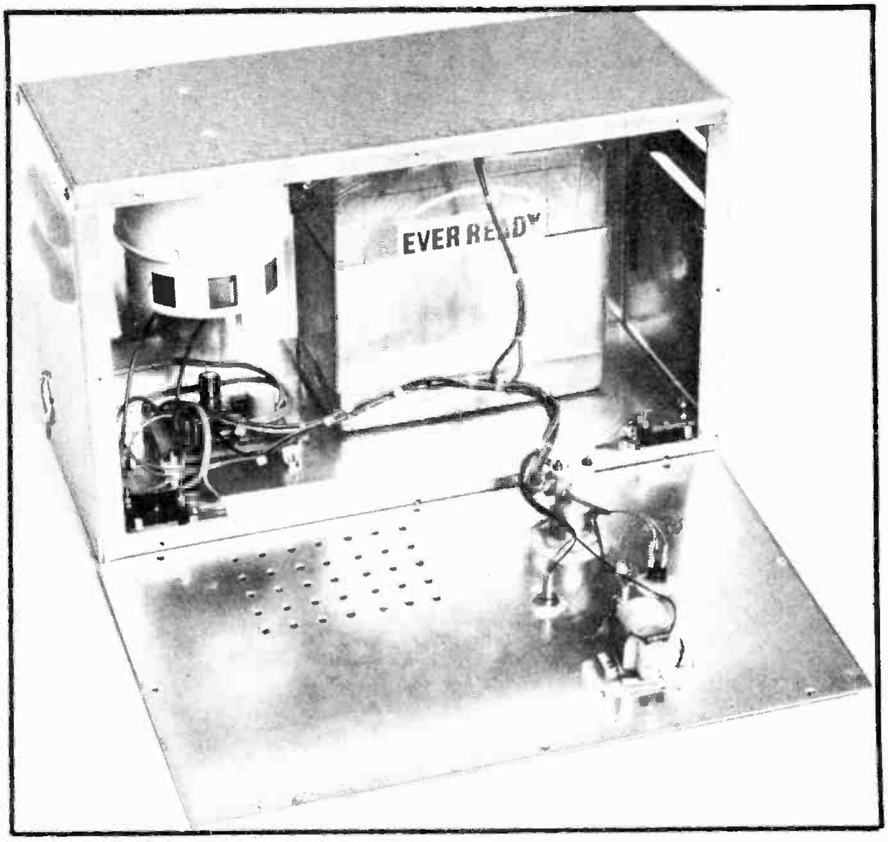
Even though single core wire can be used for the closed circuit wiring, we prefer to use 3 or 4 core throughout, as this gives more flexibility in sensors and also creates uncertainty in the mind of a would be by-passer. It also looks like telephone wiring if installed neatly.



Close-up of board and wiring, this was an earlier version — hence slightly different to overlay shown.

How it works

The circuit is based around a 4001 CMOS quad NOR gate, with the gates connected as invertors (cheaper than using invertors!). The input to ICIa is derived from the closed circuit sensors and the open circuit sensors. In the normal state the output is low and Q1 is off. When either R2 is shorted or the positive supply from R1 is interrupted the gate changes state. Q1 is turned hard on and LED 1 illuminates. R4 and C1 form a timing circuit, which prevents ICIb from giving a low output for 30 seconds from switch on. After this period, if LED1 is on ICIb and ICIc charge state switching on Q2, which triggers SCR1 which self latches. Rx is to make sure SCR1 passes at least 10mA if a bell is used which breaks its own circuit. R11 is selected to draw 100mA to simulate a load for the battery. R10 makes sure that C1 is fully discharged when the alarm is switched off, in order to get consistent timing periods.



General view of the basic unit, note anti-tamper microswitches (SW2 a,b)

Parts List

Resistors *all 5% ½W*

R1,3,7,8	1k
R2	10M
R4	1M
R5	2k7
R6	10k
R9	100R
R10	47R
R11	120R
RX	(see text)

Capacitors

C1	47 F 16V tantalum

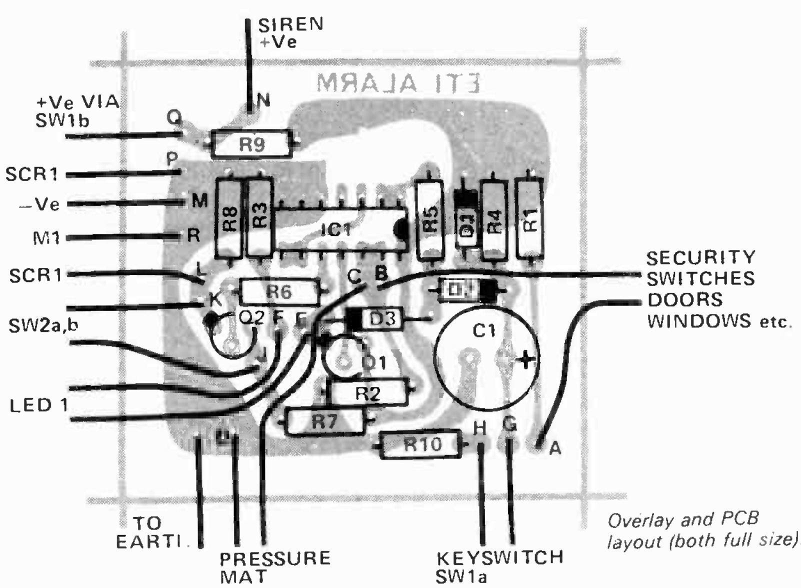
Semiconductors

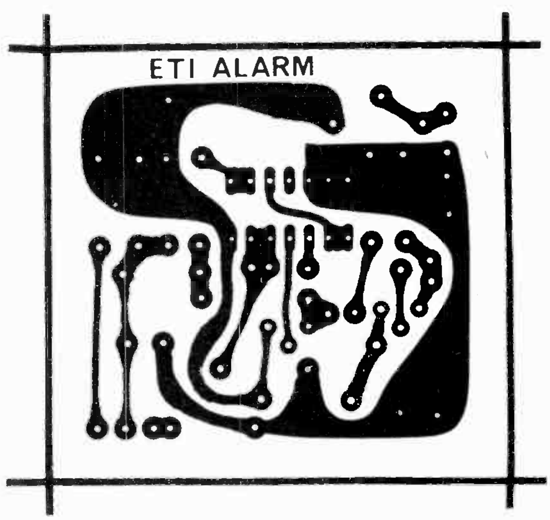
IC1	CD4001A
Q1,2	2N2222 or similar
D1,2,3	IN4148 or similar
D4	IN4001 or similar
SCR1	100V 3A thyristor
LED1	TIL 209 or similar
SW1 (a,b)	Lockswitch
SW2 (a,b)	Microswitch (normally open)
PB1,2	Push to make, release to break
Sensor switches	see text

Miscellaneous

Meter	Panel type 0-15V
Case	11½ x 5 x 7 inches
Battery	12V + connector
Siren	12V type

PCB, nuts, bolts, wire, 5 pin Din plug and socket. Insulating kit for SCR1 etc.





Overlay and PCB layout (both full size)

On returning open the main door and then switch the unit off.

CONSTRUCTION

Construction is quite straightforward, most of the components are mounted on a PCB. The main point to watch is that CMOS is involved, the usual precautions should be taken. Make sure your iron is earthed and fit the IC last. All bolts must be fitted with two nuts to prevent external removal. The front panel mounted parts should be epoxyed into place, also to prevent external tampering. The two microswitches SW2a + b should be fitted so that the front panel keeps them depressed when in place. General layout is easily seen from the photographs.

The unit should be screwed in position through the back panel when complete.

EXTERNAL UNITS

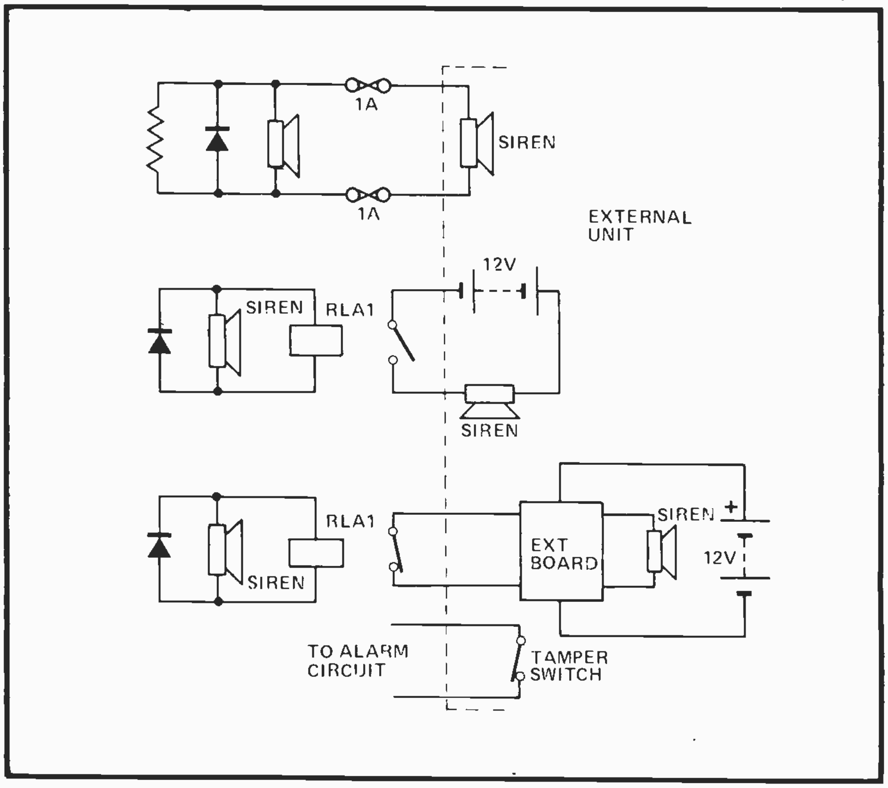
If an external siren or bell is needed there are three ways this can be done. The simplest, but least secure is to run it in parallel to the internal siren via twin wires. A 1A fuse should be placed in each of the leads -- so that a short circuit will not flatten the battery. Obviously the battery life will be reduced when powering two alarm sirens.

The second method is to run a relay in parallel with the internal siren, the external unit then needs its own power supply. The relay should be mounted at the main unit. The external power supply can be another battery or a line power supply.

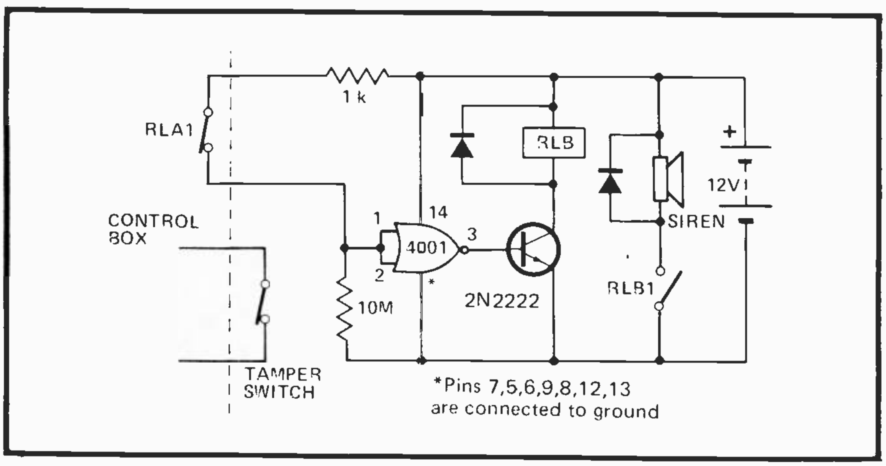
The disadvantage of both these methods, is that if the wires are cut the external alarm will not sound. If the cable is run inside metal tubing this is not so much of a problem.

BEST METHOD

The best method is to use a sensor circuit with a relay output. This can be obtained from another CMOS circuit similar to the main unit — only simpler. Again a relay is connected across the siren but if the wires to it are cut the external siren will sound. The standby current is about 1 µA so the battery can be left connected permanently. A suggested interwiring diagram is shown.



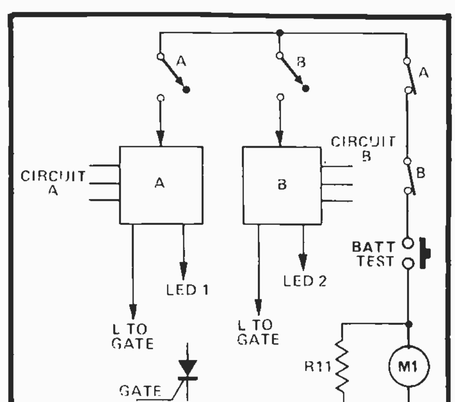
Top: Simplest external siren circuit.
Middle: Addition of a 12 volt relay (RLA1) gives another simple external siren circuit.
Bottom: Most secure method, involves the use of a CMOS chip, circuit below.



UP AND DOWN

Another possible modification is to add an upstairs/downstairs facility to the main unit. This can be done by duplicating the main board and adding an extra keyswitch to the front panel, together with a second LED. The interconnection for this is also shown.

The batteries should be checked at least once a month, and replaced when on load they register below 11 volts. ●



Method for interconnecting two modules for up/down circuits.

CERAMIC CARTRIDGE PREAMPLIFIER

Use of charge amplifier improves performance of ceramic cartridges.

MOST amplifiers of commercial design, including our own ETI designs, omit facilities for ceramic cartridges and allow only for the use of magnetic cartridges. This is because magnetic cartridges are capable of much better performance than ceramic although top line magnetics are much more expensive.

Magnetic cartridges are expensive to build whereas ceramic cartridges are relatively cheap to build so there is a crossover point, and many top line ceramic cartridges are much better value-for-money than are magnetic cartridges in the same price range. Hence many people with limited funds have asked for details of a preamplifier input stage specifically tailored for use with ceramic cartridges.

The two types of cartridge, ceramic and magnetic are entirely different in terms of electrical qualities. The ceramic cartridge has a much higher output, the working load impedances of the two are entirely different and the magnetic type requires equalization whereas the ceramic type does not (or does it?). The magnetic provides an output which is proportional to stylus velocity whilst the ceramic provides an output proportional to acceleration. This means that where a record is recorded with constant acceleration characteristic the output from a ceramic cartridge would be flat with frequency whereas the output from a magnetic cartridge would be a response rising with frequency at 6 dB/octave. Conversely if a constant velocity record characteristic were used the ceramic output would fall with frequency at 6 dB/octave.

Today all records are recorded to the RIAA standard of equalization. Tnis attenuates bass and boosts treble to provide a characteristic very close to constant acceleration. This procedure gives best compromise between the conflicting requirements of signal-to-noise ratio and of pickup trackability. To replay an RIAA equalized record with a magnetic cartridge we must use a preamplifier having the reverse characteristic, i.e, bass must be boosted and treble must be cut in order to obtain a flat frequency response. This process is used on all preamplifiers for magnetic cartridges and is loosely just known as equalization.

However a *perfect* ceramic cartridge, when replaying RIAA equalized material would give an unequalized response as shown in Fig. 1. In order to make ceramic cartridges easier to use manufacturers build in a broad mechanical resonance at the high frequency end to boost the response. At the low end, the rise in response below 50 Hz is cured by selecting a terminating impedance which causes a roll off at about 130 Hz. The response of such a cartridge would be as shown in Fig. 2. If the bass end were not corrected rumble of the turntable would be accentuated and this is clearly not desirable.

Thus clearly, the impedance into which a ceramic cartridge works is of great importance and with this in mind we investigated different methods of matching the cartridge to the amplifier with a view to obtaining the utmost from ceramic cartridges.

DESIGN APPROACH

The ceramic pickup may be simulated by a voltage source and a series capacitor.

The value of the capacitor and the magnitude of the voltage source vary

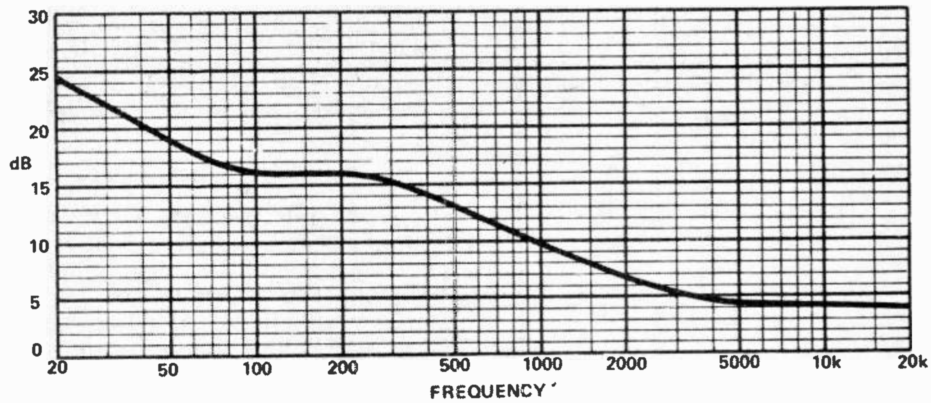


Fig. 1. Typical response of a ceramic pickup without mechanical equalization.

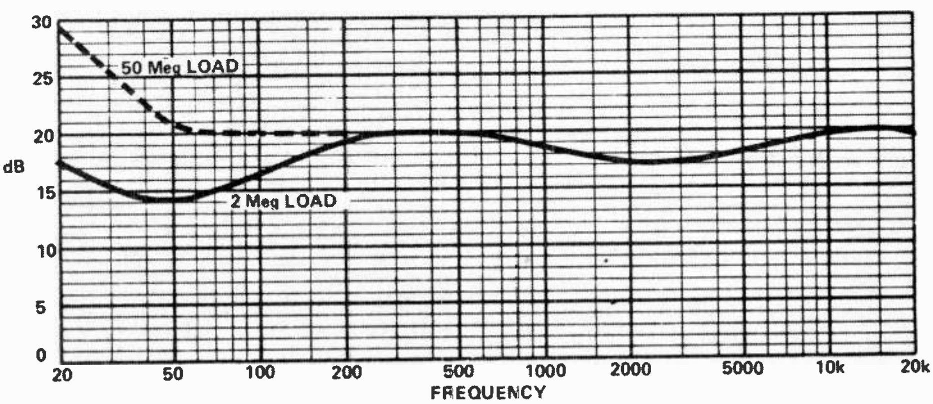


Fig. 2. Response of Decca Deram showing effect of terminating impedance at low end and of mechanical equalization at top end.

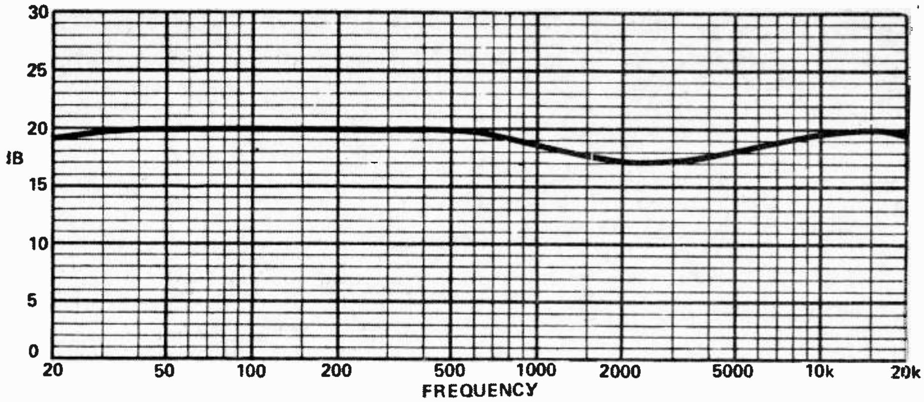


Fig. 3. Overall response of a Decca Deram into a charge amplifier.

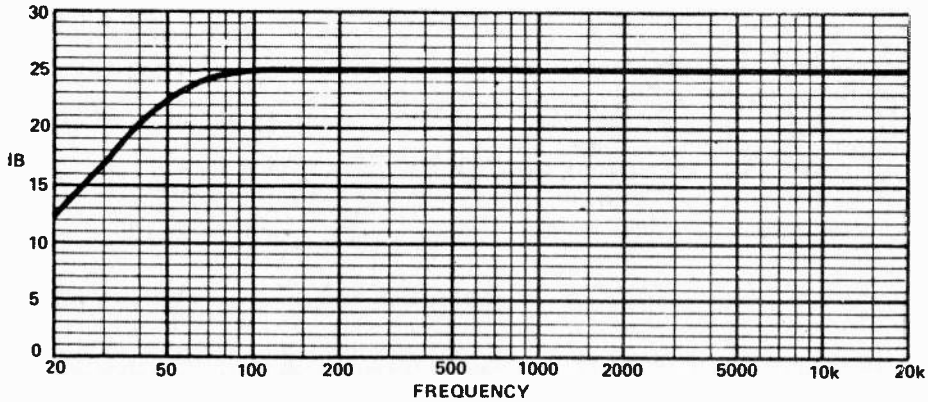


Fig. 4. Response of charge amplifier. Roll off at low end is designed to compensate for rising response of cartridge in this area.

from manufacturer to manufacturer but lie in the range 200-900 pF and 100 to 1000 mV at 1 kHz and 5cms/second.

One of the most popular and readily available cartridges is the Decca Deram and we performed all our tests with this cartridge. The unit has an output of about 150 mV and a capacitance of 600 pF. The recommended load impedance is 2 megohms and this gives the response as shown in Fig. 2. The bass response can be improved but only at the expense of greatly increasing the rumble. The dip at 2 kHz can readily be compensated for but we have not experimented in this area.

Another system commonly used is to load the unit with a low impedance (e.g. 75 k ohm) which causes a loss of bass below 3 kHz, and then boost the bass again electronically. This overcomes the need for a very high impedance. Such a technique combined with a rumble filter to cut the rising response below 50 Hz can give good results. However due to the large differences between various makes a different network needs to be designed to suit the bass roll-off characteristic of each cartridge type.

A third system which we propose, is to use a "charge" amplifier.

CHARGE AMPLIFIER

With the charge amplifier the input impedance is zero – how then does it work? A conventional inverting amplifier is shown in Fig. 5. and, as anyone familiar with amplifiers will know, the output voltage will be:–

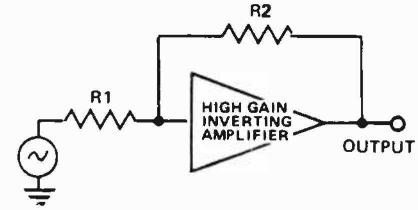


Fig. 5. Conventional inverting amplifier stage.

$$V_{out} = \frac{R2}{R1} \cdot Vin$$

What is not always realized by beginners is that R1 and R2 need not be resistive – they may be capacitors, inductors or combination of impedances. It is only the impedance that is important. Since the output of the ceramic pickup is a capacitor we may connect it directly to the input of an inverting amplifier and use a capacitor as the feedback element. The gain of the stage now becomes the ratio of the two capacitor impedances. Although the impedance of the capacitor drops with increasing frequency the ratio remains constant. Therefore, with a 'perfect' amplifier, the *frequency response is flat at* all frequencies.

In real circuits we generally need a bias resistor across the feedback capacitor. This causes a roll-off at the low end similar to that obtained when using a FET amplifier.

If a response down to 10 Hz is required a resistance of 50 megohm minimum is required. However this is

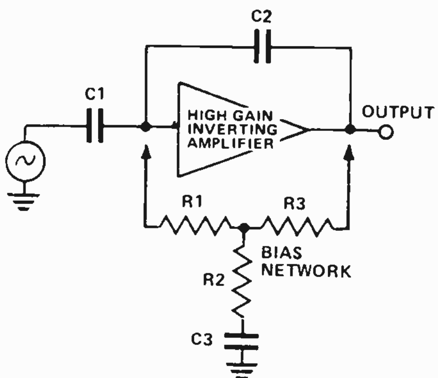


Fig. 6. Basic charge amplifier with bias and filter network. Gain control elements are capacitors. Bias network R1, 2, 3 and C3 are required for dc stability and to roll of bass response.

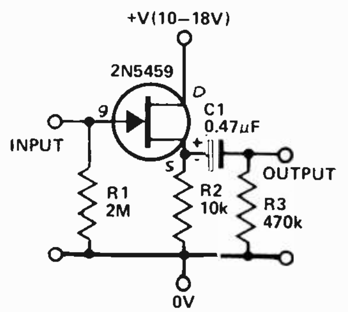


Fig. 7. Circuit of FET follower used to obtain the responses shown in Fig. 2.

TABLE 1			
GAIN (600 pF cartridge)	C2	C3	R4
unity	560 pF	0.0082μF	390 k
6 dB	330 pF	0.015μF	180 k
12 dB	150 pF	0.039μF	47 k

much too high for correct biassing and a different technique is called for.

With the arrangement illustrated in Fig. 6, the effective resistance is:—

$$R_{eff} = \frac{R2 + R3}{R2} \cdot R1$$

provided $R2 << R1$, 3 and $X_{C3} << R2$

If the value of X_{C3} approaches R2 the effective resistance drops and, if the value of R2 and C3 are properly chosen, a 12 dB/octave cut-off at the low end can be obtained which effectively removes the rising low-end response due to the recording characteristic.

Other advantages of the charge amplifier are firstly that it is easy to obtain gain (unlike the source — follower FET approach) and secondly that cable capacitance does not affect the performance in any way. One disadvantage is that the cables are slightly microphonic and movement of the leads can cause an output — this however is not an insurmountable problem.

The overall response of the Decca Deram Cartridge into a charge amplifier is given in Fig. 3, and as can be seen the response at the low end is greatly improved. As said before the drop around 2 kHz could readily be compensated for but this was not considered necessary.

If a pickup having a different capacitance were to be used the only change would be in the gain of the amplifier — the frequency response (of the amplifier) remains the same. If the gain is too high then simply changing the feedback capacitor to a higher value will restore it. However, if the low frequency cut-off is to be maintained both R4 and C3 must also be altered. Table 1 illustrates the values required.

CONCLUSION

Cost for cost the ceramic cartridge is better value for money than the magnetic type. The use of a properly designed preamplifier can produce a substantially flat response.

However whilst an almost perfect frequency response can be obtained by properly processing the output from a cartridge like the Decca Deram it can *never* sound like the Shure V15 MK 3! Other factors such as transient response and channel separation are generally not as good as those of a magnetic cartridge. Whether the inbuilt mechanical resonance is actually responsible for the poor transient response is probably known only to the cartridge manufacturers — one feels that if it were done electronically it may well be better.

This has not been presented as a normal project but rather as a basis for experimentation. The circuit described has been built up and does give the response expected. Try it. The results may be surprising. ●

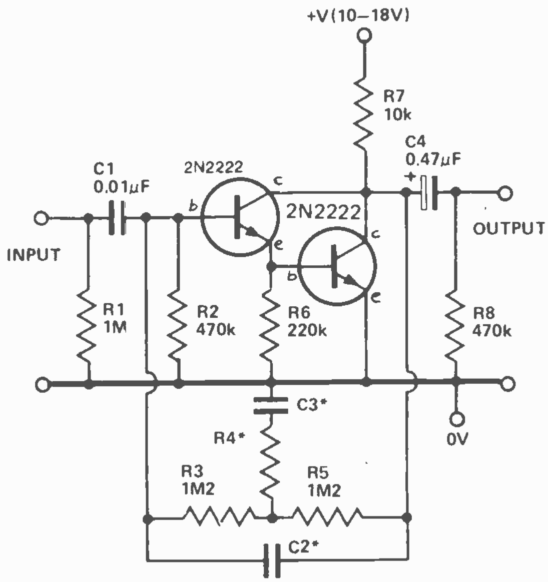
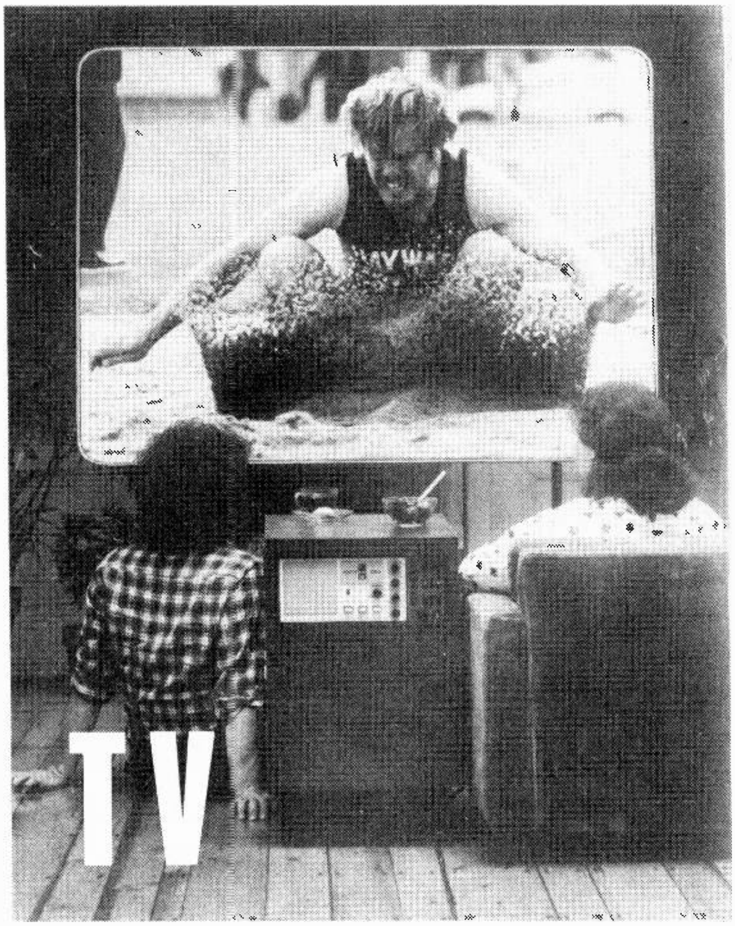


Fig. 8. Circuit of practical charge amplifier for ceramic cartridges which gave the overall response as in Fig. 4. For values of C2, 3 and R4 see table 1.

Projection TV



By Jim Essex

PROJECTION TV started around 40 years ago using the Kerr Cell. Briefly, the Kerr Cell was a device which, with the passage of current, changed its light-passing characteristics. Thus, a high intensity light source could be used to project an otherwise weak image onto a large screen. This offered hopes for the then fledgling pre-war TV industry to get around the problem of necessarily small pictures from the small picture tubes then available — some as small as 6 inches. However, war breaking out in 1939 stopped all TV work and the miniscule production of cathode-ray tubes was diverted to war to fill the voracious appetite of radar.

The Kerr Cell never did make it and was forgotten, never to return. But the mass production of Cathode-ray tube learned in war, launched TV as we know it today. It's remained essentially the same since, with the only real change coming with colour. Not until Henry Kloss's projection TV emerged in a practical form, has any real change occurred. Doubtless the Ediphor system comes to mind, — the one we're all familiar with from its wide use in projection of boxing fights in large auditoriums. But its price tag runs into $130,000 and therefore is only of limited appeal. GE has a system for classrooms and small auditoriums, but, again, the cost is too high, — around $39,000. Henry Kloss decided he'd do better, using material readily available from regular TV sets.

No, it's not done with mirrors (as in the early TV's) which used a mirror-backed lid which, when raised, reflected the image to the viewer. Methods to enlarge this image were virtually exhausted when the industry saved the day producing first the 17-inch pix tube, followed by the 21 inch which remained the standard of the trade for many years. In most of us, there was always that gnawing thought of — "why couldn't the best of the old be wed to the new to produce a useable, practical image bright enough to fill a screen similar to those used for home movies?" Well, it remained for Henry Kloss to do this.

Perhaps a word about him might be in order, here. He was an MIT drop-out, who, to fill his craving for developmental research, turned to audio. TV wasn't his cake, watching it only a few hours a week, — more out of curiosity, the screen being far too small to excite his interest. He developed a loudspeaker when sound demanded something better than was currently available for the new breed of long-playing records now appearing in the early 50s.

In the best traditions of people who like to work on electronics in their basements, spare room or what-have-you, he put together what he thought the industry lacked in an audio speaker, sold it and AR (Acoustical Research) was formed to produce it. He was in business. It was only a matter of time before the inevitable happened; if you could do it for sound, why not TV? Now president of a high quality audio products firm making, along with the speaker, — steareo cassette decks — among other things, the question of TV and why it couldn't be made more enjoyable, returned.

GREAT OAKS

About eight years ago he began like most experimenters, — from the bottom. He bought a TV kit, built it from scratch, then convinced himself it was technically possible to produce an image 10 times the size and still have "an interesting brightness" as New Yorker magazine put it. Down the street were other interesting people doing other interesting things with pictures. Like Edwin Land who hit it big with the Polaroid Land Camera. The "Brain Mafia" — as most of his age group and usually MIT grads were called, — were hitting their stride!

His claim of having never invented anything, — "I just put . . . together seemingly unrelated ideas in intelligible packages and make them work," as Mark Jacobson put it describing Kloss in his story, may be over-simplifying it. But when you realize it is an ordinary TV chassis that powers his revolutionary system, you may just say to yourself, — "why didn't I think of that?" Of course, he put his money where his mouth was, — which may be the only real difference, like two million dollars!

Within a half-dozen years, he had the model 1000-A ready. Now, they are seen throughout the U.S. — and recently in Canada.

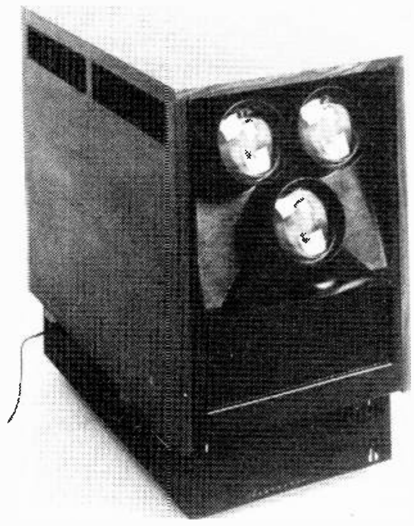
FIRST SIGHT

I first saw one at Arnie's Restaurant, — a medium sized, rather dimly-lit dining house located near the University of Waterloo, an ideal place for students to judge its merits. At one time in my career, I had worked at the University, and my scientific curiosity was somehow re-kindled at this huge screen — at the moment, showing the 6 pm news. From where I sat, I could clearly see three lenses, brightly flooded with light in the now familiar red, green, blue triad simulating the 3 guns of a colour pix tube. But, I reasoned, you can't achieve an image that big (it looked almost 7 ft.) by just magnifying an image of a CRT, even if they'd provided three separate CRT's to accomodate the three primary colours. No. And as I learned later, there's certainly more to it than that, although I understand Sony, for example, do just that; magnify a high intensity image — but from only **one** CRT, — and project it on a somewhat smaller screen. It is not too bright, and has obvious limitations. How did Henry do it?

The manager of Communications for the Advent Corporation and who I subsequently came to know, — Mr. Joseph B. Hull, Jr., — described Henry Kloss's system and the company Kloss heads, now not only making high-quality audio products, but projection TV as well.

