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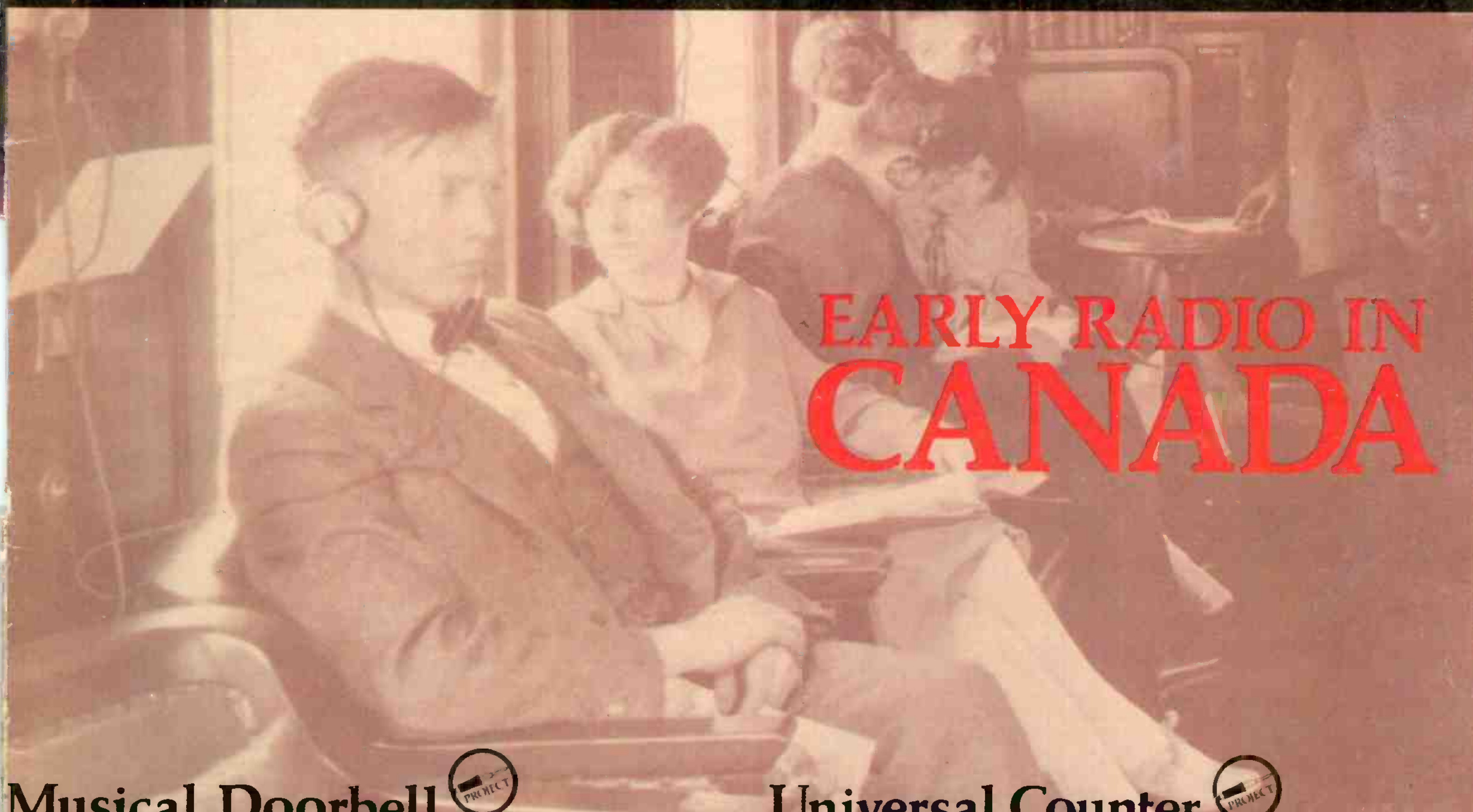
Electronics Today INTERNATIONAL

December 1981



EARLY RADIO IN CANADA

Musical Doorbell (PROJECT)

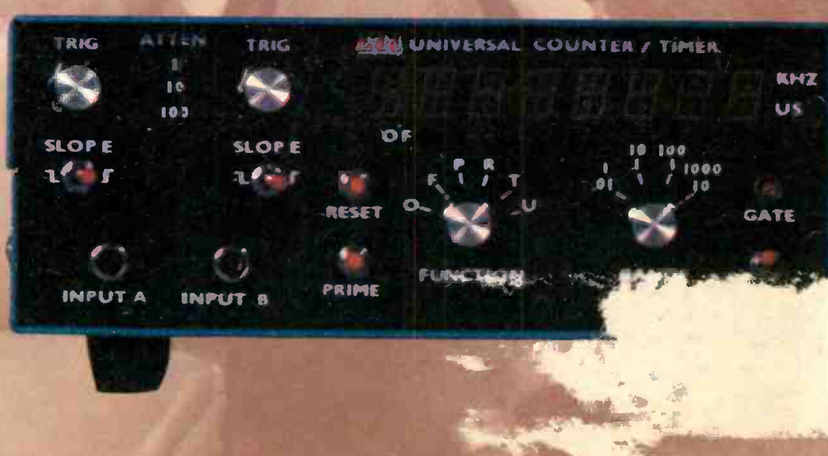
Bandpass & Beyond

4-Input Mixer (PROJECT)

Tubes

Speaker Design

Universal Counter (PROJECT)



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Please note that we now have a well-staffed mail-order dept. and we assure you of prompt delivery on items which we advertise. Orders received before Dec. 10, 1981 should reach you before Dec. 24, 1981.

NEW 6809 SINGLE BOARD COMPUTER

We are pleased to announce the arrival of this versatile new computer, which is extensively used by the University of Toronto for teaching purposes. Among its standard features are: 16K of RAM memory (expandable to 48K on board), 2 serial ports, 2 6522 parallel ports, a cassette interface, and an extremely powerful monitor.

This month we are offering this state-of-the-art computer, with an extra 16K of RAM (32K in total), in kit form for the special price of $495.

Kit Price $495
Assembled $695

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Good stock of Aardvark software available at super prices

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PROM 100 EPROM Programmer	$279
MPC4 4-Channel Serial I/O Board	$685
EXPANDOPROM EPROM Board	$197
Z80 Starter Kit	$485

For descriptions and photos, refer to ETI June 1981.

We also provide assembled and tested S.D. Systems boards at $85 extra. Versafloppy 2 is $130 extra since it requires critical tuning.

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(S100 connectors extra $5.00 each)
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1853	1.80	6522	9.99	8216	2.10	8257	8.75
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Electronics Today INTERNATIONAL

DECEMBER 1981 Vol. 5 No. 12

Features

Tubes p.26

Early Radio P.36

Radio in Canada's come a long way since the days when our cover picture was taken. It's gone from type 01A tubes and huge horn speakers to microprocessor controlled tuners, creaking radio dramas to simulcasts of everything from Stones' concerts to the discovery of intelligent life on TV. Delve into the illustrious past of broadcasting in Canada, on page 36.

ISSN 0703-8984

(Photo Credit: C-26000/Public Archives Canada)

Projects

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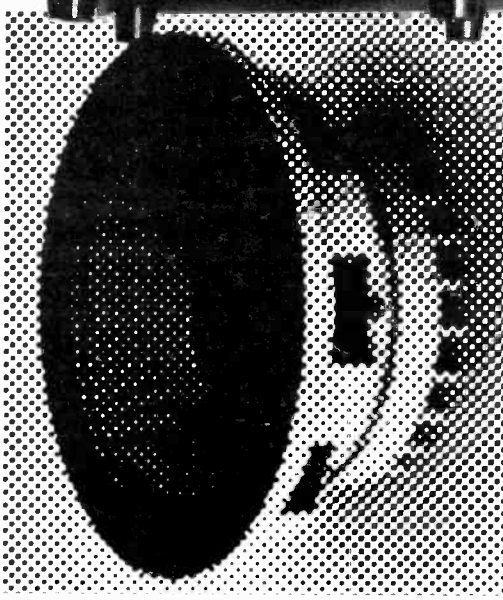

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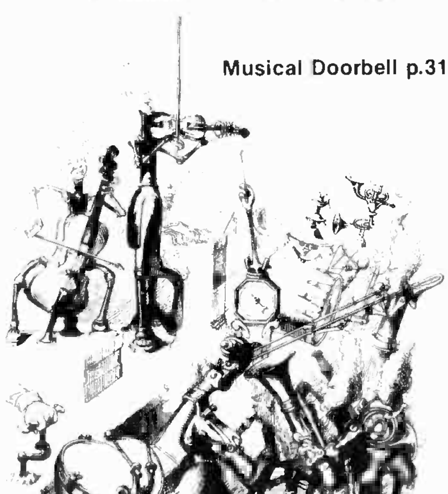


ADVERTISERS' INDEX

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

Binders
Binders made especially for ETI are available for $6.75 including postage and handling. Ontario residents please add provincial sales tax.

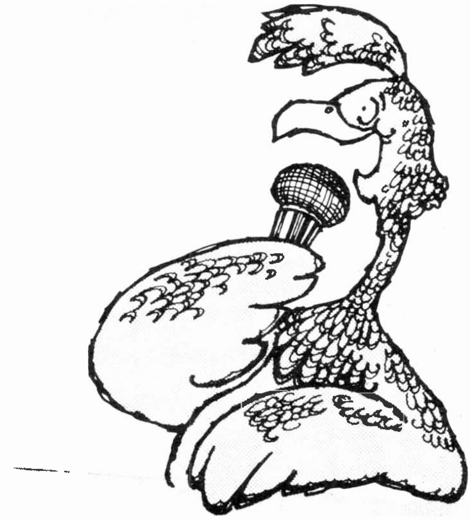
Sell ETI and ETI Special Publications
ETI is available for resale by component stores. We can offer a good discount when the minimum order of 15 copies is placed. Readers having trouble in obtaining the magazine could ask their local electronics store to stock the magazine.

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

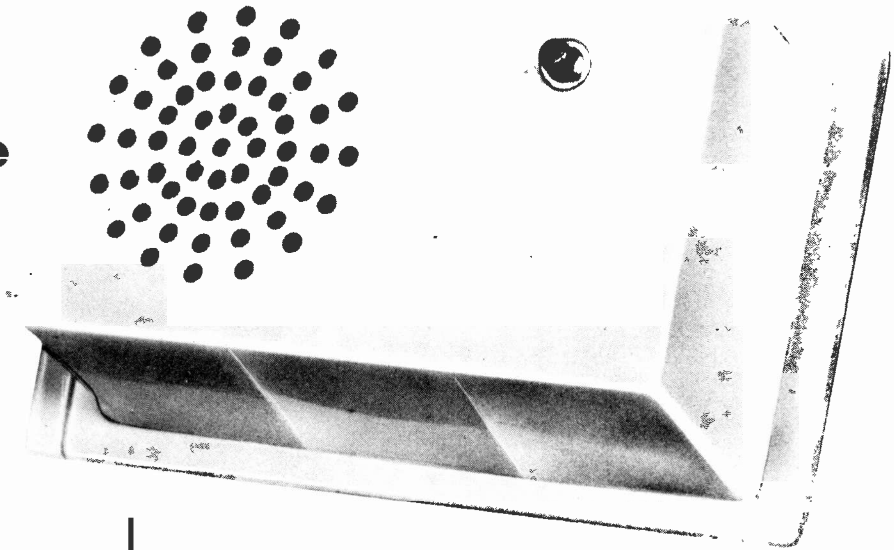
PCB Suppliers
ETI magazine does NOT supply PCBs or kits but we do issue manufacturing permits for companies to manufacture boards and kits to our designs. Contact the following companies when ordering boards.
Please note we do not keep track of what is available from who so please don't contact us for information on PCBs and kits. Similarly do not ask PCB suppliers for help with projects.

K.S.K. Associates, P.O. Box 54, Morriston, Ont. N0B 2C0.
B&R Electronics, P.O. Box 6326F, Hamilton, Ont., L9C 6L9.
Wentworth Electronics, R.R.No.1, Waterdown, Ont., L0R 2H0.
Danocinths Inc., P.O. Box 261, Westland MI 48185, USA.
Arkon Electronics Ltd., 409 Queen Street W., Toronto, Ont., M5V 2A5.
A-1 Electronics, 5062 Dundas Street W., Islington, Ont., M9A 1B9.
Beyer & Martin Electronic Ltd., 2 Jodi Ave., Unit C, Downsview, Ontario M3N 1H1.
Spectrum Electronics, Box 4166, Stn 'D', Hamilton, Ontario L8V 4L5.

MODE ROAD RUNNER



You can master complex electronics and mimic the strange bird's erratic sound with this complete Mode kit!



You can duplicate the cry of the Road Runner and create many other unusual audio effects with the Mode Road Runner kit.

All the necessary control parts for the Road Runner sound effects generator are in the Mode kit, including some that are not commonly available. Clear, step-by-step instructions help you become an expert electronics technician.

After building several Mode kits, you may become good enough to design your own devices. Even advanced students will have trouble duplicating the functions of the Road Runner and some other Mode projects without obtaining Mode's unique, very ingenious chips, diodes, and other tiny marvels.

Check out Mode's growing list of electronic projects that are entertaining, useful . . . and always instructive.

Mode kits for many useful and entertaining purposes.

1. Automatic Headlight Reminder
2. Battery Operated Fluorescent Light
3. Bug Shoo
4. Code Oscillator
5. Crystal Radio
7. Curiosity Box II
8. Dally Lighter
9. Decision Maker
10. Fish Caller
11. Hi Power 12V DC Flasher
12. Photo Electric Night Light
15. 0-20V Power Supply
16. Single Channel Color Organ
17. Electronic Siren
18. Shimmer Strobe Light
19. Tone Generator
20. 5 Transistor 1 Watt Amplifier
22. Xenon Strobe
23. 3 Channel Color Organ
24. Loudmouth Siren
25. Roulette Wheel
26. Electronic Sheet Game
27. Electronic Dice
28. Super Roulette
29. FM Mini Broadcaster
31. Electronic Shoot Out
32. Road Runner Sound Effects
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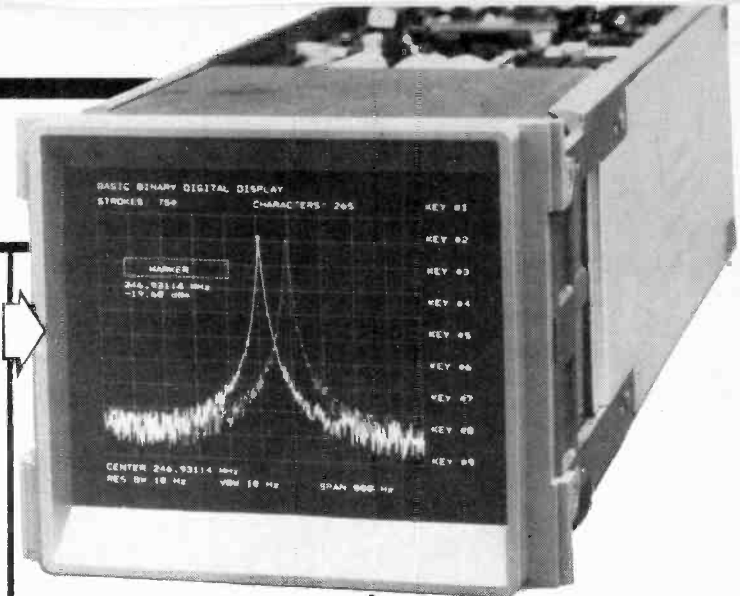
NEWS



Digital Display Module

To serve the needs of microprocessor-based instrumentation OEM's, Hewlett-Packard has introduced the first member in a new family of high-performance digital display modules, the HP 1345A — a compact, self-contained unit for high-resolution vector graphics.

The HP 1345A produces vector graphics and/or alphanumerics on its 6-inch (diagonally measured) CRT in response to digital commands from an external processor. A built-in binary interface provides easy connection to a user's external 16-bit TTL level data bus.

Typical applications for the HP 1345A Digital Display Module include spectrum and network analyzers, waveform analyzers, curve tracers, digital storage oscilloscopes and Fourier analyzers — any microprocessor-based equipment requiring complex, rapidly-changing graphics information.

The 2048 by 2048 addressable resolution provides for high-resolution graphics with very high positional discrimination on the CRT. Picture quality is further enhanced by the HP 1345A's constant writing speed which ensures a uniformly bright display. An optional 4K word vector memory (RAM) saves user memory and eliminates refresh requirements by the user processor.

Additional display flexibility is assured by three programmable intensities plus blank or off, four programmable line types and four programmable writing speeds. A programmable automatic delta-X increment enables users to conserve memory and to draw complex graphs easily with less data transfer. ASCII characters are generated internally in four programmable sizes and four orientations for labeling graphs, soft keys, etc. Average character writing time is 15 microseconds enabling hundreds of alphanumerics to be displayed without flicker.

ATOMic Computer

The Acorn Atom is a very powerful small computer, and may be the lowest priced system of its type to date. Very little larger than the size of its keyboard, it fully exploits its 6502 processor with a complete range of features. Among its on board capabilities are superfast resident BASIC, high resolution graphics, integral printer connection, I/O capacity, internal speaker and cassette interface. Optional extras provide for disks, full colour, up to 32 K of RAM and network systems.

The Atom is actually going to be available in Canada in advance of its announcement in the United States, and at a very low price. The basic Atom, with 2K of user RAM (fully expandable) will be just $349.00 Canadian. It's available directly through Gladstone Electronics, 1736 Avenue Road, Toronto, Ontario, with other dealers in Canada now being established. It is also available via mail order directly from its Canadian distributors, Torch International Computers, Ltd., Suite 212, 7420 Woodbine Avenue, Markham, Ontario.

For more information about the Atom, check the ad on our back cover, or the Atom review (we plan to have) in next month's ETI.

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A powerful microcomputer with a full standard 53 key typewriter style keyboard and built-in cassette recorder for use in entering and storing programs. Utilizing the versatile Intel 8080A micro processor, the Interact computer has 16K of RAM and 2K of ROM at its disposal. Output is in color on your own TV screen. Sound is also generated through your TV set and can consist of exhilarating computer beeps or two full octaves of music. This is truly a powerful computer capable of developing and handling a variety of programs, and with available software provides true educational stimulus (examples: Star Track, Chess, Concentration, etc.). The Interact computer offers the ideal opportunity to learn BASIC, the most popular computer language for small business and hobbyists, and with the use of the 84 page manual, you learn at your own pace.

INSTALLATION: Attach to antenna terminals of your color TV set and plug into 120 VAC wall outlet. Computer includes built-in RF modulator, FCC approved and UL and CSA listed.

PROGRAMING: Most Micro-computers start you off with an abbreviated 4K BASIC, and then later you have to relearn the more powerful language. Since this computer has 16K of RAM, we start you with Level II Microsoft 4.7 BASIC. BASIC is the most popular Micro-computer language using commands that are words we are ordinarily used to: such as, PRINT, NEW, GOTO (For go to), END, COLOR, JOY, INPUT, etc. To help you learn programing we have included an 84 page instruction manual, plus a 20 page book of program examples.

Educational and Entertaining

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New! VP 111 Microcomputer $139.50

Features
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- 1K Bytes static RAM

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Ideal for low-cost control applications

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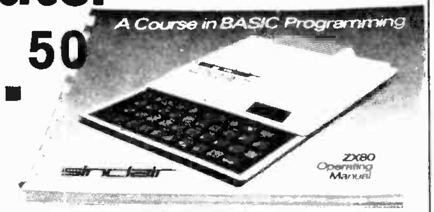
*User need only connect cables (included), a 5-volt power supply and speaker

The ZX80 Personal Computer
$275.50



The Sinclair ZX80 is an extraordinary personal computer. Compact and briefcase-sized, it weighs just 12 ounces. Yet in performance it matches and surpasses systems many times its size and price.

The ZX80 is an advanced example of microelectronics design. Inside, it has one-tenth the number of parts of existing comparable machines. This unique design - packing the system onto fewer, more advanced LSI chips - gives the ZX80 its remarkably low price.

Along with a complete 128-page course in BASIC programming, the ZX80 comes with all the necessary cords for connecting to standard color or B/W televisions and cassette recorders.

Microprocessor/Memory

Z80A 3.25MHz clock
ROM: 4K bytes containing BASIC
RAM: 1K bytes internal, externally expandable to 16K bytes

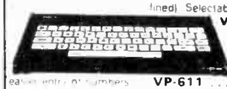
Keyboard

40 key touch-sensitive membrain with keyword entry gives an equivalent of 62 keys. After entering the statement number, the next key you touch enters the keyword printed above it automatically.

SINCLAIR ADVANCED DESIGN FEATURES
- 4K Integer Basic.
- 1 stroke entry for key words.
- Automatic error detection.
- Text editing capability.
- Machine code programming too.
- 26 string variables, any length.
- Random function, built-in.
- 1K RAM matches others 4K.

Price includes TV and cassette connectors, AC Adapter, and 128 page manual.