The heart of the system, he explained, is the patented "Lightguide Projection Tube" and the Schmidt optical system, a lens originally designed for wide-angled telescopes for observatories. But first, consider the Lightguide tube, designed and manufactured by Advent, called the Advent "VideoBeam" Tube. You recall how the three guns in a colour tube respond . . . individually, to the three colour signals transmitted. There's one red, one blue and a green gun. When properly combined on a corresponding "triad" pattern on the CRT's face (after passing the hurdle of a shadow mask, incidentally, and thereby reducing the brilliance on the tube's face) we achieve white and any colour in the spectrum between that and black. Or, in other words, a full range of visible colour can be reproduced.

Two limitations are evident; — the discrete three-dot arrangement to produce one tiny segment of picture with the obvious inherent fuzziness which results, and the tremendous angle (90 degrees at maximum) the beams must sweep to fill a raster. This is not to mention the near-impossible task of making each beam fall on its own corresponding dot on the tube face after "ramming through" the shadow mask, — all of which has a deteriorating effect on the ultimate brilliance and clarity which can be achieved. In the video beam tube — of which there are three, remember, not three separate guns within one tube as in conventional Color TV — only one electron gun is present. The electron gun's output is made to sweep back and forth across a 3 inch phosphor, properly coated to provide one of the three required guns or tubes needed to form the triad. Since this light-emitting "target" need provide only one colour, it can be uniformly coated with the single desired colour phosphor: 4C(refer to fig. 1) The efficiency thus obtained leads to a linearity (uniformity) across the screen not possible with the clusters of "colour



The business end of the Advent Console showing the three lens system. each lens being fed by its own CRT.

dots" characteristic of present colour tubes. Brightness uniformity is also enhanced by the beam having to sweep over a mere 15 degrees instead of the 90 degrees in conventional CRT's. You may now ask how this picture on the relatively small screen — actually about 2½" wide, — is gathered and focused onto a large, external screen almost 6 ft. across?

THEY DO IT WITH

Referring back to fig. 1, the light given off the small screen — or target — is directed towards the rear of the

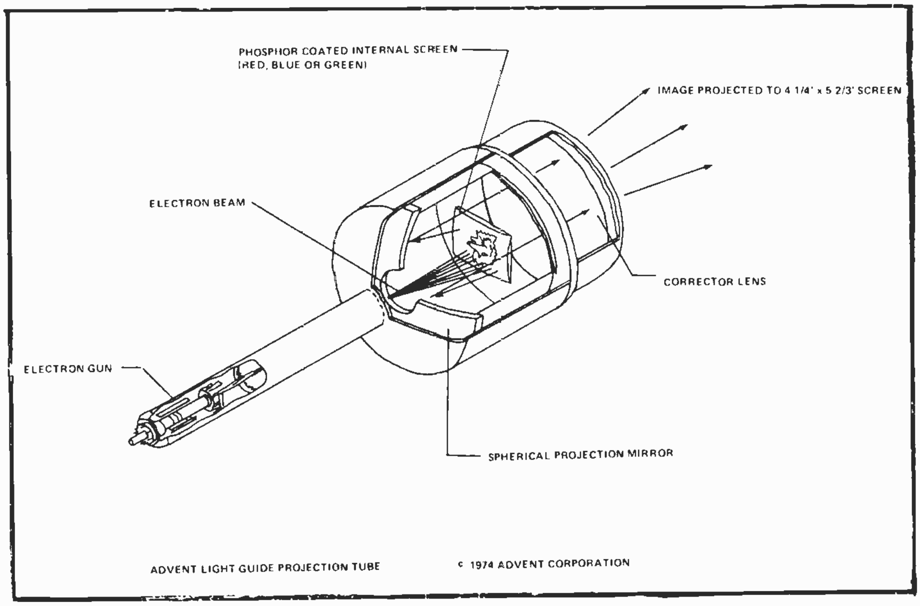


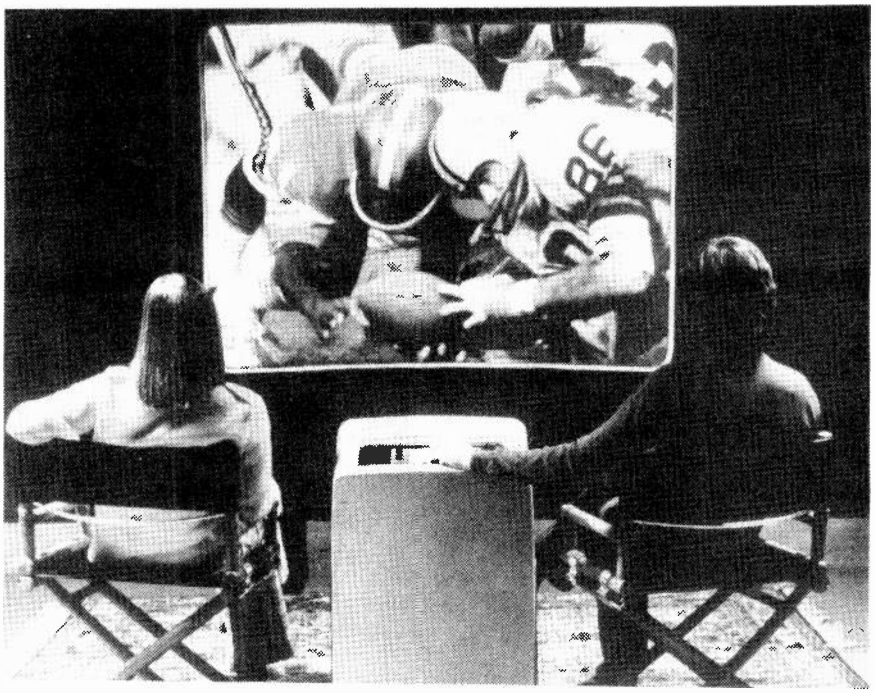
Fig. 1. The basic Advent Light guide projection tube and connector lens. A single tube is used for each of the three basic colours.

tube where it strikes a highly polished mirror located at the end. There it is reflected outward along the axis of the tube where it is gathered by the lens. The mirror focuses the light from each point on the target to the corresponding area of the big screen across the room.

Thus, the colour dots or lattices of conventional TV's are not required, nor is the shadow mask — making for higher efficiency than is possible in a direct-view pix tube. This is the "key" to getting bright projection results. And of course, the optics being "inside" the tube, there's no way they'll come out of adjustment. Before, on theatre projection systems, a trained technician was needed to do the job. All critical optical adjustments are thus made at time of manufacture, and vulnerable optics are out of the way of dust or damage. The front of the corrector lens only is exposed and this can be dusted occasionally, of course.

Voltages and control circuit functions are identical with conventional TV's, but instead of driving three guns within one tube envelope, the TV circuitry is used to drive individual guns in three separate, high-intensity small-screen tubes which are extremely bright. In addition, coupled with this system, is a special screen — designed to reflect the maximum light and detail from a surface made of highly reflective aluminum with a rigid foam backing. Manufactured under license from Kodak, it is five times more reflective than a regular lenticular or beaded screen as used in most home movies. Besides this, it is specially curved in both the horizontal and vertical to exactly match the sweep of the light travelling in a huge arc from the "TV set" 7 feet away.

This, of course, produces "critical" viewing areas — or seating, wherein



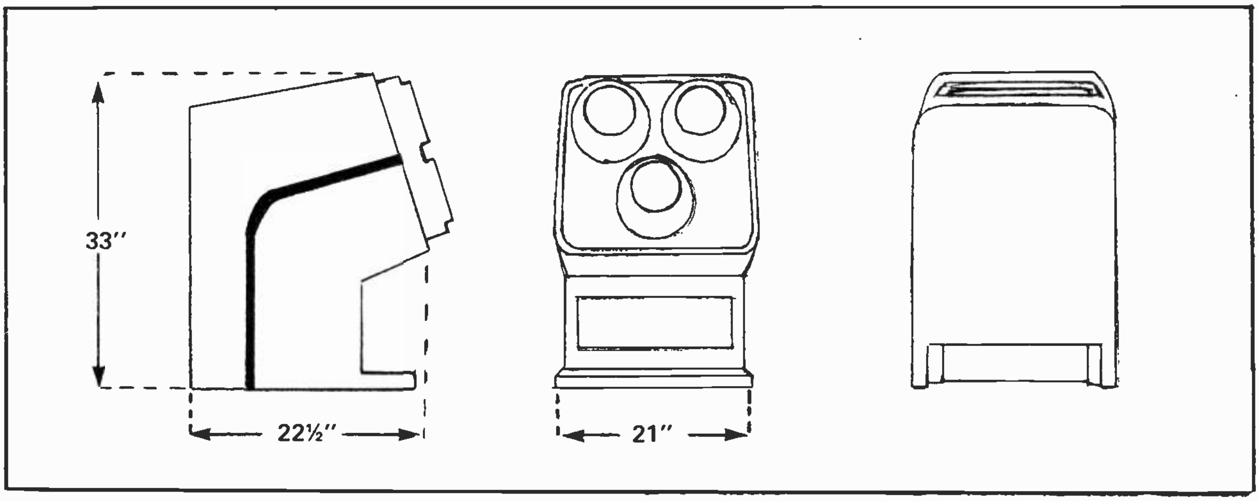
The Videobeam receiver-projector in use. An idea of the size of the screen can be gained from the viewers.

optimum viewing is enjoyed — although this is quite large and really offers no restriction. (see diagrams 2 and 3 for seating detail and screen dimmensions). The screen surface is understandably somewhat delicate, to prevent smudge marks from fingers when handled, for example.

SET-UP

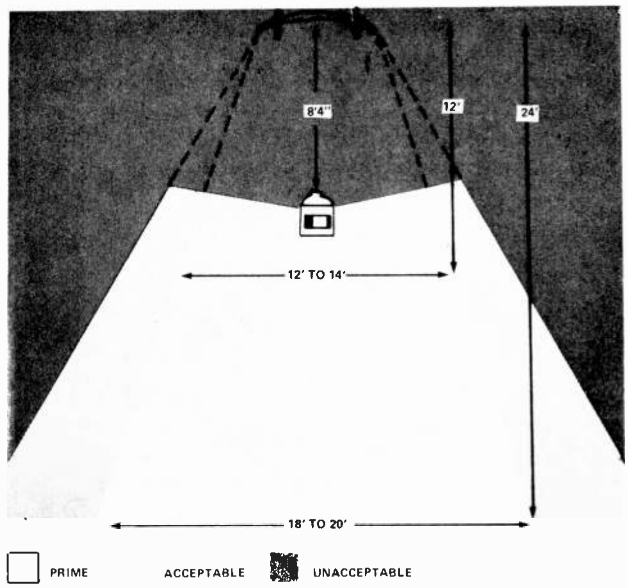
When the "Videobeam" TV is set up, the three tubes form a Triad, — green on right, red on left, blue at bottom-viewed from rear. Now, if a "dot" of light from each was aimed on the screen, properly converged so the light from each over-lapped the other, you'd get a clear, sharp corresponding WHITE "dot" on the reflective screen. When swept, you obtain a raster about 3 times the size of a regular 26" TV tube — or approximately 85" corner to corner.

The screen's distance from the "control'box" type TV is critical — about the only thing that is — and a string cord is provided so this exact distance can be checked at any time — especially after moving furniture when the Advent cabinet just might get pushed inadvertantly out of place by an over-enthusiastic housewife. Within the set itself, a cross-hatch pattern is available at the push of a switch so that correct convergence is always assured. Minute adjustments can be



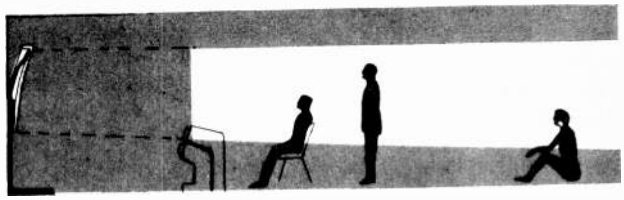
THE VIDEOBEAM RECEIVER-PROJECTOR

Projection TV



HORIZONTAL VIEWING AREA

NOTE. THE QUALITY OF THE PICTURE IN THE AREA LABELLED ACCEPTABLE HAS LOWER BRIGHTNESS AND LESS COLOR INTENSITY, BUT NEVERTHELESS REMAINS ENJOYABLE TO VIEW. FIG 2



VERTICAL VIEWING AREA

Fig. 2 (a) and (b) Showing the vertical and horizontal viewing area.

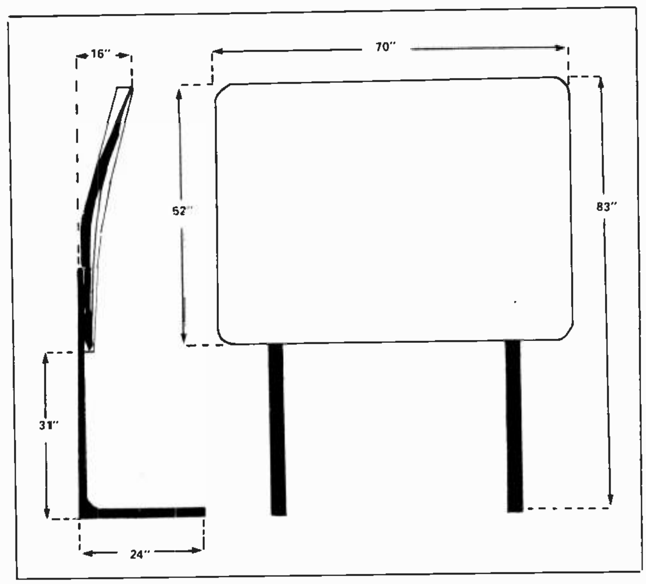


FIG. 3 THE VIDEOBEAM SCREEN

DIMENSIONS ARE APPROXIMATE

made by anyone at any time, although once set, there should be no need to change them.

LIGHT BEAMS

It is this "physical distance" which achieves what's accomplished within the smaller dimmensions of a regular CRT (and which contributes to the arc having to be only 15 degrees within a Videobeam tube as compared with the conventional color TV tube's 90 degrees). Thus, light beams replace electron beams once leaving the Schmidt optics and a whole new method of re-structuring light is now possible. And, of course, the results are nothing short of breath-taking. Perhaps the best definition of this is Henry Kloss's exclamation when demonstrating the system and a commercial appeared. "Look", said Kloss. "Look, there's a fly in that commercial. A fly flying around one of the babies. You'd never see that on a conventional set."

The process has been proven by having the first 100 manufactured sold close to the plant in Cambridge, Massachusetts. This way, close monitoring could be done and minor flaws corrected. Now, they are nationwide and making over 100 Model 1000A's per week*. Conventional type TV circuitry can be used to power the three tubes, which operate direct from the chroma output normally used to drive the red, green and blue guns. The voltage requirements for the three tubes are paralleled with the HT being actually about 28kV. All other adjustments are the same, like vertical, horizontal, focus, etc and the complete unit operates on 110V, 60 Hz, consuming about 160 watts. The complete unit (including screen) sells for $3,995.00 FOB Cambridge for the model 1000A with the Schmidt Lens system. A less expensive model — the model 750 using a refractive lens system — sells for something less. I asked Joe Hull the difference between the two and he said it was in the method of light-gathering that differentiates the one from the other. "The Schmidt system has a very wide aperature — f0.7 to be specific. This means that about 35% of the light emitted by the phosphors survives the projection process, which, if you are familiar with optics, you will recognize as being remarkably efficient. The refractive system is not as "fast", with an aperature of f1.3, or about half the efficiency of the 1000A's Schmidt system. However, be sure not to misinterpret that factor of about 2; the eye can barely recognize a 50% difference in brightness. . . ." In other words, the difference in picture brightness is comparable to an audio level difference of 3 db, which is barely discernible. The refractive system is less expensive than the Schmidt, and this may be an indication of things to come; the same — or nearly the same result — at lower cost. Certainly, when Henry Kloss started out, he envisaged a relatively low-cost home entertainment medium that'd be readily available to most everyone.

**The Electrohome Company in Kitchener, Ontario, are manufacturing the Model 750 under special licence from Advent Corporation, marketing it under the name "ELECTROHOME-ADVENT".*

MK 50361-50362 ALARM CLOCK — MOSTEK

THESE ARE MOS CIRCUITS, using depletion-load ion implantation process. Both chips work in 12 or 24 hr mode and will drive displays directly. Features included are 10mA/segment LED drive; low voltage backup (9v); forward or reverse time setting; intensity control; non-MPX display; 24hr alarm in three modes — tone, radio or tone plus radio; variable 'snooze' (1-59 mins); count hold; summer/winter time switch; clear on switch on; leading zero suppression in 12hr mode. ON 50362 ONLY: Four Year Calendar; choice of date display format; second alarm time.

The snooze inhibits an activated alarm for 10min periods. The 'sleep' will activate the radio for between 1-59 mins (adjustable).

POWER FAILURE

At the occurrence of power failure, the digits will flash at 1Hz to indicate incorrect time displayed. Set 2 (forward) switch should be closed (once power is restored). This mode is triggered when the colon output goes to V_{SS} and may occur at initial power-on.

DISPLAY MODE

The input is three state. Operation is as follows:

Display Input	Mode
V_{SS}	Alarm time displayed
Open	Time displayed
V_{DD}	Seconds displayed

When in alarm mode, the time displayed is that to which the alarm is set. It may be altered by use of the time set procedure, given below.

SETTING

The setting mode allows either a forward setting *or reverse setting* of the display. The setting inputs are:

Set 1 or Set 2 Input	Mode
V_{SS}	Forward Set
Open	—
V_{DD}	Reverse Set

When either the set 1 input or set 2 input is connected to V_{SS} the display will increment. Connecting the input to V_{DD} will decrement the display. When the display is not being set, the inputs should be left open. The set 1 input changes the hours digits at two counts per second. The set 2 input changes the minute digits at two counts per second. Carrys or borrows are not allowed during time setting.

DISPLAY FORMAT

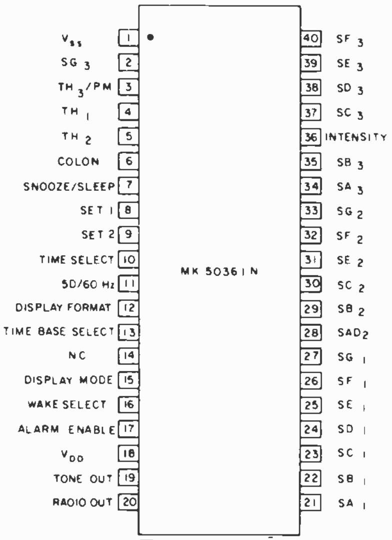
The display format is used to select a 12 hour display, 24 hour display or to blank the display. The connections are:

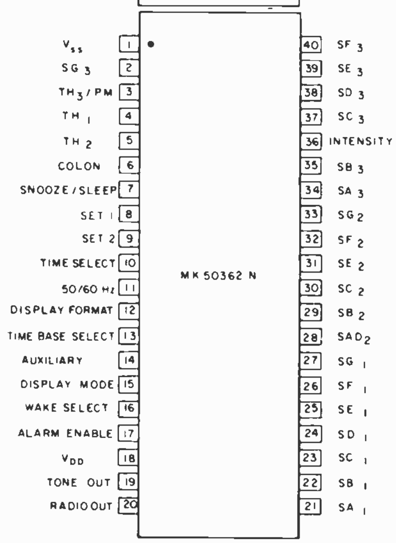
Display Format Input	Mode
V_{SS}	12 Hour
Open	Blank Display
V_{DD}	24 Hour

In the 12 hour mode, the hours digits will display time in 12 hour format with a PM output. When the input is connected to V_{DD}, the format will be 24 hour time. In the blank mode the segment outputs will float, allowing wire-or conditions.

COLON

In normal operation, the colon flashes at one Hertz rate for an activity indicator. The colon output conducts to V_{SS} with a 50% duty cycle in the 60Hz mode and 40% duty cycle in the 50Hz mode. The colon is off when displaying calendar, seconds or sleep time.





INTENSITY

The intensity input regulates the current of the segment outputs and colon output.

The intensity input regulates the current of the segment outputs and colon output. Over a range from 3KΩ to 30KΩ for the intensity resistor (R_{SENSE}), the following equation may be used to predict segment current (I_{SEG}):

$$I_{SEG} = 18 \frac{V_{FWD\ LED\ (in\ volts)}}{R_{SENSE\ (in\ Kohms)}} mA$$

Segment current is relatively independent of the voltage on the segment pins, therefore the LED display voltage supply need not be well filtered. For minimum value of R_{SENSE} (intensity control resistor), care should be taken to insure total circuit power dissipation does not exceed safe operating limits.

AM/PM OUTPUT

When in the 12 hour operating mode, the TH3/PM output conducts to V_{SS} when active. The indicator will change states when the hours change from 11 to 12. When in the 24 hour mode this output drives segments A, D & G on the most significant digit. Consideration must be given to wiring the display to accommodate both 12 hour and 24 hour operation using the same display.

TIME SELECT (Daylight saving time)

Connection of the time select pin to V_{SS} will advance the time by one hour. By opening the connection, the time will return to the original time. Connecting this input to V_{DD} will reset the clock to the Power Up mode.

ALARM ENABLE/WAKE SELECT

The alarm can operate in three modes according to the voltage on the wake select pin. The states are defined as:

Wake Input	Mode
V_{SS}	Tone
Open	Radio
V_{DD}	Radio followed by Tone

The Alarm enable pin enables alarm 1 when connected to V_{SS}. If it is left open it will disable the alarm due to an internal resistor. When the alarm occurs it may be disabled and immediately re-enabled and will activate 24 hours later at the alarm time. The alarm will self-disable after one hour of operation. The output tone will be in the range of 200 to 1000Hz and conducts to V_{SS} 8.3% of the time at a 1Hz rate.

Radio out, when activated by either the alarm or sleep function, will conduct to V_{SS}.

When the radio followed by tone mode is selected, radio out conducts to V_{SS} at alarm time. Eight minutes later the tone output will be enabled. Both remain on until inhibited by the alarm enable control, snooze, or the automatic alarm reset which occurs after one hour.

SNOOZE/SLEEP INPUT

The snooze and sleep inputs use a single pin to select snooze or sleep. The connections are:

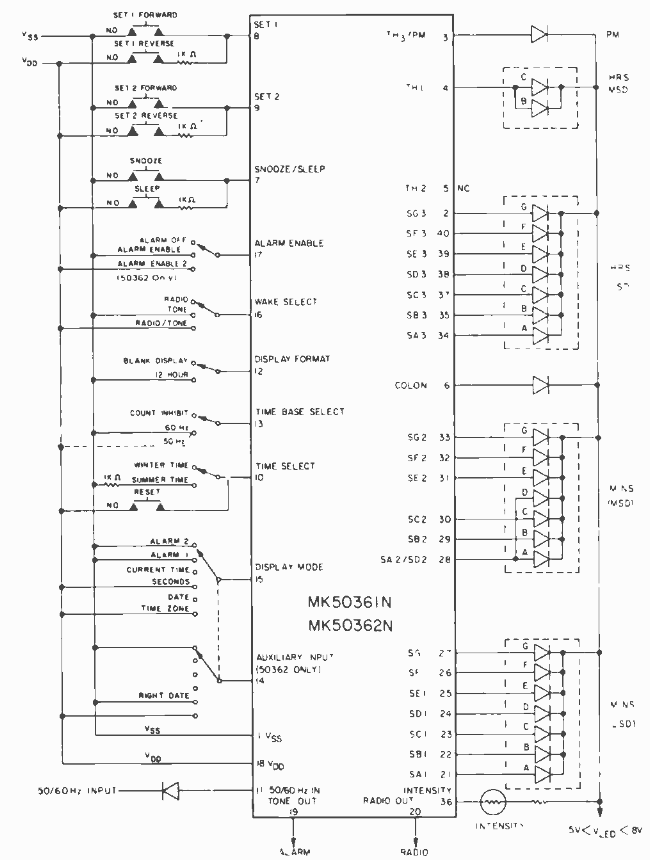
Snooze/Sleep	Mode
V_{SS}	Snooze
Open	No Change
V_{DD}	Sleep

The Snooze feature will temporarily turn off an activated radio and tone outputs to allow an additional 10 minutes' sleep. Momentarily connecting snooze to V_{SS} will activate the snooze. If left open an internal pull-down resistor will maintain the snooze feature inoperative.

Connection of the pin to V_{DD} will display the sleep time in minutes in the minutes digits. The time will start at 10 minutes, and the set 2 input is used to set the sleep time. Radio out will conduct to V_{SS} for the amount of time set. After the time decrements to zero radio out will turn off, provided that the Snooze/Sleep input is not being held at V_{DD}.

If the snooze is active, the sleep input will reset the snooze function. The snooze input will reset an active sleep time.

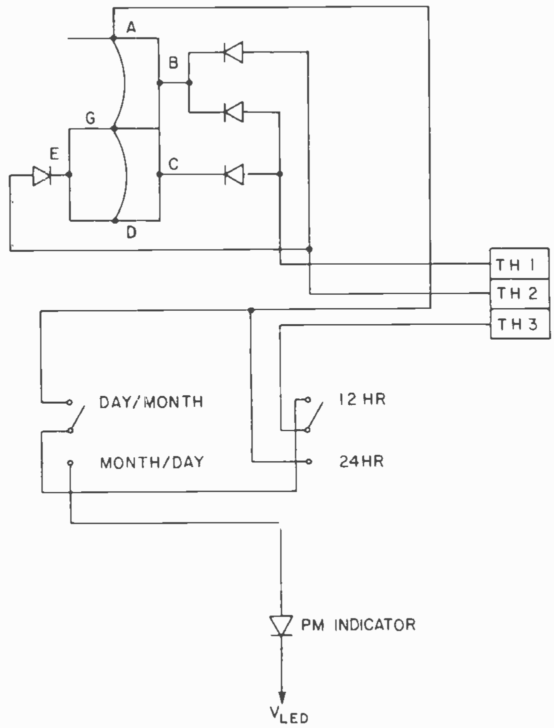
GENERALIZED CIRCUIT (12 HR. DISPLAY FORMAT)



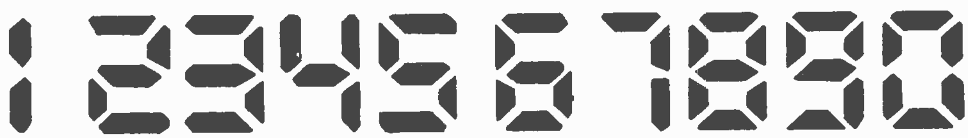
RECOMMENDED OPERATING CONDITIONS (0°C to 45°C)

PARAMETER	Min	Max	Units
Operating Voltage, V_{DD}	−12	−16	Volts
Standby Voltage, V_{DD}	−8.0	−12	Volts
Input Logic Levels: Set 1, Set 2, Display Mode, Snooze/Sleep, 50/60Hz, Display Format, Alarm Enable, Wake Select, Time Select, Time Base Select, Auxiliary	V_{SS} −1.0	V_{SS}	Volts
	V_{DD}	V_{DD} + 1.0	Volts
Intensity Control	3	30	K−OHMS
Segments, Colon		−26	Volts

SELECTABLE 12 HR. OR 24 HR. DISPLAY



DISPLAY FONT



FUNCTION SETTING

The displayed function is set using the set inputs while the appropriate function is displayed using the display mode input and auxiliary input. The set 1 input changes the hours or month digits at two counts per second. The set 2 input changes the minute or date digits at two counts per second. Carrys or borrows are not allowed during setting except for an illegal month date combination.

The MK 50362N contains an auxiliary input which allows the selection of additional features. All other functions operate like the MK 50361N.

The additional features are selected by using the Display Mode Input and the Auxiliary Input. The selection is:

Function	Display Mode Input	Auxiliary Input
Alarm 1 Set	V_{SS}	Open
Current Time	Open	Open
Seconds	V_{DD}	Open
Month Date	Open	V_{SS}
Date Month	Open	V_{DD}
Alarm 2 Set	V_{SS}	V_{SS}
Time Zone	V_{DD}	V_{DD}

MONTH—DATE CALENDAR

The calendar is a four year calendar. Connecting the Auxiliary input to V_{SS} will display a Month-Date format. A Date-Month format can be selected by connecting the Auxiliary input to V_{DD}. The display mode input must remain open.

SECOND ALARM TIME

The second alarm time can be displayed by connecting the Display Mode input and the auxiliary input to V_{SS}. To enable the alarm, the Alarm Enable pin should be connected to V_{DD}. Alarm 2 will not have an automatic shutoff. Disabling either alarm will reset snooze.

The HD-0615 Keyboard Encoder is a 16 line to four-bit parallel encoder intended for use with manual data entry devices such as calculator or typewriter keyboards. In addition to the encoding function, there is a Strobe output and a Key Rollover output which energises whenever two or more inputs are energised simultaneously. Any four-bit code can be implemented by proper wiring of the input lines. Inputs are normally wired through the key switches to the +5.0V power supply. Full typewriter encoding up to eight bits can be accomplished with two Encoder circuits by the use of double pole key switches or single pole switches with two isolation diodes per key. Outputs will interface with all popular DTL and TTL logic families. The circuit is packaged in a hermetic 24-pin dual in-line package and operates over the temperature range of 0°C to + 75°C.

TRUTH TABLE

INPUTS																OUTPUTS					
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	1	2	3	4	$\overline{ST}$	$\overline{K_{RO}}$
L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	H	H	H	H	H	H
H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	H	H	H	H	L	H
L	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	H	H	H	L	H
L	L	H	L	L	L	L	L	L	L	L	L	L	L	L	L	H	L	H	H	L	H
L	L	L	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	H	H	L	H
L	L	L	L	H	L	L	L	L	L	L	L	L	L	L	L	H	H	L	H	L	H
L	L	L	L	L	H	L	L	L	L	L	L	L	L	L	L	L	H	L	H	L	H
L	L	L	L	L	L	H	L	L	L	L	L	L	L	L	L	H	L	L	H	L	H
L	L	L	L	L	L	L	H	L	L	L	L	L	L	L	L	L	L	L	H	L	H
L	L	L	L	L	L	L	L	H	L	L	L	L	L	L	L	H	H	H	L	L	H
L	L	L	L	L	L	L	L	L	H	L	L	L	L	L	L	L	H	H	L	L	H
L	L	L	L	L	L	L	L	L	L	H	L	L	L	L	L	H	L	H	L	L	H
L	L	L	L	L	L	L	L	L	L	L	H	L	L	L	L	L	L	H	L	L	H
L	L	L	L	L	L	L	L	L	L	L	L	H	L	L	L	H	H	L	L	L	H
L	L	L	L	L	L	L	L	L	L	L	L	L	H	L	L	L	H	L	L	L	H
L	L	L	L	L	L	L	L	L	L	L	L	L	L	H	L	H	L	L	L	L	H
L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	H	L	L	L	L	L	H
ANY TWO OR MORE HIGH																X	X	X	X	L	L

ELECTRICAL CHARACTERISTICS

	PARAMETER		SYM	LIMITS MIN	TYP.	MAX.	UNITS	TEST CONDITIONS
	Input Current	"1"	I_{IH}			17	mA	V_{IN} = +5.0V
D.C.	Output Voltage	"0"	V_{OL}		+0.2	+0.4 +0.4	V	V_{IH} = +4.5V I_{OL} = 10mA V_{IH} = +3.5V I_{OL} = 3.2mA
		"1"	V_{OH}	+2.4	+4.0			V_{IL} = Open Circuit, I_{OH} = −240..A
	Power Supply Current	Operating	I_{CC}			52	mA	One Input at +5.25V
		Maximum	I_{CCM}			88	mA	All Inputs at +5.25V
A.C.	Skew Time (Note 1)		T_{SK}		80	200	ns	T_{Case} = 25°C V_{CC} = V_{IN} = +5.0V C_L < 50pF

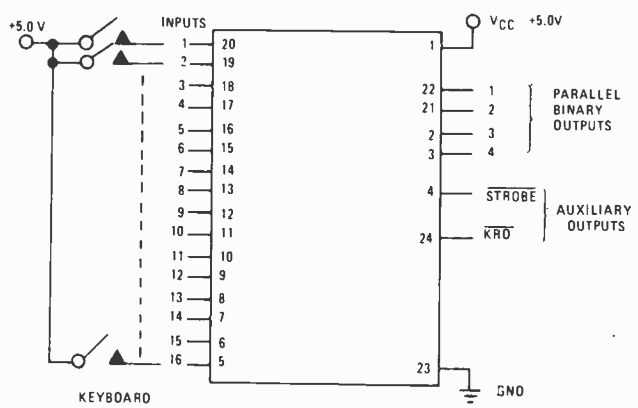


Figure 1. GENERAL CONFIGURATION FOR ENCODING TWO TO SIXTEEN KEYS

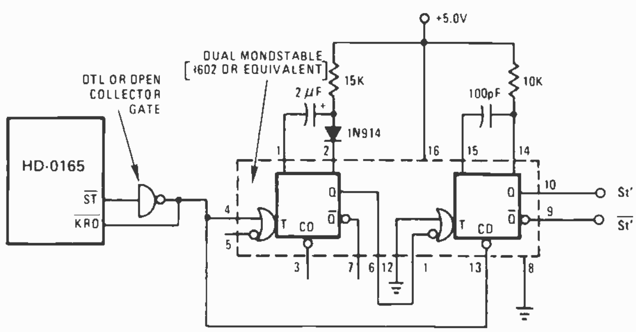


Figure 2. SWITCH BOUNCE ELIMINATION

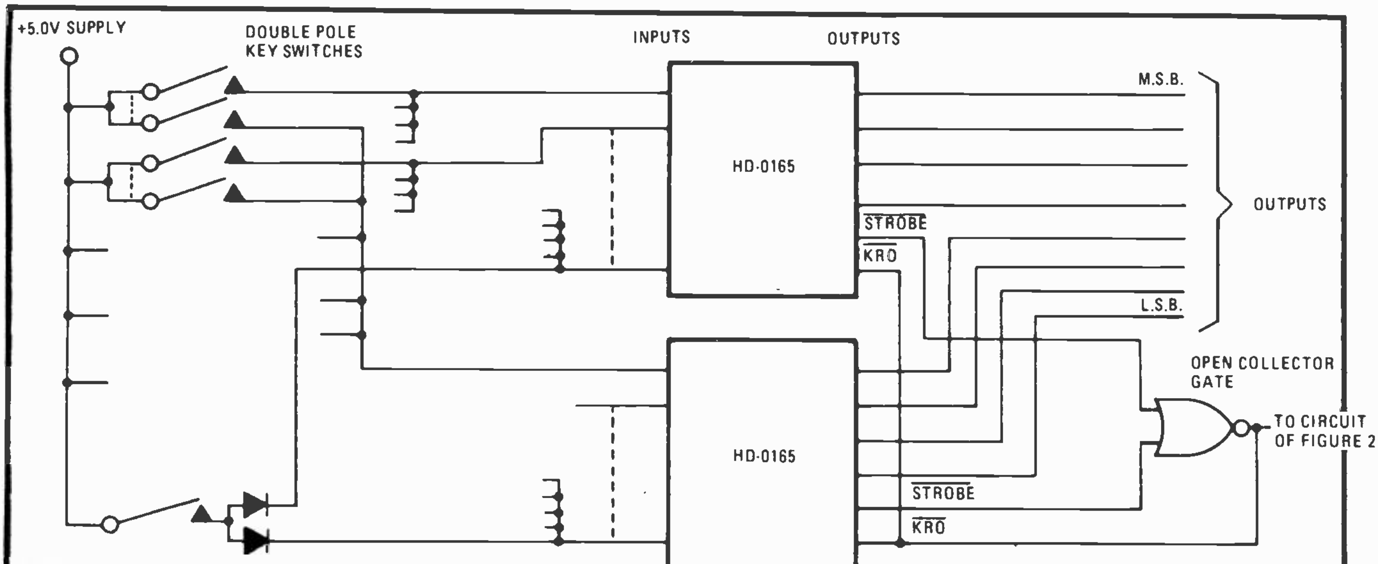


Figure 3. ENCODING UP TO 256 KEYS

TTL 7400N

SN7400N	.19	SN74126N	.46
SN7401N	.19	SN74128N	.55
SN7402N	.19	SN74132N	.89
SN7403N	.19	SN74136N	.48
SN7404N	.23	SN74141N	1.09
SN7405N	.23	SN74142N	2.50
SN7406N	.49	SN74143N	2.60
SN7407N	.49	SN74144N	2.60
SN7408N	.22	SN74145N	.89
SN7409N	.22	SN74147N	2.50
SN7410N	.19	SN74148N	1.49
SN7411N	.29	SN74150N	1.50
SN7412N	.19	SN74151N	.98
SN7413N	.45	SN74152N	4.50
SN7414N	1.25	SN74153N	.89
SN7416N	.39	SN74154N	1.50
SN7417N	.39	SN74155N	.98
SN7420N	.19	SN74156N	.69
SN7421N	.29	SN74157N	.69
SN7422N	.19	SN74159N	2.25
SN7423N	.29	SN74160N	.99
SN7425N	.29	SN74161N	.99
SN7426N	.32	SN74162N	.99
SN7427N	.30	SN74163N	.99
SN7428N	.30	SN74164N	1.10
SN7430N	.19	SN74165N	1.10
SN7432N	.29	SN74166N	1.35
SN7433N	.30	SN74167N	2.98
SN7437N	.36	SN74170N	2.60
SN7438N	.36	SN74172N	6.98
SN7440N	.19	SN74173N	1.55
SN7442N	.59	SN74174N	1.15
SN7443N	1.29	SN74175N	.99
SN7444N	1.30	SN74176N	.85
SN7445N	.99	SN74177N	.85
SN7446AN	.99	SN74178N	1.25
SN7447AN	.89	SN74179N	1.25
SN7448N	.95	SN74180N	.99
SN7450N	.19	SN74181N	2.75
SN7451N	.19	SN74182N	.79
SN7453N	.19	SN74184N	1.95
SN7454N	.19	SN74185A	1.85
SN7460N	.19	SN74186N	9.95
SN7470N	.34	SN74190N	1.33
SN7472N	.27	SN74191N	1.33
SN7473N	.33	SN74192N	1.10
SN7474N	.33	SN74193N	1.10
SN7475N	.47	SN74194N	.99
SN7476N	.36	SN74195N	.59
SN7480N	.49	SN74196N	.84
SN7481AN	1.12	SN74197N	.84
SN7482N	.79	SN74198N	1.99
SN7483AN	.90	SN74199N	1.99
SN7484AN	.99	SN74221N	1.10
SN7485N	1.35	SN74246N	1.35
SN7486N	.34	SN74247N	1.29
SN7489N	3.10	SN74248N	1.15
SN7490AN	.47	SN74249N	1.15
SN7491AN	.69	SN74251N	.99
SN7492AN	.47	SN74259N	1.75
SN7493AN	.47	SN74265N	.59
SN7494N	.84	SN74273N	1.74
SN7495AN	.69	SN74276N	.89
SN7496N	.84	SN74278N	1.99
SN7497N	2.85	SN74279N	.59
SN74100N	1.95	SN74283N	.99
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SN74105N	.60	SN74285N	4.00
SN74107N	.33	SN74290N	.69
SN74109N	.48	SN74293N	.69
SN74110N	.35	SN74298N	1.49
SN74111N	.49	SN74351N	1.79
SN74116N	1.99	SN74365N	.59
SN74118N	1.50	SN74366N	.59
SN74119N	2.50	SN74367N	.59
SN74120N	1.19	SN74368N	.59
SN74121N	.39	SN74390N	1.24
SN74122N	.49	SN74393N	1.24
SN74123N	.69	SN74490N	1.59
SN74125N	.46		

TTL LOW POWER SCHOTTKY

SN74LS00N	.25	SN74LS155N	1.35
SN74LS01N	.25	SN74LS156N	1.35
SN74LS02N	.25	SN74LS157N	1.05
SN74LS03N	.25	SN74LS158N	.99
SN74LS04N	.29	SN74LS160N	1.50
SN74LS05N	.29	SN74LS161N	1.50
SN74LS08N	.25	SN74LS162N	1.50
SN74LS09N	.25	SN74LS163N	1.50
SN74LS10N	.25	SN74LS164N	1.50
SN74LS11N	.25	SN74LS165N	1.75
SN74LS12N	.25	SN74LS166N	1.75
SN74LS13N	.63	SN74LS168N	1.75
SN74LS14N	1.14	SN74LS169N	1.75
SN74LS15N	.25	SN74LS170N	2.95
SN74LS20N	.25	SN74LS174N	1.10
SN74LS21N	.25	SN74LS175N	1.10
SN74LS22N	.25	SN74LS181N	3.25
SN74LS26N	.35	SN74LS190N	1.59
SN74LS27N	.30	SN74LS191N	1.59
SN74LS28N	.35	SN74LS192N	1.59
SN74LS30N	.25	SN74LS193N	1.59
SN74LS32N	.32	SN74LS194AN	1.25
SN74LS33N	.38	SN74LS195AN	1.25
SN74LS37N	.35	SN74LS196N	1.35
SN74LS38N	.35	SN74LS197N	1.35
SN74LS40N	.29	SN74LS221N	1.29
SN74LS42N	.80	SN74LS240N	1.95
SN74LS47A	1.20	SN74LS241N	1.95
SN74LS48N	.99	SN74LS242N	1.90
SN74LS49N	.99	SN74LS243N	1.90
SN74LS51N	.25	SN74LS244N	1.95
SN74LS54N	.25	SN74LS247N	1.15
SN74LS55N	.25	SN74LS248N	1.15
SN74LS63N	1.49	SN74LS249N	1.15
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SN74LS75N	.64	SN74LS257N	1.25
SN74LS76N	.39	SN74LS258N	1.25
SN74LS78N	.39	SN74LS259N	1.59
SN74LS83AN	1.29	SN74LS260N	.29
SN74LS85N	1.35	SN74LS261N	2.25
SN74LS86N	.49	SN74LS266N	.49
SN74LS90N	.74	SN74LS273N	1.80
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SN74LS92N	.74	SN74LS280N	1.95
SN74LS93BN	.74	SN74LS283N	1.25
SN74LS95AN	1.50	SN74LS290N	1.05
SN74LS95BN	1.35	SN74LS293N	1.05
SN74LS96N	1.49	SN74LS295AN	1.55
SN74LS107N	.44	SN74LS298N	1.55
SN74LS109N	.44	SN74LS324N	.99
SN74LS112N	.44	SN74LS325N	2.75
SN74LS113N	.44	SN74LS326N	2.80
SN74LS114N	.44	SN74LS327N	2.70
SN74LS122N	.69	SN74LS352N	1.20
SN74LS123N	.84	SN74LS353N	1.35
SN74LS124N	1.50	SN74LS365N	.64
SN74LS125N	.64	SN74LS366N	.64
SN74LS126N	.64	SN74LS367N	.64
SN74LS132N	1.10	SN74LS368N	.64
SN74LS133N	.29	SN74LS375N	.64
SN74LS136N	.49	SN74LS377N	1.80
SN74LS138N	1.10	SN74LS378N	1.35
SN74LS139N	1.10	SN74LS386N	.49
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TIP112	.70
TIP116	70
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CD4034BE	2.50	CD4555BE	.69
CD4035BE	1.15	CD4556BE	.69
CD4040BE	1.15	CD4581BE	3.25
CD4041BE	.84	CD4582BE	1.25
CD4042BE	.84	CD4585BE	1.49
CD4043BE	.79	40014PC	.79
CD4044BE	.79	40085PC	1.10
CD4046BE	1.55	40097PC	.89
CD4049BE	.47	40098PC	.89
CD4050BE	.47	40160PC	1.35
CD4051BE	.89	40161PC	1.35
CD4052BE	.89	40162PC	1.35
CD4053BE	.89	40163PC	1.35
CD4060BE	1.35	40174PC	1.25
CD4066BE	.74	40175PC	1.25
CD4068BE	.29	40192PC	1.35
CD4069BE	.29	40193PC	1.35
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MR. MARSTON'S 741 COOKBOOK

OPERATIONAL AMPLIFIERS (OP-AMPS) CAN be simply described as high-gain direct-coupled voltage amplifier 'blocks' that have a single output terminal but have both inverting and non-inverting input terminals. Op-amps can readily be used as inverting, non-inverting, and differential amplifiers in both a.c. and d.c. applications, and can easily be made to act as oscillators, tone filters, and level switches, etc.

Op-amps are readily available in integrated circuit form, and as such act as one of the most versatile building blocks available in electronics today. One of the most popular op-amps presently available is the device that is universally known as the "741" op-amp In this article we shall describe the basic features of this device, and show a wide variety of practical circuits in which it can be used.

BASIC OP-AMP CHARACTERISTICS AND CIRCUITS

In its simplest form, an op-amp consists of a differential amplifier followed by offset compensation and output stages, as shown in Fig. 1a. The differential amplifier has inverting and non-inverting input terminals, a high-impedance (constant current) tail to

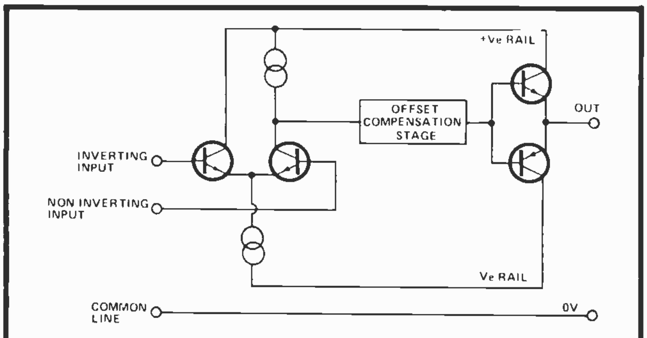

Fig. 1a Simplified op-amp equivalent circuit.

give a high input impedance and a high degree of common mode signal rejection. It also has a high-impedance (constant current) load to give a high degree of signal voltage stage gain.

The output of the differential amplifier is fed to a direct-coupled offset compensation stage, which effectively reduces the output offset voltage of the differential amplifier to zero volts under quiescent conditions, and the output of the compensation stage is fed to a simple complementary emitter follower output stage, which gives a low output impedance.

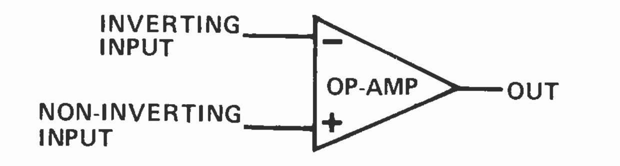

Fig.1b Basic op-amp symbol.

LINES OF SUPPLY

Op-amps are normally powered from split power supplies, providing +ve, −ve, and common (zero volt) supply rails, so that the output of the op-amp can swing either side of the zero volts value, and can be set at a true zero volts (when zero differential voltage is applied to the circuits input terminals.)

The input terminals can be used independently (with the unused terminal grounded) or simultaneously, enabling the device to function as an inverting, non-inverting, or differential amplifier. Since the device is direct-coupled throughout, it can be used to amplify both a.c. and d.c. input signals. Typically, they give basic low-frequency voltage gains of about 100 000 between input and output, and have input impedances of 1M or greater at each input terminal.

Fig. 1b shows the symbol that is commonly used to represent an op-amp, and 1c shows the basic supply connections that are used with the device. Note that both input and output signals of the op-amp are referenced to the ground or zero volt line.

SIGNAL BOX

The output signal voltage of the op-amp is proportional to the DIFFERENTIAL signal between its two input terminals, and is given by

$$e_{out} = A_0(e_1 - e_2)$$

where A_o = the open-loop voltage gain of the op-amp (typically 100 000).

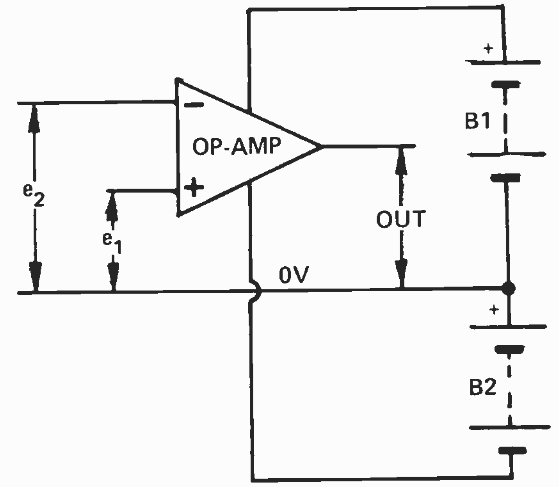

Fig. 1c Basic supply connections of an op-amp.

e_1=signal voltage at the non-inverting input terminal.

e_2=signal voltage at the inverting input terminal.

Thus, if identical signals are simultaneously applied to both input terminals, the circuit will (ideally) give zero signal output. If a signal is applied to the inverting terminal only, the circuit gives an amplified and inverted output. If a signal is applied to the non-inverting terminal only, the circuit gives an amplified but non-inverted output.

By using external negative feedback components, the stage gain of the op-amp circuit can be very precisely controlled.

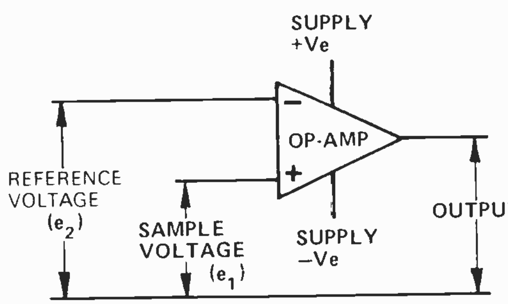

Fig. 2a Simple differential voltage comparator circuit.

TRANSFER REQUEST

Fig. 2a shows a very simple application of the op-amp. This particular circuit is known as a differential voltage comparator, and has a fixed reference voltage applied to the inverting input terminal, and a variable test or sample voltage applied to the non-inverting terminal. When the sample voltage is more than a few hundred microvolts above the reference voltage the op-amp output is driven to saturation in a positive direction, and when the sample is more than a few hundred microvolts below the reference voltage the output is driven to saturation in the negative direction.

Fig. 2b shows the voltage transfer characteristics of the above circuit. Note that it is the magnitude of the differential input voltage that dictates the magnitude of the output voltage, and that the absolute values of input voltage are of little importance. Thus, if a 1V reference is used and a differential voltage of only 200uV is needed to switch the output from a negative to a positive saturation level, this change can be caused by a shift of only 0.02% on a 1V signal applied to the sample input. The circuit thus functions as a precision voltage comparator or balance detector.

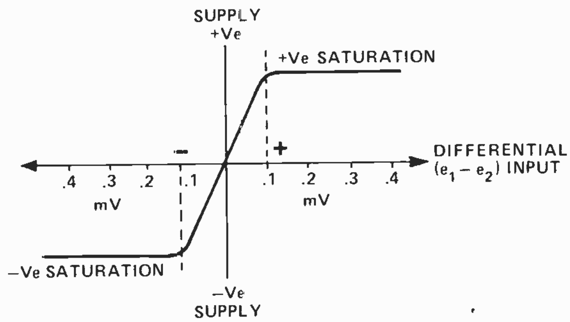

Fig. 2b Transfer characteristics of the differential voltage comparator circuit.

GOING TO GROUND

The op-amp can be made to function as a low-level inverting d.c. amplifier by simply grounding the non-inverting terminal and feeding the input signal to the inverting terminal, as shown in Fig. 3a. The op-amp is used 'open-loop' (without feedback) in this configuration, and thus gives a voltage gain of about 100 000 and has an input impedance of about 1M. The disadvantage of this circuit is that its parameters are dictated by the actual op-amp, and are subject to considerable variation between individual devices.

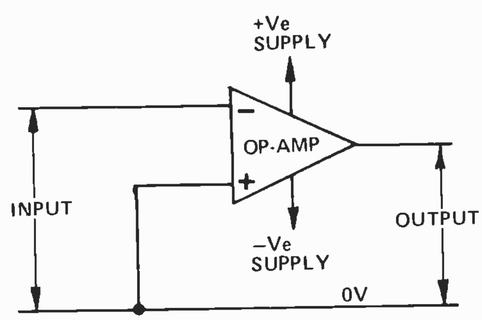

Fig. 3a Simple open-loop inverting d.c. amplifier.

CLOSING LOOPS

A far more useful way of employing the op-amp is to use it in the closed-loop mode, i.e., with negative feedback. Fig. 3b shows the method of applying negative feedback to make a fixed-gain inverting d.c. amplifier. Here, the parameters of the circuit are controlled by feedback resistors R_1 and R_2. The gain, A of the circuit is dictated by the ratios of R_1 and R_2, and equals R_2/R_1.

The gain is virtually independent of the op-amp characteristics, provided that the open-loop gain (A_o) is large relative to the closed-loop gain (A). The input impedance of the circuit is equal to R_1, and again is virtually independent of the op-amp characteristics.

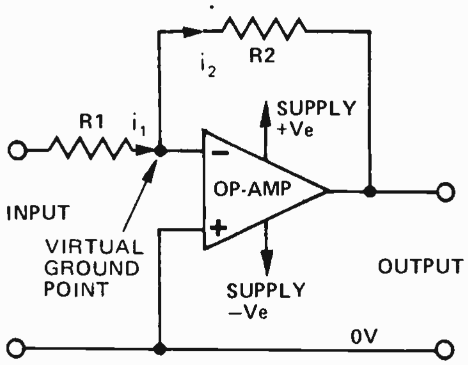

Fig. 3b Basic closed-loop inverting d.c. amplifier.

It should be noted at this point that although R_1 and R_2 control the gain of the complete circuit, they have no effect on the parameters of the actual op-amp, and the full open-loop gain of the op-amp is still available between its inverting input terminal and the output. Similarly, the inverting terminal continues to have a very high input impedance, and negligible signal current flows into the inverting terminal. Consquently, virtually all of the R_1 signal current also flows in R_2, and signal currents i_1 and i_2 can be regarded as being equal, as indicated in the diagram.

Since the signal voltage appearing at the output terminal end of R_2 is A times greater than that appearing at the inverting terminal end, the current flowing in R_2 is A times greater than that caused by the inverting terminal signal only. Consequently, R_2 has an apparent value of R_2/A when looked at from its inverting terminal end, and the R_1–R_2 junction thus appears as a low-impedance VIRTUAL GROUND point.

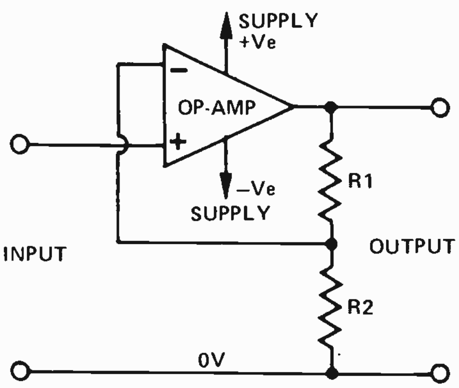

Fig. 4a Basic non-inverting d.c. amplifier

INVERT OR NOT TO INVERT . . .

It can be seen from the above description that the Fig. 3b circuit is very versatile. Its gain and input impedance can be very precisely controlled by suitable choice of R_1 and R_2, and are unaffected by variations in the op-amp characteristics. A similar thing is true of the non-inverting d.c. amplifier circuit shown in Fig. 4a. In this case the voltage gain is equal to $(R_1+R_2)/R_2$ and the input impedance is approximately equal to (A_0/A)Zin where Zin is the open-loop input impedancw of the op-amp. A great advantage of this circuit is that it has a very high input impedance.

FOLLOW THAT VOLTAGE

The op-amp can be made to function as a precision voltage follower by connecting it as a unity-gain non-inverting d.c. amplifier, as shown in Fig. 4b. In this case the input and output voltages of the circuit are identical, but the input impedance is very high and is roughly equal to $A_0 \times Z_{in}$.

The basic op-amp circuits of Figs. 2a to 4b are shown as d.c. amplifiers, but can readily be adapted for a.c. use. Op-amps also have many applications other than as simple amplifiers. They can easily be made to function as precision phase splitters, as adders or subtractors, as active filters or selective amplifiers, as precision half-wave or full-wave rectifiers, and as oscillators or multivibrators, etc.

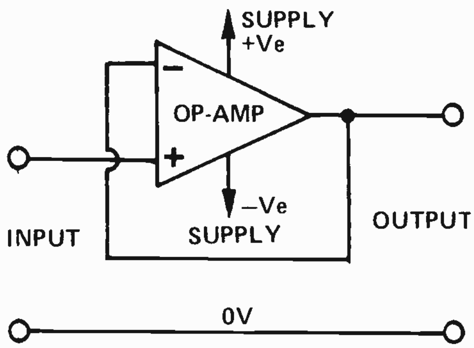

Fig. 4b Basic unity-gain d.c. voltage follower

OP-AMP PARAMETERS

An ideal op-amp would have an infinite input impedance, zero output impedance, infinite gain and infinite bandwidth, and would give perfect tracking between input and output. Practical op-amps fall far short of this ideal, and have finite gain, bandwidth, etc., and give tracking errors between the input and output signals. Consequently, various performance parameters are detailed on op-amp data sheets, and indicate the measure of "goodness" of the particular device. The most important of these parameters are detailed below.

OPEN-LOOP VOLTAGE GAIN, A_0. This is the low-frequency voltage gain occuring directly between the input and output terminals of the op-amp, and may be expressed in direct terms or in terms of dB. Typically, d.c. gain figures of modern op-amps are 100 000, or 100dB.

INPUT IMPEDANCE, Z_{in}. This is the impedance looking directly into the input terminals of the op-amp when it is used open-loop, and is usually expressed in terms of resistance only. Values of 1M are typical of modern op-amps with bi-polar input stages, while F.E.T. input types have impedances of a million Meg or greater.

OUTPUT IMPEDANCE, Z_0. This is the output impedance of the basic op-amp when it is used open-loop, and is usually expressed in terms of resistance only. Values of a few hundred ohms are typical of modern op-amps.

INPUT BIAS CURRENT, I_b. Many op-amps use bipolar transistor input stages, and draw a small bias current from the input terminals. The magnitude of this current is denoted by I_b, and is typically only a fraction of a microamp.

SUPPLY VOLTAGE RANGE, V_s. Op-amps are usually operated from two sets of supply rails, and these supplies must be within maximum and minimum limits. If the supply voltages are too high the op-amp may be damaged, and if the supply voltages are too low the op-amp will not function correctly. Typical supply limits are ±3V to ±15V.

INPUT VOLTAGE RANGE, $V_{i(max)}$. The input voltage to the op-amp must never be allowed to exceed the supply line voltages, or the op-amp may be damaged. $V_{i(max)}$ is usually specified as being one or two volts less than v_s.

OUTPUT VOLTAGE RANGE, $V_{o(max)}$. If the op-amp is over driven its output will saturate and be limited by the available supply voltages, so $V_{o(max)}$ is usually specified as being one or two volts less than V_s.

DIFFERENTIAL INPUT OFFSET VOLTAGE, V_{io}. In the ideal op-amp perfect tracking would exist between the input and output terminals of the device, and the output would register zero when both inputs were grounded. Actual op-amps are not perfect devices, however, and in practice slight imbalances exist within their input circuitry and effectively cause a small offset or bias potential to be applied to the input terminals of the op-amp. Typically, this DIFFERENTIAL INPUT OFFSET VOLTAGE has a value of only a few millivolts, but when this voltage is amplified by the gain of the circuit in which the op-amp is used it may be sufficient to drive the op-amp output to saturation. Because of this, most op-amps have some facility for externally nulling out the offset voltage.

COMMON MODE REJECTION RATION, c.m.r.r. The ideal op-amp produces an output that is proportional to the difference between the two signals applied to its input terminals, and produces zero output when identical signals are applied to both inputs simultaneously, i.e., in common mode. In practical op-amps, common mode signals do not entirely cancel out, and produce a small signal at the op-amps output terminal. The ability of the op-amp to reject common mode signals is usually expressed in terms of common mode rejection ratio, which is the ratio of the op-amp's gain with differential signals to the op-amp's gain with common mode signals. C.m.r.r. values of 90dB are typical of modern op-amps.

TRANSITION FREQUENCY, f_T. An op-amp typically gives a low-frequency voltage gain of about 100dB, and in the interest of stability its open-loop frequency response is tailored so that the gain falls off as the frequency rises, and falls to unity at a transition frequency denoted f_T. Usually, the response falls off at a rate of 6dB per octave or 20dB per decade. Fig. 5

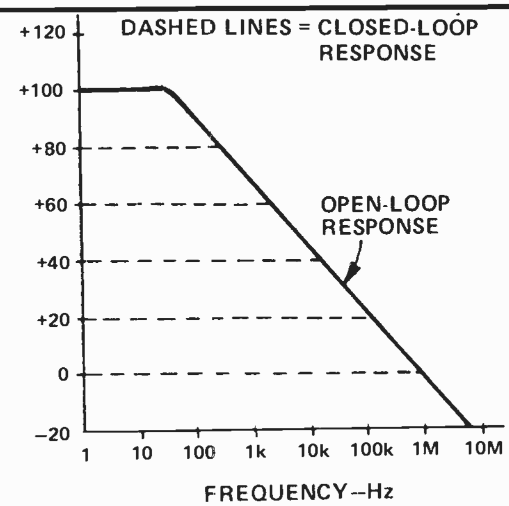

Fig. 5 Typical frequency response curve of the 741 op-amp.

shows the typical response curve of the type 741 op-amp, which has an f_T of 1MHz and a low frequency gain of 100dB.

Note that, when the op-amp is used in a closed-loop amplifier circuit, the bandwidth of the circuit depends on the closed-loop gain. If the amplifier is used to give a gain of 60dB its bandwidth is only 1kHz, and if it is used to give a gain of 20dB its bandwidth is 100kHz. The f_T figure can thus be used to represent a gain-bandwidth product.

	PARAMETER	741 VALUE
A_o	OPEN-LOOP VOLTAGE GAIN	100dB
Z_{IN}	INPUT IMPEDANCE	1M
Z_o	OUTPUT IMPEDANCE	150R
I_b	INPUT BIAS CURRENT	200nA
$V_{s(MAX)}$	MAXIMUM SUPPLY VOLTAGE	±18V
$V_{i(MAX)}$	MAXIMUM INPUT VOLTAGE	±13V
$V_{o(MAX)}$	MAXIMUM OUTPUT VOLTAGE	±14V
V_{io}	DIFFERENTIAL INPUT OFFSET VOLTAGE	2mV
c.m.r.r.	COMMON MODE REJECTION RATIO	90dB
F_T	TRANSITION FREQUENCY	1MHZ
S	SLEW RATE	1V/uS

Table 1 Typical characteristics of the 741 op-amp.

SLEW RATE. As well as being subject to normal bandwidth limitations, op-amps are also subject to a phenomenon known as slew rate limiting, which has the effect of limiting the maximum rate of change of voltage at the output of the device. Slew rate is normally specified in terms of volts per microsecond, and values in the range 1V/us to 10V/us are common with most popular types of op-amp. One effect of slew rate limiting is to make a greater bandwidth available to small output signals than is available to large output signals.

THE 741 OP-AMP.

Early types of i.c. op-amp, such as the well known 709 type, suffered from a number of design weaknesses. In particular, they were prone to a phenomenon known as INPUT LATCH-UP, in which the input circuitry tended to switch into a locked state if special precautions were not taken when connecting the input signals to the input terminals, and tended to self-destruct if a short circuit were inadvertently placed across the op-amp output terminals. In addition, the op-amps were prone to bursting into unwanted oscillations when used in the linear amplifier mode, and required the use of external frequency compensation components for stability control.

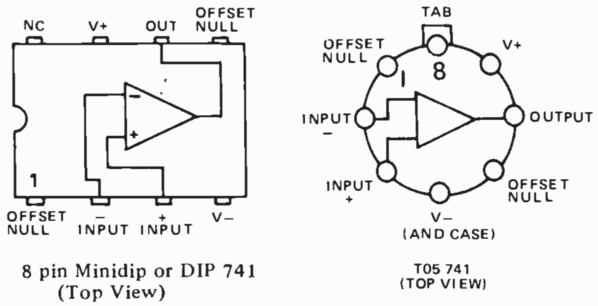

Fig. 6 Outlines and pin connections of the two most popular 741 packages.

These weaknesses have been eliminated in the type 741 op-amp. This device is immune to input latch-up problems, has built-in output short circuit protection, and does not require the use of external frequency compensation components. The typical performance characteristics of the device are listed in Table 1.

The type 741 op-amp is marketed by most i.c manufacturers, and is very readily available. Fig. 6 shows the two most commonly used forms of packaging of the device Throughout this chapter, all practical circuits are based on the standard 8-pin dual-in-line (D.I.L. or DIP) version of the 741 op-amp.

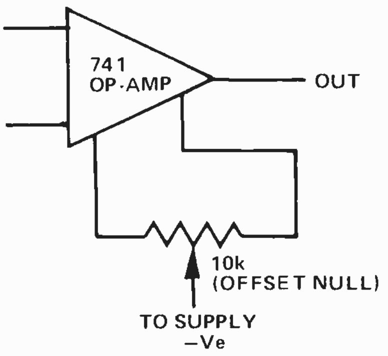

Fig. 7 Method of applying offset nulling to the 741 op-amp.

The 741 op-amp can be provided with external offset nulling by wiring a 10k pot between its two null terminals and taking the pot slider to the negative supply rail, as shown in Fig. 7.

Having cleared up these basic points, let's now go on and look at a range of practical applications of the 741 op-amp.

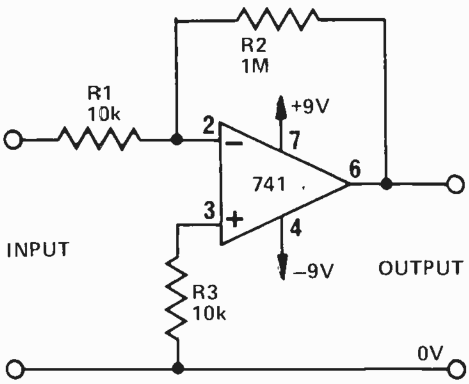

Fig. 8a x100 inverting d.c. amplifier.

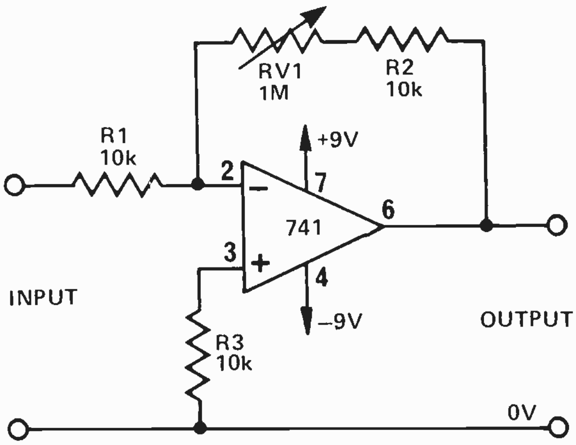

Fig. 8b Variable gain (x1 to x100) inverting d.c. amplifier.

BASIC LINEAR AMPLIFIER PROJECTS. (Figs. 8 to 11).

Figs. 8 to 11 show a variety of ways of using the 741 in basic linear amplifier applications.

The 741 can be made to function as an inverting amplifier by grounding the non-inverting input terminal and feeding the input signal to the inverting terminal. The voltage gain of the circuit can be precisely controlled by selecting suitable values of external feedback resistance. Fig. 8a shows the practical connections of an inverting d.c. amplifier with a pre-set gain of x100 The voltage gain is determined by the ratios of R_1 and R_2, as shown in the diagram.

The gain can be readily altered by using alternative R_1 and/or R_2 values. If required, the gain can be made variable by using a series combination of a fixed and a variable resistor in place of R_2, as shown in the circuit of Fig. 8b, in which the gain can be varied over the range x1 to x100 via R_2.

VARIATIONS

A variation of the basic inverting d.c. amplifier is shown in Fig. 9a. Here, the feedback connection to R_2 is taken from the output of the R_3–R_4 output potential divider, rather than directly from the output of the op-amp, and the voltage gain is determined by the ratios of this divider as well as by the values of R_1 and

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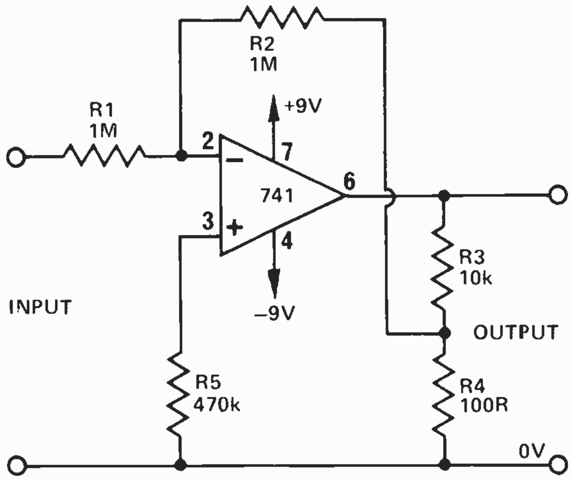

Fig. 9a High impedance x100 inverting d.c. amplifier.

R_2. The important feature of this circuit is that it enables R_1, which determines the input impedance of the circuit, to be given a high value if required, while at the same time enabling high voltage gain to be achieved.

The basic inverting d.c. amplifier can be adapted for a.c. use by simply wiring blocking capacitors in series with its input and output terminals, as shown in the x100 inverting a.c. amplifier circuit of Fig. 9b.

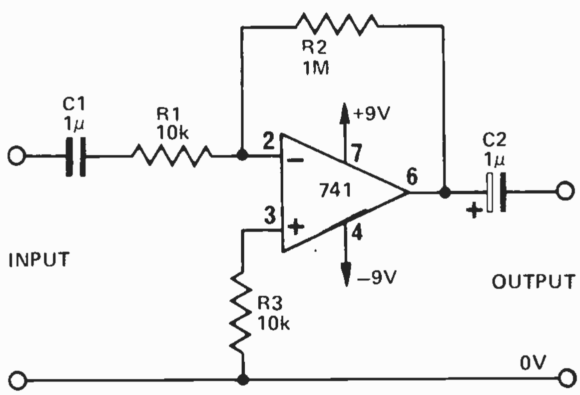

Fig. 9b x100 inverting a.c. amplifier.

NON-INVERTING . . .