☐ Please send more information on Sinclair Computers



ASCII Keyboard Fully encoded 128-character ASCII alphanumeric keyboard. 58 light touch keys (2 user defined). Selectable "Upper-Case-Only"
VP-601 . . . . **$109.75**

ASCII/Numeric Keyboard ASCII Keyboard identical to VP-601 plus 16 key numeric entry keyboard for easier entry of numbers
VP-611 . . . . **$149.75**

Cable: ASCII Keyboards to VP-711 Flat ribbon cable, 24 in. length, for connecting VP-601 or VP-611 and VP-711. Includes matching connector on both ends
VP-620 . . . . **$27.50**

Cable: ASCII Keyboards Flat ribbon cable 36 in. length with mating connector for VP-601 or VP-611 Keyboards. Other end is unterminated
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Direct to disc

In 1968 Sheffield Lab made the first modern direct-to-disc recording and since that time have produced 2 to 3 new releases each year, many of which have been honoured with Grammy nominations for engineering excellence. Each of these superb recordings has been widely acclaimed throughout the audio industry for their overall musicality and faultless quality.

Because of the limited number of discs which can be pressed when the direct-to-disc method is employed, a number of Sheffield releases are out of print and considered as collectors items. Highly prized are the very first Sheffield release "Lincoln Mayorga and Distinguished Colleagues, volume 1" and the 1975 recording "I've Got the Music in Me" by Thelma Houston and Pressure Cooker (Lab 2).

Recent and very popular releases include:

Lab 10 — "Michael Newman, Classical Guitarist"
Lab 11 — "Still Harry after all These Years", the 3rd release of Harry James and his Big Band
Lab 12 — "New Baby", Don Randi and Quest
Lab 13 — "Growing up in Hollywood Town", Lincoln Mayorga and Amanda McBroom
Lab 14 — The Drum Test Record

New releases, include:

Lab 15 — "West of Oz, Lincoln Mayorga and Amanda McBroom
Lab 17 — "Tower of Power"

Sheffield Lab direct-to-disc records will be reduced in price to a suggested list of $24.95 and distribution consolidated with such other well known audiophile labels as Crystal Clear direct-to-disc, and American Gramaphone Fresh Aire (which also carry a suggested list of $24.95) and the increadible DBX encoded discs, all of which are distributed in Canada by Audio Market Sales.

For more information, contact Tom Baldock at Audio Market Sales, Climax Industries, 850 Syer Drive, Milton, Ontario L9T 4E3 telephone (416) 878-1189.

CCTV Camera

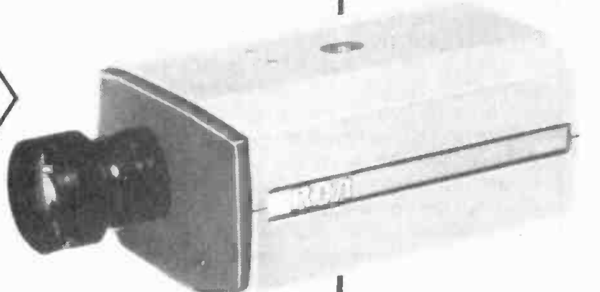
A new line-locked Vidiplex CCTV surveillance camera, TC2031, which receives both power and line lock information via its video cable has been added to the RCA Closed-Circuit Video Equipment line.

TC2031 cameras can be mounted up to 1500 feet from the separate power unit supplied with the camera, using only a single economical RG-59U cable for both video and power/line lock. The separation between camera and power unit can be doubled using RG-11U cable. Costly utility wiring is eliminated and camera size is minimized, making the TC2031 ideal for hard-to-reach places. Modular design of the separate power unit allows neat racking in multiple installations and line lock gives solid vertical interval switching as well as optimum VTR operation.

Designed using large scale integration (LSI) technology, RCA TC2000 Series cameras include the more useful features of premium cameras in an economical, compact and attractive design for general purpose use. Vidicon equipped models such as the TC2031 provide a 100,000 to 1 total automatic light range with automatic target control plus a 10:1 variable gain/bandwidth amplifier to increase sensitivity and improve signal-to-noise at the lowest camera light levels. Auto Track Electronic Focus provides high picture quality with no need for readjustment during the life of the tube, EIA RS-170 sync locked to the power line zero crossing, 2:1 interlace, automatic beam control, auto-black plus keyed clamp and the many other features of the TC2000 Series add up to dependable, maintenance free performance in a wide range of CCTV applications.

Optional User Price is $455.

For additional information, contact RCA Closed-Circuit Video Equipment, New Holland Avenue, Lancaster, PA 17604, telephone (717) 397-7661.



Fast Logic

Claimed to be the world's fastest systems of their type, a range of emitter coupled logic (ECL) gate arrays introduced by a British manufacturer offers local gate delays of 500 picoseconds and flip-flop clock rates higher than 300MHz, with low power dissipation.

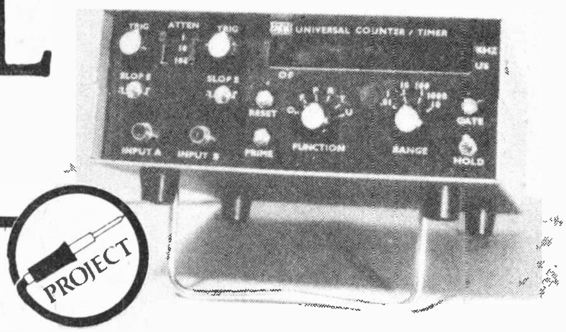
Up to 100 gate functions can be realised using the SCD 1000, an array based on the use of a single-level ECL gate which has been developed to allow relatively simple customisation for specific applications. It is customised on two layers of metalisation, and the manufacturer has developed special software to aid circuit layout. Inputs and outputs are through 28-pin connections, each of which has associated with it a buffer transistor capable of driving a 50-ohm line at ECL 10K logic levels. Power dissipation is less than one watt.

The SCD 2000 and 3000 versions show the choice which can be made between different combinations of speed and power dissipation. Customised in the same way as the SCD 1000, both offer up to 300 gate functions along with 64-pin connections. The SCD 2000 however has the same speed performance as the smaller system and some variants have a power dissipation of more than 3 watts, while the SCD 3000 offers gate delays of about 2 nanoseconds but has a maximum power dissipation of 750 mlliwatts.

According to the manufacturer, the new circuits can be used to replace ECL 10K and ECL 100K standard SSI and MSI parts, giving savings in printed circuit board design effort, system volume, and power supply requirements which make their use economical in low production volume applications, even where their performance advantages are not particularly relevant.

For more information, contact Plessey Canada Limited, 300 Supertest Road, Downsview, Ontario M3J 2M2 telephone (416) 661-3711.

UNIVERSAL COUNTER



Stand up and be counted: a universal counter based on Intersil's ICM7226, by Bill Miller and Jan Vincent.

A QUIET REVOLUTION has been taking place for the past few years. Until now the lowly digital counter has required row upon row of TTL packages and plenty of power to keep the lights flashing. Then intersil stepped into the arena with a new high density IC, the ICM7226. All those decade registers, crystal oscillators, timing logic and display drivers have been integrated into one small package that can drive eight LED displays, count at a rate of 10MHz, provide period and time measurements, and test itself. That means lower cost and easier construction for a high-quality counter. And, since the chip is CMOS, power drain is minimized, the chip runs cooler, and there is less heat to effect accuracy.

Now if that was not enough, we wanted more. So we added more. This construction project gives you a complete universal counter with all the features found on a professional frequency counter plus a few added bonuses, like extended range (to 120MHz in all modes), input attenuators, trigger level adjustments on the panel, slope selectors, easy to use controls and a priming circuit to allow you to measure time of just about any one-shot event you could dream up.

The counter is unique in that it is small enough to fit into a standard instrument enclosure, complete with power supply and all the front-end circuitry, right next to your signal generator or radio transmitter. And its construction, with seperate display and electronics board, makes the whole unit go together smoothly. You can probably find many other uses for this counter, and there are plenty of applications which would benifit from a simple-to-use counter.

Besides the IC construction and the small size, our counter has these other features. You can measure down to DC with two seperate DC-coupled inputs with industry standard 1-megohm input impedance. There's an external adjustable

HOW IT WORKS

The counter is constructed around Intersil's universal counter chip, the ICM7226B, which contains most of the circuitry necessary to produce a timer/counter. It combines a high frequency oscillator, a decade timebase counter, an 8 decade counter and latches, a 7 segment decoder, digit multiplexer and 8 segment and 8 digit driver for directly driving a common cathode LED display. The project can be divided into four sections for this discussion; the VHF front end, the LF front end, the 7226, and the power supplies.

VHF front end.
The basic element of the VHF front end is the prescaler IC from National Semiconductor (DS8629N). This unit provides the nescessary preamplification of the incoming signals to bring them up to the levels required to drive the digital logic. In addition, it prescales the input frequency by dividing it by a factor of 100. This block has a low input impedance needed by high frequency inputs and is protected from overloads by a resistor-capacitor-diode network. The output from this chip is a TTL compatible signal is the range of 100kHz to approximately 1.2MHz, and is applied through Sw7 to the input of the 7226 counter chip.

Low Frequency Front End.
The low frequency front end is comprised of an input attenuator, a J-FET preamplifier, resistor-diode input protection circuit, and a level adjustment circuit. The input attenuator allows the user to select the required sensitivity to prevent false triggering of the counter due to noise or spurious pulses applied to the input. Once the proper input signal level has been selected, the signal is applied to the J-FET preamp, which provides wideband amplification from DC to approximately 10MHz. The input sensitivity is typically 50mV at 10MHz.

IC1 is an op amp which inverts the incoming signal and performs two functions. It adjusts the trigger level by adding a DC component to the signal and it acts as a schmidt trigger to square up the signal before it is applied to the logic circuitry. Part of the trigger circuit allows you to aply an inverted or non-inverted signal to the 7226, giving you the capability of triggering on the positive or negative going edge of the waveform. This selection enables the measurement of time for periodic pulses and one shot events. The final output of the low frequency front end is a TTL compatible signal in the range from DC to approximately 10MHz, and is applied directly to the input of the 7226 counter chip. Note, there are two low frequency front end circuits used in this project, one for each input to the counter chip. The two channels are used in combination to measure time intervals of repetetive pulses or events, and in measuring the frequency ratio of two incoming frequencies. A complete discussion of the operation of these types of measurements is found in the description of the operating functions.

ICM7226 counter chip
As stated previously, the basic block of the counter is the Intersil ICM7226B decade counter chip. This counter can function as a frequency counter, period counter, frequency ratio (f_a/f_b) counter, time interval counter or as an event totalizer. The counter uses a 10MHz crystal timebase, and has an on-chip oscillator circuit. For period and time interval measurements, the 10MHz timebase is used to provide 0.1 uS resolution. In the frequency mode, gating times are user selectable from 0.01 sec, 0.1 sec, 1 sec or 10 sec ranges. A complete discussion of the various functions can be found in the list of operating functions and on the Intersil datasheet.

Power supplies
The final section is comprised four low current power supplies. The basic requirement is to supply well regulated power to the logic chips and the front end circuits. The four supplies are very simple and make extensive use of monolythic regulating ICs. The four supplies required are +10.5 Volts, +5.1 Volts, -10.0 Volts and -5.0 Volts. The printed circuit boards have been designed with the on-board supplies, including the power transformer.

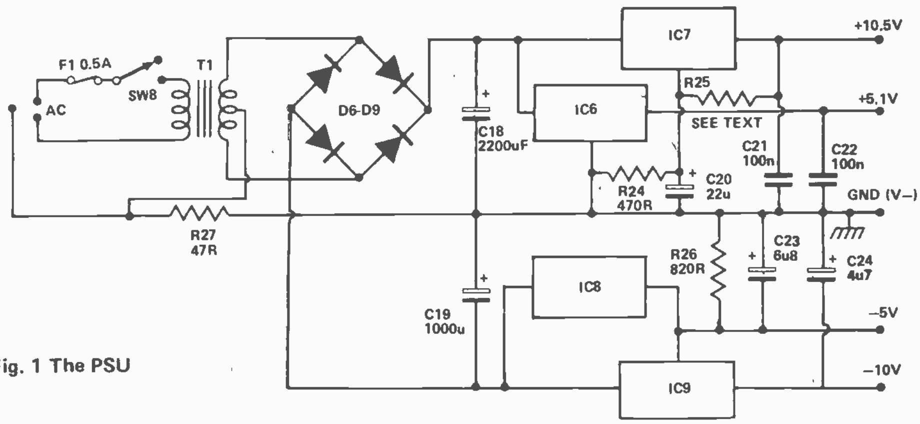


Fig. 1 The PSU

trigger-level control for each channel to adjust input sensitivity on either positive or negative-going signals. plus, there's an input attenuator to help protect the input from over-voltage conditions and to prevent damage in the event of overload. At about the 10MHz level, there is a second input circuit that takes over to extend the range of the 7226 to more than 120MHz. With this input you can measure signals from 150kHz to over 120MHz, with a sensitivity of about 50mV. This counter could work with a short whip antenna set up near your radio transmitter.

The display has some pretty special features as well. There is a LED eight-digit, half-inch display for easy reading, and leading-zero blanking of unused digits. A very important bonus is a switch selectable time-base. Most counters supply only a 1-second time-base, too short for many applications and too long for high frequency use. Our counter has a complete timebase with a 10-second gate time for audio work as well as selectable settings of 1 second, 0.1 second and 0.01 second for the best speed in measurement at full accuracy.

Construction of the counter is easy and straight forward, but, as with any project proper care must be taken in the work. Handling the IC's requires care to prevent static discharge from tools or fingers; check and double check the polarity of all the IC's, diodes and transistors before applying the power. Aside from these basic precautions, there are no special skills required. There are seven IC's that make up the bulk of the circuitry, plus a few other components. The careful board layout keeps the high frequency signals away form the digital display and minimizes the number of jumpers.

The circuit

As mentioned earlier, the counter is based on a single IC that contains the essential electronics for a complete universal counter. The schematic diagram shows the complete counter with three inputs — one for extended operation to 120MHz, and two inputs for basic operation from DC to about 10MHz. The reason for the seperate frequency ranges is that it is difficult and expensive to design a wide-band input circuit to handle this extreme range of input conditions. With two types of inputs, we can tailor each for maximum performance, and keep the cost low. If you wish to measure RF signals above 10MHz, you connect your signal to the input at the back of the enclosure. The signal is first applied to a combination preamplifier and ECL/TTL prescaler chip, where it is amplified and divided in frequency by a factor of 100. The result is then routed to SW7, which selects the 120MHz range or the 10MHz range. In our version, we mounted S1 on the rear apron of the enclosure beside the high frequency input.

On the other hand, if you want to apply a signal that falls in the range of DC to 10MHz, you would use the front panel connections. Notice that the input marked Channel A is the primary input used for all frequency, unit counting and period measurements. Channel B is used only in conjunction with Channel A for measurements of time intervals. More on how to use it later. From the input, the signal is amplified and converted to TTL levels, adjusted for trigger level sensitivity and slope, and applied to the counter chip. This chip contains the complete universal counter circuit including a crystal oscillator, time-base divider, control logic, eight decade counters, eight latches and display multiplexing circuits.

Construction

For best results, you should use PC boards to speed construction. The first matter of business in constructing the unit is to build up the power supply. The printed circuit board has been designed to accomodate the power transformer and all the power supply components. Use a fine tip soldering iron and the smallest gauge solder you have. All the components for the power supply except R25 can be installed. Be sure to polarize all the diodes, capacitors and the regulators correctly. Now, temporarily connect a 1k pot and a 220 ohm resistor in series, and place this combination into the circuit instead of R25. Apply power and check the voltages. Using the temporary 1k pot, adjust for 10.5 volt (point "h" on the PCB). Replace the pot-resistor combination with the nearest value fixed resistor for R25.

Thanks to that one big IC, the rest of the counter is easy to assemble. Mount all other components on the board, being careful to avoid solder bridges and to double check polarities. Use IC sockets for the large IC's. Once the main board is assembled, clean the bottom of the board with flux remover.

Prepare the front and back panel. In our version, all the controls except the high frequency input and control switch, are mounted on the front panel.

Assemble the display board using collared (insulated feedthrough) wirewrap pins soldered to both the

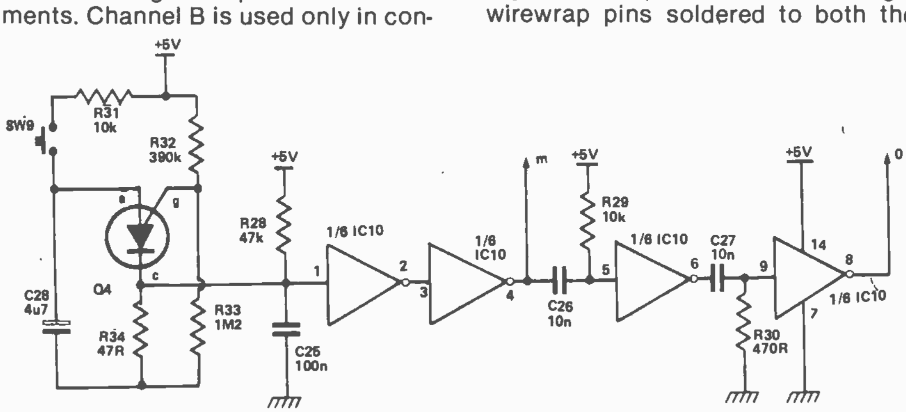


Fig. 2 The priming Circuit

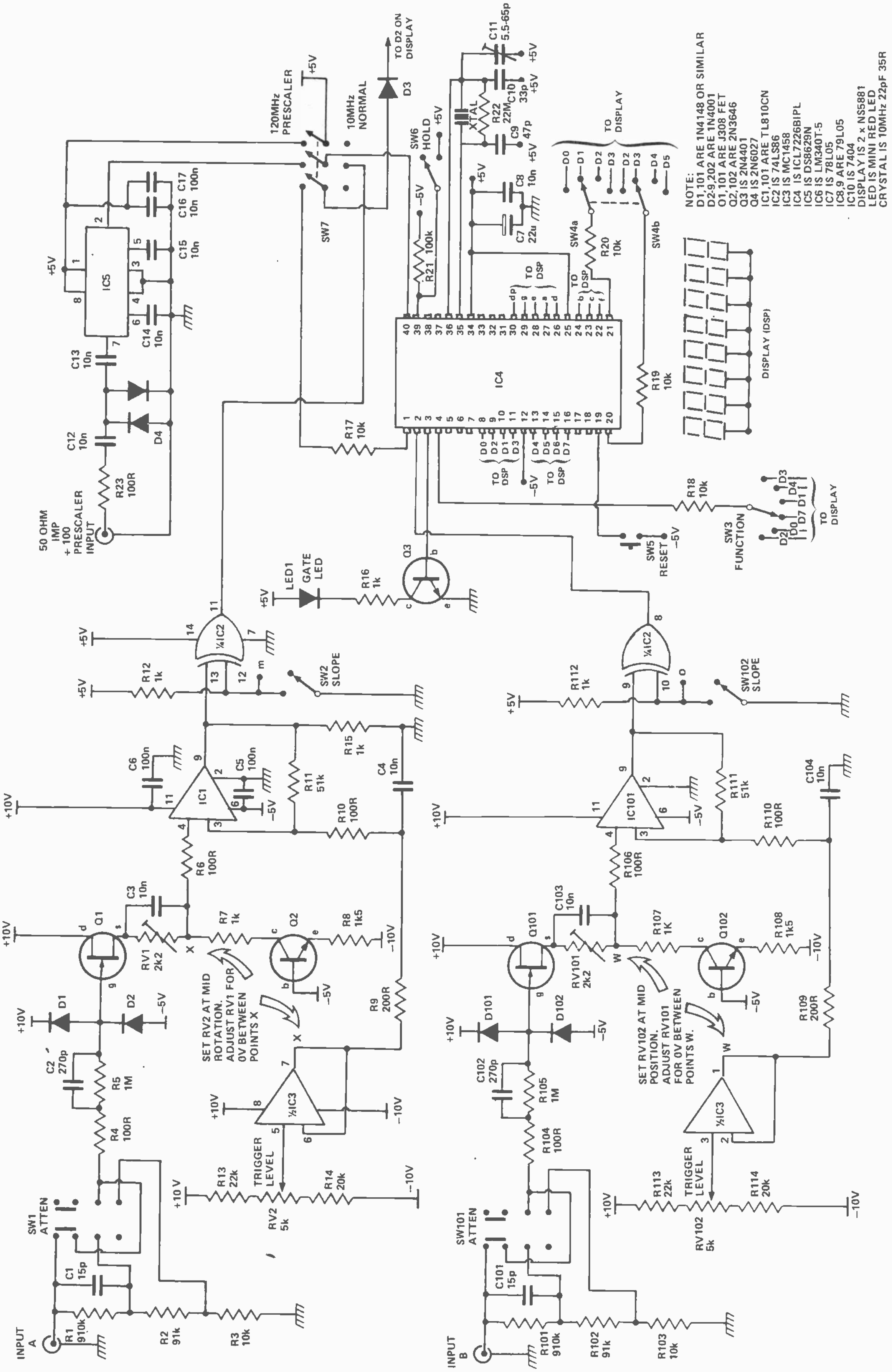


Fig.1. The circuit diagram

PARTS LIST

Resistors ¼W, 5%

R1,101	910K
R2,102	91K
R3,17, 18,19,20, 29,31,103	10K
R4,6,10, 23,104, 106,110	100R
R5,105	1M
R7,12,15,16, 107,112	1K
R8,108	1K5
R9,109	200R
R11,111	51K
R13,113	22K
R14,114	20K
R21	100K
R22	22M
R24,30	470R
R25	See Text
R26	820R
R27	47R, 2 Watt
R28	47K
R32	390K
R33	1M2
R38	47R

Switches

SW1,101	DP3T mini slide
SW2,102	SPST mini toggle
SW3	SP6T rotary
SW4	DP4T rotary
SW5	spst N/O mom.
SW6	SPST mini toggle
SW7	TPDT mini toggle
SW8	SPST toggle
SW9	SPST N/O mom.