The amp can be made to function as a non-inverting amplifier by feeding the input signal to its non-inverting terminal and applying negative feedback to the inverting terminal via a resistive potential divider that is connected across the op-amp output. Fig. 10a shows the connections for making a fixed gain (x100) d.c. amplifier.

The voltage gain of the Fig. 10a circuit is determined by the ratios of R_1 and R_2. If R_2 is given a value of zero the gain falls to unity, and if R_1 is given a value of zero the gain rises towards infinity (but in practice is limited to the open-loop gain of the op-amp). If required, the gain can be made variable by replacing R_2 with a

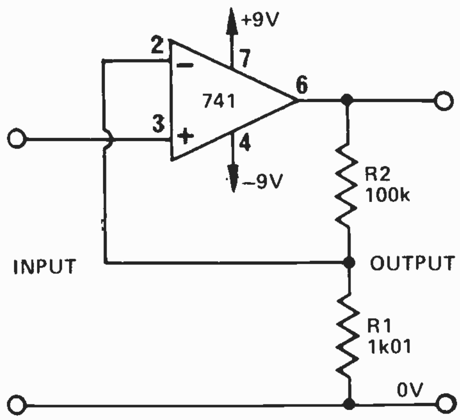

Fig. 10a Non-inverting x100 d.c. amplifier.

potentiometer and connecting the pot slider to the inverting terminal of the op-amp, as shown in the circuit of Fig. 10b. The gain of this circuit can be varied over the range x1 to x100 via R_1.

. . . AND RESISTANCE TO INPUTS

A major advantage of the non-inverting d.c. amplifier is that it has a very high input resistance. In theory, the input resistance is equal to the open-loop input resistance (typically 1M) multiplied by the open-loop voltage gain (typically 100 000) divided by the actual circuit voltage gain. In practice, input resistance values of hundreds of megohms can readily be obtained.

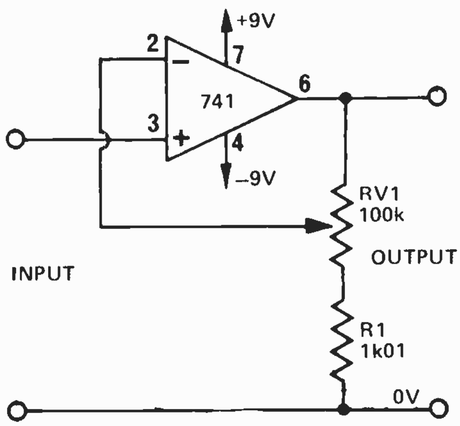

Fig. 10b Non-inverting variable gain (x1 to x100) d.c. amplifier.

BLOCKING OUT

The basic non-inverting d.c. circuit of Fig. 10 can be modified to operate as a.c. amplifiers in a variety of ways. The most obvious approach here is to simply wire blocking capacitors in series with the inputs and outputs, but in such cases the input terminal must be d.c. grounded via a suitable resistor, as shown by R_3 in the non-inverting x100 a.c. amplifier of Fig. 11a. If this resistor is not used the op-amp will have no d.c. stability, and its output will rapidly drift into saturation.

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Clearly, the input resistance of the Fig. 11a circuit is equal to R_3, and R_3 must have a relatively low value in the interest of d.c. stability. This circuit thus loses the non-inverting amplifier's basic advantage of high input resistance.

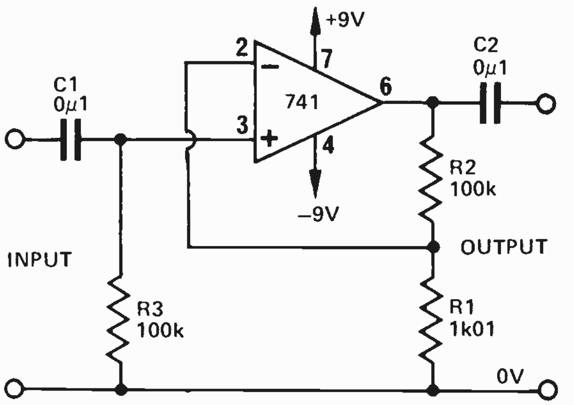

Fig. 11b Non-inverting, high input-impedance, x100 a.c. amplifier.

DRIFTING INTO STABILITY

A useful development of the Fig. 11a circuit is shown in Fig. 11b. Here, the values of R_1 and R_2 are increased and a blocking capacitor is interposed between them. At practical operating frequencies this capacitor has a negligible impedance, so the voltage gain is still determined by the ratios of the two resistors. Because of the inclusion of the blocking capacitor, however, the inverting terminal of the op-amp is subjected to virtually 100% d.c. negative feedback from the output terminal of the op-amp, and the circuit thus has excellent d.c. stability. The low end of R_3 is connected to the C_3–R_1 junction, rather than directly to the ground line, and the signal voltage appearing at this point is virtually identical with that appearing at the non-inverting terminal of the op-amp.

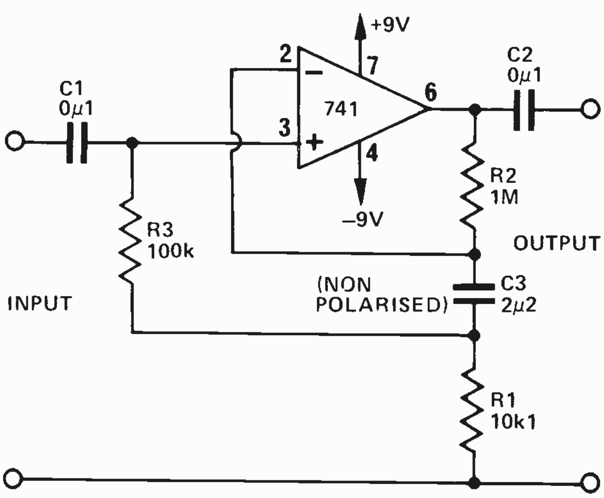

Fig. 11a Non-inverting x100 a.c. amplifier.

Consequently, identical signal voltages appear at both ends of R_3, and the apparent impedance of this resistor is increased close to infinity by bootstrap action.

This circuit thus has good d.c. stability and a very high input impedance. In practice, this circuit gives a typical input impedance of about 50M.

VOLTAGE FOLLOWER PROJECTS (Figs. 12 to 13).

A 741 can be made to function as a precision voltage follower by connecting it as a unity-gain non-inverting amplifier. Fig. 12a shows the practical connections for making a d.c. voltage follower. Here, the input signal is applied directly to the non-inverting terminal of the op-amp, and the inverting terminal is connected directly to the output, so the circuit has 100% d.c. negative feedback and acts as a unity-gain non-inverting d.c. amplifier.

The output signal voltage of the circuit is virtually identical to that of the input, so the output is said to 'follow' the input voltage. The great advantage of this circuit is that it has a very high input impedance (as high as hundreds of megohms) and a very low output impedance (as low as a few ohms). The circuit acts effectively as an impedance transformer.

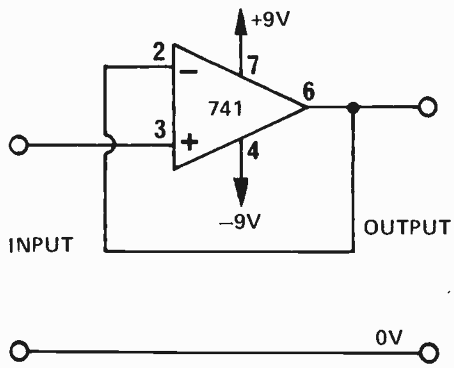

Fig. 12a d.c. voltage follower.

PRACTICE, AND ITS LIMITS

In practice the output of the basic Fig. 12a circuit will follow the input to within a couple of millivolts up to magnitudes within a volt or so of the supply line potentials. If required, the circuit can be made to follow to within a few microvolts by adding the offset null facility to the op-amp.

The d.c. voltage follower can be adapted for a.c. use by wiring blocking capacitors in series with its input and output terminals and by d.c.-coupling the non-inverting terminal of the op-amp to the zero volts line via a suitable resistor, as shown by R_1 in Fig. 12b. R_1 should have a value less than a couple of megohms, and restricts the available input impedance of the voltage follower.

LACED UP OHMS

If a very high input-impedance a.c. voltage follower is needed, the circuit of Fig. 12c can be used. Here, R_1 is boostrapped from the output of the op-amp, and its apparent impedance is greatly increased. This circuit has a typical impedance of hundreds of megohms.

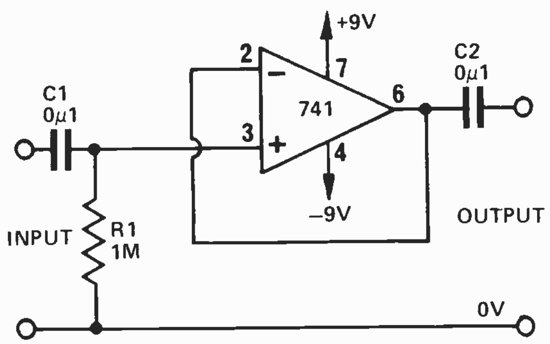

Fig. 12b a.c. voltage follower.

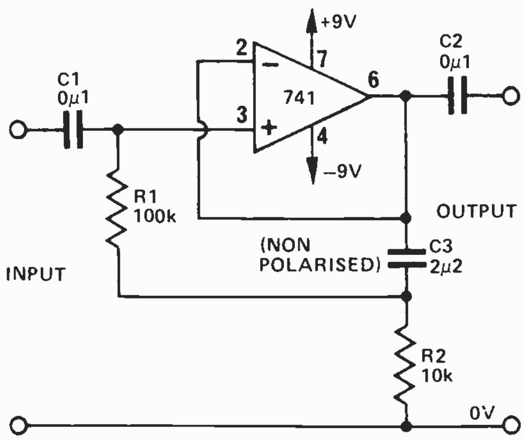

Fig. 12c Very high input-impedance a.c. voltage follower.

DRIVING CIRCUITS AMP-LY

The 741 op-amp is capable of providing output currents up to about 5mA, and this is consequently the current-driving limit of the three voltage follower circuits that we have looked at so far. The current-driving capabilities of the circuits can readily be increased by wiring simple or complementary emitter follower booster stages between the op-amp output terminals and the outputs of the actual circuits, as shown in Figs. 13a and 13b respectively.

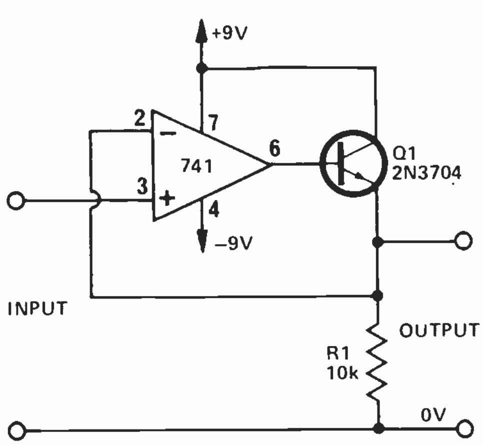

Fig. 13a Unidirectional d.c. voltage follower with boosted output (variable from 0V to +8V at 50mA.)

Note in each case that the base-emitter junction(s) of the output transistor(s) are included in the negative feedback loop of the circuit. Consequently, the 600mV knee voltage of each junction is effectively reduced by a factor equal to the open-loop gain of the op-amp, so the junctions do not adversely effect the voltage-following characteristics of either circuit.

The Fig. 13a circuit is able to source current only, and can be regarded as a unidirectional, positive-going, d.c. voltage follower. The Fig. 13b circuit can both source and sink output currents, and thus gives bidirectional follower action. Each circuit has a current-driving capacity of about 50mA. This figure is dictated by the limited power rating of the specified output transistors. The drive capability can be increased by using alternative transistors.

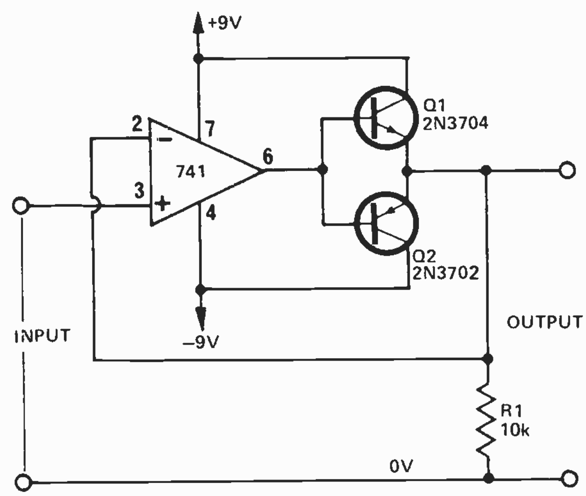

Fig. 13b Bidirectional d.c. voltage follower with boosted output (variable from 0V to± ±8V at 50mA).

MISC AMP PROJECTS (Figs. 14 to 22)

Figs. 14 to 22 show a miscellaneous assortment of 741 amplifier projects, ranging from d.c. adding circuits to frequency-selective amplifiers.

Fig. 14 shows the circuit of a unity-gain inverting d.c. adder, which gives an output voltage that is equal to the sum of the three input voltages. Here, input resistors R_1 to R_3 and feedback resistor R_4 each have the same value, and the circuit thus acts as a unity-gain inverting d.c. amplifier between each input terminal and the output. Since the current flowing in each input resistor also flows in feedback resistor R_4, the total current flowing in R_4 is equal to the sum of the input currents, and the output voltage is equal to the negative sum of the input voltages. The circuit is shown with only three input connections, but in fact can be provided with any number of input terminals. The circuit can be made to function as a so-called 'audio mixer' by wiring blocking capacitors in series with each input terminal and with the output terminal.

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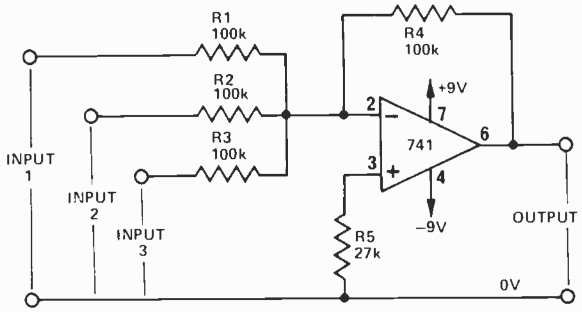


Fig. 14 Unity-gain inverting d.c. adder, or 'audio mixer'.

FIG. 15 shows how two unity-gain inverting d.c. amplifiers can be wired in series to make a precision unity-gain balanced phase-splitter. The output of the first amplifier is an inverted version of the input signal, and the output of the second amplifier is a non-inverted version.

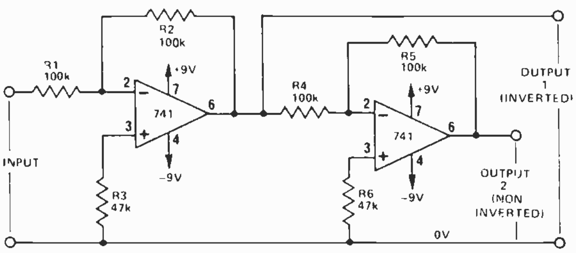


Fig. 15 Unity-gain balanced d.c. phase-splitter.

FIG. 16 shows how a 741 can be used as a unity-gain differential d.c. amplifier. The output of this circuit is equal to the difference between the two input signals or voltages, or to e_1-e_2. Thus, the circuit can also be used as a subtractor. In this type of circuit the component values are chosen such that $R_1/R_2=R_4/R_3$, in which case the voltage gain $A_v=R_2/R_1$. The circuit can thus be made to give voltage gain if required.

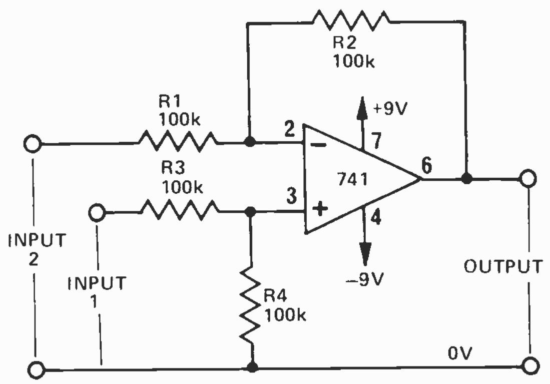
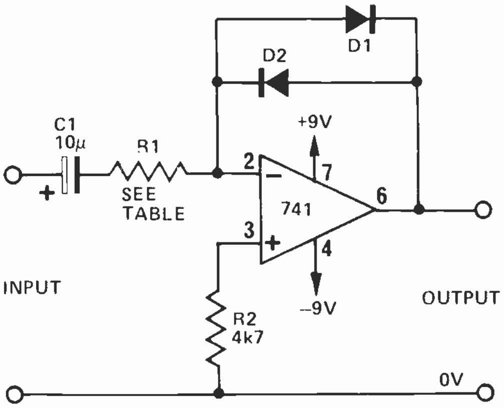


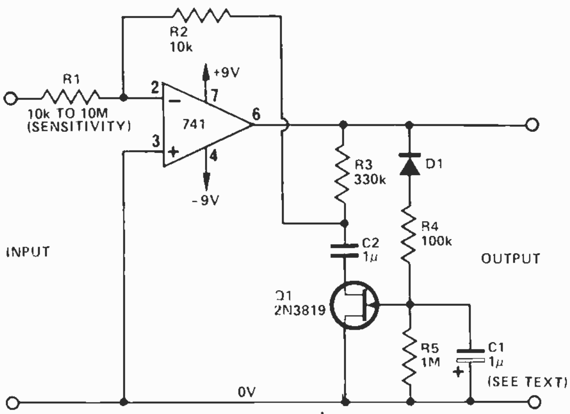
Fig. 16 Unity-gain differential d.c. amplifier, or subtractor.

FIG. 17 shows the amp can be made to act as a non-linear (semi-log) a.c. voltage amplifier by using a couple of ordinary silicon diodes as feedback elements. The voltage gain of the circuit depends on the magnitude of applied input signal, and is high when input signals are low, and low when input signals are high. The measured performance of the circuit is shown in the table, and can be varied by using alternative R_1 values.



INPUT VOLTS (RMS)	R_1 = 1kΩ		R_1 = 10kΩ	
	V_{OUT} (R.M.S.)	GAIN	V_{OUT} (R.M.S.)	GAIN
1 mV	110 mV	X 110	21 mV	X 21
10 mV	330 mV	X 33	170 mV	X 17
100 mV	450 mV	X4 5	360 mV	X 3 6
1V	560 mV	X 0 56	470 mV	X 0 47
10V	600 mV	X 0 07	560 mV	X 0 056

Fig. 17 Circuit and performance table of non-linear (semi-log) a.c. voltage amplifier.



V_{IN} (R_1 = 10KΩ)	V_{IN} (R_1 = 100KΩ)	V_{IN} (R_1 = 1MΩ)	V_{IN} (R_1 = 10MΩ)	V_{OUT}
50 mV	500 mV	5 V	50 V	2.85 V
20 mV	200 mV	2 V	20 V	2.81 V
10 mV	100 mV	1 V	10 V	2.79 V
5 mV	50 mV	500 mV	5 V	2.60 V
2 mV	20 mV	200 mV	2 V	2 03 V
1 mV	10 mV	100 mV	1 V	1 48 V
500 μV	5 mV	50 mV	500 mV	0 89 V
200 μV	2 mV	20 mV	200 mV	0.40 V
100 μV	1 mV	10 mV	100 mV	0 20 V
50 μV	500 μV	5 mV	50 mV	0 10 V

Fig. 18 Circuit and performance details of constant-volume amplifier.

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FIG. 18 shows how the 741 can be used together with a junction-type field-effect transistor (JFET) to make a so-called constant-volume amplifier. The action of this type of circuit is such that its peak output voltage is held sensibly constant, without distortion, over a wide range of input signal levels, and this particular circuit gives a sensibly constant output over a 30dB range of input signal levels.

The measured performance of the circuit is shown in the table. C_1 determines the response time of the amplifier, and may be altered to satisfy individual needs.

ACTION TAKEN

The action of the Fig. 18 circuit relies on the fact that the JFET can act as a voltage-controlled resistance which appears as a low value when zero bias is applied to its gate and as a high resistance when its gate is negatively biased. The JFET and R_3 act as a gain-determining a.c. voltage divider (via C_2), and the bias to the JFET gate is derived from the circuits output via the D_1-C_1 network. When the circuit output is low the JFET appears as a low resistance, and the op-amp gives high voltage gain.

When the circuit output is high the JFET appears as a high resistance, and the op-amp gives low voltage gain. The output level of the circuit is thus held sensibly constant by negative feedback.

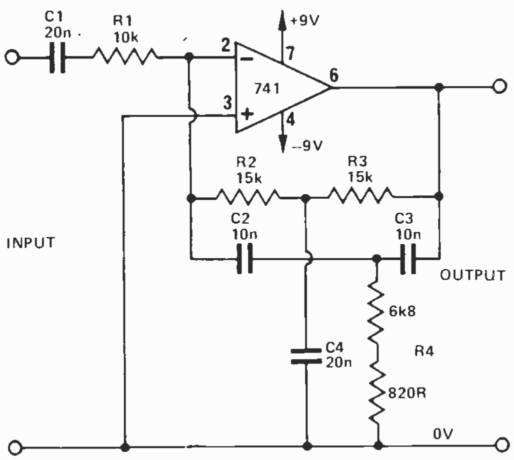

Fig. 19 1kHz tuned (acceptor) amplifier (twin-T).

CHOOSE YOUR FREQUENCY

The 741 op-amp can be made to function as a frequency-selective amplifier by connecting frequency-sensitive networks into its feedback loops. Fig. 19 shows how a twin-T network can be connected to the op-amp so that it acts as a tuned (acceptor) amplifier, and Fig. 20 shows how the same twin-T network can be connected so that the op-amp acts as a notch (rejector) filter. The values of the twin-T network are chosen such that $R_2 = R_3 = 2 \times R_4$, and $C_2 = C_4/2$, in which case its centre (tuned) frequency $= 1/6.28\ R_2.C_2$. With the component values shown, both circuits are tuned to approximately 1kHz.

Finally, to complete this section, Figs. 21 and 22 show the circuits of a couple of variable-frequency audio filters. The Fig. 21 circuit is that of a low-pass filter which covers the range 2.2kHz to 24kHz, and the Fig. 22 circuit is that of a high-pass filter which covers the range 235Hz to 2.8kHz. In each case, the circuit gives unity gain to signals beyond its cut-off frequency, and gives a 2nd order response (a change of 12dB per octave) to signals within its range.

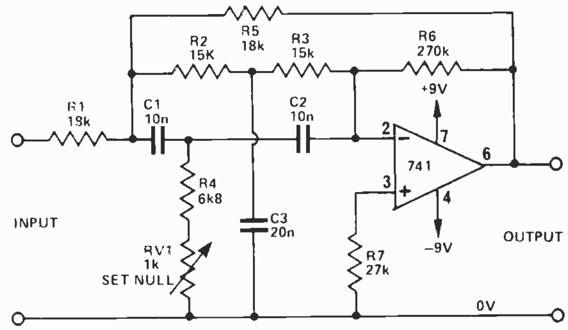

Fig. 20 1kHz notch (reject) filter.

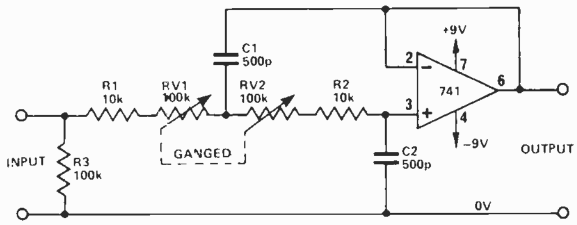

Fig. 21 Variable low-pass filter, covering 2.2kHz to 24kHz.

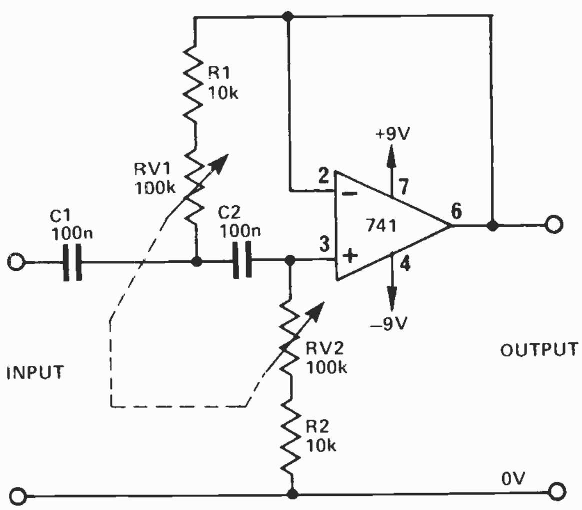

Fig. 22 Variable high-pass filter, covering 235Hz to 2.8kHz.

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INSTRUMENTATION PROJECTS (Figs. 23 to 31)

Figs. 23 to 31 show a variety of instrumentation projects in which the 741 can be used. The circuits range from a simple voltage regulator to a linear-scale ohmmeter.

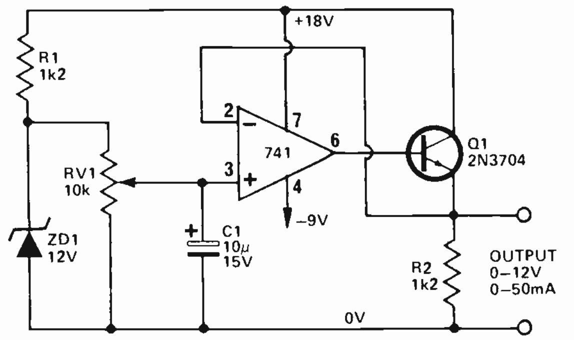

Fig. 23 Simple variable-voltage supply.

FIG. 23 shows the circuit of a simple variable-voltage power supply, which gives a stable output that is fully adjustable from 0V to 12V at currents up to a maximum of about 50mA. The operation of the circuit is quite simple. ZD_1 is a zener diode, and is energised from the positive supply line via R_1. A constant reference potential of 12V is developed across the zener diode, and is fed to variable potential divider RV_1.

The output of this divider is fully variable from 0V to 12V, and is fed to the non-inverting input of the op-amp. The op-amp is wired as a unity-gain voltage follower, with Q_1 connected as an emitter follower current-booster stage in series with its output.

Thus, the output voltage of the circuit follows the voltage set at the op-amp input via RV_1, and is fully variable from 0V to 12V. Note that the circuit uses an 18V positive supply and a 9V negative supply.

Also note that the voltage range of the above circuit can be increased by using higher zener and unregulated supply voltages, and that its current capacity can be increased by using one or more power transistors in place of Q_1.

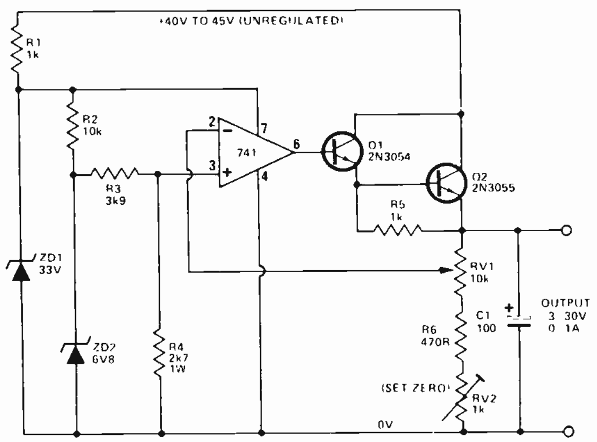

Fig. 24 3V - 30V, 0-1 amp stabilised p.s.u.

FIG. 24 shows how a 741 op-amp can be used as the basis of a stabilised power supply unit (P.S.U.) that covers the range 3V to 30V at currents up to 1A. Here, the voltage supply to the op-amp is stabilized at 33V via ZD_1, and a highly temperature-stable reference of 3V is fed to the input of the op-amp via ZD_2.

The op-amp and output transistors Q_1-Q_2 are wired as a variable-gain non-inverting d.c. amplifier, with gain variable from unity to x10 via RV_1, and the output voltage is thus fully variable from 3V to 30V via RV_1. The output voltage is fully stabilized by negative feedback.

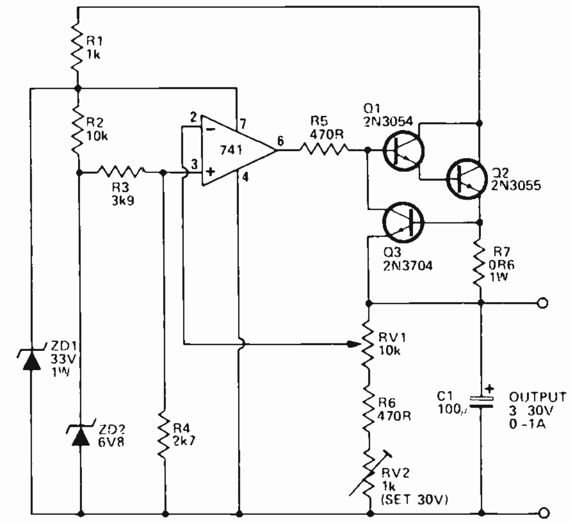

Fig. 25 3V - 30V stabilised p.s.u. with overload protection.

FIG. 25 shows how overload protection can be applied to the above circuit. Here, current-sensing resistor R_7 is wired in series with the output of the regulator, and cut-out transistor Q_3 is driven from this resistor and is wired so that its base-collector junction is able to short the base-emitter junction of the Q_1-Q_2 output transistor stage.

Normally, Q_3 is inoperative, and has no effect on the circuit, but when P.S.U. output currents exceed 1A a potential in excess of 600mV is developed across R_7 and biases Q_3 on, thus causing Q_3 to shunt the base-emitter junction of the Q_1-Q_2 output stage and hence reducing the output current. Heavy negative feedback takes place in this action, and the output current is automatically limited to 1A, even under short-circuit conditions.

FIG. 26a shows how a 741 can be used in conjunction with a couple of silicon diodes as a precision half-wave rectifier. Conventional diodes act as imperfect rectifiers of low-level a.c. signals, because they do not begin to conduct significantly until the applied signal voltage exceeds a 'knee' value of about 600mV.

When diodes are wired into the negative feedback loop of the circuit as shown the 'knee' voltage is effectively reduced by a factor equal to the open-loop gain of the op-amp, and the circuit thus acts like a near-perfect rectifier.

The overall voltage gain of the Fig. 26a circuit is dictated by the ratios of R_1 and R_2 to R_3, as in the case of a conventional inverting amplifier, and this circuit thus gives a gain of unity. The circuit can be made to

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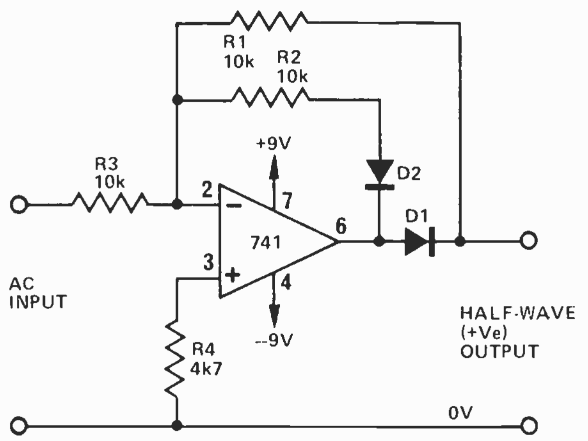


Fig. 26a Precision unity-gain half-wave rectifier.

act as a precision half-wave a.c./d.c. converter by designing it to give a voltage gain of 2.22 to give form-factor correction, and by integrating its rectifier output, as shown in Fig. 26b.

Note that each of the Fig. 26 circuits has a high output impedance, and the outputs must both be fed into loads having impedances less than about 1M.

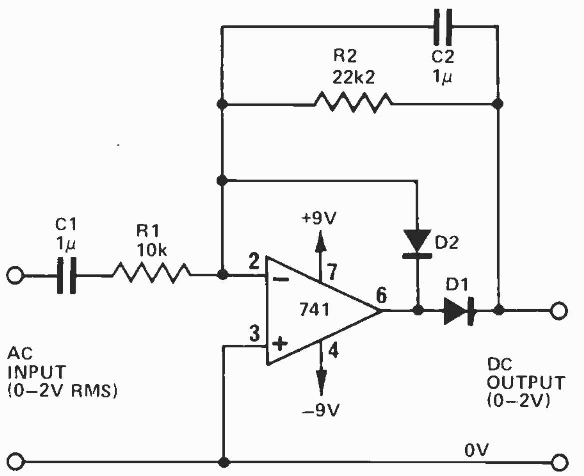
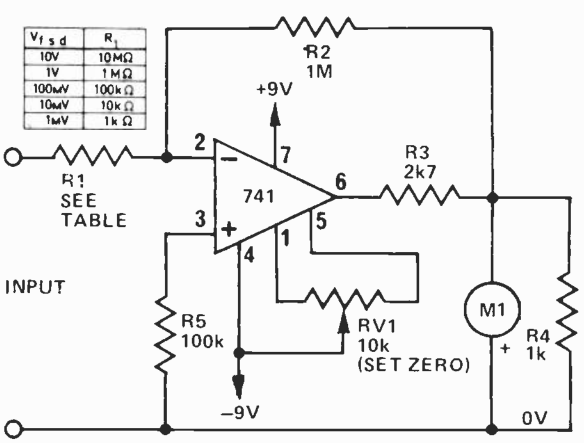


Fig. 26b Precision half-wave a.c./d.c. converter.

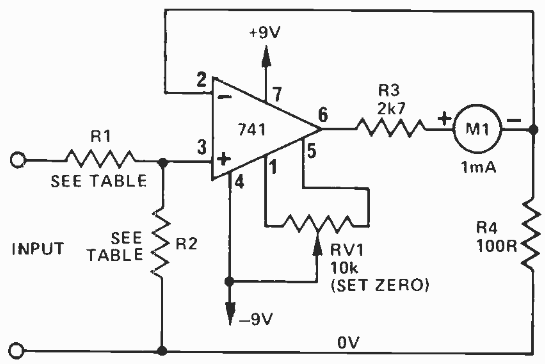


V_{fsd}	R_1
10V	10MΩ
1V	1MΩ
100mV	100kΩ
10mV	10kΩ
1mV	1kΩ

Fig. 27 High-performance d.c. voltmeter converter.

FIG. 27 shows how op-amp can be used as a high-performance d.c. voltmeter converter, which can be used to convert any 1V f.s.d. meter with a sensitivity better than 1k/V into a voltmeter that can read any value in the range 1mV to 10V f.s.d. at a sensitivity of 1M/V. The voltage range is determined by the R_1 value, and the table shows some suitable values for common voltage ranges.

FIG. 28 shows a simple circuit that can be used to convert a 1mA f.s.d. meter into a d.c. voltmeter with any f.s.d value in the range 100mV to 1000V, or into a d.c. current meter with any f.s.d. value in the range 1uA to 1A. Suitable component values for different ranges are shown in the tables.



VOLTMETER		
fsd	R_1	R_2
1000V	10MΩ	1kΩ
100V	10MΩ	10kΩ
10V	10MΩ	100kΩ
1V	900kΩ	100kΩ
100mV	0Ω	100kΩ

CURRENT METER		
fsd	R_1	R_2
1A	0Ω	0.1Ω
100mA	0Ω	1Ω
10mA	0Ω	10Ω
1mA	0Ω	100Ω
100μA	0Ω	1kΩ
10μA	0Ω	10kΩ
1μA	0Ω	100kΩ

Fig. 28 Simple d.c. voltage or current meter.