Capacitors

C1,101	15pF ceramic 300V
C2,102	270pF ceramic 300V
C3,103 4,104	10nF mini
C5,6	100nF mini
C7	22uF 16V tantalum
C8	10nF mini
C9	47pF ceramic 5%
C10	33pF ceramic 5%
C11	5.5 - 65pF trimmer Phillips 010GA/60E
C12-16	10nF ceramic
C17	100nF ceramic
C18	2200uF 25V radial electrolytic
C19	1000uF 25V radial electrolytic
C20	22uF 16V tantalum
C21,22	100nF mini
C23	6u8 16V tantalum
C24,28	4u7 16V tantalum
C25	100nF mini
C26,27	10nF ceramic

Potentiometers

RV1,RV101	2k2 horiz trimmer
RV2,RV102	5k linear

Misc.

Transformer Hammond 161F20
Case Approx 7x9x3 inch
printed circuit board, knobs, ribbon cable, coax mini cable RG174/U fuse holder, power cord.

Semiconductors

D1,D101 D2,D202 D3,D4,D5 D6,D7	1N4148 or similar
D8,D9	1N4001
Q1,Q101	J308 FET
Q2,Q102	2N3646
Q3	2N4401
Q4	2N6027
IC1,IC101	TL810CN
IC3	MC1458
IC4	ICL7226BIPL
IC5	DS8629N
IC6	Lm340T-5 (do not use 7805)
IC7	78L05
IC8,IC9	79L05
IC2	74LS86
IC10	7404
display	2 x NSB5881
LED	mini red LED
Crystal	10MHz 22pF 35R

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display and the display board. Be sure to add the seven jumpers to the display board before the completed unit is mounted on the front panel.

Mount all the switches and controls on the front and back panels. Begin wiring up the interconnections by using the component overlay as a guide. The easiest method is to use a length of ribbon cable for all the interconnections. The signal cable must be a high quality shielded cable from the input jacks to the printed circuit board. Be sure to bring the cases of SW1 and SW101 and both trigger level pots to the ground (0 volts), or better yet bring the whole front and back panel to ground level. This prevents hum pick up or spurious coupling between the controls and the inputs.

A few very important precautions are necessary. Keep all signal carrying cables away from the 7226 and the display. The 500Hz multiplex frequency is easily induced into the front end circuit. Check and double check the polarity of the 7226 before applying power; this is a very expensive IC to destroy by applying reverse power.

Using coloured ribbon cable, connect the rotary switches to the PCB (see rotary switch detail drawing). Finally, secure the crystal to the board using a drop of silicon sealant.

Calibration

Calibrating the counter is a snap if you have a frequency standard available. Ideally, that standard should be better than ±0.0005% accurate at room temperature to get the maximum accuracy. Using a 10MHz source, connect the frequency standard and turn on the counter. For best results you should calibrate at room temperature and allow at leats five minutes for the counter to stabilize before starting. You should get a reading very close to 10MHz, then adjust trimmer capacitor C11 until the reading is exactly 10MHz. Disconnect the standard and you are ready to go.

If a standard is not available, use a source of known frequency, and adjust C11 for the closest reading possible. Always allow the equipment to warmup before taking any measurements to get the best accuracy. See the schematic for details on adjusting trim pots RV1, RV101.

Now that the counter is completed you will want to begin using your new test instrument. Be sure to connect your signal to the correct inputs, adjust the input attenuator for the correct signal levels; x1 for signals to 1V RMS; x10 for signals to 2V RMS; and x100 for signals over 2V RMS. These levels overlap.

Using the counter is straightforward and needs little explaination. Remember, that the decimal point denotes kilohertz for the low frequency inputs and megahertz for the VHF input. All times are in microseconds. If the prescaler oscillates, connect a 100k resistor from pin 6 to 0V on the bottom of the PCB. This reduces sensitivity and will get rid of any oscillations.

The counter has a wide range of functions to match the wide operating frequency range. The six basic functions that can be selected are:

Frequency measurement — Using the prescaler circuit, frequencies to more than 120MHz can be accurately measured, with little or no loading of the external circuit. By selecting the gating time, the accuracy of the reading is dependant only on the calibration of timebase oscillator of the 7226 counter. Signals of less than 10MHz are applied to the channel A input, which has an impedance of 1M.

Period measurements — The counter can handle input signals to approximately 2MHz in the period measurement mode. The 7226 provides an accurate timebase which is counted and gated by the incoming signal, the result being displayed and scaled in microseconds. The operation of the period measurements is such that the displayed value is an average reading, averaged over several measurement cycles. For period and time interval measurements, the 10MHz timebase gives a 0.1 microsecond resolution, that can be read down to the nanosecond range.

Time Interval — The time interval function allows you to measure the time between two events, such as the time between two pulses. This function requires either a repetitive signal applied to input A and B, or for the two inputs to be prepared before the signals are applied. This is the function of the priming circuit; it prepares the counter inputs for a single event on the two inputs. As input A goes negative the internal counter begins counting time in 0.1 microsecond units. When input B drops, the counter stops and displays the time interval between the two transitions. To initiate the counter into the primed one-shot mode, take the following steps. Set trigger level controls to 11:00 o'clock and scope switches to the open or non-inverting position. The function switch must be in the (time) mode and the range switch in the .01 - 1 range. Depress the prime switch and hold in momentarily. If the gate light does not go out then press reset and try the prime switch again. The gate light turning off indicates the unit is primed and the next transition at input A will start the count and A pause at input B will finish it, displaying the result in uSec. This function will display one-shot events from fractions of a uSec, to 10 Sec.

Unit counter — The counter can be used as a high speed unit or event counter. It can actually count at a rate of 120 million events per second, and display more than 90 million on the display. The operation is very straight-forward. By applying a signal to input A, which drops from a positive voltage level to a ground or negative voltage level, the counter will increment once for each positive to negative transition. The counter is returned to zero by depressing the RESET button, or the display may be held at any value by using the HOLD switch, The hold switch does not reset the counter; it simply prevents further input pulses from incrementing the count. Normal operation is continued upon returning the hold switch to the normal position.

Frequency Ratio — The Frequency ratio function allows you to display the relative ratio between two frequencies. In connecting two signals to input A and B, the higher frequency signal should be connected to input A. The resulting display is an average measurement of the ratio between the two inputs. For obvious reasons this ratio must always be equal to or greater than 1. The maximum frequency for this mode of operation is approximately 10MHz at input A and 2MHz at input B.

Oscillator — The counter can be used to monitor the internal timebase by selecting the OSCILLATOR function.

Continued on Page 59

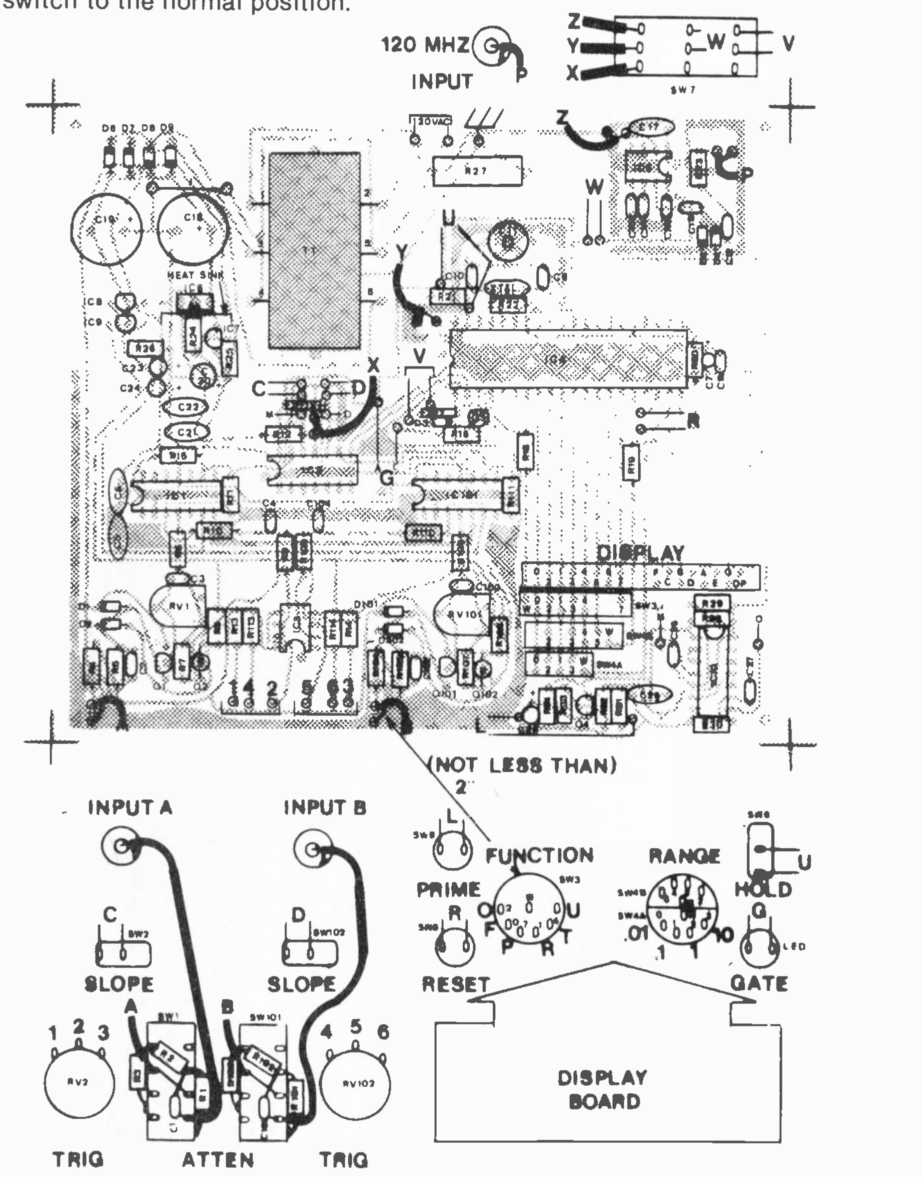


Fig. 4 Parts Placement

COAX

Electronics Today INTERNATIONAL

NEXT MONTH

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

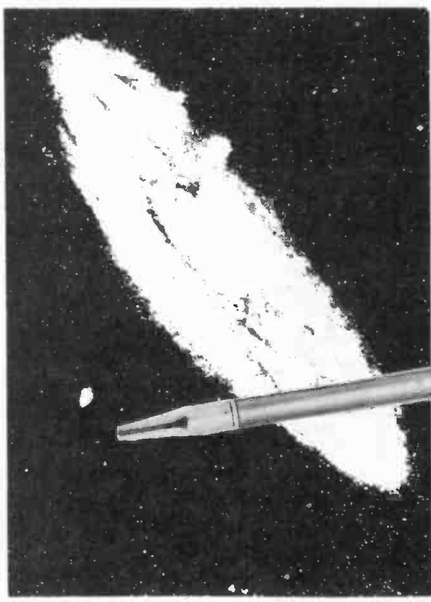
JANUARY

Loudspeaker Design Principles
Next month, David Tilbrook will be completing his discussion of loudspeaker design, and we'll be presenting a construction project to show you how to build a first rate four way system. This is a speaker system that will grace any stereo, unless you play a lot of Anne Murray, in which case you really don't deserve it.

1981 Index
If you've been planning on having your issues of ETI bound in wombat hide and turned into valuable reference works to treasure and pass onto your children (and who wouldn't), you'll definitely want the '81 index.

Stores Survey
Getting parts for projects can be a problem, especially if you live in someplace that really wasn't designed for human habitation. . . like Ottawa. Next month, we'll be presenting a list of all the Canadian electronics stores we could find, several of which will still accept payment in beaver pelts.

SLR Electronics
The electronics inside cameras have been getting extremely sophisticated over the years. Next year's new models are expected to include sixteen bit micro-processor image evaluation systems that de-activate the shutter when the lens is focused on someone particularly ugly, and a voice synthesizer to go 'say cheese'. A look inside, next month.

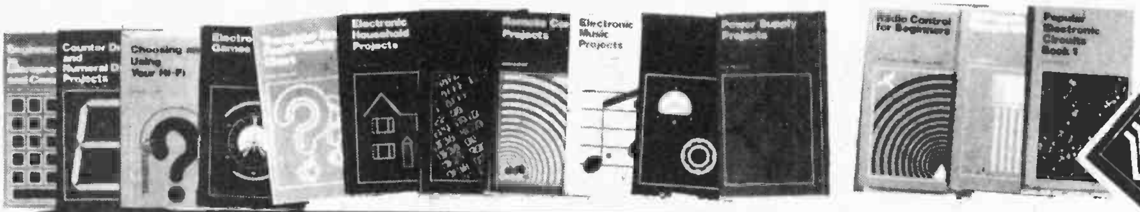


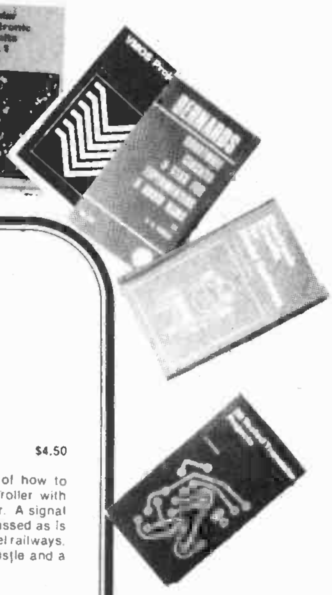
Big Bang
Yes, we were planning a short bit on electronics in guerilla warfare, but this isn't it. Several years ago, it seems there was this large explosion which caused here to be. Terribly handy, as without it, the universe would be much smaller, and we'd be having a nasty time finding readers.

Temperature Controlled Soldering Iron
If your soldering iron is too hot, it can damage delicate PCB tracks, incinerate parts, and, in extreme cases, give you a sunburn. This little project gives you full control over the amount of heat it emits.

Plus!
- News!
- Tech tips
- Computing Today
- Informative Canadian Ads
- The Secret of The Universe

(If we come across it by then)





BABANI BOOKS

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This book is divided into three parts: Part I, understanding audio IC's, Part II, Pre-amplifiers, Mixers and Tone Controls, Part III Power Amplifiers and Supplies. Includes practical constructional details of pure IC and Hybrid IC and Transistor designs from about 250mW to 100W output.

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F.G.RAYER, T.Eng.(CEI),Assoc.IERE
Relays, silicon controlled rectifiers (SCR's) and bi-directional triodes (TRIACs) have a wide range of application in electronics today. This book gives tried and practical working circuits which should present the minimum of difficulty for the enthusiast to construct. In most of the circuits there is a wide latitude in component values and types, allowing easy modification of circuits or ready adaptation of them to individual needs.

BP39: 50 (FET) FIELD EFFECT TRANSISTOR PROJECTS $5.50
F.G. RAYER, T.Eng.(CEI),Assoc.IERE
Field effect transistors (FETs), find application in a wide variety of circuits. The projects described here include radio frequency amplifiers and converters, test equipment and receiver aids, tuners, receivers, mixers and tone controls, as well as various miscellaneous devices which are useful in the home.

This book contains something of particular interest for every class of enthusiast — short wave listener, radio amateur, experimenter or audio devotee.

BP42: 50 SIMPLE L.E.D. CIRCUITS $3.55
R.N. SOAR
The author of this book, Mr. R.N. Soar, has compiled 50 interesting and useful circuits and applications, covering many different branches of electronics, using one of the most inexpensive and freely available components — the Light Emitting Diode (L.E.D.). A useful book for the library of both beginner and more advanced enthusiast alike.

BP44: IC 555 PROJECTS $7.55
E.A. PARR, B.Sc.,C.Eng., M.I.E.E.
Every so often a device appears that is so useful that one wonders how life went on before without it. The 555 timer is such a device. Included in this book are Basic and General Circuits, Motor Car and Model Railway Circuits, Alarms and Noise Makers as well as a section on the 556, 558 and 559 timers.

BP46: RADIO CIRCUITS USING IC's $5.90
J.B. DANCE, M.Sc.
This book describes integrated circuits and how they can be employed in receivers for the reception of either amplitude or frequency modulated signals. The chapter on amplitude modulated (a.m.) receivers will be of most interest to those who wish to receive distant stations at only moderate audio quality, while the chapter on frequency modulation (f.m.) receivers will appeal to those who desire high fidelity reception.

BP47: MOBILE DISCOTHEQUE HANDBOOK $5.90
COLIN CARSON
The vast majority of people who start up "Mobile Discos" know very little about their equipment or even what to buy. Many people have wasted a "small fortune" on poor, unnecessary or badly matched apparatus.

The aim of this book is to give you enough information to enable you to have a better understanding of many aspects of "disco" gear.

BP48: ELECTRONIC PROJECTS FOR BEGINNERS $5.90
F.G. RAYER, T.Eng.(CEI), Assoc.IERE
Another book written by the very experienced author — Mr. F.G. Rayer — and in it the newcomer to electronics, will find a wide range of easily made projects. Also, there are a considerable number of actual component and wiring layouts, to aid the beginner.

Furthermore, a number of projects have been arranged so that they can be constructed without any need for soldering and, thus, avoid the need for a soldering iron.

Also, many of the later projects can be built along the lines as those in the 'No Soldering' section so this may considerably increase the scope of projects which the newcomer can build and use.

BP65: SINGLE IC PROJECTS $6.55
R.A.PENFOLD
There is now a vast range of ICs available to the amateur market, the majority of which are not necessarily designed for use in a single application and can offer unlimited possibilities. All the projects contained in this book are simple to construct and are based on a single IC. A few projects employ one or two transistors in addition to an IC but in most cases the IC is the only active device used.

BP66: BEGINNERS GUIDE TO MICROPROCESSORS AND COMPUTING $7.55
E.F. SCOTT, M.Sc., C.Eng.
As indicated by the title, this book is intended as an introduction to the basic theory and concepts of binary arithmetic, microprocessor operation and machine language programming.

There are occasions in the text where some background information might be helpful and a Glossary is included at the end of the book.

BP67: COUNTER DRIVER AND NUMERAL DISPLAY PROJECTS $7.55
F.G. RAYER, T.Eng.(CEI), Assoc. IERE
Numeral indicating devices have come very much to the forefront in recent years and will, undoubtedly, find increasing applications in all sorts of equipment. With present day integrated circuits, it is easy to count, divide and display numerically the electrical pulses obtained from a great range of driver circuits.

In this book many applications and projects using various types of numeral displays, popular counter and driver IC's etc. are considered.

BP68: CHOOSING AND USING YOUR HI-FI $7.25
MAURICE L. JAY
The main aim of this book is to provide the reader with the fundamental information necessary to enable him to make a satisfactory choice from the extensive range of hi-fi equipment now on the market.

Help is given to the reader in understanding the equipment he is interested in buying and the author also gives his own opinion of the minimum standards and specifications one should look for. The book also offers helpful advice on how to use your hi-fi properly so as to realise its potential. A Glossary of terms is also included.

BP69: ELECTRONIC GAMES $7.55
AUTHOR: R.A. PENFOLD
In this book Mr. R. A. Penfold has designed and developed a number of interesting electronic game projects using modern integrated circuits. The text is divided into two sections, the first dealing with simple games and the latter dealing with more complex circuits.

BP70: TRANSISTOR RADIO FAULT-FINDING CHART $2.40
AUTHOR: CHAS. E. MILLER
Across the top of the chart will be found four rectangles containing brief descriptions of these faults: vis: — sound weak but undistorted: set dead, sound low or distorted and background noises. One then selects the most appropriate of these and following the arrows, carries out the suggested checks in sequence until the fault is cleared.

BP71: ELECTRONIC HOUSEHOLD PROJECTS $7.70
AUTHOR: R. A. PENFOLD
Some of the most useful and popular electronic construction projects are those that can be used in or around the home. The circuits range from such things as '2 Tone Door Buzzer', Intercom, through Smoke or Gas Detectors to Baby and Freezer Alarms.

BP72: A MICROPROCESSOR PRIMER $7.70
AUTHOR: E.A. PARR, B.Sc., C.Eng., M.I.E.E.
A newcomer to electronics tends to be overwhelmed when first confronted with articles or books on microprocessors. In an attempt to give a painless approach to computing, this small book will start by designing a simple computer and because of it simplicity and logical structure, the language is hopefully easy to learn and understand. In this way, such ideas as Relative Addressing, Index Registers etc. will be developed and it is hoped that these will be seen as logical progressions rather than arbitrary things to be accepted but not understood.

213: ELECTRONIC CIRCUITS FOR MODEL RAILWAYS $4.50
M.H. BABANI, B.Sc.(Eng.)
The reader is given constructional details of how to build a simple model train controller; controller with simulated inertia and a high power controller. A signal system and lighting for model trains is discussed as is the suppression of RF interference from model railways. The construction of an electronic steam whistle and a model train chuffer is also covered.

221: 28 TESTED TRANSISTOR PROJECTS $5.50
R.TORRENS
Mr. Richard Torrens is a well experienced electronics development engineer and has designed, developed, built and tested the many useful and interesting circuits included in this book. The projects themselves can be split down into simpler building blocks, which are shown separated by boxes in the circuits for ease of description, and also to enable any reader who wishes to combine boxes from different projects to realise ideas of his own.