FIG. 29 shows the circuit of a precision d.c. millivoltmeter, which uses a 1mA f.s.d. meter to read f.s.d. voltages from 1mV to 1000mV in seven switch-selected ranges.

FIG. 30 shows the basic circuit of a precision a.c. volt or millivolt meter. This circuit can be used with any moving-coil meter with a full scale current value in the range 100uA to 5mA, and can be made to give any full scale a.c. voltage reading in the range 1mV to 1000mV. The tables show the alternative values of R_1 and R_2 that must be used to satisfy different basic meter sensitivities, and the values of R_3 and R_4 that must be used for different f.s.d. voltage sensitivities.

HOME OHM

Finally, to conclude, Fig. 31 shows how the 741 op-amp can be used in conjuncton with a 1mA f.s.d. meter to make a linear-scale ohmmeter that has five decade ranges from 1k to 10M.

The circuit is divided into two parts, and consists of a voltage generator that is used to generate a standard test

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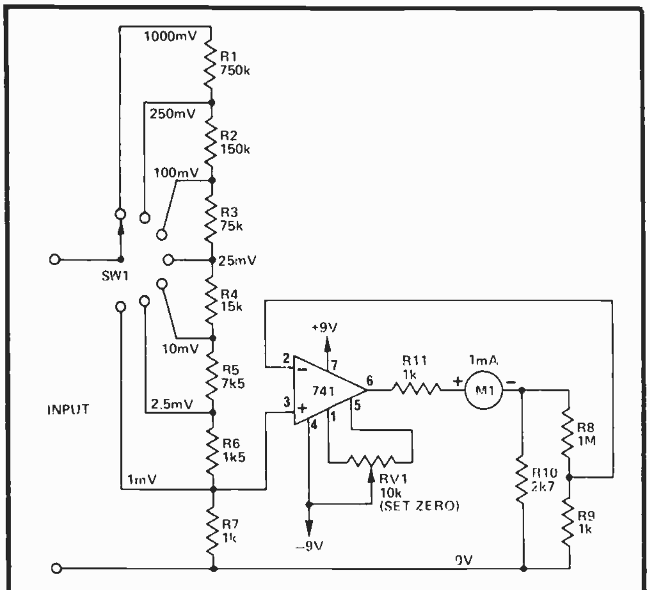
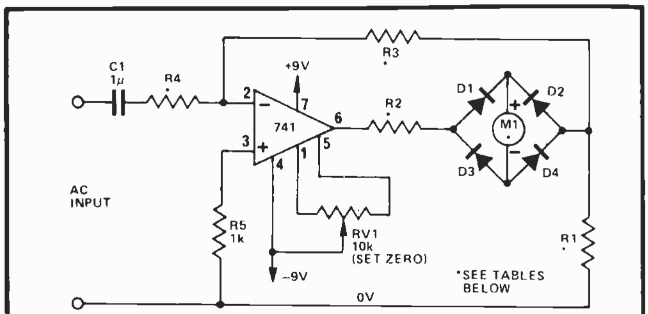


Fig. 29 Precision d.c. millivoltmeter.



M_1	R_1	R_2
100μA	9kΩ	27kΩ
500μA	1.8kΩ	5.6kΩ
1mA	900Ω	2.7kΩ
2.5mA	360Ω	1.5kΩ
5mA	180Ω	470Ω

VALUES FOR USE WITH DIFFERENT METER MOVEMENTS

$V_{f.s.d.}$	R_4	R_3
1000V	10MΩ	10kΩ
100V	10MΩ	100kΩ
10V	10MΩ	1MΩ
1V	1MΩ	1MΩ
100mV	100kΩ	1MΩ
10mV	10kΩ	1MΩ
1mV	1kΩ	1MΩ

DIFFERENT f.s.d. VOLTAGE SENSITIVITIES

Fig. 30 Precision a.c. volt/millivolt meter.

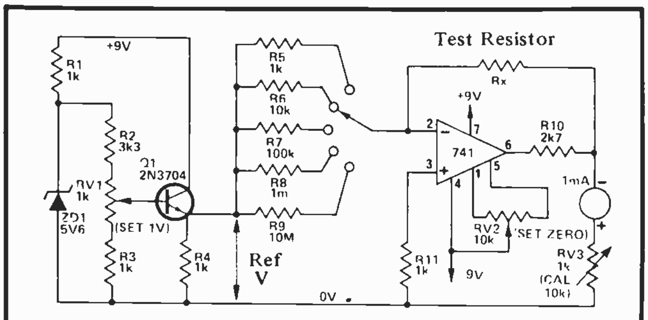


Fig. 31 Linear-scale ohmmeter.

voltage, and a readout unit which indicates the value of the resistor under test.

The voltage generator section of the circuit comprises zener diode ZD_1, transistor Q_1, and resistors R_1 to R_4. The action of these components is such that a stable reference potential of 1V is developed across R_4, but is adjustable over a limited range via RV_1. This voltage is fed to the input of the op-amp readout unit. The op-amp is wired as an inverting d.c. amplifier, with the 1mA meter and RV_3 forming a 1V f.s.d. meter across its output, and with the op-amp gain determined by the values of ranging resistors R_5 to R_9 and by negative feedback resistor R_x.

Since the input to the amplifier is fixed at 1V, the output voltage reading of the meter is directly proportional to the value of R_x, and equals full scale when R_x and the ranging resistor values are equal. Consequently, the circuit functions as a linear-scale ohmmeter.

CALIBRATION

The procedure for initially calibrating the Fig. 31 circuit is as follows: First, switch the unit to 10k range and fix an accurate 10kΩ resistor in the R_x position. Now adjust RV_1 to give an accurate 1V across R_4, and then adjust RV_2 to give a precise full scale reading on the meter. All adjustments are then complete, and the circuit is ready for use.

MISCELLANEOUS 741 PROJECTS

The 741 op-amp can be used as the basis of a vast range of miscellaneous projects, including oscillators and sensing circuits. Four such projects are described in this final section.

FIG. 32 shows how the 741 op-amp can be connected as a variable-frequency wien-bridge oscillator, which covers the basic range 150Hz to 1.5kHz, and uses a low-current lamp for amplitude stabilisation. The output amplitude of the oscillator is variable via RV_4 and has a typical maximum value of 2.5V r.m.s. and a t.h.d. value of 0.1%. The frequency range of the circuit is inversely proportional to the C_1-C_2 values. The circuit can give a useful performance up to a maximum frequency of about 25kHz.

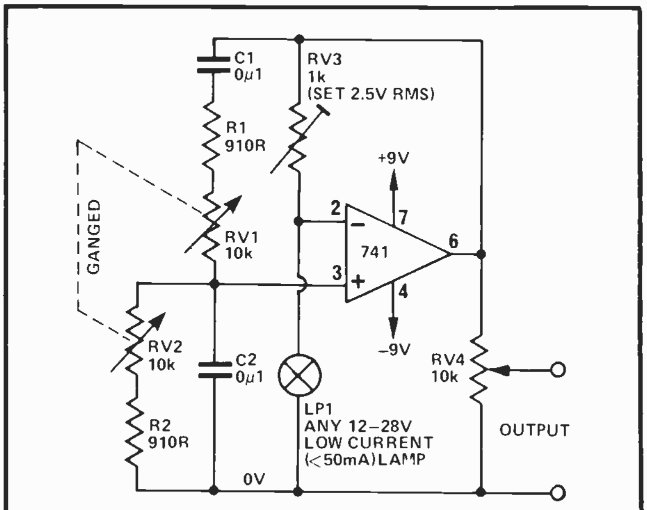


Fig. 32 150Hz - 1.5kHz Wien-bridge oscillator.

Fig. 33 shows how either a 741 or a 709 op-amp can be connected as a simple variable-frequency square-wave generator that covers the range 500Hz to 5kHz via a single variable resistor. (The circuit produces a good symmetrical waveform.)

The frequency of oscillation is inversely proportional to the C_1 value, and can be reduced by increasing the C_1 value, or vice-versa. The amplitude of the square wave output signal can be made variable, if required, by wiring a 10kΩ variable potential divider across the output terminals of the circuit and taking the output from between the pot slider and the zero volts line.

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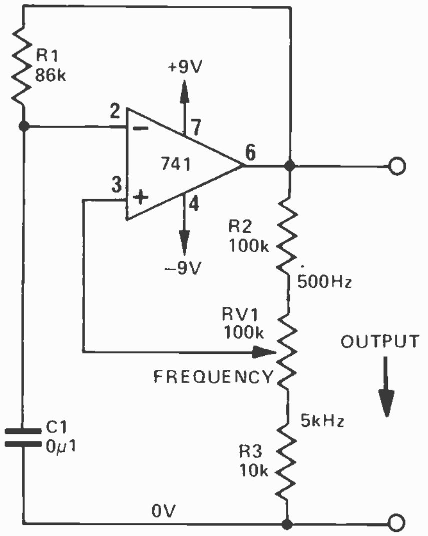


Fig. 33 Simple 500Hz - 5kHz square wave generator.

FIGS. 34 and 35 show a couple of useful ways of using the 741 op-amp in the open-loop differential voltage comparator mode. In each case, the circuits are powered from single-ended 12V supplies, and have a fixed half-supply reference voltage applied to the non-inverting op-amp terminal via the R_1-R_2 potential divider and have a variable voltage applied to the inverting op-amp terminal via a variable potential divider.

The circuit action is such that the op-amp output is driven to negative saturation (and the relay is driven on) when the variable input voltage is greater than the reference voltage. Conversely, the op-amp output is driven to positive saturation (and the relay is cut off) when the variable input voltage is less than the reference voltage.

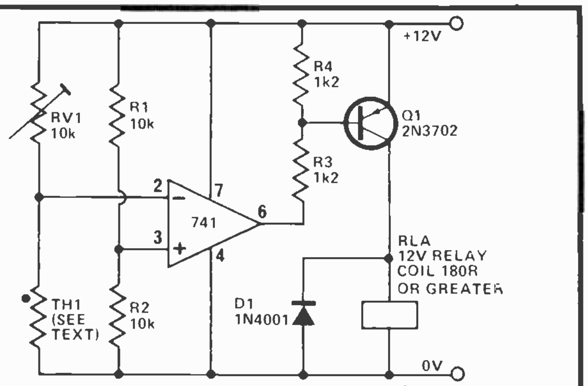


Fig. 34 Precision frost or under temperature switch can be made to act as a fire or over temperature switch by transposing R_1 and TH_1 positions.

FROSTY RECEPTION

The Fig. 34 circuit is that of a precision frost or under-temperature switch, which drives the relay on when the temperature sensed by thermistor TH_1 falls below a value pre-set via RV_1. The circuit action can be reversed, so that it operates as a fire or over-temperature switch, by simply transposing the RV_1 and the TH_1 positions. In either case, TH_1 can be any negative-temperature-coefficient thermistor that presents a resistance in the range 900Ω to 9kΩ at the required trip temperature.

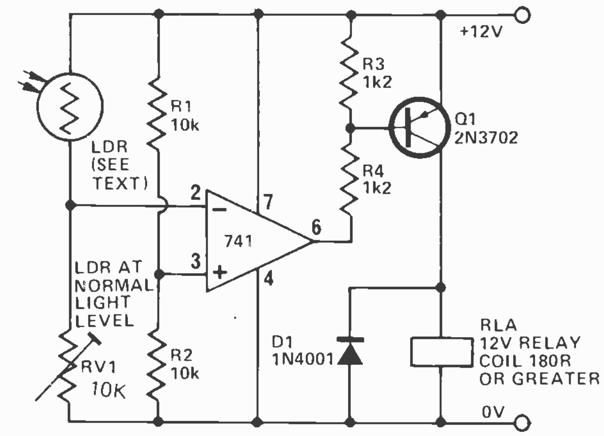


Fig. 35 Precision light-activated switch can be made to act as a dark-activated switch by transposing R_1 and LDR positions.

LIGHT WORK

The Fig. 35 circuit is that of a precision light-activated switch, which turns the relay on when the illumination level sensed by light-dependent resistor LDR exceeds a value pre-set by RV_1. The circuit action can be reversed so that the relay turns on when the illumination falls below a pre-set level by simply transposing the RV_1 and LDR positions. In either case, the LDR can be any cadmium-sulphide photocell that presents a resistance in the range 900Ω to 9kΩ at the desired switch-on level. ●

electronics today international

What to look for in the June issue:

G.S.R. MONITOR

Back in April we explained what biofeedback was and just how it can be used to control some of the internal body processes.

Perhaps the best way to start experimenting with this fascinating subject is to use a galvanic skin response monitor. The G.S.R. Monitor we describe is simple to build and use— one of the fascinations of biofeedback being the speed and ease with which control can be learnt.

Multimeter Guide

There's more to meters than meets the eye – and the pocket. Knowing which one to buy can be a problem with so many available. We set out to guide you in your choice and show you what to look for.

SIGNAL INJECTOR/ TRACER

No excuses for this all too familiar project it's short and easy to build but it is also very good and what's more, useful.

+25

A generation away

Electronic systems and discoveries that we take for granted were not even dreamed of a generation ago. Will the same thing happen in the next generation? What will our children take for granted in 25 years time?

We take a look at the systems of the future and try to forsee just how electronics will develop. Evalution or Revolution; part one starts in June.

The articles described here are in an advanced state of preparation, but circumstances may necessitate changes in the issue that appears.

DIGITAL SOUND SYNTHESIS

The music synthesiser has now been around for some time—too long some may say—and its abilities have been amply demonstrated by various rock groups. The main limitation on the use of a synthesiser as a live instrument being that it is monophonic (only one note at a time). Next month we suggest various digital techniques that may be employed in the design of a basic MULTI-PHONIC system, which would overcome most of the inherent monophonic limitations without the size and complexity of a full polyphonic system.

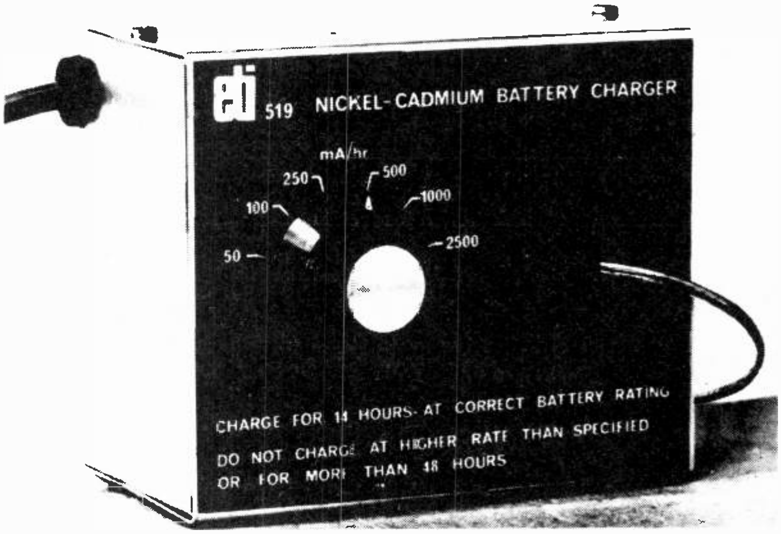
Sound Operated Flash

Dramatic pictures and sequences, even shots for research purposes can easily be taken with our Sound Operated Flash. Another down to earth project which can be cheaply built to produce some amazing pictures.

NICKEL-CADMIUM BATTERY CHARGER

Universal unit will charge practically any nickel-cadmium battery currently in use.

eti project



THERE is an increasing proliferation of portable equipment, such as flash guns and calculators, which could, or already do, use rechargeable batteries of the nickel-cadmium type.

If the equipment was originally fitted with rechargeable batteries, a charger may well have been provided. But when replacing ordinary dry cells with rechargeable types a charger will be required. Unfortunately, nickel-cadmium battery packs come in a variety of voltages and ampere-hour ratings and a charger supplied for one piece of equipment (eg, an electronic flash) will seldom, if ever, be suitable for other equipment such as an electronic calculator.

The ETI 519 battery charger will charge almost any nickel-cadmium battery in use today. The charging rate is switch-selectable for batteries from 50 mA/h to 2500 mA/h capacity.

Any battery voltage up to 20 volts is *automatically* accommodated. No voltage selection is required.

Charging time is approximately 14 hours for a flat battery and proportionally less for one that is partially discharged.

Overcharging at the correct ampere/hour rate will not damage a nickel-cadmium battery. Thus an overnight charge for a partially discharged battery may be safely given. In fact, provided the correct ampere/hour charging rate has been selected no damage will occur if left on charge for 48 hours.

CONSTRUCTION

The circuit is a very simple one. Practically any method of construction may be used provided care is taken with the insulation of 120 Vac wiring.

In our prototype unit we assembled all components on tag strips, with the exception of the range resistors which were mounted directly on the range switch itself.

If only a single range is required, a

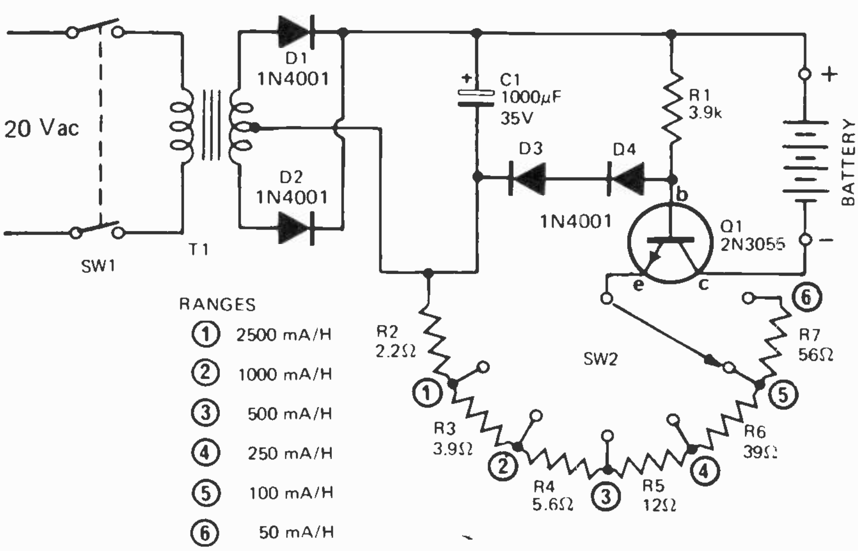


Fig. 1. Circuit diagram of the Nickel-Cadmium Battery Charger.

TABLE 1

BATTERY VOLTAGE	TRANSFORMER**	R1
1.25—3.75	12.6 V CT	1.8k
5—10	24 V CT	2.2k
11.25—20	40 C CT	3.9k
21—30*	60 V CT	5.6k

*** Capacitor C1 voltage rating should be 50V.**

**** Current rating of the transformer, in mA, should be greater than the maximum mA/h battery rating divided by 10. A single winding transformer of half voltage may be used if a bridge rectifier is employed.**

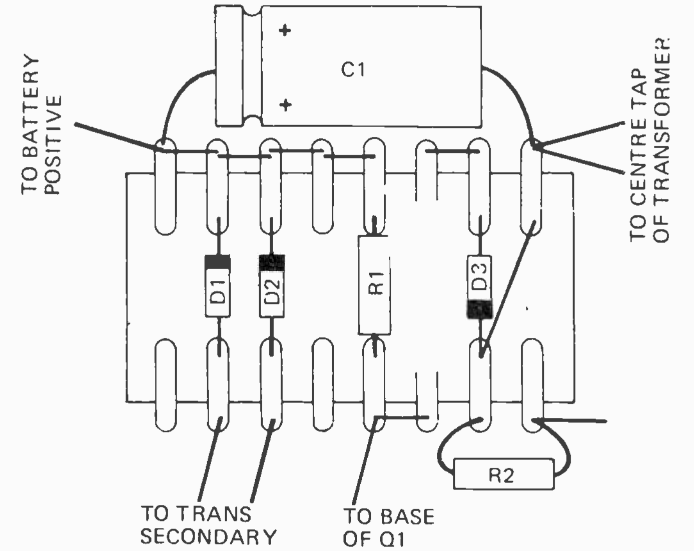


Fig. 2. Layout of components on the tag-strip.

How it works

Current regulators operate in opposite fashion to voltage regulators. In a current regulator, the current remains constant regardless of changes in load impedance – the output voltage varies to maintain constant load current.

In this circuit, the 120 Vac line is reduced by T1 to 40 Vac. This is then rectified by D1, D2 and filtered by C1 to provide approximately 28 Vdc.

This dc supply is then regulated by Q1 and its associated components to produce a current level selected by SW2.

Transistor Q1 is biased by D3 and D4 such that there is about 1.2 V between the base of Q1 and the negative side of C1. As there is 0.6 V between base and emitter of Q1, there will be 0.6 V developed across the resistor network R2-R7. Therefore the emitter current of Q1 must be 0.6 V divided by the resistor value selected by SW2.

The emitter current generated as above will produce an approximately equal collector current which charges the battery and remains constant provided there is at least one volt between the collector and emitter of Q1.

PARTS LIST

ETI 519

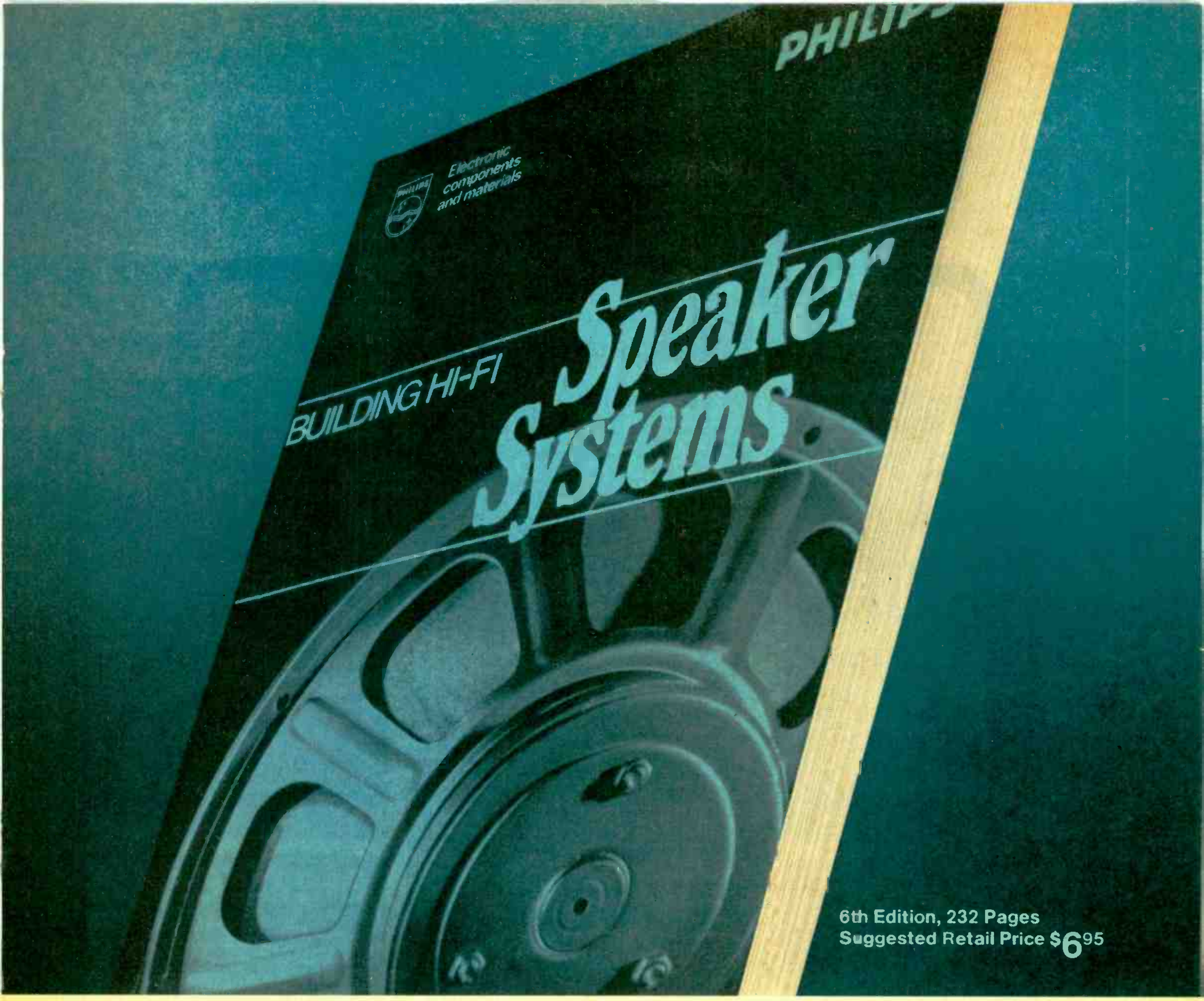
R1	Resistor	3k9	½W	5%
R2	"	2R2	"	"
R3	"	3R9	"	"
R4	"	5R6	"	"
R5	"	12R	"	"
R6	"	39R	"	"
R7	"	56R	"	"

D1-D4 Diodes 1N4001 or similar
C1 Capacitor 1000mF 35V electrolytic
Q1 Transistor 2N3055
T1 Transformer 120V pri 40Vct sec 500mA
SW1 Two-pole on-off switch
SW2 Six-position single-pole rotary switch
Metal box, bracket for 2N3055, line cord and plug.

single resistor may be used. Its value in ohms should be 6000 divided by the mA/h rating of the battery. The nearest 5% nominal value to that calculated as above will be adequate.

By virtue of the nature of the constant current supply any battery, or bank of batteries up to 20 volts may be charged. If the 20 volt capability is not required a different transformer may be used as detailed in Table 1.

The transistor dissipates a fair amount of heat and hence should be mounted on a piece of aluminium to act as a heatsink. This piece of aluminium should be insulated from the case, or if not, the transistor should be mounted on the aluminium via a mica washer and insulating bushes. ●



New from Philips

The definitive work on speaker enclosure design and construction

Since its first publication in 1969, "Building Hi-Fi Speaker Systems" has become a classic in its field.

And now in a completely updated sixth edition, it includes seventeen new enclosure designs and the theories behind them. These enclosures–which are designed for Philips DeForest quality speakers–can be built by anyone who has basic cabinetry skills.

Also included are curve charts defining frequency response and distortion, energy response, living room response, impedance and crossover characteristics for each enclosure.

This book is a definite must for anyone who wants a superior sound system at less cost.

Available only from Philips DeForest distributors and dealers (see list on opposite page).

PHILIPS Electron Devices Division

PHILIPS

PUBLICATIONS FROM ETI

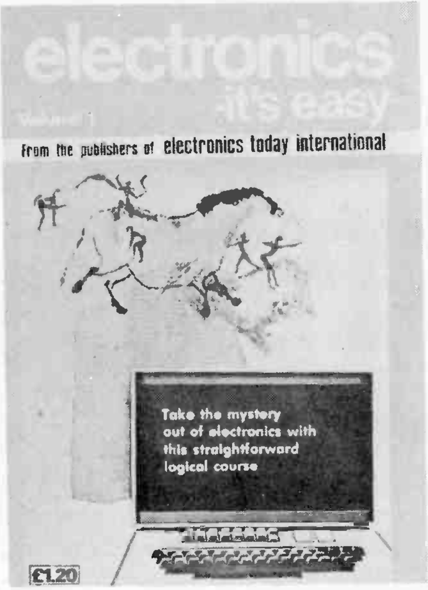
CIRCUITS No. 1:

A brand new concept from the house of ETI more than 100 pages packed with a wide range of experimenters circuits. Based on the 'Tech Tips' section carried in the overseas editions of ETI, Circuits 1 is the first of a series of specials - produced for the enthusiasts who know what they want, but not where to get it! Circuits 1 will also act as a catalyst for further development of ideas, ideal for the experimenter. The collection of more than 200 circuits is complemented by a comprehensive index, making searches for a particular circuit quick qnd simple. Also, similar circuits can be compared easily, due to the logical layout and grouping used throughout. Last and by no means least, Circuits 1 has no distracting advertisements in the main section!

TOP PROJECTS No. 4:

A collection of 28 constructional projects reprinted from ETI. This is the fourth in a series published by the British edition (Nos. 1,2, and 3 are not available). Projects are complete and include: Sweet Sixteen Stereo Amp, Waa-Waa, Audio Level Meter, Expander/Compressor, Car Anti-Theft Alarm, Headlight Reminder, Dual-Tracking Power Supply, Audio Millivoltmeter, Thermocouple Meter, Intruder Alarm, Touch Switch, Push-Button Dimmer, Exposure Meter, Photo Timer, Electronic Dice, High Power Beacon, Temperature Controller, Electronic One-Armed Bandit plus many more.

$5.00 FOR CIRCUITS No. 1
$2.50 FOR TOP PROJECTS No. 4



ELECTRONICS — IT'S EASY:

Volumes 1 and two of the best introductory series to electronics ever published in a magazine. Volume three, completing the series, will be available in a few months.

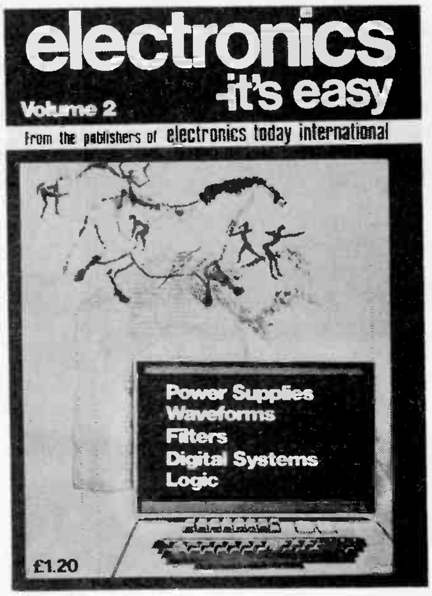
Electronics - It's Easy! takes a fresh look at electronics: it avoids the usual introductions to the subject which mostly seem designed to frighten you away before you reach page 10!

Volume one leads the raw beginner from a gentle introduction, explaining circuits in 'black-box' form up to the use of operational amplifiers.

Volume two deals with more advanced techniques, and deals with digital and logic circuits.

These books have sold extremely well in Australia and in Britain. In Holland they form the basis for a correspondence course.

$6.00 FOR BOTH,
$3.50 INDIVIDUALLY



THESE PUBLICATIONS ARE AT PRESENT ONLY AVAILABLE FROM ETI

Send your orders, with payment (not cash), to
ETI PUBLICATIONS
Electronics Today International
Unit Six
25 Overlea Boulevard
Toronto, Ontario
M4H 1B1

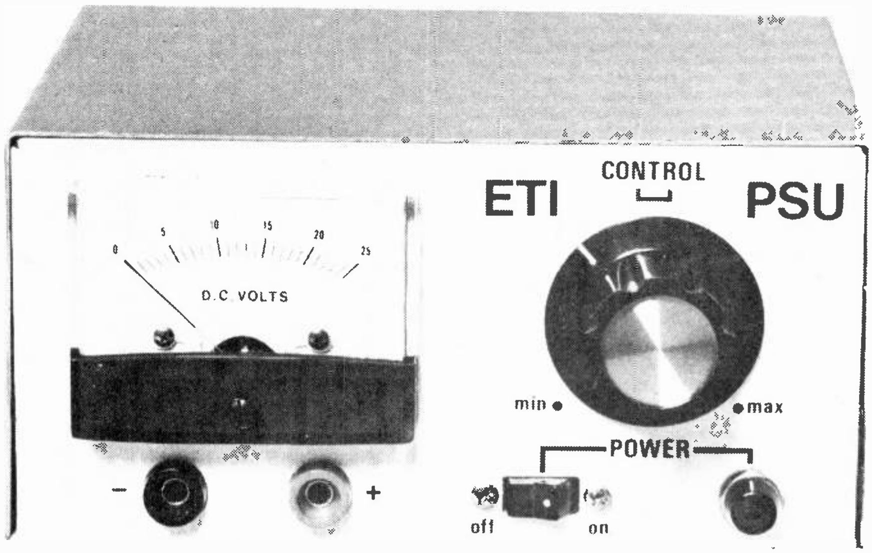
Please specify which publications you require, and print your name and address clearly.

—SHORT CIRCUITS—

BENCH SUPPLY

A NEW COMPONENT from Fairchild makes this power supply much simpler than other designs of similar capability. The 78MGT2C is a long title, in fact written in our type, the name is longer than the device!

The meter should be looked upon as an optional 'luxury' extra. The design will function perfectly without it, and will be very much cheaper to construct. Use a decent pot, and calibrate it.



CONSTRUCTION

Physically the most difficult part of construction will undoubtedly prove to be drilling the case. Mount all the components to the PCB as shown in the overlay, noting that BR1 and C1 are mounted onto T1, not the board.

The short circuit protection resistor R2 is specified as 0R5 (½ ohm) at 5W. You could use two 1R in parallel (at 2.5W each) if you have trouble obtaining the component.

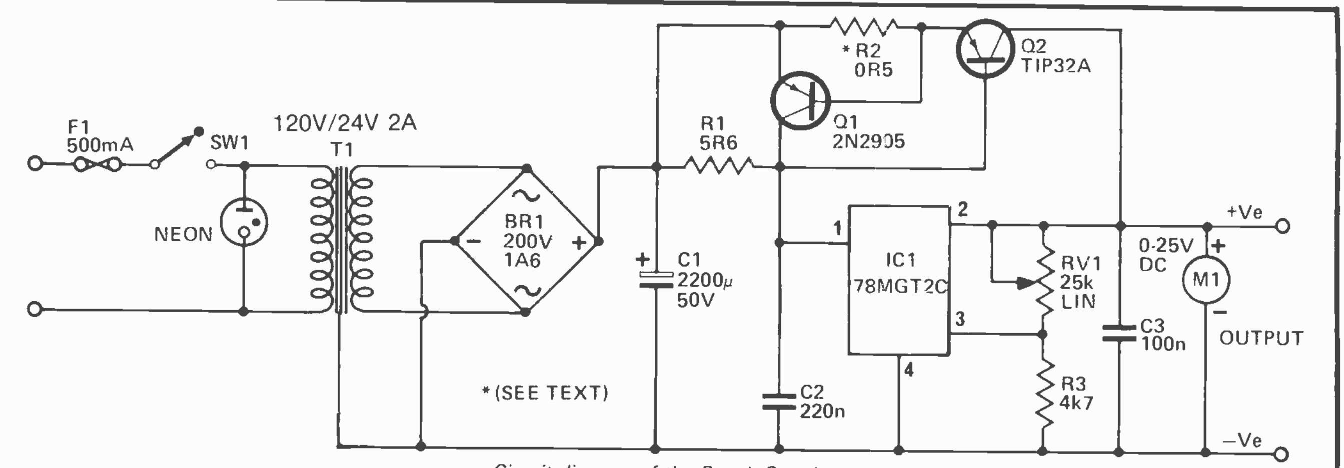
Q2, the output series pass transistor, must be isolated from the case which functions as its heatsink. Also ensure the connections to C1 do not short to the case while you're at it! The heatsinks for IC1 can be bent to any convenient shape or size, the minimum size for which may be taken to be that which we used! There is no DC (output) fuse, as the IC can look after itself better than any fuse!