223: 50 PROJECTS USING IC CA3130 $5.50
AUTHOR: R.A.PENFOLD
In this book, the author has designed and developed a number of interesting and useful projects which are divided into five general categories: I — Audio Projects II — R.F. Projects III — Test Equipment IV — Household Projects V — Miscellaneous Projects.

224: 50 CMOS IC PROJECTS $4.25
R.A. PENFOLD
CMOS IC's are probably the most versatile range of digital devices for use by the amateur enthusiast. They are suitable for an extraordinary wide range of applications and are also some of the most inexpensive and easily available types of IC.

Mr. R.A. Penfold has designed and developed a number of interesting and useful projects which are divided into four general categories: I — Multivibrators II — Amplifiers and Oscillators III — Trigger Devices IV — Special Devices.

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BP24: 50 PROJECTS USING IC741 $4.25
RUDI & UWE REDMER
This book originally published in Germany by TOPP has achieved phenomenal sales on the Continent and Babani decided, in view of the fact that the integrated circuit used in this book is inexpensive to buy, to make this unique book available to the English speaking reader. Translated from the original German with copious notes, data and circuitry, "must" for everyone whatever their interest in electronics.

BP33: ELECTRONIC CALCULATOR USERS HANDBOOK $4.25
M.H. BABANI, B.Sc.(Eng.)
An invaluable book for all calculator users whatever their age or occupation, or whether they have the simplest or most sophisticated of calculators. Presents formulae, data, methods of calculation, conversion factors, etc., with the calculator user especially in mind, often illustrated with simple examples. Includes the way to calculate using only a simple four function calculator: Trigonometric Functions (Sin, Cos, Tan): Hyperbolic Functions (Sinh, Cosh, Tanh) Logarithms, Square Roots and Powers.

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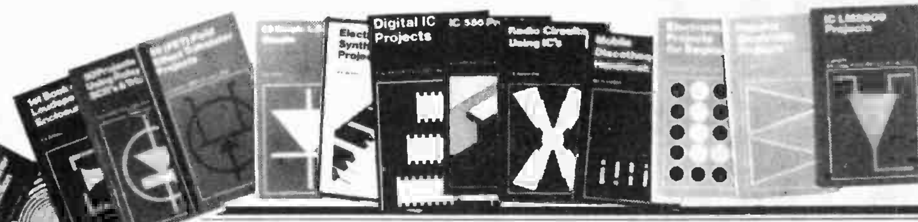

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BP81: ELECTRONIC SYNTHESISER PROJECTS $7.30
M.K. BERRY
One of the most fascinating and rewarding applications of electronics is in electronic music and there is hardly a group today without some sort of synthesiser or effects generator.

Although an electronic synthesiser is quite a complex piece of electronic equipment, it can be broken down into much simpler units which may be built individually and these can then be used or assembled together to make a complete instrument.

BP83: VMOS PROJECTS $8.20
R.A. PENFOLD
Although modern bipolar power transistor give excellent results in a wide range of applications, they are not without their drawbacks or limitations. This book will primarily be concerned with VMOS power FETs although power MOSFETs will be dealt with in the chapter on audio circuits. A number of varied and interesting projects are covered under the main heading of: Audio Circuits, Sound Generator Circuits, DC Control Circuits and Signal Control Circuits.

BP84: DIGITAL IC PROJECTS $8.10
F.G. RAYER, T.Eng.(CEI),Assoc.IERE
This book contains both simple and more advanced projects and it is hoped that these will be found of help to the reader developing a knowledge of the workings of digital circuits.

To help the newcomer to the hobby the author has included a number of board layouts and wiring diagrams. Also the more ambitious projects can be built and tested section by section and this should help avoid or correct faults that could otherwise be troublesome.

An ideal book for both beginner and more advanced enthusiast alike.

BP85: INTERNATIONAL TRANSISTOR EQUIVALENTS GUIDE $12.25
AUTHOR: ADRIAN MICHAELS
This book will help the reader to find possible substitutes for a popular user-orientated selection of modern transistors. Also shown are the material type, polarity, manufacturer selection of modern transistors. Also shown are the material type, polarity, manufacturer and use. The Equivalent are sub-divided into European, American and Japanese. The products of over 100 manufacturers are included.

An essential addition to the library of all those interested in electronics, be they technicians, designers, engineers or hobbyists.

Fantastic value for the amount of information it contains.

BP86: AN INTRODUCTION TO BASIC PROGRAMMING TECHNIQUES $8.25
AUTHOR: S. DALY
This book is based on the authors own experience in learning BASIC and in helping others, mostly beginners, to program and understand the language.

Also included are a program library containing various programs, that the author has actually written and run, these are for biorhythms, plotting a graph of Y against X, standard deviation, regression, generating a musical note sequence and a card game.

The book is complemented by a number of appendices which include test questions and answers on each chapter and a glossary.

BP87: SIMPLE L.E.D. CIRCUITS $5.90
AUTHOR: R.N. SOAR
Since it first appeared in 1977, Mr. R.N. Soar's book has proved very popular. The author has developed a further range of circuits and these are included in Book 2. Projects include a Transistor Tester, Various Voltage Regulators, Testers and so on.

205: FIRST BOOK OF HI-FI LOUDSPEAKER ENCLOSURES $3.55
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This book gives data for building most types of loudspeaker enclosure. Includes corner reflex, bass reflex, exponential horn, folded horn, tuned port, klipschorn labyrinth, tuned column, loaded port and multi speaker panoramic. Many clear diagrams for every construction showing the dimensions necessary.

BP80: POPULAR ELECTRONIC CIRCUITS — BOOK 1 $8.25
R.A. PENFOLD
Another book by the very popular author, Mr. R.A. Penfold, who has designed and developed a large number of various circuits. These are grouped under the following general headings; Audio Circuits, Radio Circuits, Test Gear Circuits, Music Project Circuits, Household Project Circuits and Miscellaneous Circuits.

BP90: AUDIO PROJECTS $8.10
AUTHOR: F.G. RAYER
Covers in detail the construction of a wide range of audio projects. The text has been divided into preamplifiers and mixers, power amplifiers, tone controls and matching and miscellaneous projects.

BP49: POPULAR ELECTRONIC PROJECTS $6.25
R.A. PENFOLD
Includes a collection of the most popular types of circuits and projects which, we feel sure, will provide a number of designs to interest most electronics constructors. The projects selected cover a very wide range and are divided into four basic types: Radio Projects, Audio Projects, Household Projects and Test Equipment.

BP 50: IC LM3900 PROJECTS $5.90
H.KYBETT,B.Sc., C.Eng.
The purpose of this book is to introduce the LM3900 to the Technician, Experimenter and the Hobbyist. It provides the groundwork for both simple and more advanced uses, and is more than just a collection of simple circuits or projects.

Simple basic working circuits are used to introduce this IC. The LM3900 can do much more than is shown here, this is just an introduction. Imagination is the only limitation with this useful and versatile device. But first the reader must know the basics and that is what this book is all about.

BP51: ELECTRONIC MUSIC AND CREATIVE TAPE RECORDING $5.50
M.K. BERRY
Electronic music is the new music of the Twentieth Century. It plays a large part in "pop" and "rock" music and, in fact, there is scarcely a group without some sort of synthesiser or other effects generator.

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

No. 215: Shortwave Circuits & Gear For Experimenters & Radio Hams $3.70
Covers constructional details of a number of projects for the shortwave enthusiast and radio "Ham". Included are: an add-in crystal filter, adding an "S" meter in your receiver; crystal locked H.F. Receiver; AM tuner using phase locked loop; converter for 2MHz, 40 to 800 MHz RF amplifier, Aerials for the 52, 144MHz bands, Solid State Crystal Frequency Calibrator, etc.

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AUTHOR: F.A. WILSON, C.G.I.A., C.Eng.,

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The aim of this series of books can be stated quite simply — it is to provide an inexpensive introduction to modern electronics so that the reader will start on the right road by thoroughly understanding the fundamental principles involved.

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

Each book is a complete treatise of a particular branch of the subject and, therefore, can be used on its own with one proviso, that the later books do not duplicate material from their predecessors, thus a working knowledge of the subjects covered by the earlier books is assumed.

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This book is aimed primarily at the electronics enthusiast who wishes to experiment with remote control. Full explanations have been given so that the reader can fully understand how the circuits work and can more easily see how to modify them for other purposes, depending on personal requirements. Not only are Radio control systems considered buy also Infra-red, visible light and Ultrasonic systems as are the use of Logic ICs and Pulse position modulation etc.

BP74: ELECTRONIC MUSIC PROJECTS $7.70
R.A. PENFOLD
Although one of the more recent branches of amateur electronics, electronic music has now become extremely popular and there are many projects which fall into this category.

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

BP75: ELECTRONIC TEST EQUIPMENT CONSTRUCTION $7.30
F.G. RAYER, T.Eng. (CEI), Assoc. IERE
This book covers in detail the construction of a wide range of test equipment for both the Electronics Hobbyists and Radio Amateur. Included are projects ranging from an FET Amplified Voltmeter and Resistance Bridge to a Field Strength Indicator and Heterodyne Frequency Meter. Not only can the home constructor enjoy building the equipment but the finished projects can also be usefully utilised in the furtherance of his hobby.

BP76: POWER SUPPLY PROJECTS $7.30
R.A. PENFOLD
Line power supplies are an essential part of many electronics projects. The purpose of this book is to give a number of power supply designs, including simple unstabilised types, fixed voltage regulated types, and variable voltage stabilised designs, the latter being primarily intended for use as bench supplies for the electronics workshop. The designs provided are all low voltage types for semiconductor circuits.

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

BP78: PRACTICAL COMPUTER EXPERIMENTS $7.30
E.A. PARR, B.Sc., C.Eng., M.I.E.E.
Curiously most published material on the microprocessor tends to be of two sorts, the first treats the microprocessor as a black box and deals at length with programming and using the "beast". The second type of book deals with the social impact. None of these books deal with the background to the chip, and this is a shame as the basic ideas are both interesting and simple.

This book aims to fill in the background to the microprocessor by constructing typical computer circuits in discrete logic and it is hoped that this will form a useful introduction to devices such as adders, memories, etc. as well as a general source book of logic circuits.

BP79: RADIO CONTROL FOR BEGINNERS $7.30
F.G. RAYER, T.Eng.(CEI),Assoc.IERE
The aim of this book is to act as an introduction to Radio Control for beginners to the hobby. The book will commence by dealing with the conditions that are allowable for such things as frequency and power of transmission. This is followed by a "block" explanation of how control-device and transmitter operate and receiver and actuator(s) produce motion in a model.

Details are then given of solid state transmitting equipment which the reader can build. Plain and loaded aerials are then discussed and so is the field-strength meter to help with proper setting up.

The radio receiving equipment is then dealt with which includes a simple receiver and also a crystal controlled superhet. The book ends with the electro-mechanical means of obtaining movement of the controls of the model.

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BANDPASS & BEYOND

Here's some more from Mr. Orr. Our circuit specialist looks at the development of bandpass design, switched capacitor techniques and some new ICs.

MANY MACHINES SUCH AS SPECTRUM analysers and vocoders use analysing filter banks; these are often quarter octave devices extending over six octaves. If quarter octave filtering is to be successful then the bandpass filter responses must be very sharp, having almost flat tops and a fast roll-off slope at either side. A poor slope would mean that the filter bank would not be able to resolve incoming signals; for example a sinewave might give a high output in several of the channels. Also, a very peaky response would give large interfilter 'dips' in the overall response (Fig. 1). An approximation of the square ideal resonse can be obtained by using multiple tuned filters. The response of a single pole bandpass filter is shown in Fig. 2.

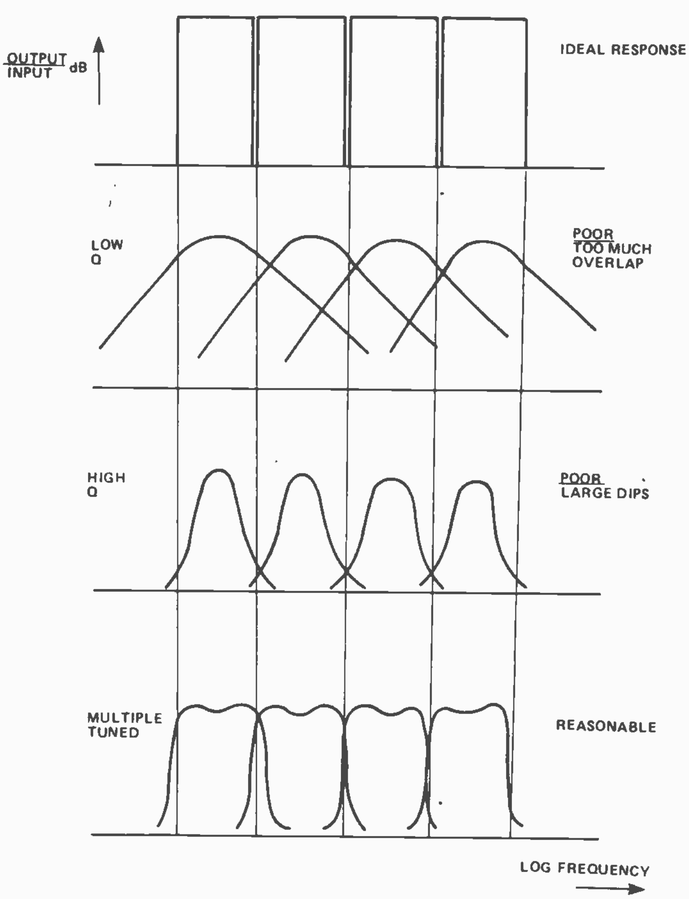


Fig. 1. Various responses of an analysing filter bank.

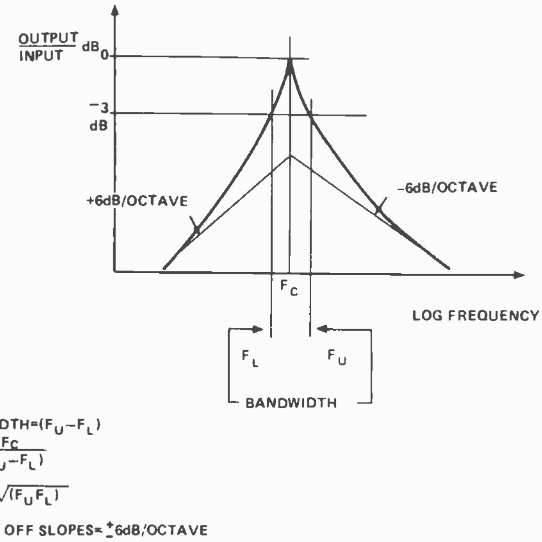


Fig. 2. Single pole bandpass response.

By Design

When designing bandpass filters it is important to decide what type of filters to use. Figure 3 shows two bandpass responses. Response A is a peaky filter, whereas B has a flat top to it, but still has the same roll off as A. One sensible design solution would be to use bandpass filters for A, and a highpass/lowpass structure for B. A rule of thumb for making this decision is to calculate the fractional bandwidth:

$$\frac{F_U - F_L}{F_U \times F_L}$$

If this is greater than unity then use lowpass/highpass filters; if it is less than unity use multiple tuned band pass filters. Some standard bandpass filter designs are shown in Fig. 4. The multiple feedback circuit requires only one op-amp, but is limited to low Q operation (less than 5) and the centre frequency and Q are interactive.

The state variable design can produce high Q factors of the order of several hundred. Tuning is performed by changing the R and/or C components. The Q factor is independently variable and is invariant with changes in frequency.

The biquadratic design is similar to the state variable filter. Tuning is performed by changing the R and/or C components and the Q factor is determined by the ratio of Rq to R. As it is tuned to operate at higher frequencies the Q factor will increase linearly in proportion to that frequency.

A voltage controlled biquadratic filter is shown in Fig. 5. This employs the relatively new CA3280, which is a dual improved performance version of the CA3080. As the Q factor is a function of frequency, the useful operating range is about 20 to 1.

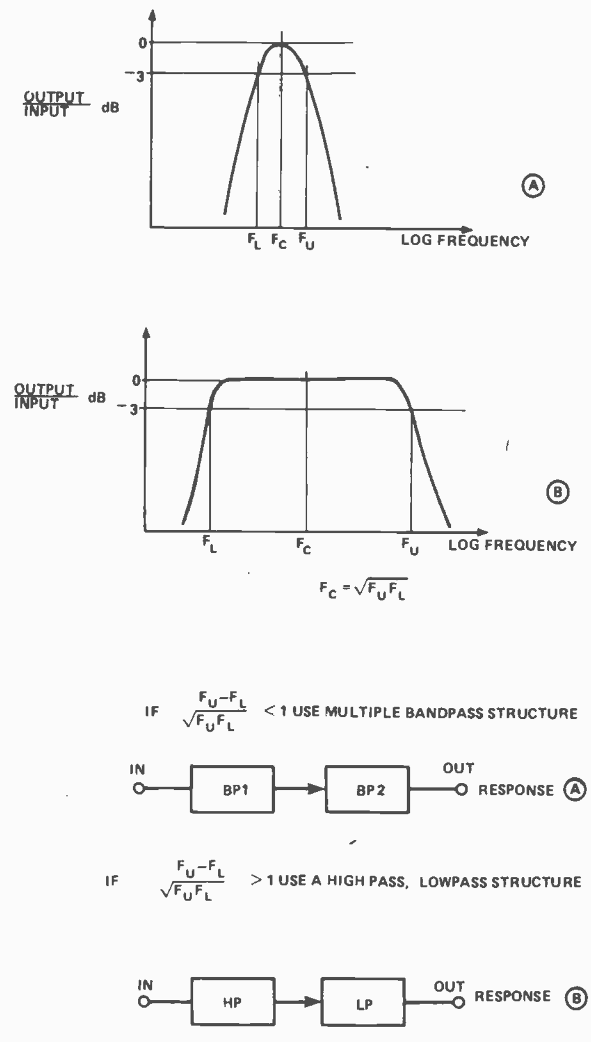


Fig. 3. Two bandpass resonses and how to realise them.

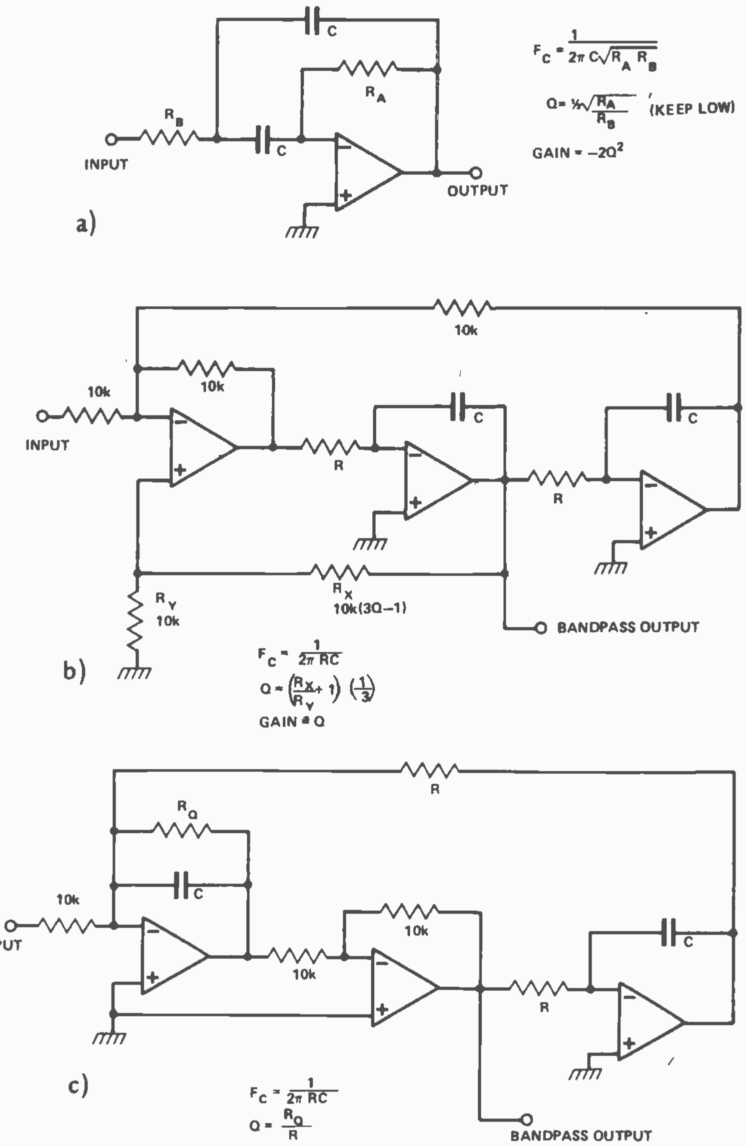


Fig. 4. Standard bandpass filter designs. a) Multiple feedback. b) State variable. c) Biquadratic.

A simple analysing octave filter bank is shown in Fig. 6. this is implemented using double tuned filters with Q factors of five. The component values for two channels are shown in the table of Fig. 6a. Note that some compromises will have to be made in order to implement the design using low cost resistors. For example, a 255k resistor could be made using two 510k resistors in parallel. The filter bank is converted into a spectrum analyser by adding an envelope follower to each channel and then multiplexing the envelope voltages into an XY display (Fig. 6c).