How it works

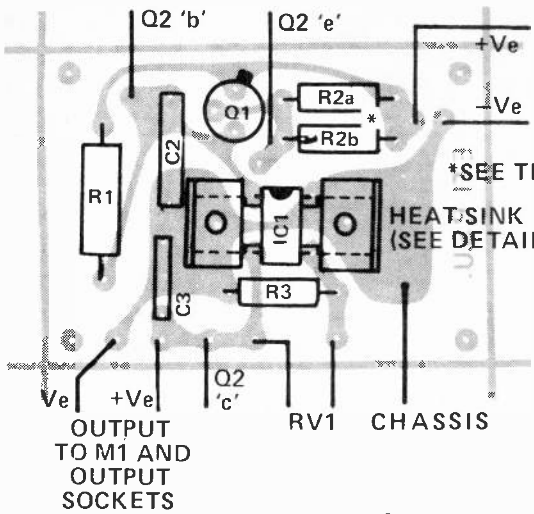
What can we say? IC1 does all the work. C1 is provided to smooth out the full wave rectified DC from BR1. The voltage at the output pin 2 of IC1 is varied by varying the control voltage applied to pin 3.

Q2 is used to enable more current to be drawn than IC1 could provide. Unaided, it could supply 500mA. In this circuit loads can draw in excess of 1.5A without the supply shutting down. Should the dissipation of the chip exceed safe limits, the output will be limited.

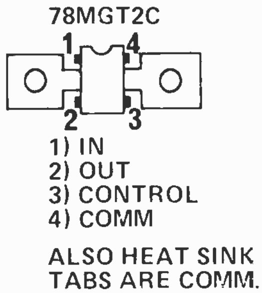
Short circuit protection for the series pass transistor is provided by R2 and Q1. C2 and C3 provide input and output by-passing, and their retention is recommended to ensure stability in all possible conditions.



Circuit diagram of the Bench Supply



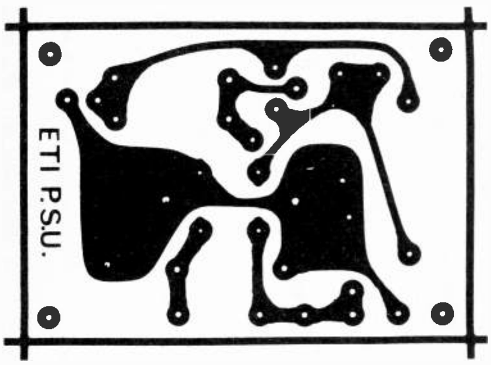
Component Overlay



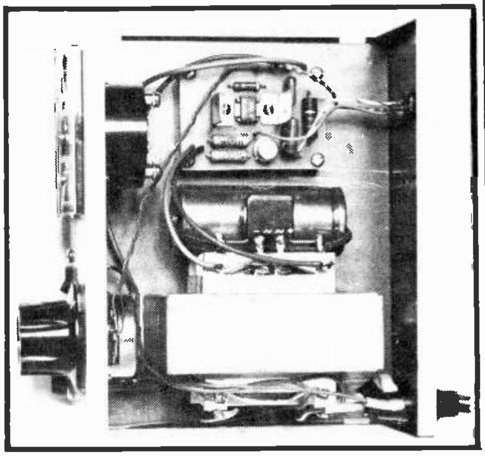
Parts List

RESISTORS	
R1	5R6 1W
R2	0R5 5W *(SEE TEXT)*
R3	4k7 ½W
CAPACITORS	
C1	2,200u 50V electrolytic
C2	220n polyester
C3	100n polyester
SEMICONDUCTORS	
Q1	2N2905 or similar
Q2	TIP 32A or similar
IC1	uA78MG T2C (positive voltage regulator)
BR1	200V 1.6A Bridge Rectifier
POTENTIOMETER	
RV1	25k Lin. rotary
SWITCH	
SW1	Off/On rocker type 3A 120V
METER	
M1	0-25V DC panel type
TRANSFORMER	
T1	117V - 24V 2A type

MISCELLANEOUS
Knob, insulating kit for Q2, fuse holder, fuse, 4mm. red and black sockets, grommet, P.C.B. pillars, nuts, bolts, etc, neon.



PCB Foil Pattern (full size)



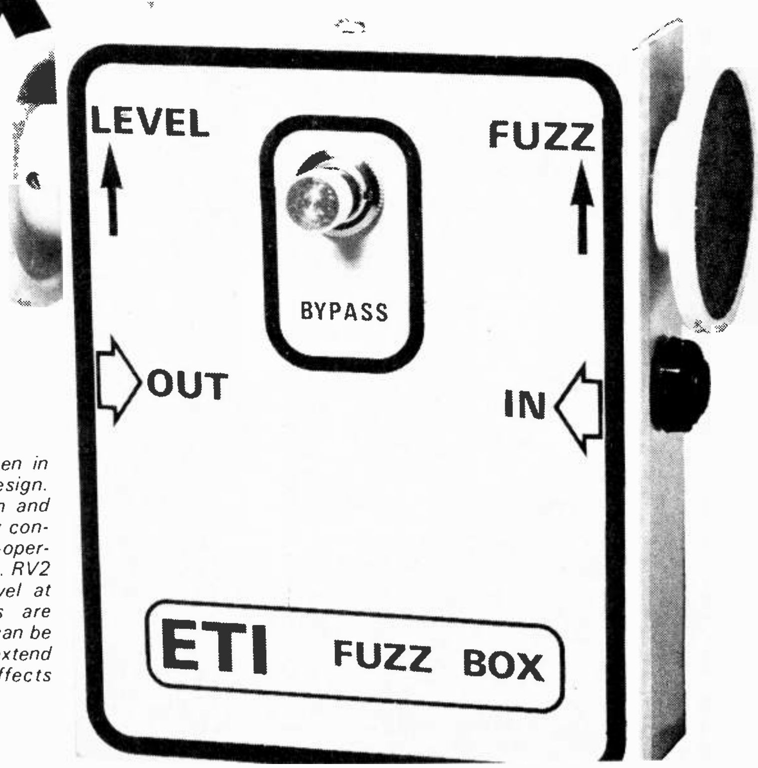
FUZZ BOX

STRANGE AS IT SOUNDS, by far the most popular and sought after effect these days is distortion. More fuzz boxes have been constructed and purchased than any other of the myriad types of guitar 'modifiers' on the market.

Although the aim is basically very simple, some very high prices are being asked, which would tend to make one think (or hope!) that there is more to the principle than meets the soldering-iron. We've kept ours simple: the total cost including board and case should be approximately $13.00.

CONSTRUCTION

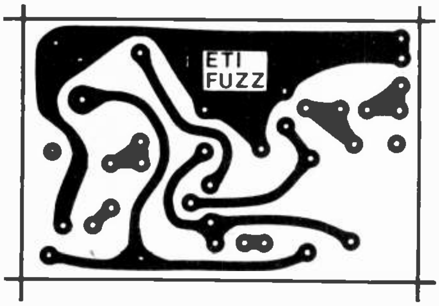
The stereo jack SK2 is used to switch the unit on and off; when a mono jack is inserted it shorts two contacts, and completes the supply circuit. The battery specified

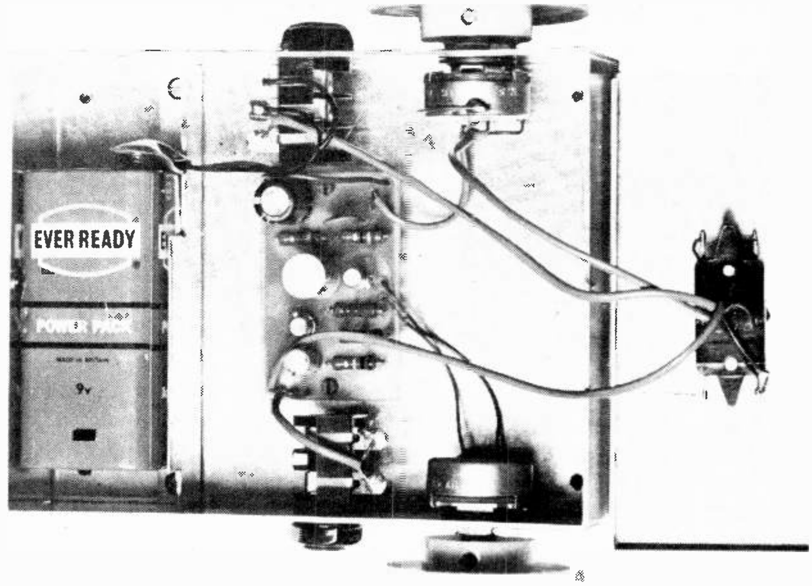


Care has been taken in the mechanical design. The bypass switch and both level and fuzz controls can be foot-operated whilst playing. RV2 can be set so level at fuzz and bypass are equal, however it can be used with RV1 to extend the range of effects possible.

Transistors Q1 and Q2 amplify the incoming signal, and the gain is such that the input will 'overload' when used with an electric guitar. RV1 adjusts the amount of feedback present, and hence voltage gain.

The output is therefore a 'squared' version of the input signal, the amount of 'squaring' being variable by RV1.





Parts List

RESISTORS	All ½W 5%
R1	39k
R2	100k
R3	680R
R4	5k6
R5	56R

CAPACITORS	
C1	10u 16V electrolytic
C2	100u 16V electrolytic
C3	47n ceramic
C4	47u 16V electrolytic

SEMICONDUCTORS	
Q1,2	2N2222

POTENTIOMETERS	
RV1	1k Lin. rotary
RV2	100k Log. rotary

SWITCH	
SW1a,b	Double pole, double throw, push on/push off, footswitch.

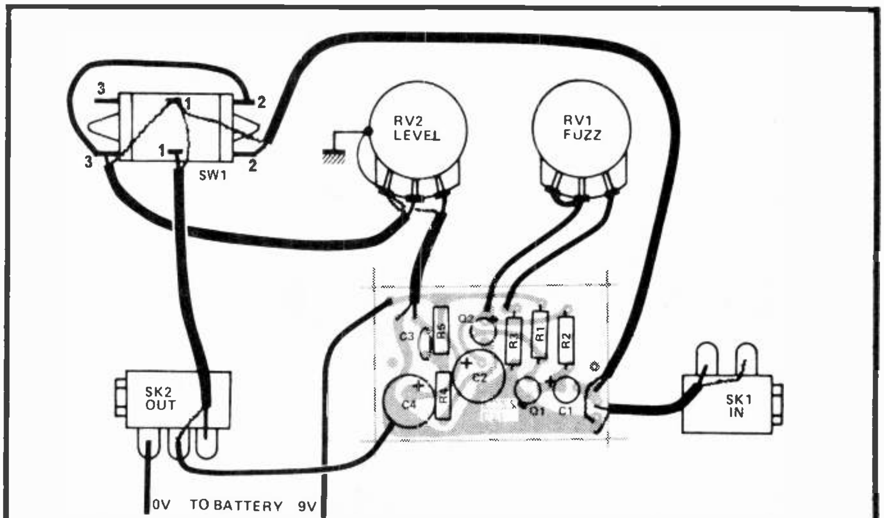
SOCKETS	
SK1	Mono ¼" jack socket
SK2	Stereo ¼" jack socket

CASE

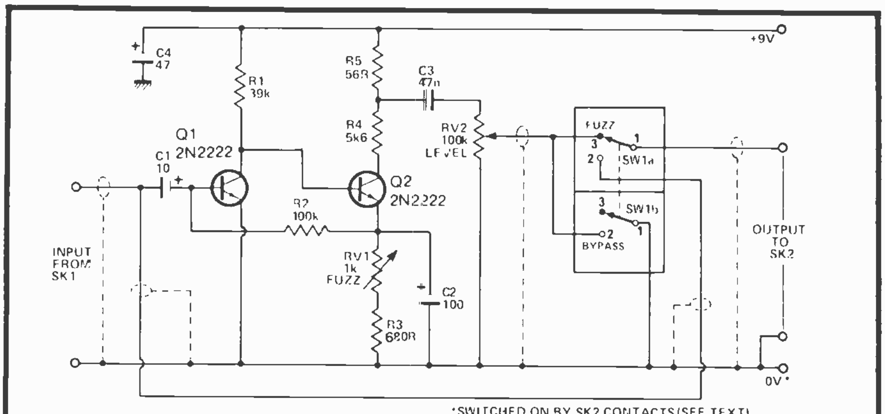
6" x 4" x 2" approx. Metal type

MISCELLANEOUS

2 large knobs, battery, battery clip, screened wire, P.C. board pillars, nuts, bolts, etc., P.C. board as shown.



Component Overlay



Circuit Diagram

should last a long, long time, as current drain is quite small. Use screened wire where shown on the circuit; to link SW1 and the output, and the 'bypass' signal with the output.

This switch, SW1, not only switches the signal through the circuit, but also takes the output from RV2 to ground when in the 'non-fuzz' position, preventing breakthrough of the distorted signal onto the line.

Assemble the PCB in the usual manner; watch the orientation of the transistors lest you get a 'fuzzed' junction. Take the case of RV2 to the 'ground' side of the pot. ●

A favorite pastime of Canadian electronics enthusiasts is to drool over the American magazines, lapping up the ads for just about anything, for just about nothing. An initial burst of enthusiasm to get started on a pet project is often tempered by caution at the thought of buying from so far away, and the hobbyist is discouraged before reaching the post office for a money order.

There are, unbeknownst to many, quite a few Canadian distributors and mail order operations of various sizes. Their advertisements, in the past, have not had a medium through which to reach a wide market, but we hope that ETI will change this situation.

When checking component availability, we at ETI make use of a number of catalogues from these mail order companies, and as a service to all concerned we present here a review of those we have. We feel that as an aid to project completion, a well stocked library of catalogues is just as useful as a soldering iron or screwdriver. Whether one lives in a major city, with handy distributors, or far from a parts source, a catalogue is a guide to what parts are available, at what cost, and frequently provides needed data and specs.

Some companies make a charge for their catalogue, but they are far from making a profit on it, and for the time saved, the reader is making a good investment. Also, some catalogues contain coupons applicable to purchases, encouraging the reader to save money.

Our review indicates what each catalogue contains, a rough idea of how much, and some out of the ordinary features we have found useful. It should be noted that what is in a catalogue is not necessarily the complete stock of that company. This is especially true in the case of ICs and other semiconductors, where the market changes so rapidly that catalogues have difficulty keeping up. We try to indicate this where possible.

Different styles of catalogues are published with different readers in mind. The first three catalogues are chiefly for industrial use, providing extensive data, including mechanical and electrical specs on an enormous variety of items. They are useful for weight lifting practice and submarine ballast also. At the other end of the scale are "pocket portables" that are little more than price lists, for the reader who knows exactly what to buy.

CATALOGUE REVIEW

A SURVEY OF CATALOGUES FROM MAIL ORDER COMPONENT SUPPLIERS

Electro Sonic Inc.,
1100 Gordon Baker Rd.,
Willowdale, Ontario
M2H 3B3

electrical
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Electro Sonic's most recent catalogue at the time of writing is five years old, and is reportedly about to be replaced by a new version. The old one is no longer available from the distributor, but is reviewed as it is still used by many companies, and may be held at a local library. The extensive data includes mechanical and electrical specs, plus applications information, formulae, and illustrative photos and line drawings. Electro Sonic also carries a large stock of semiconductors (including ICs) and tubes not listed. This catalogue has been updated periodically with 'Educational' and 'Industrial' newsletters, announcing new items, and revising the pricing.

CESCO Electronics Ltd.,
Head Office:
4050 Jean Talon St. W.,
Montreal, P.Q.
Also Toronto, Ottawa, Quebec

CESCO's catalogue contains the most comprehensive collection of data on ICs and other semiconductors, making it an invaluable reference. Again the style is similar to that described for Electro Sonic. Coverage of other areas is also quite extensive, as would be expected of an industrial catalogue. It is up-to-date, both with respect to specs, and also prices. Thus it gives the reader a good idea of all design parameters.

Saynor Electronics Limited,
99 Scarsdale Rd.,
Don Mills, Ontario
M3B 2R4

Saynor has avoided ICs but has a large selection of IC sockets and PC board supplies, and components in almost every other field in connection (no pun) with electronics. Much the same presentation as Electro Sonic's catalogue, but data and prices are more up-to-date.

J & J Electronics Ltd.,
310 Notre Dame Ave.,
Winnipeg, Manitoba
R3B 1P4

The catalogue from J & J Electronics shows a definite orientation toward the hobbyist market, both in range of products and product description. Less data is provided, but this may be an asset for some, since essential data does not become confused with frequently unimportant details. In addition to their 76 and 77 catalogues, J & J has (have?) published other flyers and useful pamphlets such as their 'An Introduction To CMOS'.

Gladstone Electronic Supply Co. Ltd.,
1736 Avenue Rd.,
Toronto, Ontario
M3M 3Y7

Our review of Gladstone's published works is based upon their 75 and 76-77 catalogues, plus flyers. The catalogues are strong in the areas of stereo equipment, and components oriented toward the tube TV service business. The selection includes 'bargain' parts 'paks', and also a comprehensive line of kits from Amtron. Illustrations and text descriptions for most items.

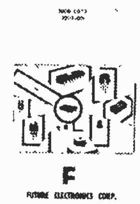
Radio Shack, Head Offices:
3999 Philips Ave.,
Burnaby, B.C. V5A 3K4
P. O. Box 34000, Barrie,
Ontario L4M 4W5
8092 South Service Rd.,
Trans-Canada HWY,
St-Laurent, P.Q. H4S 1M5

Probably the most colourful of our assortment, the Radio Shack catalogue is approximately one third audio equipment, one quarter CB and car audio, and the remainder components, tools and equipment for the hobbyist. The catalogue lists almost the entire contents of most Radio Shack stores, which includes a supply of the more popular items. One of Radio Shack's chief merits is that with over 525 Canadian stores they are all over everywhere.

Dominion Radio & Electronics Co.,
535 Yonge St.,
Toronto, Ontario
M4Y 1Y5

Dominion Radio's catalogue appeared in the last issue of ETI, so many readers will be able to judge for themselves. A good assortment of components is offered, though low in the IC department. We could list numerous useful or unusual items, but see their ads in this issue instead.

Future Electronics Corp.,
5647 Ferrier St.,
Montreal P.Q.
H4P 2K5
Also Toronto



Future's 77 pocket size catalogue provides a concise, clear list of their large selection of semiconductors (specialty of the house) with one line IC descriptions, and essential data on the discretes. An unusual section is devoted to RF Wattmeters and accessories.

This company has over-the-counter facilities in Montreal and Toronto under the name Active Electronics Corp.

Coronet Electronics Supply Ltd.,
649A Notre Dame St. W.,
Montreal, P.Q.
H3C 1H8

Sorry, no front cover shot for this catalogue - we didn't think it would reproduce too well. Unfortunately, this is representative of the inside as well. It is a shame that what is probably a good collection of parts is obscured by poor production. Perhaps Coronet could be persuaded to expend a little more effort in this direction. As for the products themselves, many of the most needed items are available, including Exar's line of ICs and CSC's breadboarding and related products.

ETCO,
183G Hymus Blvd.,
Pointe Claire, P.Q.
H9R 1E9
Also Montreal

Here we find the most diverse assortment of new and surplus items. The style is '20th century Poly Paks', hence the reader has quite a time browsing through the mixture of components and equipment. The only organized sections are those noted in the chart. Other items include motors, power supplies, radiation survey meters, parabolic mikes, etc.. The reader may be interested in the dials and knobs offered, often difficult to find.

Chips,
P. O. Box 1030,
Oakville, Ontario,
L6J 5E9

We have just received a flyer from these people which covers assorted components of general interest, plus details of a couple of kits they are preparing. It would be difficult to call this one a catalogue, but perhaps in a few years...

E.T.I.

	Digital ICs							Linear ICs													Trans-formers							Hardware																
	CMOS	TTL	Clocks	Calculator	TV Games	Microprocessor	Memories	Audio	Op Amps	Timers	TV/IF/RF	Stereo	Volt. Reg.	Transistors	Diodes	LEDs, Displays	Resistors	Pots	Capacitors	Var. Caps.	Power	Audio	RF/IF	Tubes	Relays	Meters	Speakers	Connectors	Switches	PCB Parts	Prepunched Board	Cases/Chassis	Heatsinks	Nuts & Bolts	Audio Equipment	Test Equipment	Tools	Data Books	Kits	New Products	Surplus	Overall data content	Pages	Year
ELECTROSONIC	M	M						M	M	M	H	M	M	M	H	M	H	H	H	H	H	H	H		H	H	L	M	H	M	M	M	H	M	L	M	H	H	L	X		H	993	72
SAYNOR														H	H	H	H	H	H		H	H	H		H	H		H	H	H	H	H	H	M	L	H	H			X		H	942	76
CESCO	H	H				H	H	H	H	H	H	H	H	H	H	H	H	H	H	L	H	H	H		H	M	L	H	H	M	H	H	M	M	L	M	H	H	L	X		H	352	77
J & J	H	M	H	H	M	M	M	M	M	M	M	M	M	H	H	H	L	M	L	L	M				L	M	L	M	M	M	M	M	M	L	L	L	M	L	M	X	X	H	92	76
GLADSTONE		L	L	L										L	L	L	L	L	M	L	L	L	L	H		L	M	M	M	L		L	L	M	H	M	M	H	M	X	X	M	174	75-77
RADIO SHACK	L	L	L	L			L	L	L	L			L	L	L	M	L	M	L	L	L	L	L	M	L	L	M	M	M	M	L	M	L	L	H	M	M	M	M	X	X	M	163	77
DOMINION RADIO								L	L					M	M		H	M	H	M	L			H	L	M	M	H	M	M	L	M	L	L	M	M	M	L	M	X	X	M	32	77
CORONET	H	H	M			L	L	M	H	M	M	M	H	H	M	H	L	M	M		L	M			L	L		L	M	M	M	M	L	L	L	L	M	L	L	X	X	M	52	77
FUTURE	H	H				M	H	M	H	M	M	M	H	H	H	H	L		M										L							L		L		X		L	64	77
ETCO							see text																	H		H	M	H	H			see text								X	X	M	64	77
SUPREME	H	H							L	L				M	H	M	M	M	M		L	L					M				L	M							L	X	X	M	60	77
TRINTRONICS	H	H					M	M	M	M	M		M	M	L	H	M																							X		L	22	77
CANMOS	H	H						L	M	M	L		M	M	L		M	L	M	L	M									L		M						L		X		M	16	77
CHIPS	M	M						M	M	L	H			M	M	L	L		L											M									L	X	X	M	12	77
HEATHKIT																																							H	X		M	72	77

THE ABOVE CHART shows the list of company names, versus their catalogue contents in major areas of hobbyist interest. The catalogues are listed in approximate order of decreasing weight, with Heathkit listed separately as their catalogue covers a slightly different field.

We have given a subjective rating to each section, based on how useful each would be, hence H=heavy, M=medium, L=light use. A section was judged useful if it contained a large number of items (good selection) and also if it had a large amount of data (useful as a reference). An idea of the average volume of data presented throughout is also shown, along with an indication of whether the catalogue lists new and/or surplus components.

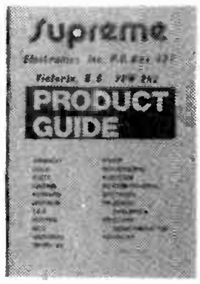
CANMOS Electronics,
Box 1690,
Peterborough, Ontario
K9J 7S4

A clean and sharply produced catalogue is this, with well-organized layout of a modest selection of most needed items. CSC products and some Hammond cabinetry. This company also provides PC boards for many ETI projects, although these are not listed in the catalogue.

Trintronics Limited,
P. O. Box 181, Station G,
Toronto, Ontario
M4M 3G7

A modest production, but well laid out: easy to read and find what you want. A minimum description of most parts is sufficient to avoid mistakes, but not enough data for actual design and selection. Exar's ICs are included.

Supreme Electronics Inc.,
P. O. Box 327,
Victoria, B.C.
V8W 2N2



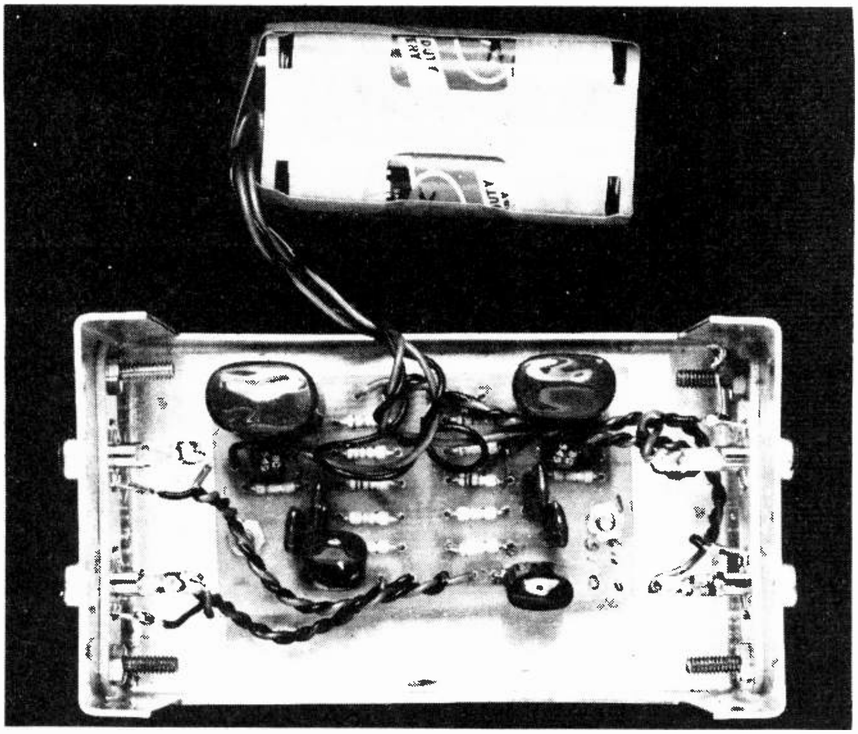
A handy assortment of ICs and semiconductors appears in this publication. Descriptions and illustrations with most of the products. Of special interest are the CSC line, EICO home security products, and a line of equipment cooling fans.

Heathkit:
Heath Schlumberger,
1480 Dundas Street E.,
Mississauga, Ontario
L4X 2R7

Also Montreal, Ottawa, Winnipeg,
Edmonton, Vancouver

This catalogue does not really cover the same field as the others, but we felt we should include it for completeness. It is a guide to a large line of kits including quality audio equipment, ham gear, radio control, test equipment, and loads more.

STEREO RUMBLE FILTER



This internal view shows how the rumble filter is assembled.

Active filter design improves clarity of bass reproduction.

IN BYGONE DAYS rumble filters were very popular because even the best of turntables, used then, generated considerable vibration due to bearing and motor deficiences. These vibrations, mechanically transmitted to the pickup cartridge, resulted in an audible output. Hence high-pass filters were often incorporated in amplifiers to reduce this objectionable rumbling sound to an acceptable level, and as bass response seldom extended below 50 Hz, a simple RC filter with 6 dB per octave roll-off below 50 Hz was considered adequate.

Modern turntables have far smoother bearing and drive arrangements than their early counterparts – and for this reason many amplifier manufacturers no longer include a rumble filter facility.

Those that do are rarely satisfactory. Their slope is generally inadequate and the main effect of switching them in is to roll off the low-frequency response to the detriment of programme content.

At first sight it would seem better to exclude the rumble filter altogether and just make sure that our turntables do not generate any appreciable rumble.

Surprisingly perhaps, a rumble filter is still very much required and if designed correctly can make an appreciable improvement to reproduction – even when used with turntables that generate no rumble at all!

The reason why will be clearly apparent if you take the front grille

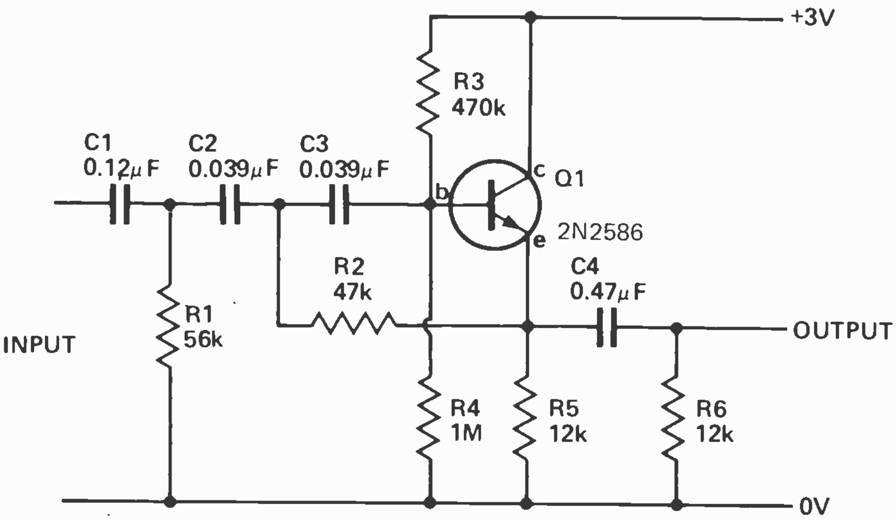


Fig. 1. Circuit diagram of the rumble filter. Two required for stereo.

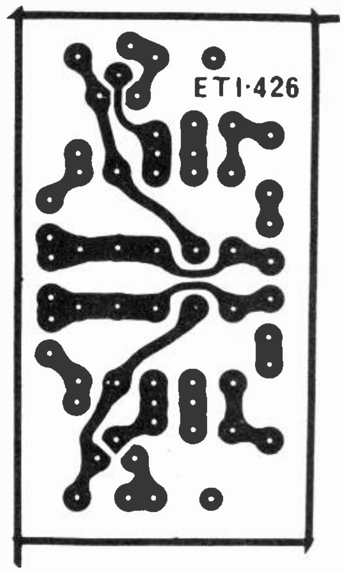


Fig. 2. Printed circuit board layout for the rumble filter 40mm x 70mm.

off one of your speakers and — with the phono-cartridge tracing a section of record that has no recorded content (or very low level content) — turn the volume control up fairly high. You will almost certainly find that the cone of the bass driver is making wild excursions to and fro, probably at frequencies between 5 Hz and 15 Hz.

So it's sub-audible — why then does it matter?

Well it really does — and we'll explain just why later in this article — but first let us consider just where this 5 Hz — 15 Hz content comes from.

Firstly, modern turntables and arms have mechanical resonances lying within the 5-15 Hz region. Secondly, stereo cartridges are sensitive in the vertical as well as horizontal planes and will respond to uneveness in record or turntable surfaces. They will also respond to a defect in the record surface known as pressing rumble.

In addition the noise finds its way onto the record during the actual recording process. This recorded noise is due to LF noise and rumble sometimes being induced in the recording lathe by seismic disturbances, and by vibration in drive gears and cutting head carriage rails.

Lastly vibration of a low frequency nature, due to people walking past the turntable or vehicles passing by outside, may well excite the turntable and arm resonances even though the turntable is reasonably well sprung.

WHY SUB-AUDIO NOISE MATTERS

This very low-frequency noise is responsible for a remarkable amount of intermodulation distortion which generally makes the bass sound muddy. In extreme cases it may cause the reproduction to sound as if speaker cone break-up is occurring. The reasons for this are as follows.

Preamplifier stages usually have two or three transistors around which large negative feedback is applied for equalization and/or tone control. At sub-audio frequencies these feedback networks are not generally effective. Thus the LF signals may well receive considerably more amplification in the preamplifier than would normally be expected. Secondly although the magnitude of the LF signal may not itself be sufficient to overload the preamplifier, the combined LF and music signals may well cause the preamplifier to clip. Even if clipping does not occur the LF signal will cause intermodulation distortion despite the fact that the LF signal is inaudible!

Most modern power amplifiers are quite capable of amplifying this noise signal, presenting it to the loudspeaker at a surprisingly high power level. The speaker itself has very little acoustic loading at these low frequencies and the cone will thus move considerably and may even be driven beyond its linear excursion region. Even if not actually overdriven, the presence of such large cone excursions will produce a high level of intermodulation distortion.

Whilst elimination of factors causing the noise is by far the best procedure, a lot of these factors are completely beyond the control of the average hi-fi owner. Hence a rumble filter would, seem to be the obvious answer. But, we do not want to sacrifice any low frequency response and we want signals in the offending 5-15 Hz region to be attenuated as far as possible — two apparently conflicting requirements. In addition, as LF noise cannot be allowed to enter the equalization stages of the preamplifier,

HOW IT WORKS

The filter consists of three separate sections:–

1. A passive RC filter consisting of R1 and C1.
2. An active filter comprising C2, 3, R2, 3, 4 & 5 and Q1.
3. A passive filter comprising C4 and R6.

The active filter (from input of C2 to output to C4) is a standard design with the exception that values have been selected to give a peak in the response at the cut-off frequency. The maximum lift is about 2 dB and this characteristic, combined with those of the two RC filters, gives a sharp knee to the roll-off. The composite filter has a lift of 0.2 dB before turning over sharply.

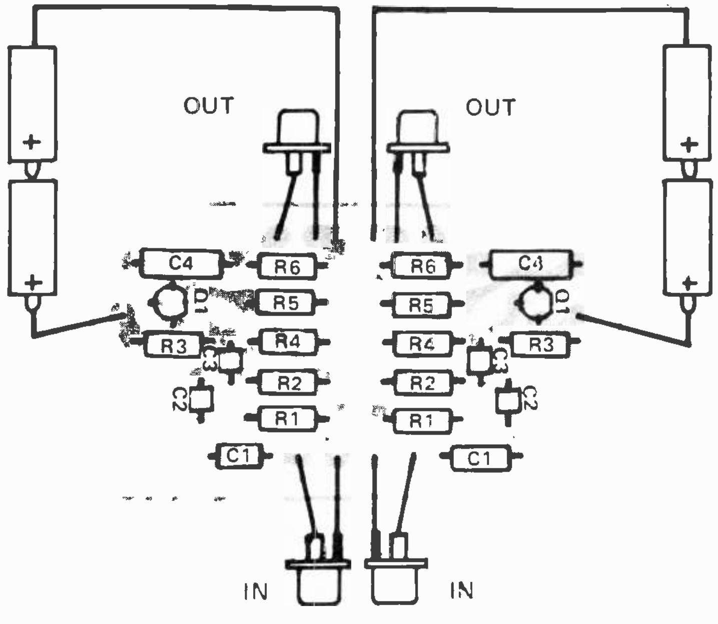
Thus low frequency response is maintained substantially flat down to 50 Hz and is only 2 dB down at 40 Hz. Thereafter the response drops very rapidly and is in excess of 30 dB down below 15 Hz where most LF noise occurs.

Current drain of the two filters is only 100 μA and the batteries will last their normal shelf life of about 12 months, thus no power switch is required. Batteries should be replaced annually.