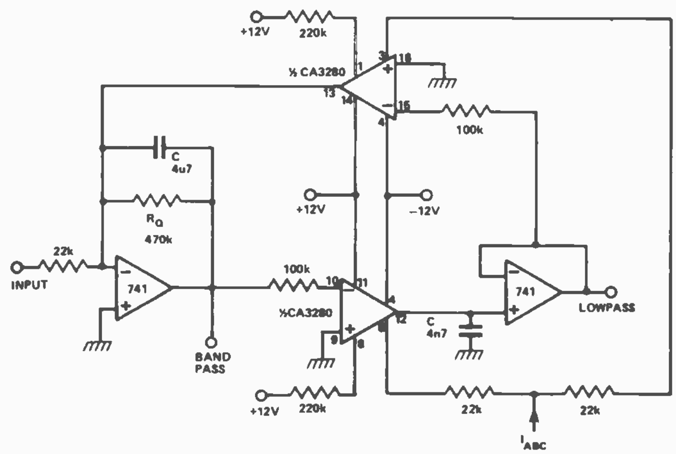
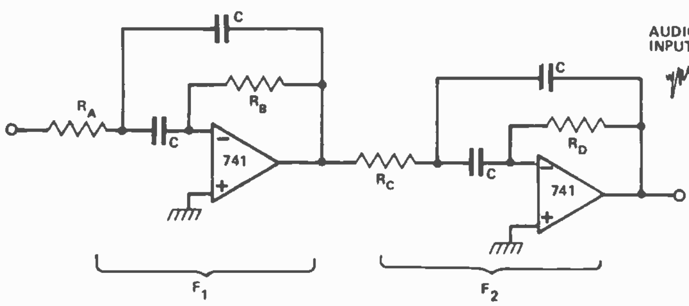


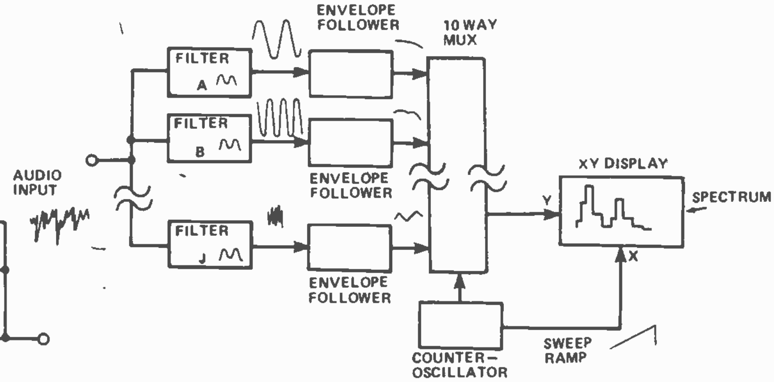
Fig. 5. A voltage-controlled biquadratic filter. Note that the CA3280 has two +12V supplies (pins 14 and 11) but only one −12V supply (pin 4). (We don't know why either.)

Other Design Applications

Figure 7 shows a design for a parametric audio equalizer. This device has variable cut and lift and a resonance and frequency control. The resonance control is arranged such that as the Q increases, the input signal is attenuated (RV2a), thus maintaining the same overall gain at resonance, independent of the Q setting. The filter is a state variable design which is situated in the feedback/feedforward loop of an op-amp. Thus RV3 controls whether overall response is a bandpass cut or lift. The resonant frequency is tuned by RV1 and SW1 is used to switch frequency ranges. The Q factor is set by RV2.

R_A	R_B	C	F_1	Q	R_C	R_D	C	F_2	Q	
3k6	360k	15n	290Hz	5	5k1	510k	15n	205Hz	5	FILTER D
1k8	180k	15n	580Hz	5	2k55	255k	15n	410Hz	5	FILTER E





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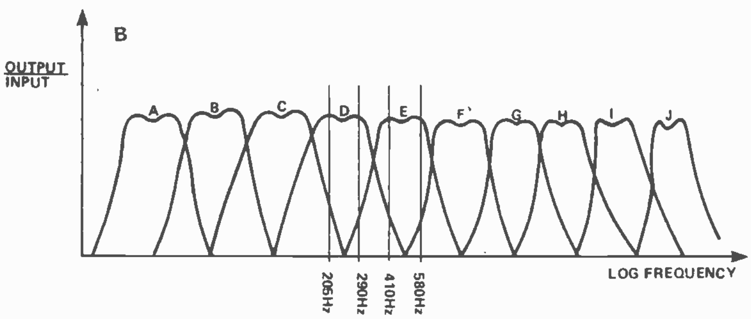


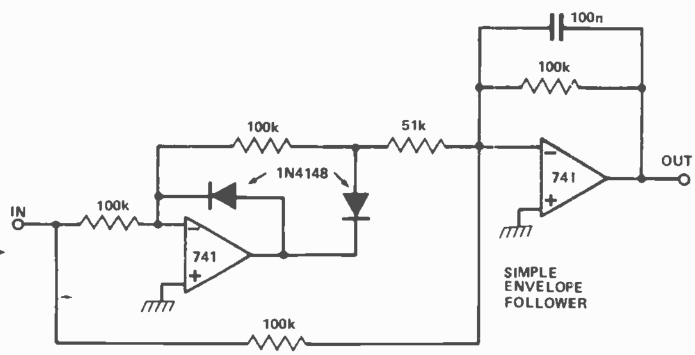


Fig. 6. An analysing filter bank suitable for a spectrum analyser. a) Circuit for each of the ten filter stages (A to J), and component values for two of the stages. b) Graph of the ten filter responses. c) Block diagram of the spectrum analyser and a suitable circuit for the envelope follower.

The TCA580N (Signetics) is an IC that can be used to simulate an inductance and in doing so may be used to synthesize many conventional LCR filter circuits (Fig. 8). The device has a pair of floating input terminals which generate the impression of being an inductor. This inductor is programmed by three passive components, R_{G_1}, R_{G_2}, C_2. By connecting a capacitor (C_1) across the input terminals, a parallel resonant circuit (C_1L) is produced.

Moving Story?

The SSM2040 is a four section mobile filter that can be exponentially voltage controlled over a 10,000 to 1 frequency range. The device contains an exponential function generator that controls four variable transconductance amplifiers each having their own output buffers. The IC may be used for electronic music synthesis, musical effects, tracking filters and many other applications where filter mobility is needed.

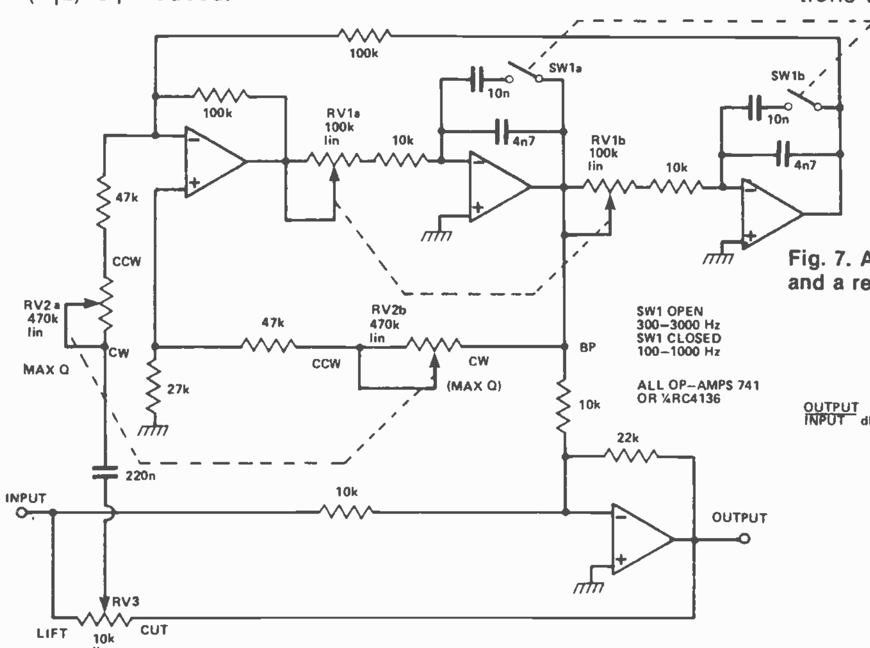
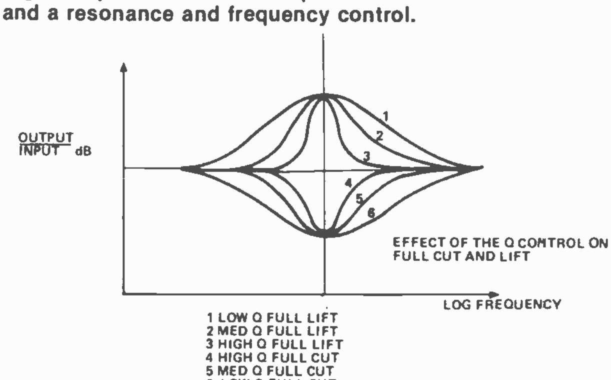


Fig. 7. A parametric audio equaliser with variable cut and lift and a resonance and frequency control.



A four pole lowpass filter for electronic music is shown in Fig. 9. Each stage is a single pole mobile lowpass filter, four of these filters are connected up in cascade and fed into an output amplifier. A resonance feedback route is provided so that the Q factor may be manually controlled. The voltage control of frequency is set to − 1 V/octave.

By modifying the external components, the device can be transformed into an all pass filter, (Fig. 10). This filter has a flat amplitude response and a phase shift that changes by 180° as a function of frequency. As the SSM2040 has four stages, the whole filter has a variable 720° phase shift. When the filter output is mixed with the original signal, two notches are produced in the frequency resonse occuring when the phase between the original and phase shifted signal is 180° and 540°.

As the phase shift is slowly modulated up and down in frequency, the notches also move producing the characteristic phasing sound.

Monomania

Monolithic filters are becoming more and more common. One such device that lends itself to integration is the transversal filter. Fig. 11a. This device can produce a steep roll-off slope, a high out-of-band attenuation and most significantly a linear phase response. The transversal filter is a tapped analogue delay line. The input signal is sampled and this sample moves down along a bucket brigade delay line. Each bucket has a separate output so that the signal may be monitored at each stage via a weighting resistor. It is possible to weight the resistors such that they draw out the impulse resonse of the required filter performance.

When fed with an input signal that is being shifted down a delay line, this impulse response results in it being converted into a frequency response. The filter frequency is directly linked to the clock frequency, and thus it is impossible to make the transversal filter mobile.

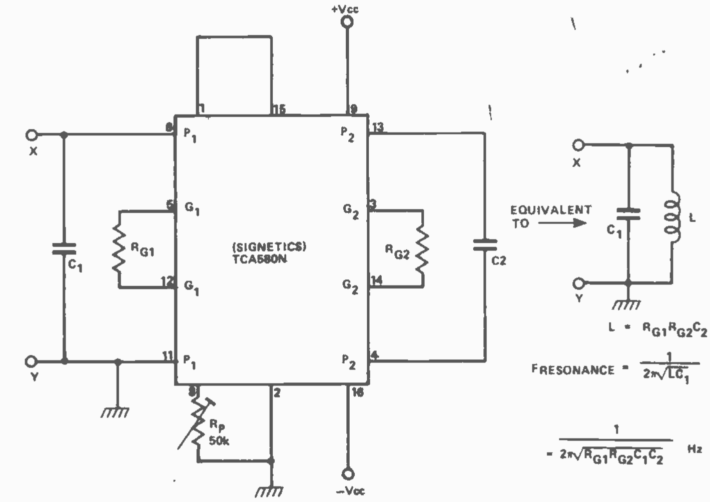
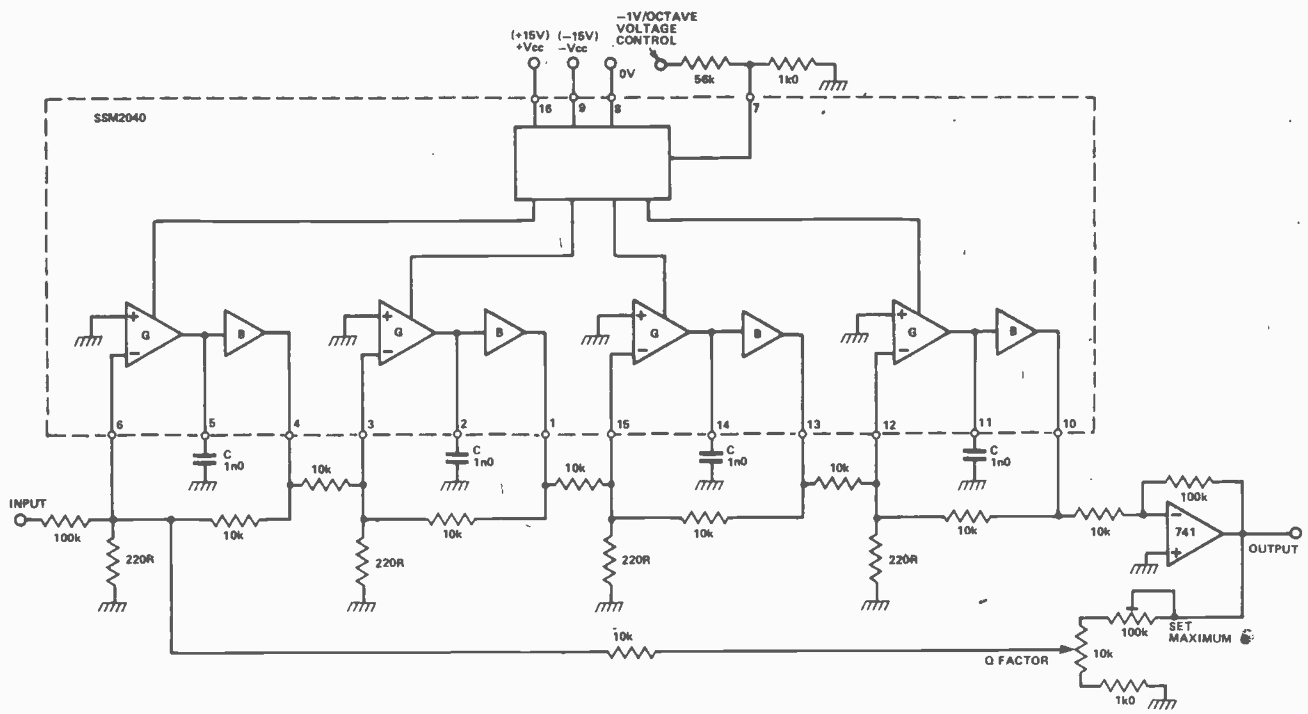


Fig. 8. A monolithic gyrator using the TCA580N. It can simulate inductances up to one millihenry.

+Vcc TO −Vcc	14V
SUPPLY CURRENT	0.8mA
Q FACTOR(200Hz)	500 TO 5000
MAXIMUM SIMULATED INDUCTANCE	1mH
FREQUENCY RANGE	DC TO 10kHz

It is necessary, as with all sampled data systems, to precede the device with an antialiasing filter and to recover the signal. There are now several transversal filters available, but they are still relatively expensive and are best used only where linear phase response is of prime importance.

Fig. 9. A four pole lowpass filter using the SSM2040. The transconductance amps are labelled G and their output buffers B.



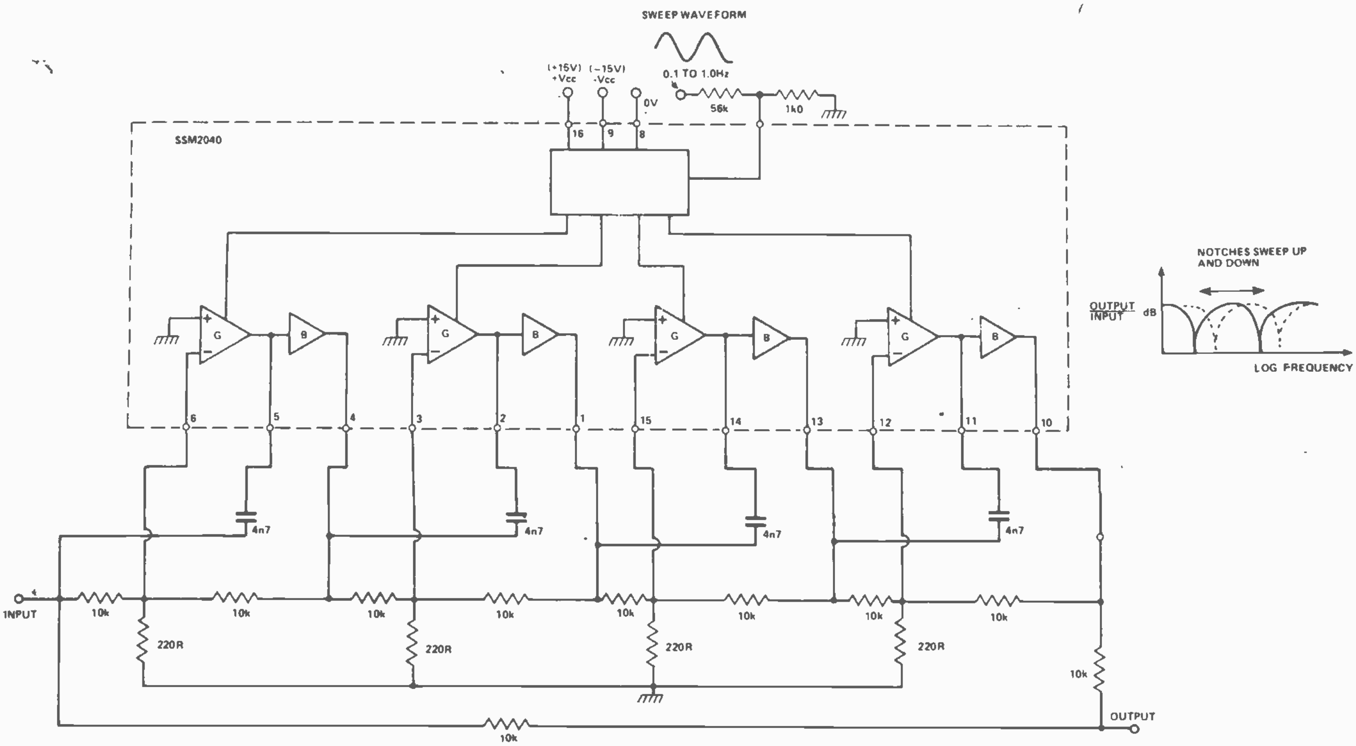


Fig. 10. The SSM2040 connected as a two-notch phasing unit.

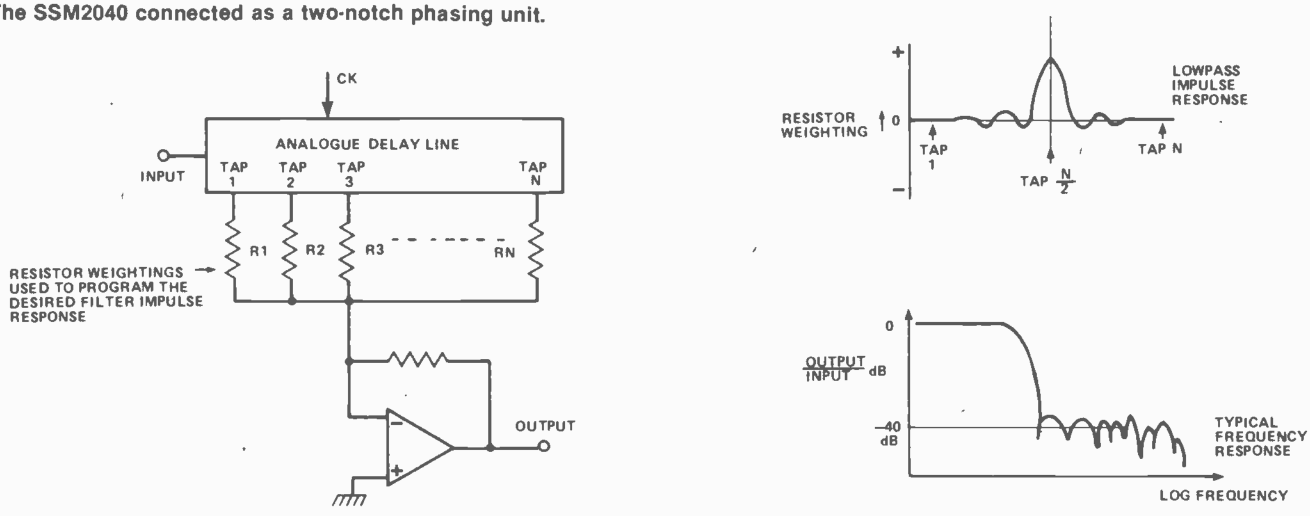


Fig. 11. The transversal filter, with graphs of impulse and frequency responses for a lowpass design.

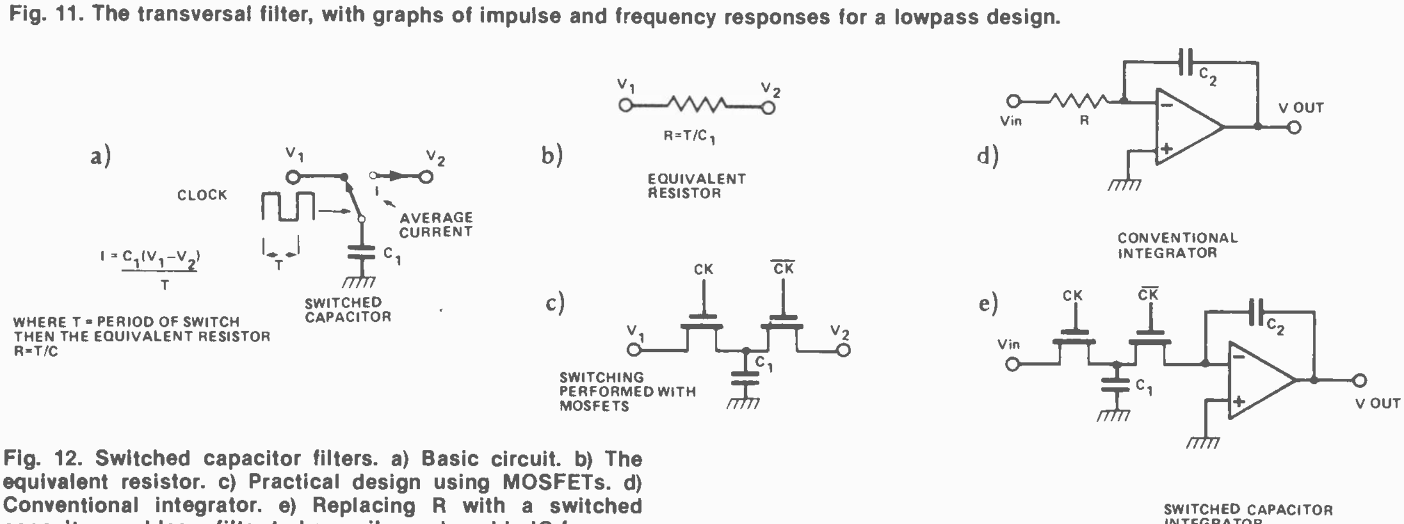


Fig. 12. Switched capacitor filters. a) Basic circuit. b) The equivalent resistor. c) Practical design using MOSFETs. d) Conventional integrator. e) Replacing R with a switched capacitor enables a filter to be easily produced in IC form.

Recent Monos

A more recent monolithic device is the switched capacitor filter, which can be used to implement many standard lowpass and bandpass filter structures, Fig. 12. The problem with producing monolithic recursive filters is that stable high tolerance components such as resistors and capacitors are very difficult to make, and the filter performance depends heavily upon these tolerances. However, it is possible to simulate resistors with switched capacitor techniques. With the switch as shown in Fig. 12a C_1 is charged up to V_1. When the switch is thrown to its other position the capacitor is discharged into V_2. By continually switching the switch, a current I can be made to pass from V_1 to V_2. This simulates a resistance R (where R equals the period of the switch divided by C_1). The switching is performed by two MOSFETs (Fig. 12c) driven by antiphase clock signals. The simulated resistor can be used to construct an integrator (Figs. 12d,e) which can then be used to build up conventional filter structures. For example a state variable filter would have a resonant frequency F_c, where

$$F_c = \frac{1}{2\pi R C_2}$$

$$\text{but } R = \frac{T}{C_1}$$

$$\text{therefore } F_c = \frac{C_1}{2\pi C_2 T}$$

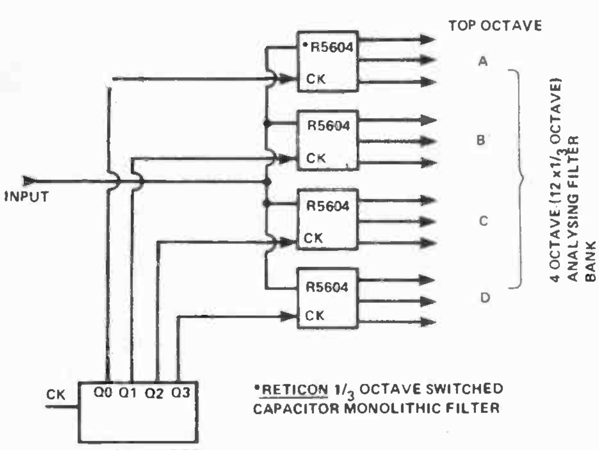


Fig. 13. Switched capacitor filter bank using the R5604 from Reticon.

Note that F_c is linearly proportional to 1/T, which is the clock frequency.

Reticon make a switched capacitor bandpass filter which contains three filters at one-third octave spacing, thus making filterbank design relatively simple (Fig. 13). Maybe in a few years time it will be possible to purchase a wide range of low cost monolithic filters. If that day comes, you won't need to learn how to design active filters!

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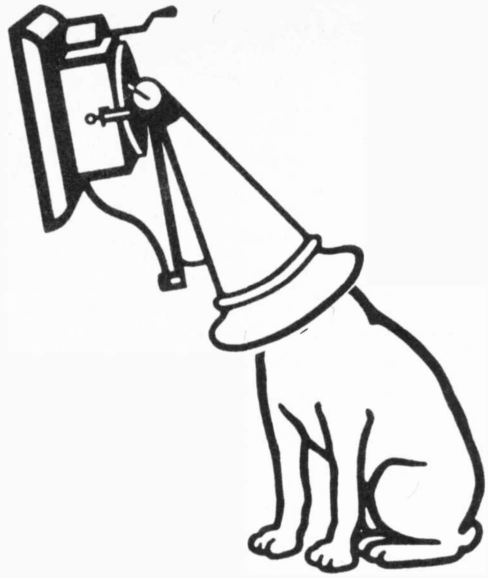

His Master's Temper

Really, what good is a dog that sits around the house all day staring into a Victrola, collecting various fleas. Little Nipper, here, has been doing it for about sixty years. He might be dead; for all the use he is, he could very well have been stuffed back in '27. He doesn't even like cheese.

A while ago, Nipper's owner got a bit cross with his diminutive canine, and decided to jam his pointy little head into the speaker, to see if it would wake the little mutt up. Actually, it did, too. Nipper came out of his coma, and started wandering around the house, barking cheerfully and slamming the Vicrola into the furniture. He pulverized the cat, smashed two completely authentic Ming vases from Sears, and very nearly did a double gainer off the sun deck into the pool (it's so difficult to judge just how hard you have to kick them to get them over the edge).

To date, no one has had any success extracting Nipper from the horn. Various techniques have been tried, including soap, freezing, a chain saw, pulling between cars, and, lastly, plastic explosives. However, nothing's done much good, and the remnants of this poor little dog are still in that thing.

We feel very sorry for Nipper, symbol of a mega-corporation though he may be. Therefore, we have set up a fund to help get him out. Subscribe now to ETI, and, if Nipper is still alive by the time we get your order (unlikely, considering the size of the pile driver they plan to try next week), we'll contribute one dollar for each one year subscription (just $16.95) and two dollars for each two year subscription (just $29.95) to the "Buy an Atomic Bomb to Free Nipper Fund".

If he is dead, we promise to observe one minute of silence for each subscription order, after everbody has gone home for the evening.

So have a heart. If you want, you can probably have Nipper's, if you can find it (it was headed East, last time it was spotted). Subscribe now, and help this poor little animal. You'll feel better, and so will we. So would Nipper, if he were real.

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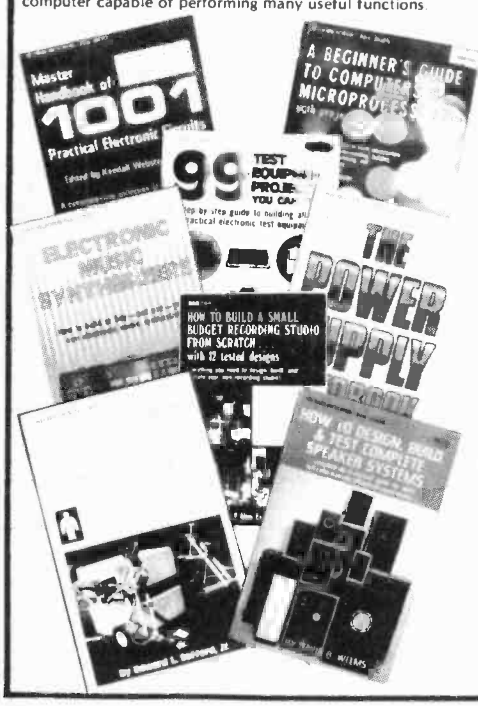

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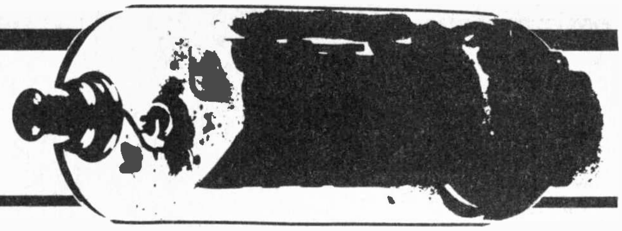
TUBES



Vacuum tube equipment is anything but extinct. Find out the basics of this hot, smelly, inefficient and mildly funky technology. By Steve Rimmer.

A LONG TIME AGO, back in the so-called 'dark ages', there weren't any transistors. Instead they had another device, called the vacuum tube. This, in fact, lead to the phrase 'dark ages'. The tubes drew so much current that if two or more people in the same town turned on their TVs simultaneously, all the lights would brown out. Most people who get into electronics these days run into tubes only as novel curiosities or as little crunching noises underfoot, and never have cause to be concerned about how the little monsters actually work. No great loss, this, for the most part; a digital watch made out of tubes would require a guy 1200 feet tall to wear it.

Oddly enough, though, after general abandonment for quite a while, tubes are enjoying a bit of a renaissance. This may be akin to that last bob to the surface before going down for the third time. However, even with the latest heavy trips happening in solid state technology, there are still a few things better done with vacuum tubes. There are also a lot of cases where in the grossly underbudgeted experimenter can find affordable tube-type equipment where solid state works would be cause for a trip to the loan counter.

It's actually rather amazing exactly how much can be achieved with something as seemingly primitive as a tube. We're going to have a peer at how these little monsters work, so the ol' glass transistors won't be a total mystery, and the next time Great Aunt Remora asks you to fix her mighty Prince of the Airwaves all band receiver and wax cylinder player, you won't have to have your arm set in a fake cast.

Skin a Cathode.

We're not going to get too hairy into the theory of tubes . . . just enough to get by on. If you're really hot to know more, there are dozens of excrutiatingly boring books on the subject available.

Your basic amplifying tube is called a triode, which, as you might expect, is an evacuated glass envelope containing three odes. Except, we don't call 'em odes, because it sounds silly. 'Elements' is more common. These are your 'cathode', your 'control grid' and your 'anode'. They are represented diagramatically in Fig. 1. The cathode is a metal plate that gets hot due to its being near a small electric heater called the 'heater' . . . clever name, right, or the 'filament', as in a light bulb. Away across the vacuum tube is another plate, quite like the cathode, except that it doesn't get hot, having no heater. Because the cathode gets hot it spews electrons off into space, which will go streaming toward anything more positive than the cathode . . . a bit of bias voltage will qualify the anode for this distinction. Electrons can flow to the anode, but because the anode is cold, once they get there they can't flow back, even if the anode were to go negative with respect to the cathode. Sounds like a sort of diode effect, doesn't it?

I think I detect a pattern here.

With electrons streaking madly across the gap between the aforementioned odes, it is possible to regulate their quantities by inserting a third element in

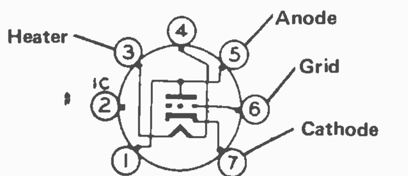


Fig. 1 A triode

the gap, the control grid. Actually grid-like in structure, the control grid is placed quite close to the cathode and biased such that it is slightly negative with respect to it. Thus, electrons passing through the grid are repelled from it toward the anode. However, it takes very little negative voltage on the grid to restrict the electron flow, and, as it happens, quite a large change in the current from the cathode to the anode can be achieved with only a small change of grid voltage.

This is, of course, amplification, without which Jimi Hendrix would never have been possible.

As you may have heard, the operation of a triode tube is essentially similar to that of a FET. They are basically voltage controlled, high impedance devices as opposed to transistors which are current controlled and low impedance components. This is a very useful analogy . . . except that some tubes have more than one grid. These, however, will go away if you pretend you don't believe in them.

Oh, very well. We'll explain them.

There are several conceptual problems with triodes, one of which is that they are unfriendly in some applications, especially at radio frequencies, because there is a lot of inter-electrode capacitance . . . capacitance between them odes we was speakin' about a piece back. In order to break this up, another grid is inserted in between the control grid and the anode, called the 'screen grid'. It gets biased (and decoupled) at some voltage slightly below that on the anode. The resulting concoction is called a tetrode.

Tetrodes, as it turns out, are not remarkably useful. The extra grid cures the capacitancce problem, but causes a new one in its place. Electrons barrelling into the anode often cause other electrons to go flying back into the vacuum, in a process called 'secondary emission'. These wind up on the screen grid, where they tend to make it do funny things. The only way to stop them from doing this is to install yet another grid, this one called the 'supressor grid', in between the screen and the anode. It is usually connected to the cathode, or, sometimes, to ground. Since it is negative with respect to the anode, it repels the secondary electrons back towards the anode before they can get into trouble.

Count up those odes. Everybody get five? Good. It's a pentode. A bit of a kluge, I suppose, but it works.

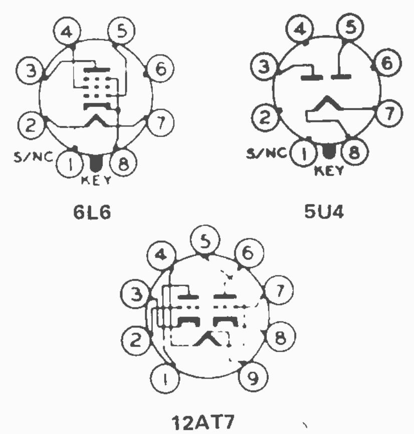
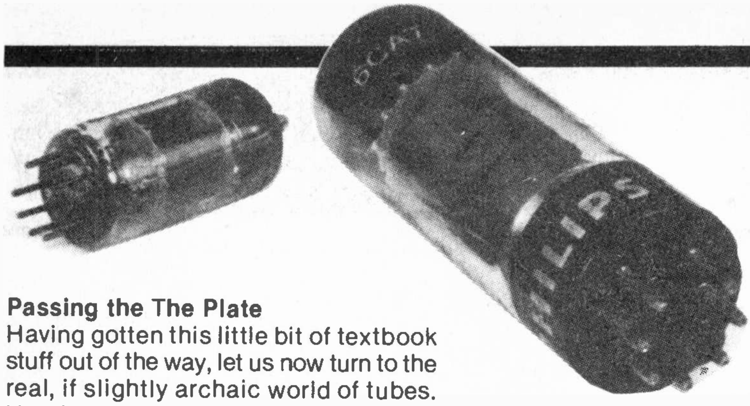


Fig. 2 Three common tubes



Passing the The Plate

Having gotten this little bit of textbook stuff out of the way, let us now turn to the real, if slightly archaic world of tubes. Herein we're going to look at the generalities of dealing with these scorching little beasts. It should be stated, for any purists reading this bit and fuming at the ears, that these are genuine abbreviations of the truth for the sake of getting it all into three pages of text; its all good most of the time, but there are a few things left out.

Tubes come in three sizes; seven pin, eight pin and nine pin. The seven and nine pin deals are miniature types, having the pins protruding directly from the glass of the envelope. The eight pin, or octal types, have plastic bases which contain the pins. There are hundreds of different tube types in existence, but only a very few that are commonly encountered. These are as follows:

-5Y3,5U4,5X4, etc. A family of octal tubes having one cathode and two anodes, for use as full wave rectifiers.
-6AL5. A seven pin tube having two separate diodes, for use as small signal rectifiers and such-like.
-6L6,6F6,6V6, etc. A family of octal power pentodes, of which the 6L6 is the biggest. Fancier versions are known as KT66 and KT88. Usually found in the output stages of audio power amplifiers.
-12AT7,12AU7,12AX7, etc. A family of nine pin dual triodes, all identical except for different gain. The AX7 is the highest. The 12 volt filaments are tapped for use on six volts as well.

There are a few other sweeping generalities of tube lore that may prove useful. First of all, the anode is often called the 'plate', leading to 'plate voltage', 'plate current', and so forth. The control grid is usually just called the 'grid', with the other, now orphaned grids being called the 'screen' and 'suppressor'. Tubes often contain two additional elements, called the 'internal shield' and the 'getter'. The former is usually to separate the elements of dual tubes. The latter is a metal ring which is used in the initial evacuation of the tube. Neither of these need be concerned about in the general operation of tubes, except that odd things may happen if voltages are connected to them.

Some tubes are made with metal contacts up top, from which a wire hangs. This is usually the connection to the plate; the internal geometry of the tube makes it impractical to run it down to the base. The only common exception is an octal tube called the 6J7, where it's the grid.

Unlike in solid state devices, the numbers of tubes can tell you a few things. For instance, the first numerical digits tell you the filament voltage. 5Y3 has a five volt heater, 6AL5 has a six volt one. Well, 6.3 volts, actually, although the extra third of a volt doesn't make much difference. Some tube numbers will have extra letters tacked on the end, like 6L6GBA. These usually refer to the shape of the glass envelope . . . not too important, unless the tube is being held in by some sort of gadget that only works with one particular shape.

Lastly, you might run into tubes that appear to be made of metal. This is just a disguise invented by the military. If you drop them they'll break just like the regular kind.

Tubes are built to much tighter specifications than are solid state devices. However, their circuits are also usually much more finicky. Thus, especially in sophisticated RF and timing circuits, tubes from different manufacturers may produce different results . . . sometimes to the extent that some circuits will only work with some brands of tubes.

Powers That Be

The relative voltages on the elements of your basic tube are pretty well constant, and, as with transistors, if you know about what they are supposed to be, you can figure out what is wrong if they turn out to be something else. Here goes.

The cathode is held at or near ground. Usually it's a few volts positive, by virtue of a cathode resistor, often bypassed by a capacitor. Sometimes pentodes will have a connection from the cathode to the suppressor; it is usually the case, though, that this connection is made internally, and the suppressor is often not even drawn in.

The grid is usually a few volts negative with respect to the cathode. There aren't usually any negative voltages handy, at least with small signal amplifiers, so the same result is arrived at by setting the grid near ground and making the cathode positive. The grid usually has a large, 100K to 1M, resistor hanging off it to ground. This keeps it effectively at ground potential and gets rid of any stray electrons that somehow manage to stick to it.

The screen is usually fed from the plate voltage supply via a voltage divider, and will usually have a capacitor to ground to keep it from varying in voltage with the current through the tube.

The plate is connected through a load, such as a coil, transformer or resistor, to the plate supply voltage, called the B+. The B+ is usually between 150 and 350 volts, and the actual plate voltage anywhere between 90 and 250. Higher plate voltages produce higher gain, but also cause the tube to produce more noise, as the electrons smash into the plate at higher speeds. Pentodes, having more internals for the electrons to hit, produce more noise than triodes. In equipment having really small signal stages, the associated tubes usually get fed from a low B+ supply.

The heater is usually fed from the winding of a transformer. However,

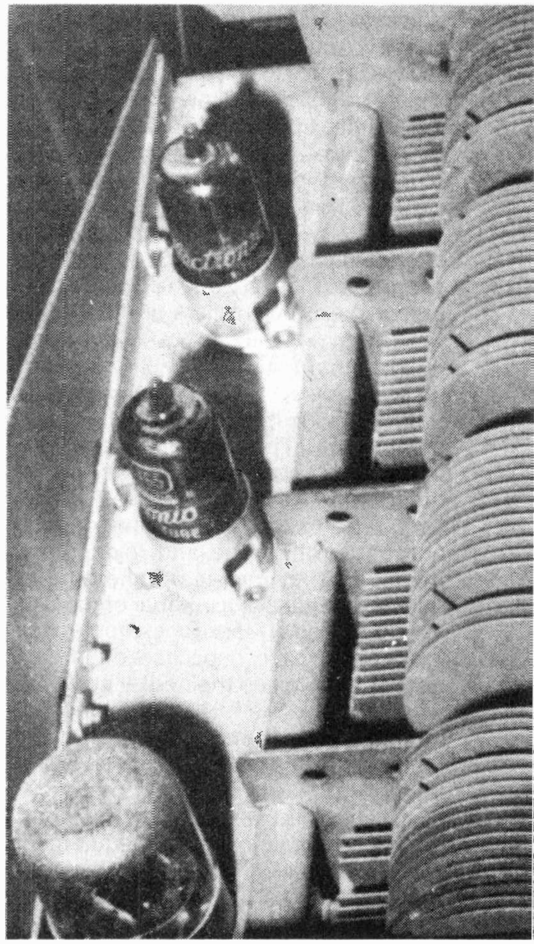


Fig. 3 Tubes in an RF front end

because the AC voltage can couple hum to the cathode, tubes used in very small signal circuitry often have their filaments fed with DC.

And The Hairy Bits

In order to be able to give a decent explanation about how to deal with all the problems plaguing tube equipment, it would be necessary to boot all the advertisers out of this issue, abandon all the other features, and possibly devote part of next month to the conclusion. Absolutely nobody was in favour of this idea . . . I wasn't even all that thrilled about trying to write the thing. Thus, we're going to look at a few of the fundamental differences between tube and solid state circuitry. Armed with this priceless knowledge, the rest should be child's play.