PARTS LIST

R1	Resistor	56k	¼W	5%
R2	"	47k	"	"
R3	"	470k	"	"
R4	"	1M	"	"
R5,6	"	12k	"	"
C1	Capacitor	0.12mF	polyester	
C2,3	"	0.039mF	"	
C4	"	0.47mF	"	
Q1	Transistor	2N2586 or similar		
*	for stereo 2 of each of the above			

PC Board
2 dual phono sockets
2 dual battery holders or one 4 way holder.
4 1.5V batteries.
2 8mm long spacers
1 small aluminium box.



STEREO RUMBLE FILTER

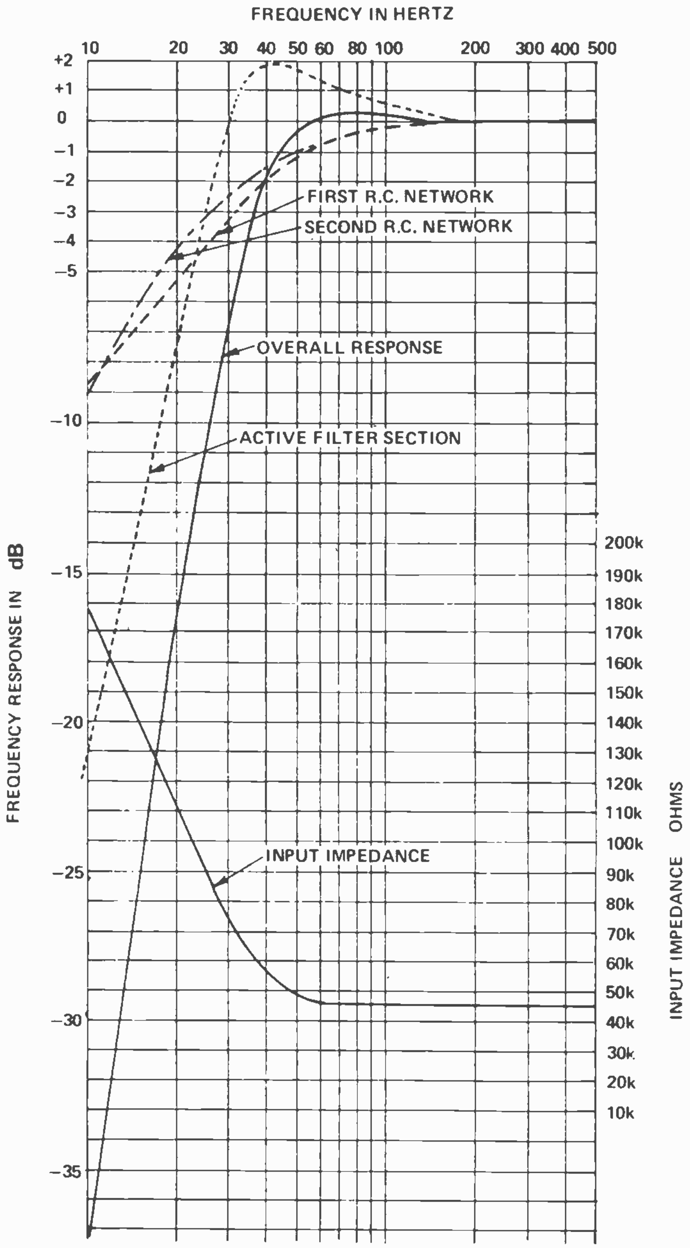
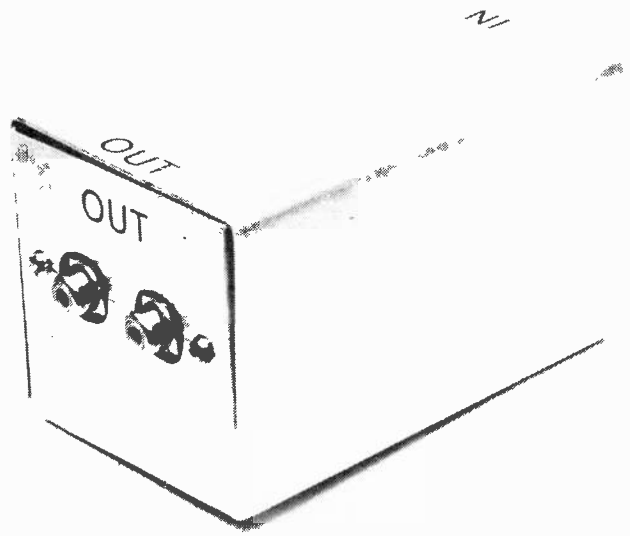


Fig. 4. Characteristics of the rumble filter.



SPECIFICATION

Input Impedance (rises below 50 Hz)	47k
Output Impedance	< 5k
Input voltage (maximum)	250mV
Cut-off Frequency (−3dB)	36 Hz
Cut-off Slope (maximum)	24dB/octave
Attenuation at 10 Hz	37 dB
Gain at 1 KHz	−0.2 dB.

the filter must be situated before the preamplifier. This also poses problems as the signals at this point are very low-level, and there is a danger of introducing hum which would be merely replacing one fault by another.

THE SOLUTION

To maintain response down to at least 50 Hz, whilst obtaining 30 dB or more attenuation to LF noise, we must use a filter which has a sharp knee and an ultimate attenuation slope of 24 dB per octave. The most satisfactory (and cheapest) method of doing this is to use an active high-pass filter – and this is the approach we have used. To obviate the possibility of hum-pickup, the unit uses a battery power supply, one each for left and right channel filters. The use of separate batteries prevents ground loops and ensures that channel separation is maintained. As current drain is very low the batteries may be expected to last their shelf life (12 months or so) and for that reason an on/off switch has not been included.

The unit fits between the turntable and the amplifier, cuts any frequency below 35 Hz and has a total attenuation of 37 dB at 10 Hz increasing at 24 dB/octave below that.

CONSTRUCTION

We built our unit onto a small printed circuit board, but layout is not critical and other alternative methods, such as matrix or Veroboard, may be used successfully.

The signal levels involved are extremely small (about 100 μV at 50 Hz) and for this reason a metal box is a must if hum pickup is to be minimized. And, as said before, two separate battery supplies should be used in order to avoid earth loops. We used a conventional four-way battery holder to hold the two sets of batteries. These holders normally connect all four batteries in series. However it is a simple matter to snip the connection between the two sets of two cells.

The phono sockets for both input and output should be insulated from the metal case. When connecting the unit we found minimum hum was introduced by grounding the turntable to the metal box and then, by taking a separate ground from the metal box to the amplifier. However experimentation in the positioning of grounds may well show that some other configuration is best for your particular setup. ●

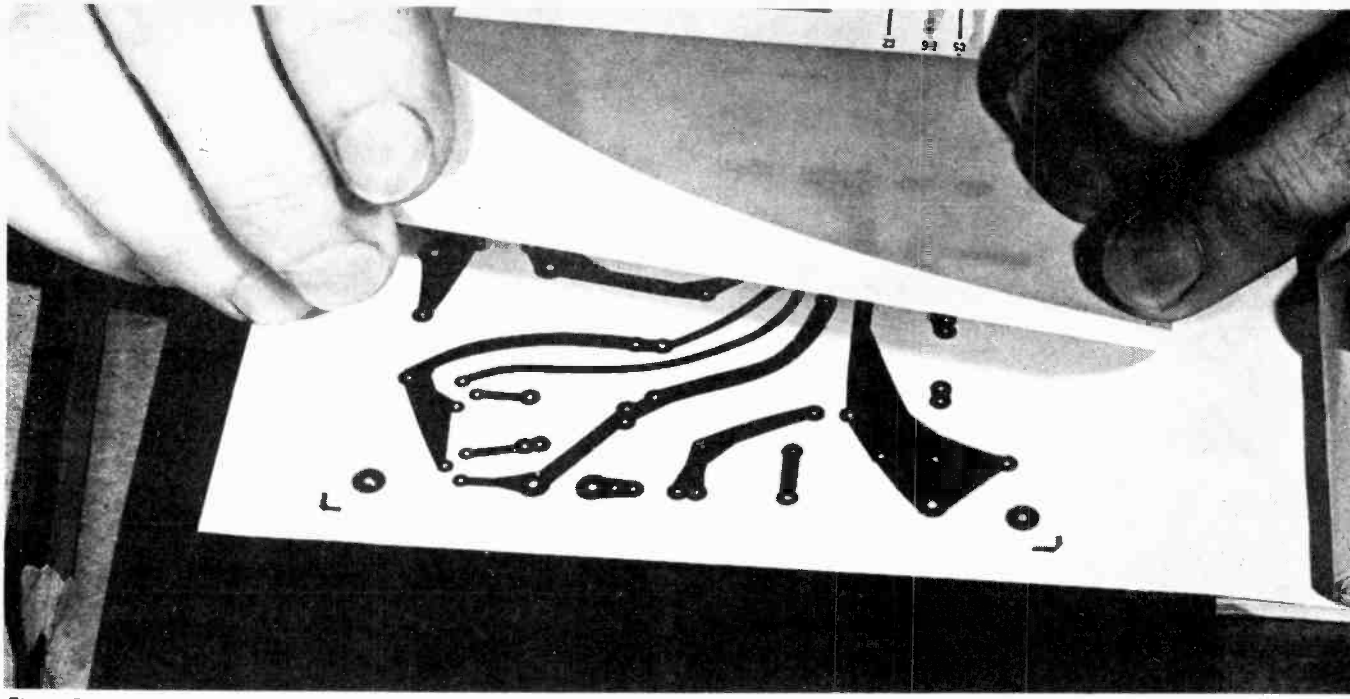
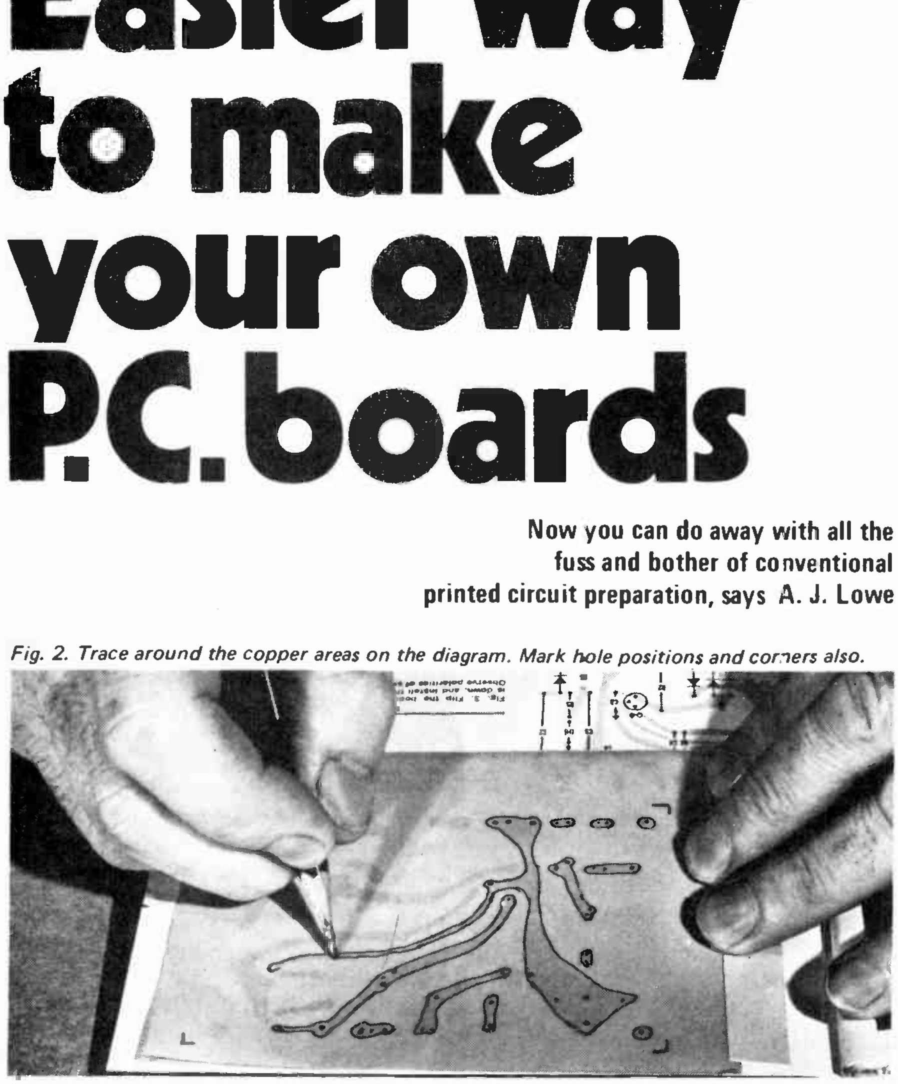


Fig. 1. Place the Letrafilm over the diagram.

Easier way to make your own P.C. boards

Now you can do away with all the fuss and bother of conventional printed circuit preparation, says A. J. Lowe

Fig. 2. Trace around the copper areas on the diagram. Mark hole positions and corners also.



At last! Here's a quick, clean method of preparing printed circuit boards for etching – and it's for the home constructor.

Photographic methods are fine if you want to produce a large number of identical boards, but far too slow, expensive and involved for the 'one-off' man who simply wants to make one board – usually from a diagram in a magazine.

The standard method, for the experimenter, involves the use of tracing paper, carbon paper, and a resist paint. Sure, it works – but those who have used it know how hard it is to get narrow clean-edged lines with paint. Sometimes the paint is thin and porous and lets the etchant through, and sometimes it runs across narrow gaps, leaving short circuits to be cleaned up later. Sometimes the paint is thick and hard to manage. Besides, it takes ages for the paint to dry.

This new method requires no tracing paper, no carbon paper, no paint, no brushes, no solvents – and you can have a printed circuit board ready in an hour or so.

It depends on the use of a cut-out colour film used in the graphic arts field, called LETRAFILM. Made by the manufacturers of the widely-used Letraset stick-on letters, it is obtainable from artists' shops and drawing office supply houses.

Letrafilm is a thin sheet of film available in a range of 50 colours, sticky on one side and matte on the other. The sticky side is backed with a translucent paper support. The matte side can be written or drawn on with ease. The film is quite impervious to etchants and so makes

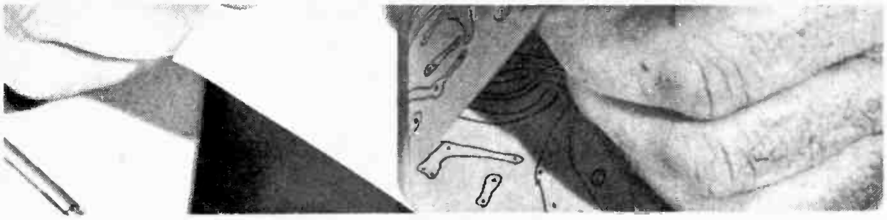


Fig. 3. Separate the Letrafilm from its backing support.

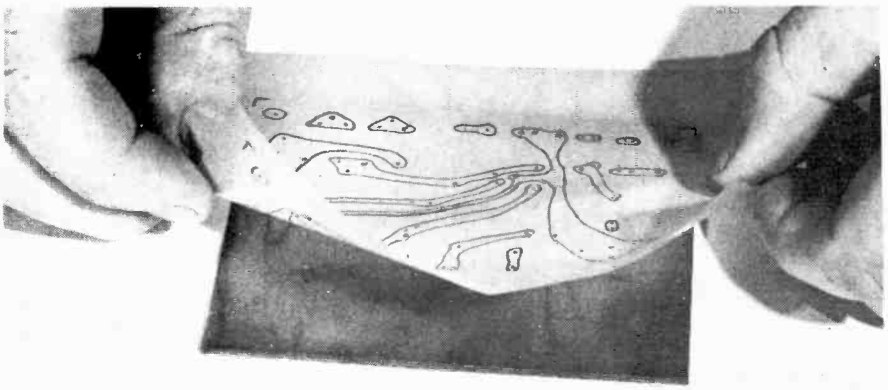


Fig. 4. Place the film down on the copper side of the p.c. board.

Fig. 5. Press the film down gently.

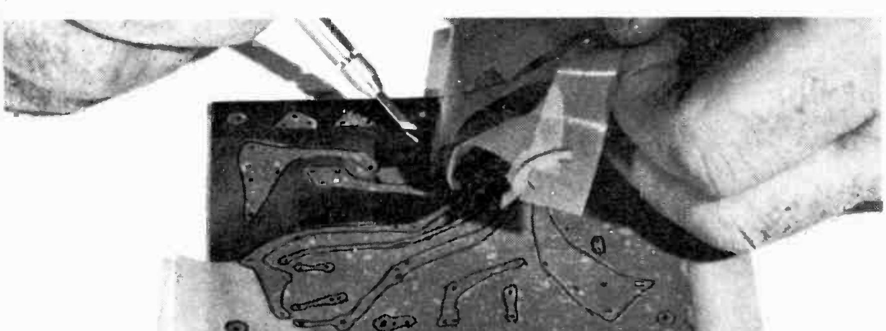


Fig. 6. Cut around the copper areas with a sharp craft knife.

Fig. 7. Remove the unwanted film, leaving film over the areas where copper is to remain.

an ideal resist. It is available in sheets 10" x 15" and is quite inexpensive. Only a few pence worth will cover the typical printed circuit board. A light colour, such as pale yellow, is ideal for this application.

Here's how to use it:

1) Cut a piece of Letrafilm, complete with its backing, about 3/8" or so larger all round than the printed circuit board.

2) Place a sheet of aluminum, or phenolic board, or even printed circuit board, below the diagram of the printed circuit. This gives a hard support for the next few operations.

3) Lay the Letrafilm over the diagram (see Fig. 1) and hold it down at one side with sticky tape. It will be found that the diagram can be seen quite clearly through the Letrafilm.

4) Trace around the copper (i.e. black) areas in the diagram with a pencil. (Fig. 2), making sure that the corners of the board are marked as well. The position of holes for the component leads should be marked with a pencil dot. This is another advantage of this method over the paint method, in which hole positions have to be gauged later.

Many diagrams prepared professionally, using stick-down circles and lines, have lots of fine curves and indentations where none is really required. There's no need to follow unnecessary detail and it may be eliminated as tracing proceeds.

5) Remove the Letrafilm from the diagram and carefully separate the film from its backing sheet (Fig. 3).

6) Lay the film, sticky side down, on to the thoroughly cleaned copper surface of the printed circuit board, using the corner marks as a guide (Fig. 4).

7) Press the Letrafilm gently down on to the printed circuit board. (Fig. 5). Do not press too hard, as this will make later removal of the unwanted film portions unnecessarily difficult. Small air bubbles need not be squeezed out.

8) Cut around the pencilled outlines of the copper areas with a sharp craft knife (Fig. 6). This process is much easier than painting, and quicker — and clean sharp lines are automatic.

Do not, at this stage, do anything about the dots marking component lead hole positions.

9) When cutting is complete, carefully peel away the *unwanted* film

from the board – that is, the film which does not cover areas where copper is required. This is done by gently lifting the film at one corner and easing it back. It will break as you progress, but that's no disadvantage (Fig. 7). Watch that none of the 'islands' lifts, due to bad cutting along the pencil lines. If one does lift, press it back and cut around it once again.

10) When all the unwanted film has been lifted, lay a sheet of paper over the board and press down firmly all over it. This bonds the film to the wanted copper so that it acts as an effective resist (Fig. 8). Make sure that no air bubbles are near the edge of an island. In the middle they don't matter.

11) Etch the board. This can be done in your usual etching bath. For those who have never made a printed circuit board before, an effective etching solution is 4oz. of ferric chloride dissolved in 10oz. of hot water. This will etch a typical board in 20 to 30 minutes. Protect your eyes and hands – the solution is corrosive.

12) When etching is complete, remove the board from the etching bath and wash it clear of etching solution under running water. Dry the board by dabbing it with a rag.

13) With a scriber, mark the positions of the holes for component leads by pressing through the film into the copper (Fig. 9). The pencil dots already made (see introduction 4 above) give the positions.

14) Remove the remaining Letrafilm. This can be peeled and rubbed off (Fig. 10).

15) Clean away any residual adhesive from the film by cleaning the board with an abrasive domestic cleaning powder and, if needed, some steel wool. The board is now clean and ready marked for drilling (Fig. 11).

16) To prevent the copper oxidising, it should be sprayed with a special printed circuit board lacquer. Alternatively – and much more cheaply – it can be brushed with a rosin solution (one lump of rosin dissolved in a little methylated spirit). This makes a first-class flux and maintains the shiny look of the board.

Well, there it is – a simple, clean, efficient and quick method of doing-it-yourself and, at the same time, saving money. ●

Fig. 8. Press down hard, to bond the remaining film to the board.

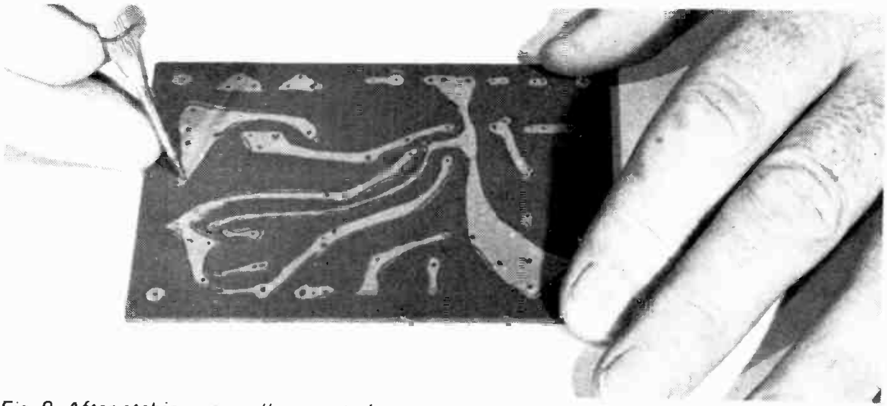


Fig. 9. After etching away all unwanted copper, mark hole positions with a scriber.

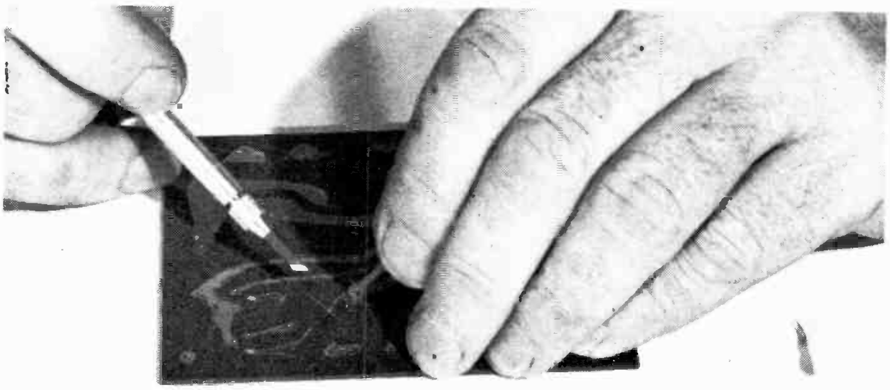


Fig. 10. Remove remaining film from the board.

Fig. 11. The board, cleaned and ready for drilling.

Choosing a Microcomputer

By Rick Smith
(Computermaster Systems, Toronto)

THE WHOLE HOBBY of micro-computing, or "personal computing" is now entering a terrific expansion period. Over the past year, new magazines have started, stores have opened, clubs have been formed and many people have been introduced to the idea of owning your own computer. These people have been reading books and magazines, trying to absorb as much information as they can in order to select which micro-computer they'll buy to suit their own needs.

The trouble is that a computer is a fairly expensive item for leisure use. While a family can easily lay out several thousand dollars on a camper or boat, the benefits are enjoyed by several people for years. On the other hand, a computer plus peripherals can easily cost as much, but is generally a purely personal investment.

This means that if you're planning buying a computer, and you're new to computers, you want to get it right. Here's a few hints:

The Microkit 8/16 can incorporate either an 8080 or 6800 processor. Available software includes an excellent text editor.

PSYCHOLOGY

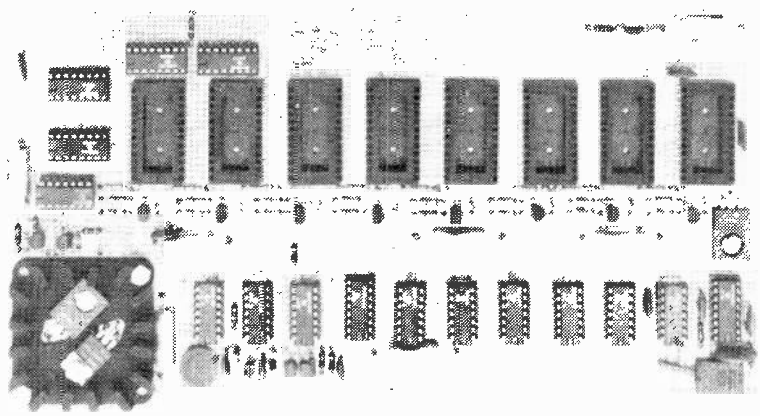
The problem of convincing the family (ie, usually your wife), that a computer is useful for doing household accounting, that it's great for teaching the kids arithmetic, and that these TV games pale into insignificance beside **Star Trek** or **Wumpus** is a tricky one and is best left to you (you know your wife better than I do, honest!). Try to keep the conversation off your previous attempts at ham radio, beer making, astronomy, woodworking etc, the remains of which almost fill the basement. Read all the magazines, and point out all the articles on domestic and useful applications of computers. Don't get enthusiastic about them all; she knows perfectly well that you'll never manage more than a few.

If you're lucky she may be one of those people (like you) who are mesmerized by computers; if so, a joint visit to your friendly neighbourhood computer store to see a few demo systems may do the trick, after pre-warning the proprietor not to discuss prices of course.

If you are a youngster, and anticipate parental opposition, use the "computers as a career" trick. Visit your book store and buy some academic-looking volumes of computer science and also investigate college courses. Leave books and college syllabuses (syllabi?) scattered around and see what happens. (The chances are that if you're keen enough to want to own your own computer, you ought seriously to consider it as a career anyway.) Avoid references to previous large investments in motorbikes, hockey gear etc.

Once you have your computer working, your first job is to make it do something impressive or useful and make sure everyone knows about it — like teaching the kids arithmetic. This is the first step towards breaking down opposition to that new floppy disk — i.e. if you don't live up to at least *some* of your earlier promises you have no chance later.

Finally, after reading this, tear out the page and burn it in case your dear lady mistakes it for a real cookbook. We'll both feel a lot safer that way!



The Cromemco "Bytesaver" is used to store programs in the form of EPROMs. It includes a PROM programmer and software for driving it.

BACKGROUND

Assuming that you've gotten over that hurdle and also that you've got the necessary pieces of paper, i.e. dollars, what do you do now? That depends on how much you know and what you want to do. Let's deal with both these points in turn.

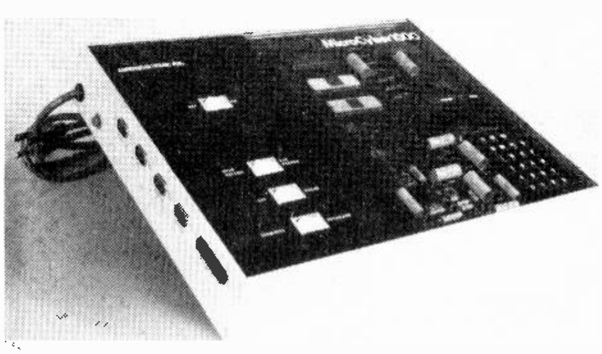
If you're a complete novice, then defer buying a computer for a while until you know enough to make a wise choice of machine. The only exception I would make to this is if you are absolutely loaded with money, in which case I would say; Buy everything the salesman shows you and then learn by doing. Seriously, if you are in this fortunate position an Imsai/Altair with 1K memory will let you learn the basics of microprocessor/computer operation and provide the basis of almost any application-tailored system.

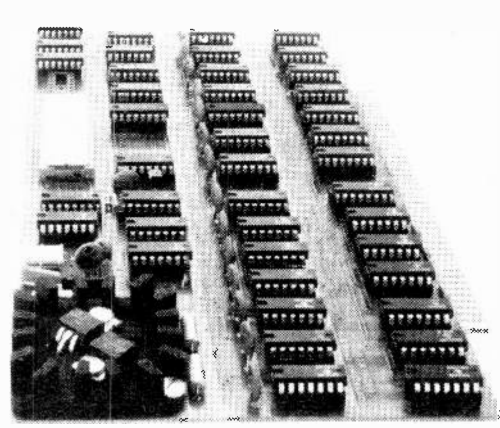
Unfortunately most of us have to watch those pennies to a greater or lesser extent, and so we trade off potential against cost. The general rule with all things is that you get what you pay for, and microcomputers are no exception. Unfortunately, microprocessors being as complex and versatile as they are, the ingenuity of the designer can make small, low-cost systems do things that larger more expensive systems can't do. But this is often at the expense of some other facility, or more often expandability in the sense of freedom to configure the system the way you need. Many single board computers fall into this category — they were designed with the idea that most applications would use that one board plus perhaps some interface electronics; unfortunately hobbyists don't work that way. They usually want to keep adding memory and peripherals, and with the single board computer this usually means ripping memory and peripheral interfaces off this card to reduce it to only a basic CPU. It may be cheaper to buy an ordinary CPU board in the first place.

We've said that you don't want to blow your cash on some nine-day wonder that will be obsolete by the time you've built it. This is not a great problem in practice. Most manufacturers realize that this thought occurs to potential purchasers, and so they endeavour to provide options for their own systems such as high level languages (usually BASIC), peripherals such as printers, video terminals and cassette interfaces. If you have sufficient memory and a few peripherals plus BASIC, you can have an awful lot of fun even with the most non-standard system in the world.

FLEXIBILITY

This is a very important point for the beginner who may not know exactly what he wants to do with his system. If you want to try various applications and especially if you're not very hot on hardware, then the Altair/Imsai/S100 bus is the way to go, almost certainly. A great number of companies are offering plug-in boards and peripherals for computers using this system. Examples are: plug-in video display terminals, floppy disk controllers, various cassette interfaces, serial and/or parallel interfaces, floating-point arithmetic boards, colour graphics boards, video digitizers, PROM programmers, speech synthesizers, music synthesizers, front panels, upgraded CPU's, AC power controllers, blank wire-wrap cards — the list goes on and on. These cards will, in theory, work with any





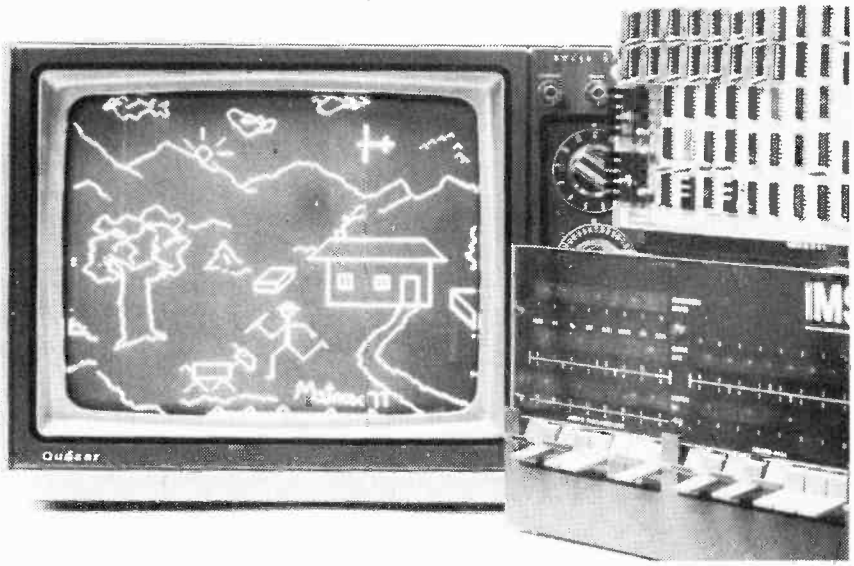
The MicroCyber 1000 above is an expanded version of the popular 6502 Kim single board computer. The Z-80 based CPU card by Cromemco on the right will instantly upgrade any 8080 system (almost). Advantages include a vastly expanded instruction set and higher speed.

S100 system; in practice there may be minor problems with some of the more specialized boards, but only minor mods are usually needed.

Bear in mind that S100-based systems are often more expensive — the basic price quoted for most computers in this class is for the case, PSU, CPU card and front panel only. You still have to buy some memory to get it to work at all and in order to do anything interesting you'll need a lot of memory, a video display terminal and a cassette interface plus BASIC. At Canadian prices, you are now in the region of $1,500 — an Imsai 8080 is $900.00 basic.

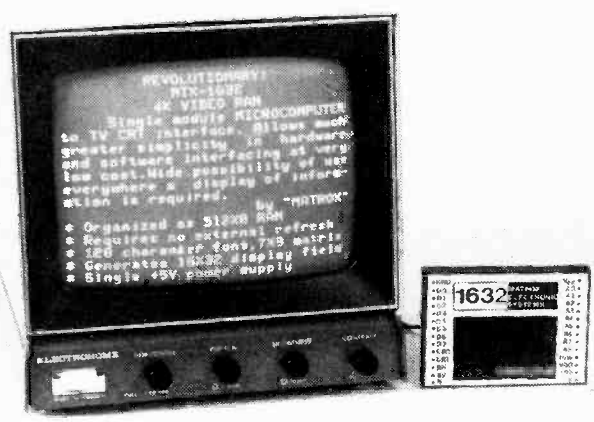
If you know your interests lie in the software domain only, then the problem is simpler — slightly. You're main requirement is for memory both in RAM form, and also backup storage in the form of cassettes or, in the future, perhaps floppy disk. You may also want a line printer in addition to a video display terminal. Many systems offer these in addition to the S100 setups. Southwest Technical Products Co., for instance, have a nice 6800 based system which satisfies these requirements and many other systems which are comparatively new, and don't have many hardware-compatible extras, are able to support a lot of memory and the basic peripherals a programming type needs.

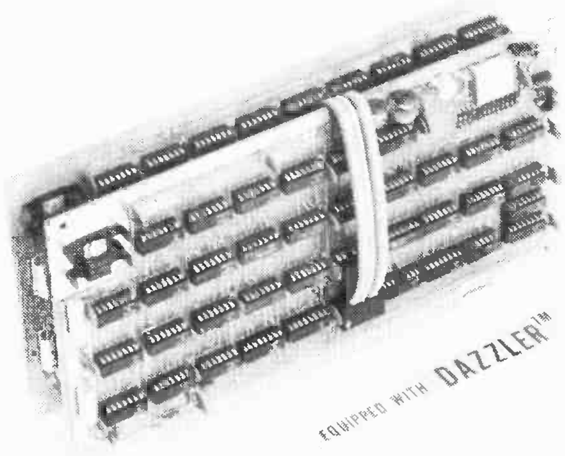
The best way to gain knowledge of this thorny topic is to read every article you can get your hands on and better still, to talk to other computer users at club meetings. For a variety of reasons magazine writers always avoid both lavishing praise on a system and more importantly, making harshly critical statements about a particular model, since mistakes do happen and a company's reputation could be unjustly ruined. An individual at a club, however, can talk individually about his own experiences with his system



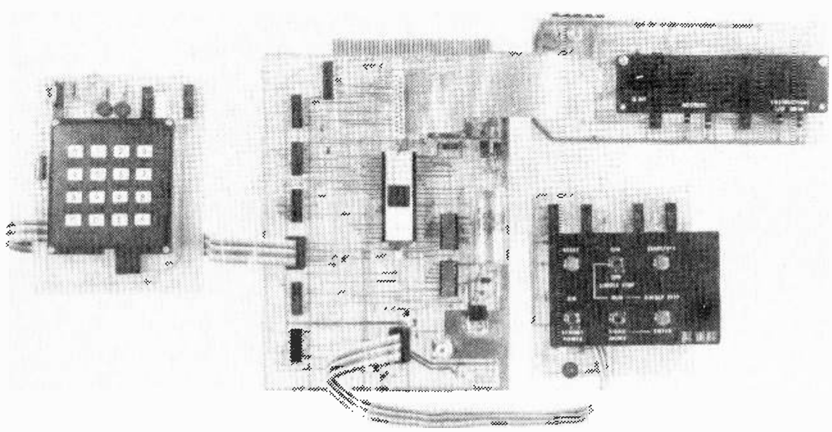
The Matrox ALT-256 is a 256 X 256 high resolution graphics generator for the S-100 bus. $395.00 and a 2-4 week wait will bring you this machine from Matrox Electronic Systems, P.O. Box 56, Ahuntsic Stn., Montreal, Quebec, H3L 3N5.