No children that you know of? They may be able to help you on the classified page.

Tube type equipment is built on metal chassis, as opposed to PC boards. The tubes are plugged into sockets that protrude through openings in the metal, and most of the passive components, such as resistors and capacitors, are strung between the lugs of the sockets. This is called point-to-point wiring, and, boy, is it messy.

The biggest hassle with tube equipment is heat. The tubes just cook. The heat dries out capacitors, shifts the values of resistors around, and breaks down all sorts of insulation. It causes the coatings on wires to get brittle, and, if you move the leads, they may just flake off into dust. It also causes a number of more or less harmless effects; for example, wax impregnated paper capacitors often form coatings of wax on their outer surfaces which makes them look really horrid, although they'll function perfectly well. Heat will also cause the colour codes on resistors to change colour very realistically, so you can't always trust the markings.

On the other hand, tube equipment was built on production lines which, for the most part, were all hand wiring deals. As the devices came off the lines they were checked and, if the failure rate began to increase, due to simple bad luck with the way the tolerances were going, it was quite common to change the value of a part to bring things back into line. In other words, you gots ta have an updated schematic befores yuz starts clippin' resistors.

The most important thing about dealing with tubes is to realize the inherent reliability of the tubes themselves. They fail less frequently than do the components they're connected to. Shame, in a way, because they're the easiest to change. The only really reliable way to test a tube is to replace it with a good one and see if the problem goes away. Tube testers, like transistor testers, only work under certain circumstances. In the case of the ones at the drug store, this is usually when the tube either has a migraine headache or the heartbreak of psoriasis.

Powering Down

All in all, I think tubes are pretty neat. A good way to look at them, especially if you are fairly poor, is to consider the specifications of the box they live in. If it will do what you want, it really doesn't matter what it uses to do it with. And, with tube equipment, there is the added advantage that the cabinets can be used to warm coffee, or even to fry fish on.

Tubes are very highly funky, and even if you really have a tube amp because it was twenty-two bucks at a garage sale, you can let on that you're into tube sound, which is very hip and underground. Tubes make useful nightlights, and, when they go gassy and start glowing blue, are entertaining to watch at parties.

Finally, tubes are ecological. When a transistor dies, it's useless. However, dead tubes are fabulously functional, possibly even more so than live ones. If you have a bottle cutter you can make all the useless household paraphenalia you used to be able to make before coffee came packed in plastic. The bases can be recycled to hold relays. Even the internal elements can be removed and stomped on for a good time.

The likelyhood of Texas Instruments ever having to worry about competition from the vacuum tube division of Sylvania is probably fairly slim. However, tube type equipment is still very much alive, and may well be worth checking into.

After all, at the least, you can tie a bunch of it together and use it as an anchor. ETI

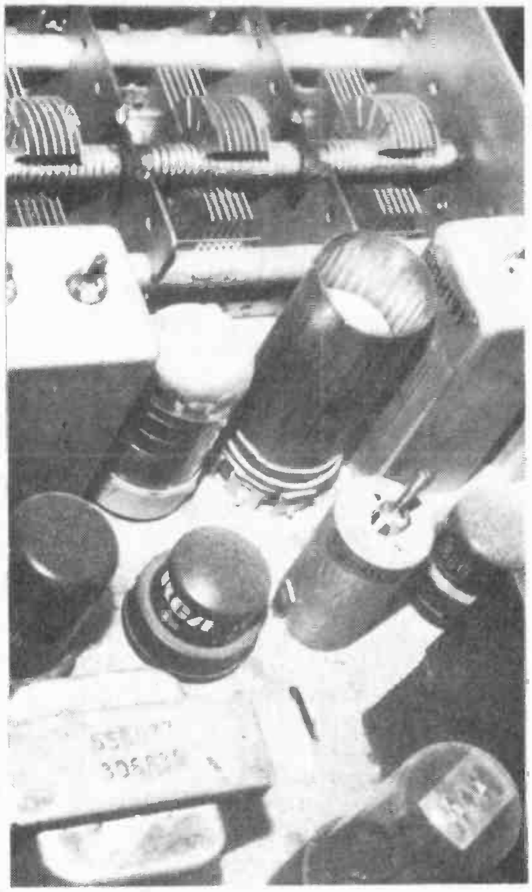


Fig. 4 More tubes in real life

Fig. 5 A 5000 Watt transmitting tube

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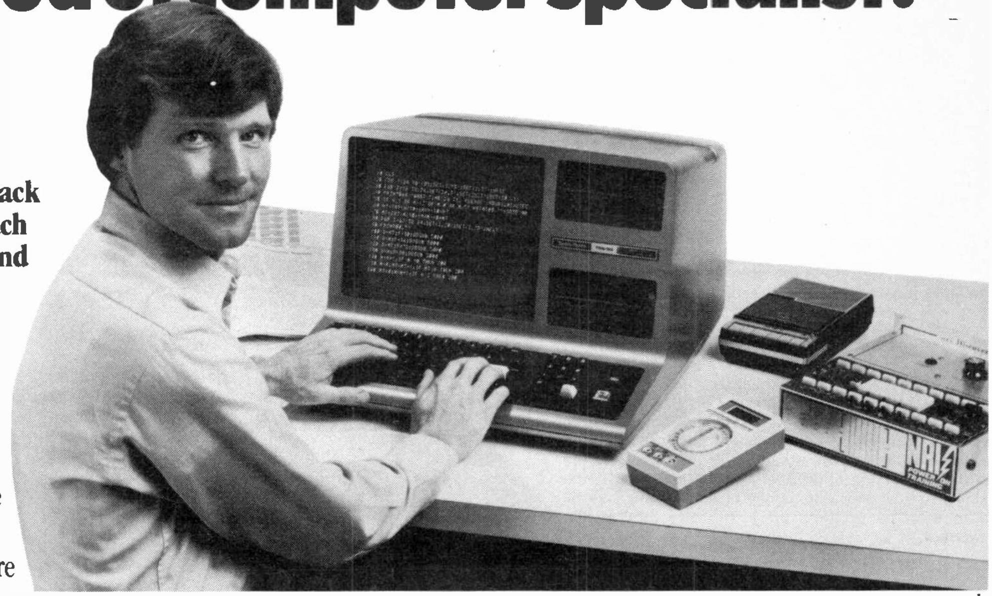

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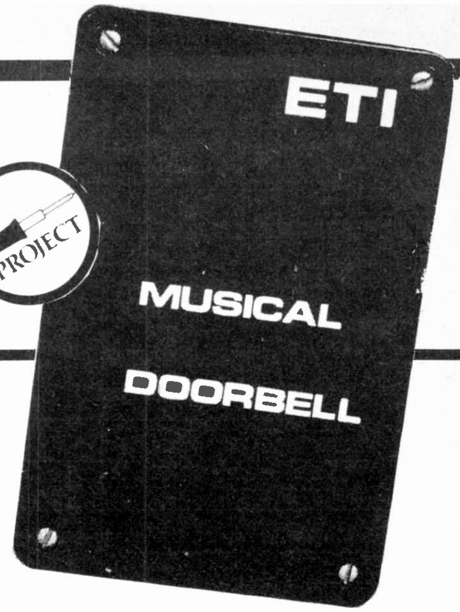
MUSICAL DOORBELL



An inexpensive programmable doorbell project for your home. This instrument will play any nine-step melody of your choice.

MODERN DOORBELLS come in two basic types, the simple electrical 'ding-dong' (chime) or the sophisticated microprocessor-controlled multi-tune Oh Canada, etc. types. In either case you pay your money and have to accept the sounds that the manufacturers have pre-programmed into your particular device. If you ever get tired of your bell's limited range of sounds, you have little option but to buy a new unit.

We have decided to overcome this by designing a musical doorbell project that the owner can self-program to play any desired (but brief) melody. The essence of our project is that it is simple; it is devoid of hard-to-get micros, PROMs, double-sided PCBs, etc, yet gives an entertaining performance.

Our doorbell is designed to play a nine step melody made up of a selection of five basic notes or tones. The melody lasts for 2-3 S. If the bell-button is briefly operated, the complete melody plays once only; if the bell-button is held closed, the melody repeats continuously. The unit is designed so that the owner can select or 'program' his own melody by hard wiring the interconnections between various pins on the unit's PCB. The nine step, five note choice enables any one of a selection of almost two million (5^9) different melodies to be programmed into the unit!

A feature of our doorbell is that it incorporates a bistable electronic switch that connects power to the unit in such a way that it consumes virtually zero power when in the 'standby' mode. Whenever the bell-button is pressed, the bistable connects power to the unit for the duration of the tune play and then automatically disconnects the power when the melody is complete; this facility ensures long battery life.

Construction

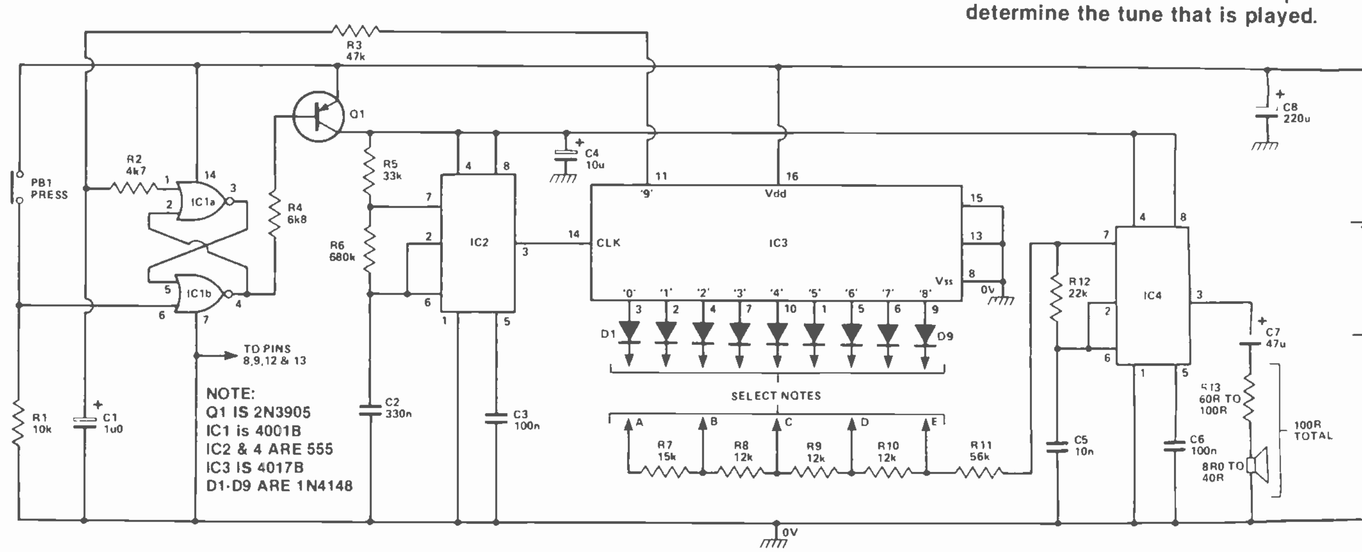
Construction of this unit should present very few problems, if the overlay is followed with care. Note that IC1 and IC3 are CMOS devices and are best mounted in suitable sockets. Also note that an insulated link is connected between pin 3 of IC2 and pin 14 of IC3 on the underside of the board and that Veropins are used to facilitate top-side connections on the PCB.

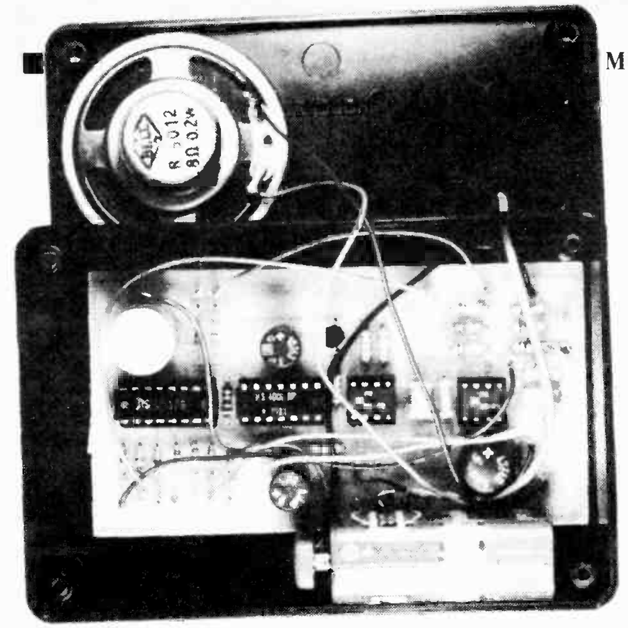
When construction of the PCB is complete, connect up a suitable speaker, battery and push-button switch and prepare to give the unit a functional check. When selecting a speaker, note that output volume is proportional to speaker impedance and that a high impedance unit will give the loudest results.

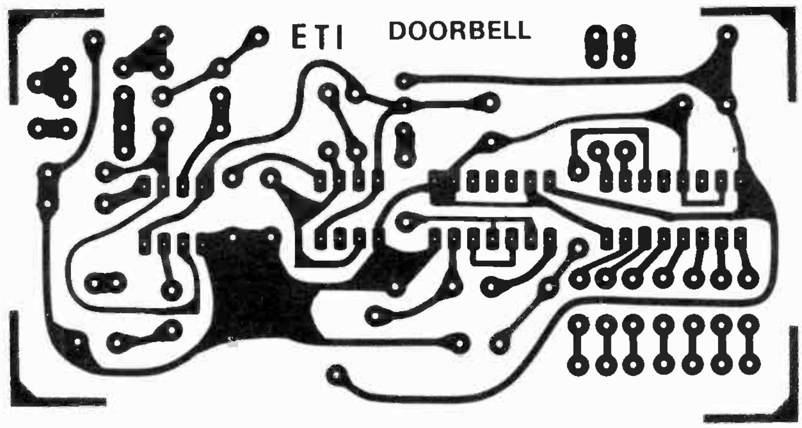
When you are ready to try out the unit, connect a flying lead from D1 to one of the A -E note-select points and press PB1 to test the first note in the sequence. You can then wire in the D2 to D9 note-selection connections, one at a time, to establish the rest of the sequence, testing the unit at each step in the wiring sequence.

Once you've finished 'programming' your unit you can fit the PCB, battery and speaker into a suitable box, hang the unit on your front door and finally connect it up to a suitable push-button switch.

Fig. 1. Circuit diagram of the Musical Doorbell. The connections you make between diodes D1-D9 and the points A-E determine the tune that is played.







HOW IT WORKS

The circuit comprises a bistable (IC1) and a transistor power switch (Q1), two 555 astable multivibrators (IC2 and IC4) and a 4017 decade counter/divider (IC3). The bistable (IC1) is designed around two gates of a CMOS 4001B and controls the base bias of Q1, which in turn controls the positive power supply connections to IC2 and IC4, the two 555 chips.

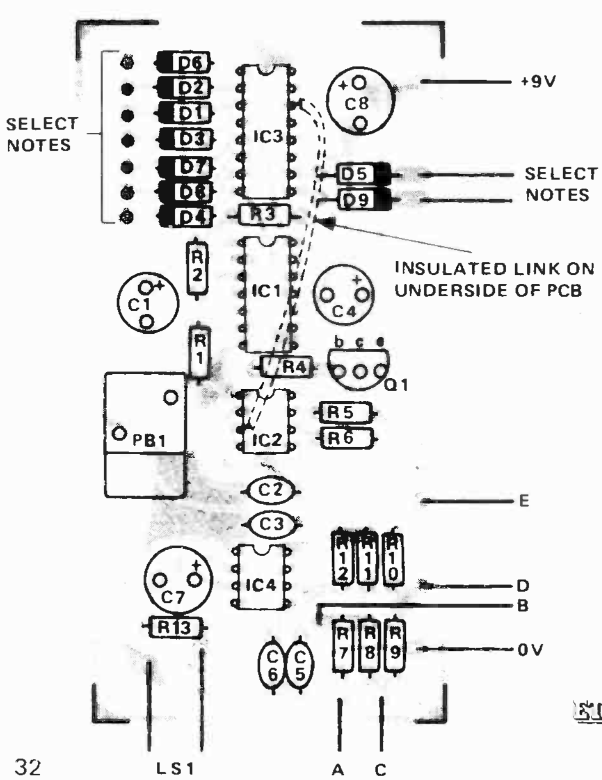
Normally, the output (pin 4) of the bistable is high, so Q1 receives no base drive and is cut off. Under this condition, IC2 and IC4 consume no power: IC1 and IC3, being CMOS devices, also draw negligible power under this condition. The entire circuit, in fact, consumes a typical 'standby' current of only a microamp or so.

The circuit is activated by briefly pressing PB1, thereby causing the IC1 bistable to change state and connect power to the IC2 and IC4 astables via Q1. IC2 is wired as a low frequency astable (a few Hertz) and delivers clock pulses to IC3. IC3 is a 4017B decade counter/divider; it has ten decoded outputs, which sequentially go high on the arrival of successive new clock pulses, only one output being high at any given time. In our application, the first nine decoded outputs are used to sequentially select (via D1 to D9) timing resistors in a second astable, the IC4 tone generator, which drives a speaker via C7.

The first nine clock pulses from IC2 thus cause nine tones to be sequentially selected via the R7-11 resistor network. On the arrival of the tenth clock pulse, pin 11 of IC3 goes high and resets the IC1 bistable via R3 and C1, thereby cutting off Q1 and removing power from IC2 and IC4, thus completing the operating cycle.

The action of the IC1 bistable is such that, if PB1 is briefly pressed, the instrument plays a single sequence of nine notes (total duration is 2-3 S) and then automatically switches off. If PB1 is held closed, however, the sequence continuously repeats. Note that the owner can set up any tone sequence that he wishes by suitably interconnecting the diode outputs of IC3 to the 'A' to 'E' selection pins on the R7-11 note-selection chain.

Fig. 2. Component overlay.



PARTS LIST

Resistors All ¼W, 5%	
R1	10k
R2	4k7
R3	47k
R4	6k8
R5	33k
R6	680k
R7	15k
R8,9,10	12k
R11	56k
R12	22k
R13	100R

Semiconductors	
IC1	4001B
IC2,4	555
IC3	4017
Q1	2N3905
D1-9	1N4148

Capacitors	
C1	1u0 63V electrolytic PCB type
C2	330n polycarbonate
C3,6	100n polycarbonate
C4	10u 63V electrolytic PCB type
C5	10n polycarbonate
C7	47u 25V electrolytic PCB type
C8	220u 25V electrolytic PCB type

Miscellaneous	
LS1	Any 8R0 to 40R speaker: see text
PB1	momentary action
B1	9V
Case	

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IEEE

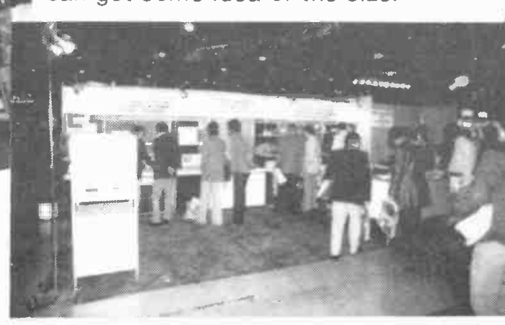
The IEEE show is a yearly gathering of the brightest lights in electronics. John Van Lierde was there, and is still seeing spots before his eyes.

THE BEST WAY to find out what's happening in any given field of interest is to get out and find the people that are involved. The 1981 International Electrical, Electronics Conference and Exposition is a good place to start, being, among other things, a veritable lodestone for manufacturers, researchers, engineers and buyers.

This year's IEEE Show took place on October 5, 6, and 7 at Exhibition Place, Toronto. During that time over 13,000 people passed through the doors to see and hear what's state in the state of the art. Manufacturers and distributors filled some 200 booths displaying the very latest electronic devices. Also during the show, over 100 papers were read, covering such diverse fields as biomedical instrumentation, satellite communications, computer music and speech synthesis, power systems and much more.

The exhibition itself represents a tremendous opportunity to see and handle equipment that previously one could only read about. Because the manufacturers and their representatives are right there, it's a good chance to learn firsthand what's new. Even if you're not looking for something, the browsing is quite enjoyable and there are plenty of literature handouts and some freebees to be had.

If you missed it this year, don't worry, it's an annual event. If you're doubtful, the photos tell a bit about what our advertisers were doing. Multiply that by about twenty and you can get some idea of the size.



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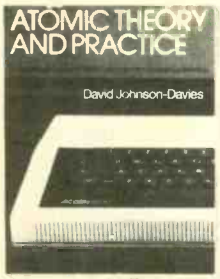

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EARLY RADIO IN CANADA

So you think all the furor over pay TV, satellite TV and suchlike is a relatively recent phenomenon? Not so. Hearken back to the early days of Canadian nationalism with Jim Essex and see the origins of broadcasting in Canada.

AS MERELY ONE of many who have watched the swift evolution of broadcasting in Canada, I was intrigued by the fact all this has taken place in less than half the years of the nation's life-time. Recalling some of the early attempts by adventurers in radio and the primitive beginnings of others, it seems impossible today's giant had such a humble start.