The E & L MMD-1 is shown here with its optional "piggy-back" board which incorporates a cassette interface and extra memory.

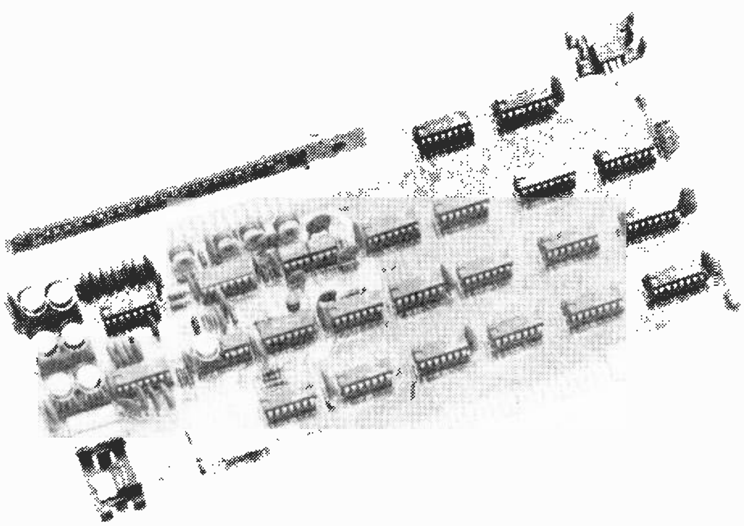




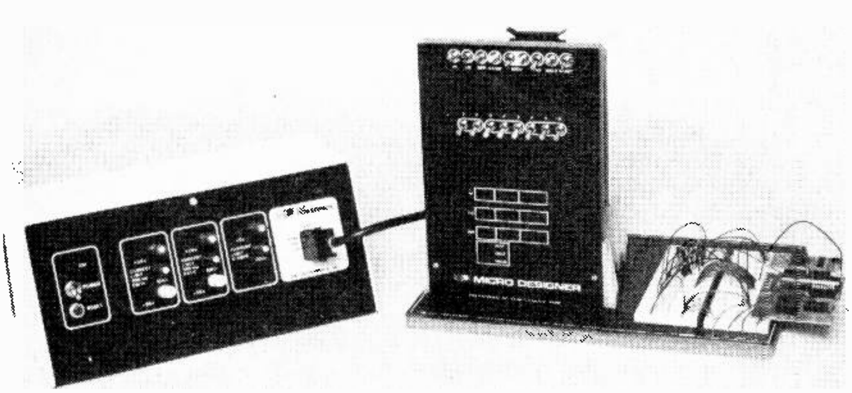
Matrox's MTX-1632 4K video RAM (above) is specially designed for incorporation into video display terminals. Cromemco's Dazzler colour TV interface on the right is excellent for experimenting with computer art.



The Infinite UC1800 kit in exploded form.



Cromemco's D+7A I/0 board simplifies games applications enormously.



E & L Micro Designer is used in the "Bugbooks".

and usually knows the pitfalls involved. Store operators are usually helpful as well, bearing in mind of course that they want to sell their products.

In short, if you forsee expanding your system in various directions in the future, the S100 bus of Altair/Imsai/ Polymorphic and the rest is the best and will be around for a long time. If you are sure of your requirements, then you may be able to cut costs and come up with a better system, by choosing a different machine such as SWTPC, Wavemate, OSI, etc.

SOFTWARE

Here's another thorny subject. Again, the 8080 based machines such as the Imsai and Altair are out in front because there's just so much software available. The only machine-specific parts of any program are the Input/Output routines which are for a specific interface device at a particular address. However, most I/O boards use the same serial interface chips, and can be located at any address, so that the I/O routines will work. If there are specific problems, the I/O routines can often be patched or re-written to suit your system.

The major piece of software desirable for your system is a BASIC interpreter. BASIC is a high-level language (Beginner's All-purpose Symbolic Instruction Code) which enables you to write programs quickly and simply in something like the English language. It has statements like FOR N = 1 TO 20, I = I+N*N, NEXT N, PRINT I which are easy to learn. Computer games are almost always written and published (hint, hint!) in BASIC. A BASIC interpreter is the program which generates the machine code instructions that actually execute the BASIC statements. A typical BASIC interpreter is 6-8K bytes in length and you always buy it from your computer store, never write one yourself unless a) you think you can make money from it (it has to be good) and b) you don't mind being a candidate for the funny farm afterwards. People who write interpreters live in a strange world of linear hashes, symbol tables and thunks (?) way above us lesser mortals who can barely write programs to add two and two.

COMMERCIAL SOFTWARE

Software holds the key to the success of many systems. Processor Technology for example, appear to be chasing after the high-level software and games fans with their Sol-20 system. The Sol is backed up with several versions of BASIC, plus FOCAL (a calculator-type language originally developed for DEC's PDP8) as well as math programs and games.

Other high level languages can be expected to appear; in fact FORTRAN and COBOL are rumoured to be available, though as they are intended for commercial uses, they are expensive.

An interesting variation used by professionals developing microcomputer based products is PL/M, Intel's special implementation of PL/1 for microprocessor development. Both Motorola and National Semiconductor have similar languages for their microprocessors while RCA use FORTH, a language specially suited to take advantage of their CDP 1802's multiple stacks. These special versions of PL/1 have special capabilities to enable the programmer to write sections of assembly language and embed these into the PL/M program. Unfortunately, these languages are a) too expensive and b) not practical in memory requirements for the hobbyist.

If your interests lie in electronic control systems or you have special interface and I/O requirements be prepared to write some assembly language. This is a convenient form of machine code in which each statement is a direct instruction to the processor, compared with BASIC's LET Z1 = 5*N+SIN × /5 type of statement which may invoke several hundred bytes of machine code in its execution. Most computers are supplied with assembler programs which convert assembly language to machine code which can then be run. Check this carefully — assembly language is a very useful capability.

GOING IT ALONE

As we have said, various S100 compatible cards are available, including processors, memory and I/O, and now you can buy complete front panels and the mother boards that they all plug into. So what's to stop you buying these separately, in kit form, building a power supply and putting your own design together? Nothing, if you have the skills and experience to do it. But really you couldn't have acquired that experience without first building a similar 8080, S100 based computer. The advantages of a home-brew computer are: 1) you know the design intimately 2) you'll probably save money 3) you can modify it greatly without knocking the resale value down. Disadvantages: 1) You'll find no-one able to help directly when the going gets tough. 2) Documentation standards will be low, 3) you'll miss out on software support, user groups etc. 4) Cosmetics and mechanical design will probably be ropey.

If you know you can do it, go ahead — if you think you can, hold fire until you know you can. Of course, we don't want to discourage you, but think about what you're letting yourself in for. If you stick with well-known kits and select wisely without modifying, you shouldn't have too much trouble, but as soon as you try anything like altering the bus definition slightly, then you could be in it up to your neck.

KIT BUILDING

Assuming that you decide to buy an Imsai or Sol or Polymorphic or whatever, should you buy it assembled or in kit form? The answer, for most readers of this magazine, is to buy a kit. If you're reading ETI you've probably built a few projects before, some of them at least as complex as the individual boards of a computer kit. Besides, the difference in price on a basic Imsai 8080 is $300.00! If you have problems when building your kit, the store you bought it from can usually help out.

On the subject or prices, and buying, don't, whatever you do, delay buying a computer because of the trends in calculator and watch prices. While it is true that microprocessor and memory chip prices have fallen dramatically, and will continue to do so, this does not mean that computer prices will fall. On the contrary, the silicon in a typical computer is only a small part of the cost — the case, printed circuit boards and connectors, switches and power supply account for the bulk of it. The prices of these components will not go down; they will go up, and this is reflected in recent price hikes by Imsai and Polymorphic, which the rest of the industry are expected to follow.

Don't be fooled by the prices in US publications. Import duty and taxes add considerably to these and if you try to buy from the States to save you will be paying all kinds of shipping and handling charges, charges for filling in Customs forms, as well as encountering delays and skirmishes with that delightful band of Civil Servants, "Customs Canada", who will delight in inspecting your computer piece by piece, and charging you anything from 23.2% to over 50% duty and Federal Sales Tax on identical items. It's a lot simpler to deal with your local store, who will take care of these hassles for you.

YOU'RE ON YOUR OWN

That's really as much as we can tell you about buying a microcomputer. We purposely haven't done a step-by-step comparison of Imsai vs Altair vs SWTPC, simply because a lot of the information is available in advertisements or from stores, and the rest can be got by asking a few people. Most of the information is probably irrelevant to your application anyway, and we'd have missed out the vital data you really needed.

Don't get tied up in questions of processor speed and instruction set. Virtually all of the popular processors (Z-80, 8080, 6800, 6502 etc) are more than adequate in both areas. Since you're using the system for your own pleasure only, neither of these is a problem — doubling processor speed may halve system reaction time from ¼s to ⅛s — big deal! The only problem may be in applications such as high-speed reactive games.

Soak up all the information you can — it's your decision and it's one that's fun to make. ●

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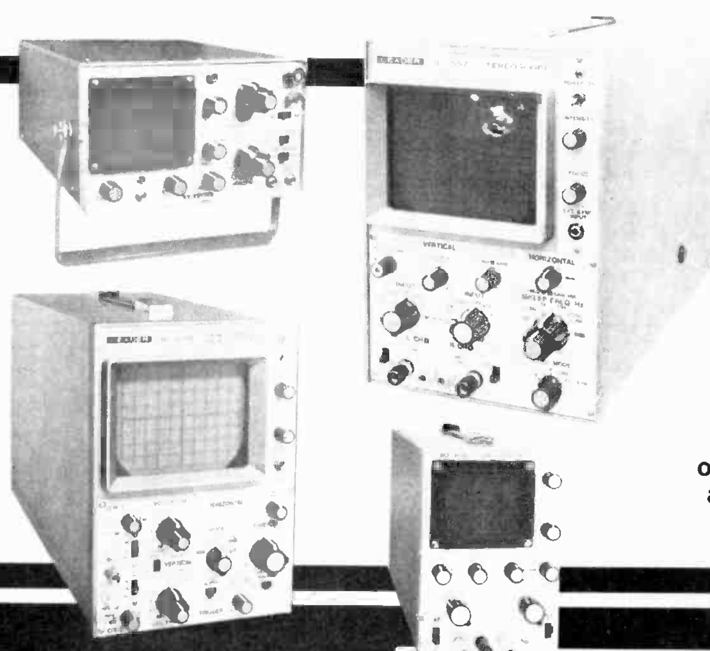

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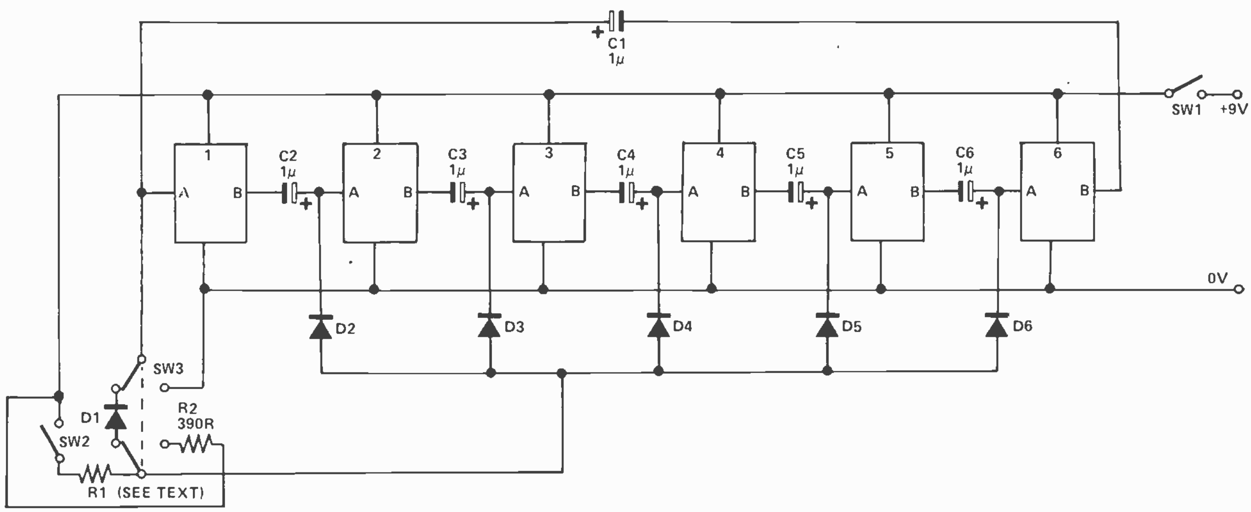


'FREEZING' SEQUENTIAL OSCILLATOR

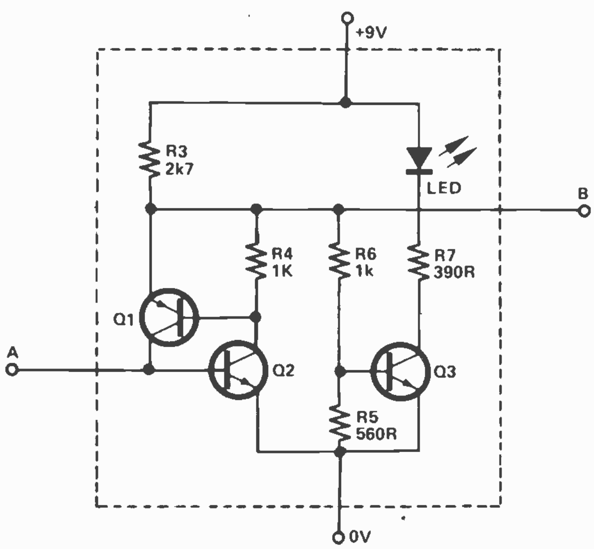
After switch on, SW3 (a dpdt) is operated and then returned to its normal position. This switches off the first module, and switches on all the others via the diodes. A biased switch may be used.

On the closure of SW2, a number of LEDs will flash in sequence. On the opening of SW2, the circuit will 'freeze' in whatever state it was in, the LED remaining on.

The basic circuit consists of a number of transistor pairs, one for each LED. They are connected in a 'ring' by capacitors from the emitter of one pair to the base of the next. The LED associated with each pair is driven by the inverter-driver transistor Q3.

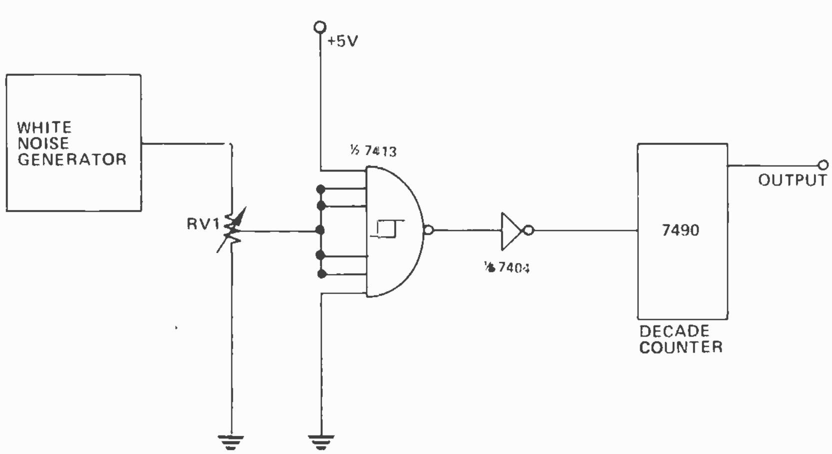
The rate of oscillation is dependent on R1, a value of 10 k gives a rate just faster than the eye can perceive.

Q1 is a 2N2604. Q2, Q3 are 2N2222s. All diodes are 1N4148s.



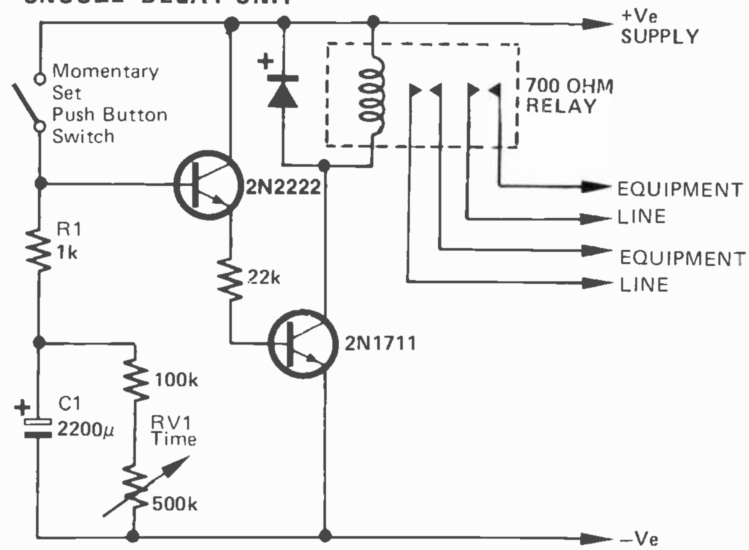
RANDOM PULSE GENERATOR

The 7413 provides a means of 'squaring up' waveforms before applying them to logic circuits. A reverse biased germanium diode is used to provide random 'sine-wave' type pulses, i.e. white noise. The output from the white noise generator is fed into the input of the 7413. When the output from the generator attains the value of 1.8V, the output goes low and the output from the hex inverter goes high. This output is then fed to the counter. By making the output from the white noise generator variable, via a potentiometer, some degree of control over the 'randomness' may be obtained.



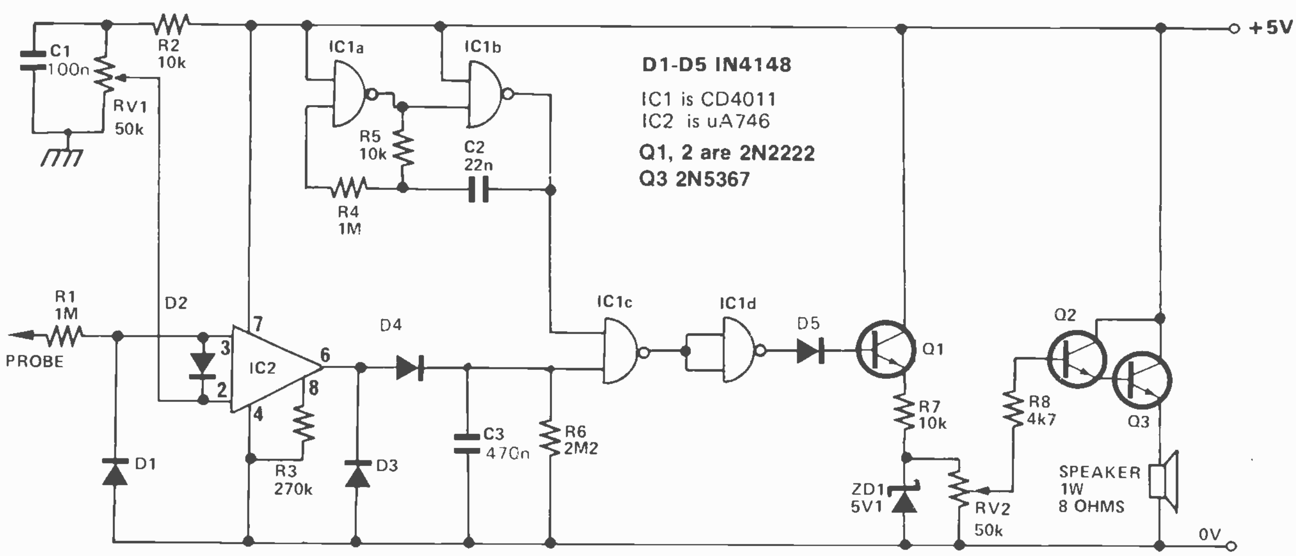
tech-tips

'SNOOZE' DELAY UNIT



This unit is intended to turn off a piece of equipment after a predetermined time. The supply voltage is taken from the equipment to be switched and the relay contacts are wired in parallel with the power switch on the equipment.

When the equipment is turned on by its own power switch and the 'set' switch is activated, the large electrolytic capacitor C1 in the delay unit is charged up via limiting resistor R1. C1 discharges slowly through R2 and RV1 but while the charge is retained above a sufficient level, this charge keeps the two transistors turned on and the relay activated. The equipment power switch may now be turned off, power being maintained through the relay. When the capacitor is discharged the relay is released, turning off the equipment. Delay times are proportional to C1 and R2 + RV1. Time delays in the order of an hour are possible.

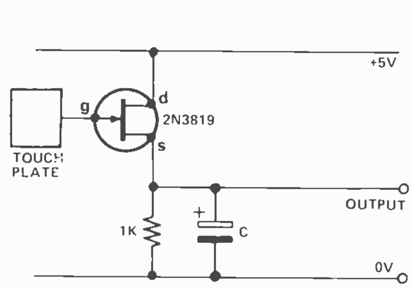


AUDIBLE LOGIC STATE INDICATOR

The indicator will work with either TTL or CMOS circuits. A useful feature is that the unit can be powered by the same supply as the one supplying the circuit under test. Logic state 1 at the probe will produce an audible tone on the loudspeaker. A switching signal at the probe also activates the loudspeaker.

RV1 sets the threshold level at which IC2 will switch on. This is normally set at maximum (wiper at the R2 end). RV2 sets the volume of the audible tone, and can be adjusted as required.

IC2 can be substituted by the equivalent LM741 but R3 must be removed first.



TOUCH-SWITCH FOR LOGIC

An n-channel field-effect transistor is the basis of this simple trigger. In its quiescent state the voltage at the output is about 3V. When the plate is briefly touched with a finger, the minute currents between the body and the plate alter the electric field at the gate of the transistor. The effect is to cause a drop in output voltage. It falls almost to zero and can be used to trigger a TTL flip-flop. This can be constructed in the usual way, using two NAND gates from a 7400 IC. If several triggering circuits are required, it is more convenient to use the 74118 sextuple bistable latch.

The value of the capacitor is not critical, but 10uF is convenient. The touch-plate can be an area of copper etched an a circuit-board, a square of aluminum foil, or simply a thumb-tack pressed into an insulating support.

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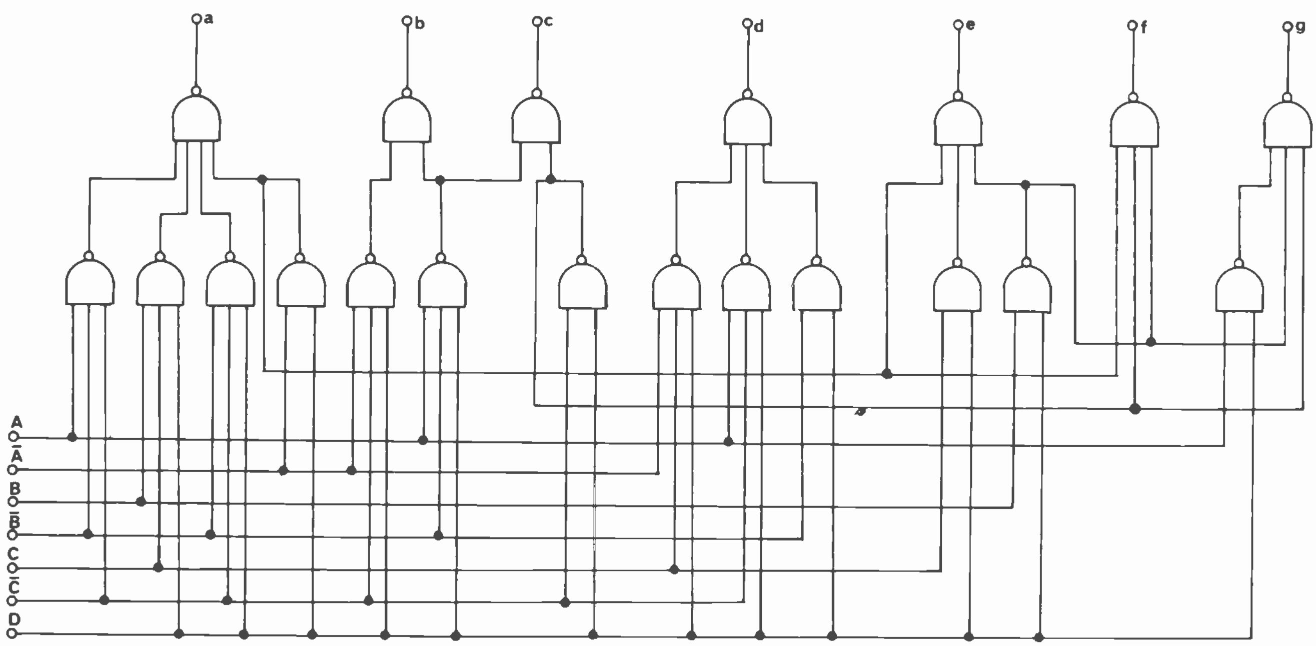


HEXADECIMAL TO 7-SEGMENT DECODER.

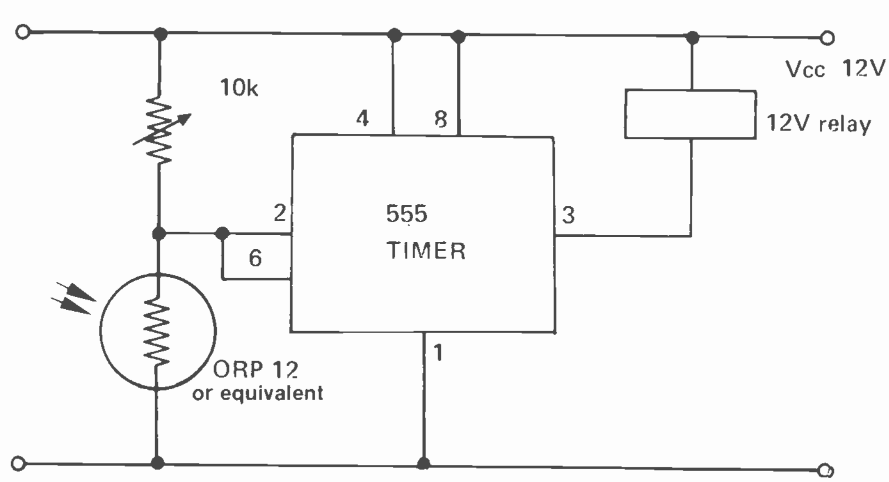
The circuit described below provides an extension to the 7448 BCD to seven-segment decoder, converting it into a hexadecimal to seven-segment decoder which will give the numerals 0-9 and the characters A, b, C, d, E, and F as output for a four bit binary input.

(Inputs of A, $\overline{A}$, B, $\overline{B}$, C, $\overline{C}$, D are needed with an inverting buffer - fan out 30 - on the D input.)

The 7448 is disabled by bringing the blanking input low when the input is greater than 0111_2 (i.e. D is connected to B1/RBØ on the 7448.) Outputs from the 7448 and the add-on decoder are OR-ed together creating a single seven-segment output.

D	C	B	A	a	b	c	d	e	f	g
Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø
Ø	Ø	Ø	1	Ø	Ø	Ø	Ø	Ø	Ø	Ø
Ø	Ø	1	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø
Ø	Ø	1	1	Ø	Ø	Ø	Ø	Ø	Ø	Ø
Ø	1	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø
Ø	1	Ø	1	Ø	Ø	Ø	Ø	Ø	Ø	Ø
Ø	1	1	Ø	1	Ø	Ø	Ø	Ø	Ø	Ø
Ø	1	1	1	Ø	Ø	Ø	Ø	Ø	Ø	Ø
1	Ø	Ø	Ø	1	1	1	1	1	1	1
1	Ø	Ø	1	1	1	1	1	Ø	1	1
1	Ø	1	Ø	1	1	1	Ø	1	1	1
1	Ø	1	1	Ø	Ø	1	1	1	1	1
1	1	Ø	Ø	1	Ø	Ø	1	1	1	Ø
1	1	Ø	1	Ø	1	1	1	1	Ø	1
1	1	1	Ø	1	Ø	Ø	1	1	1	1
1	1	1	1	1	Ø	Ø	Ø	1	1	1

TRUTH TABLE for the 'add-on' decoder. Note that when the input is Ø11Ø$_2$ (6$_{10}$) a logical one is inserted in the 'a' column to provide the resulting seven-segment '6' with a cap, thus differentiating it from a 'b'.



SCHMITT TRIGGER

A very useful schmitt trigger can be made by utilising a single 555 timer with its trigger and threshold inputs connected together. The schmitt has a very low input current (1.5uA) and can directly drive a relay taking up to 200mA of current.

The circuit shows a 555 schmitt being used to energise a relay when the light level on a photoconductive cell falls below a preset value; the relay energises when the voltage on pins 2 and 6 is greater than 2/3Vcc and de-energises when the voltage falls below 1/3Vcc. This gives a hysteresis of 1/3Vcc. The circuit can be used in many other similar applications where a high input impedance and low output impedance are required with the minimum component count.

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Damping Factor	200	400	400
Hum & Noise	115dB below 70 watts	115dB below 110 watts	115 dB below 170 watts
Input Sensitivity	0dB (0.775V) 70 watts	0dB (0.775V) 110 watts	0dB (0.775V) 170 watts
Input Impedance	47k	47k	47k
Power Requirement	± 35Volts	± 45Volts	± 55 Volts
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Sensitivity	30 mv @ 60 MHz 10 mv @ 25 MHz	150mv @ 600 MHz
Range	1 Hz to 60 MHz	10 MHz to 600 MHz
Max. Input Voltage	120v RMS to 10 MHz	2.5V
Time Base	10MHz XTAL ± 2 ppm 15° to 55° C	
Power	117V 50 60 HZ 15W	
Size	8.8 ×8 ×2.8 (223.5x203.2x71.12 mm)	
Weight	3 lbs 10 oz (1.64 kg)	

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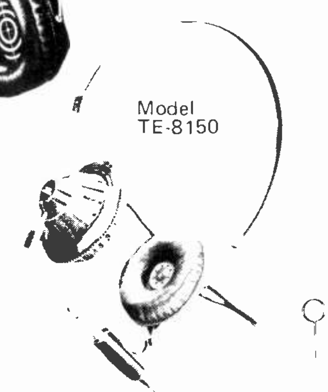

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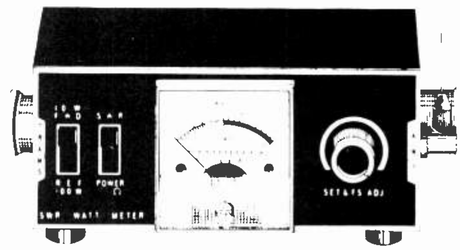

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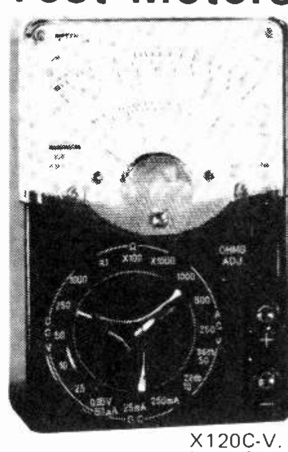

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OPEN CIRCUIT

by Tom Graham

YOUR RESPONSE to Electronics Today (which incorporates Electronic Workshop) has, to put it mildly, been fantastic.

The letters, personal comments and phone calls indicate that we're doing something right, and we hope that, as we gain experience, we can provide the kind of features and projects that you want. The projects that we have run so far appear to have been popular — we hope that the articles we are planning will be as successful.

We have received a few comments on the European terminology that occasionally crops up in the magazine — most of the comments are not unfavourable. We must admit to being a little idiosyncratic in this area — but for a very good reason. Electronics Today International is not one magazine; it is five, operating independently around the world. This means that we are able to invest a lot of time and money in each project, in order to develop it to a very high quality.

It is so easy for mistakes to be made in the preparation of articles, and we minimise these by cutting down the number of stages an article goes through before printing. Once we have our final prototype completed and working perfectly, the circuit diagram is drawn once, so that errors that may occur in re-drawing are avoided. This is why our circuit diagrams are different from the North American style you may be used to. If other editions around the world decide to use the same project, their circuit diagram will be identical, although there may be variations in the component types and even the method of construction. Our internationalism also enables us to bring you articles on electronics from around the world — we know there are a lot of interesting things happening outside Silicon Valley, U.S.A.!

Finally, the Canadian scene is the important one to us. We are striving to bring you news and events from Canada, but we need information input from you. If your company is releasing a new product, make sure you Marketing or Advertising Department let us know with a press release. Since there isn't another magazine like ETI in Canada, they're probably not in the habit of doing this. Similarly, if your radio, or computer, or electronic club are doing something interesting, or even if you've come across something new or unusual, let us know.

A magazine is, in one sense, a data processing machine — if you help us with the input, we can work wonders on the output.

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INFORMATION

COMPONENT NOTATIONS AND UNITS

We normally specify components using the recently agreed International Standard. Many readers will be unfamiliar with this but it's simple, less likely to lead to error and will be used by everyone 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: 1.8Mohms is 1M8, 56kohms is 56k, 4.7kohms is 4k7, 100ohms is 100R, 5.6ohms is 5R6.

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Written queries can only be answered when accompanied by a self-addressed, stamped envelope, and the reply can take up to three weeks. These must relate to recent articles and not involve ETI staff in any research. Mark your letter ETI Query.

NON-FUNCTIONING PROJECTS

We cannot solve the problems faced by individual readers building our projects unless they are concerning interpretation of our articles. When we know of any error we shall print a correction as soon as possible at the end of News Digest. Any useful addenda to a project will be similarly dealt with. We cannot advise readers on modifications to our projects.

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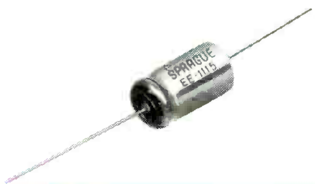

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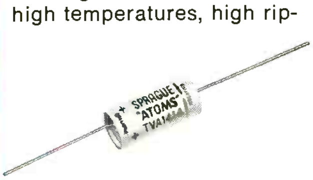

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