Early in the post-war years, the second station in a little over a decade in which I was Engineer, CKBW Bridgewater, N.S., began broadcasting. Located on the south shore of that province, this station in 1947 plugged the previously sparsely filled radio spectrum in that area (due to peculiar local rock-strata formations which left only weak signals from neighbouring commercial Halifax radio stations or even the powerful 50 KW transmitter of CBA at Sackville, N.B.) This local situation was, to me at least, illustrative of Canadian radio where, whenever powerful regional CBC stations failed to provide adequate signal strengths, commercial enterprise stepped in to fill the gap.

My impressions of the immense changes in Canadian radio (which saw the whispering voice of a mere handful of stations in the 30's grow to over 300 radio stations today) was exemplified by this experience.

Compared with my earlier experiences in radio in Ontario in the 30's, it offered the comparison needed to appreciate the vast changes to sophistication in broadcast equipment spanning a dozen odd years.

The CKBW of 1947, in which I had taken my place in radio in the interval, first as engineer of the succeeding station of 10AK at Stratford (later CJCS), to that station 11 years later, offered a kaleidoscope of radio's change with the years. CKBW was an ultra-modern station: the experimental station of 10AK in Stratford in 1936 was not. But it was typical of the experimental stations of that age and a credit to the spirit of

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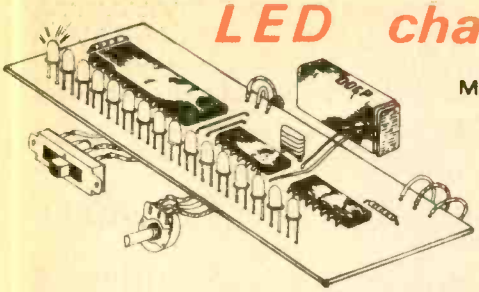

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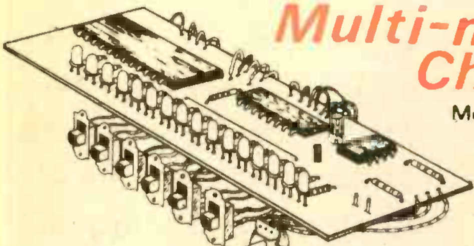

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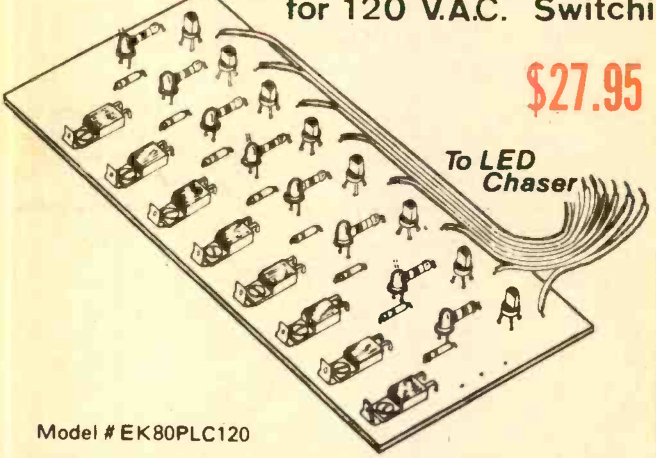

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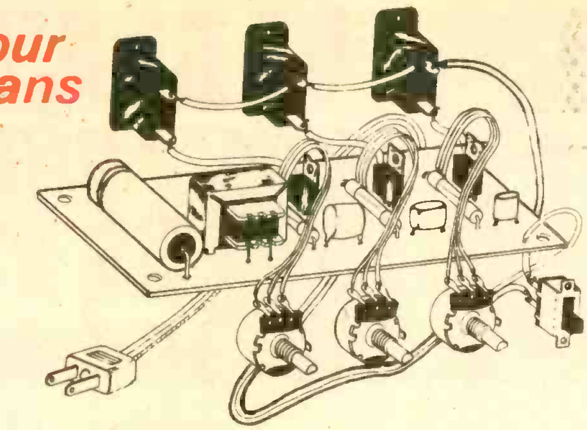


Three Channel 500 W. Switching

Model # EK80C500 — $19.95

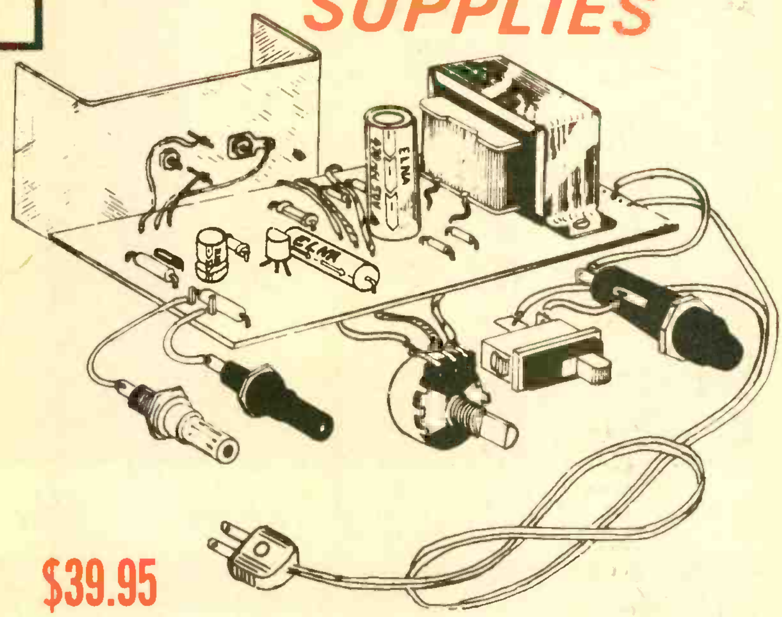
Three Channel 1500 W. Switching

Model # EK80C1500 — $29.95

An excellent item for parties, dances, etc. Three individual controls let you vary the amount of light for Bass, Midrange and Treble. Each output is fused for added circuit protection and will handle up to 50 watts of audio input power. A 200 watt adaptor is available (extra).

30th Anniversary Sale

POWER SUPPLIES



$39.95

0-28 VOLT POWER SUPPLY KIT

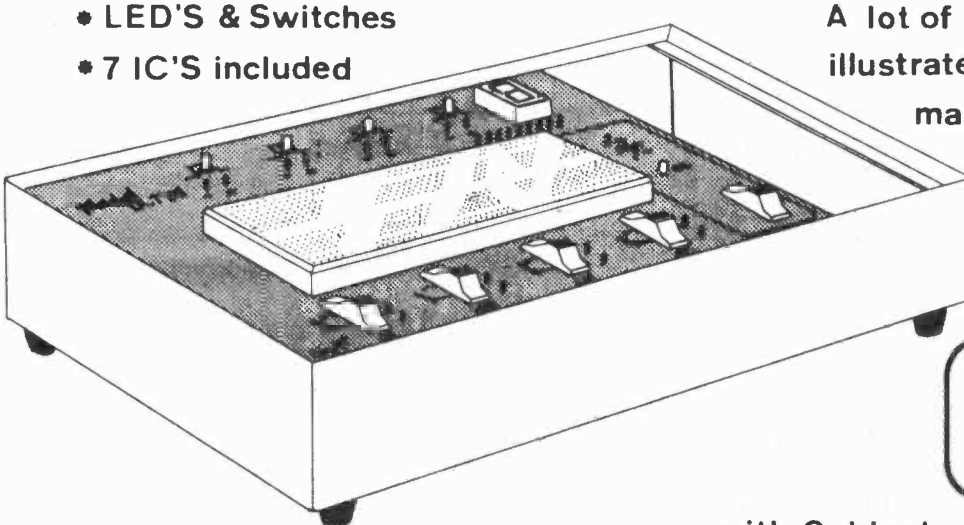
A true 0 to 28 volts capable of delivering 1 amp continuous. Full wave rectification, filtering and capacitance multiplication provides a clean dc source for sensitive audio and digital work. An ideal supply for the experimenter.

30th Anniversary Sale

— Student LOGIC TRAINER & Course —

Trainer Consist of:

- 5 V.D.C. Power supply
- Proto Board
- LED'S & Switches
- 7 IC'S included



Student LOGIC Workbook covers:

gates, clock, binary, decoder driver, & readouts with tests on each subject. A lot of reseach went in to this well illustrated book, large illustrations making LOGIC simple and easy to understand, each student works on his or her trainer building and testing LOGIC circuits.

MODEL:
DLT-01 $55^{95} EA.
Less cabinet & supply

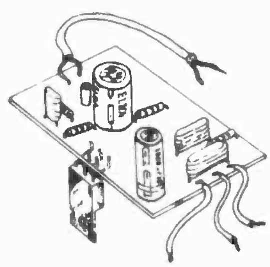
with Cabinet and Supply $98^{55}

– INTRODUCTION

Digital Electronics is a vast and ever growing field in the Electronic Industry. In fact, it is revolutionizing our way of life. From simple electronic games to the NASA space shuttle "Enterprise", digital electronics plays a major part. It is this reason Edu-Kit has prepared a basic digital course so the understanding of some of the basic components may be simplified. General topics discussed are AND gates, NAND gates, OR gates and NOR gates. A single digit counter has been added to supply a better understanding of how gates are applied.

5 Watt IC AMPLIFIER

Model # EK80A005



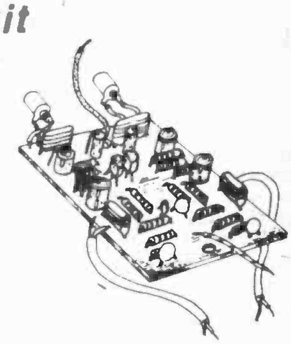
$21.95

A general purpose 5 watt amplifier with Thermal Overload and Short Circuit Protection. Because of its low operating voltage and high power output, it allows the user to use it as an add-on amplifier for car stereo.

Specifications:	
Frequency Response:	40Hz to 15KHz B(-3dB)
Power Output:	5 watts at 4 ohms 7 watts at 2 ohms
Distortion:	5% at 7 watts at 2ohms
Load Impedence:	2 to 16 ohms
V Supply:	12 to 15vdc

STEREO Pre-Amp kit

Model # EK80SP001



$12.95

Anyone with a ceramic input receiver can enjoy the quality of a magnetic cartridge with this simple but very effective Stereo Phono Preamp.

Specifications:	Standard RIAA
Frequency Response:	20Hz to 2KHz + 1.5dB
Input Sensitivity:	5mv input for 500mv output
Maximum Output:	700mv rms
Input Overload:	100mv rms
S/N Ratio:	Greater than 60dB

DOMINION RADIO & ELECTRONICS COMPANY

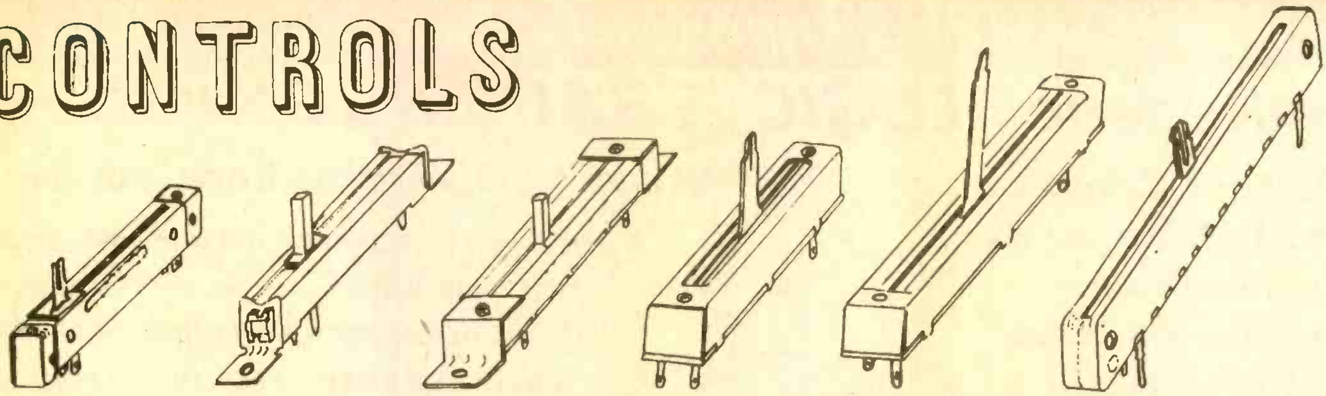
A DIVISION OF DREECO ELECTRONICS LTD.

THE HOME OF RADIO & ELECTRONIC SUPPLIES

535 YONGE STREET
TORONTO, ONTARIO
M4Y 1Y5

30th Anniversary Sale

CONTROLS



40mm SLIDE	45mm SLIDE	35mm SLIDE	40mm SLIDE	55mm SLIDE	60mm SLIDE
.99	.99	.99	$1.29	$1.59	$2.49
C1300 10K	C1301 5K	C1302 50K	C1304 100K	C1307 10K	C1312 5K LIN
		C1303 1M	C1305 500K	C1308 50K	C1313 50K LIN
			C1306 1M	C1309 100K	
				C1310 500 K	
				C1311 1M	

KNOBS

49¢

C1314

C1315

1951 Prices in 1981

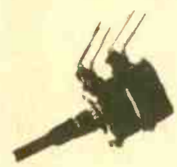
CONTROL PRICES

Trim Pots	.20
Singles	.25
Single with switch	.30
Duals	.35
Dual with switch	.40
Triples	.60

4 SECTION CONTROLS

$1.39 ea.

Your Choice
20 Mπ
25 kπ
100 Kπ



SINGLE CONTROLS

100
360
470
500
750
1K
2K
5K
10K
20K
25K
50K
200K
1Meg
2Meg

TRIMMER POTS

100
220
470
1K
2.5K
5K
10K
20K
50K
100K
500K
1Meg

DUAL CONTROLS

Front	Rear	Front	Rear
200	5K	200K	200K
500	5K	250K	15K
5K	500	500K	500
5K	5K	650K	750K
10K	500	1M	200
10K	5K	1M	500
15K	250K	1M	50K
20K	200	1M	500K
20K	20K	1M	1M
20K	200K	2M	250
47K	47K	2M	50K
50K	500	2M	2M
100K	500		

SINGLE w/Sw.

500 ohm
10K ohm
50K ohm

DUAL w/Sw.

50K	10K
50K	500K
300K	100K
1M	500K
1M	3M
5M	1.5M

TRIPLE CONTROLS

200	10K	10K
10K	10K	500
500K	5M	500
1M	1M	1M

DOMINION RADIO & ELECTRONICS COMPANY

535 Yonge Street, Toronto, Ontario, M4Y 1Y5

30th Anniversary Sale
Special Bargains

CAPACITORS

AXIAL LEAD

uF	WV16 SV20	WV25 SV32	WV50 SV63
1			25
2.2			25
3.3			25
4.7			25
10	.25	.25	30
22	.30	.30	35
33	.30	35	35
47	.35	.35	35
100	.35	.40	.50
220	.35	.40	.55
330	.40	.50	65
470	.45	.55	.75
1000	.60	.70	1.00
2200	.75	1.05	
3300	1.05	1.35	
4700	1.65	1.95	

TANTALUMS

DIPPED SOLID TANTALUM
CAPACITANCE TOLERANCE +/- 20%

uF	WV16 SV20	WV25 SV32	WV35 SV46
0.22			
0 33			
0 47			.35
0.68			.35
1 0			.35
1.5			.35
2 2			.35
3.3			.35
4.7	.35		.35
6.8	.35		.35
10	.45	.50	55
15	50	.55	85
22	.55	65	1.35
33	.65	1 20	2.25
47	1.95	2.75	
68	2.75		
100	3.50		

CAPACITORS
NISSEI POLYESTER FILM

uF	Price	uF	Price	uF	Price	uF	Price
.0010	20	.012	20	.0027	.20	027	.25
.0012	.20	.015	.20	0033	20	.033	.25
.0015	.20	.047	30	.0039	.20	039	25
.0018	.20	.056	.30	0047	20	.12	35
0022	.20	.068	.30	.0056	.20	15	40
.0068	20	.082	.30	.018	25	18	.45
.0082	.20	.10	.30	.022	25	.22	.50
.010	20						

POWER SUPPLY

1400	16	.65	6800 Com 25	6.95
1600	16	.65	15000 RPE10	4.50
2200	16	.75	12000 Com 40	6.95
2500	10	.65	14000 Com 40	7.50
1000 Can	16	1.50	15000 RPE 10	4.50
			15000 Can 16	4.90
4700 Elec	40	1.75	15000 Can 25	5.50
			15000 Com 50	11.95
4700 Com	100	8.95	44000 Com 35	14.95
6800 RPE	25	6.95	80000 Com 20	14.95

TRANSISTORS

PART No.	REPLACE	
2N2906 -	ECG-159	1.79
BF-245 -	ECG-133	1.99
2N3391 -	ECG-199	1.15
BF-199 -	ECG-161	1.59
TIS 92 -	ECG-128	2.40
BD136 -	ECG-185	2.99
BD135 -	ECG-184	2.79
2SC1505-	ECG-198	2.95
2SC1520-	ECG-198	3.00
2SC1507-	ECG-198	2.95
2SC1446-	ECG-198	2.95
MJE2370-	ECG-242	3.59
AD161 -	ECG-155	4.95
2SC1025-	ECG-175	2.95
2SC1304-	ECG-124	2.59
2SC1104-	ECG-124	2.59
2SD24Y -	ECG-124	2.59
AD162 -	ECG-131	3.99
AD139 -	ECG-104	1.89
2SC1160-	ECG-175	3.50
2N3614 -	ECG-121	3.95
2SC1106-	ECG-162	9.95
BD182 -	ECG-130	4.79
BU205 -	ECG-165	9.95
BU108 -	ECG-165	9.95
2SC940 -	ECG-283	11.95
2SC939 -	ECG-163A	12.95
BF245A -	ECG-133	2.25
2SC945 -	ECG-199	.89
2SC1685 -	ECG-199	.89
2SC454 -	ECG-289	1.59
2SC839 -	ECG-123A	1.59
2N6558 -	ECG-191	4.25
2SC458 -	ECG-289	1.49
2SB77 -	ECG-102A	1.99
2N1613 -	ECG-128	1.99
AC-187 -	ECG-103A	2.30

RADIAL LEAD

UF	WV16 SV20	WV25 SV32	WV50 SV63
1			.25
2.2			.25
3.3			.25
4.7		.25	.25
10	.25	.25	.25
22	.25	.25	.25
33	.25	.25	.30
47	.25	.30	.35
100	.30	.30	.35
220	.30	.35	.45
330	.35	.40	.60
470	.40	.50	.85
1000	.60	.75	
2200	1.00		

CMOS DIGITAL LOGIC

part	price	description
4000	.30	Dual 3 input NOR plus Inverter
4002	.25	Dual 4 input NOR
4006	.95	18 Stage Static Shift Register
4007	.15	Dual Complimentary Pairs plus Inverters
4008	.95	4-bit Full Adder
4011	.35	Quad 2 input NAND
4014	.75	8-bit Static Shift Register
4015	.95	Dual 4-bit Static Shift Register
	.40	Quad Bilateral Switch
4021	.95	8-bit Static Shift Register
4024	.75	7 Stage Binary Counter
4027	.60	Dual JK Flip Flop
4028	.95	BCD to Decimal Counter
4030	.35	Quad XOR
4033	1.25	Decade Counted/Divider
4041	1.35	Quad True/Compliment Buffer
4042	.95	Quad Type D Latch
4043	1.10	Quad NOR S/R Latch

ZENERS 19¢

TYPE #	VOLTAGE	WATTAGE
BZX61-C75	3.3V	1W
IN4623	4.3	1W
IN751A	5.1	1W
IN4733A	5.1	1W
IN4734	5.6	1W
14-515-04	6.2	1W
114574	6.2	.5
IN753A	6.2	1W
IN754A	6.8	1W
IN752A	5.6	1W
17-515-35	6.8	1W
HZ7B	7	1W
IN755A	7.5	1W
IN74738A	7.5	1W
IN757A	9.1	½W
IN4739A	9.1	.5
BZX61-C9V1	9.1	1W
IN757A	9.1	1W
IN758A	10	1W
IN759A	12V	1W
IN964B	13	.5
3E216D5	14	1W
IN966	16	1W
BZX61-C18	18	1W
HZ20C	20	1W
BZX61-C20	20	1W
GE5028	20	.1W
14-515-31	22	.5
IN4751A	30	1W
BZX61-C30	30	1W
BZX79-C36	36	½W
BZX61-C56	56	1W
IN5045	56	5W
BZX61-C68	68	1W
IN4764A	100	1W
IN5593B	183	1W

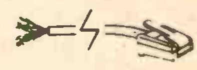
TTL

7400 ... .45	7423 ... .55	7472 ... .55	74123 ...1.10
7401 ... .45	7425 ... .65	7473 ... .70	74125 ... .98
7402 ... .45	7426 ... .65	7474 ... .70	74141 ...1.15
7403 ... .40	7427 ... .55	7475 ... .98	74150 ...2.50
7405 ... .75	7430 ... .45	7476 ... .70	74151 ... .98
7406 ... .85	7440 ... .45	7485 ...1.40	74154 ...2.50
7407 ... .95	7441 ...1.35	7486 ...1.50	74160 ...1.75
7408 ... .75	7442 ...1.35	7490 ...1.15	74164 ...1.25
7409 ... .45	7446 ...1.45	7491 ...1.15	74177 ...1.45
7410 ... .39	7447 ...1.65	7492 ... .85	74190 ...1.65
7411 ... .55	7448 ...1.75	7493 ... .85	74191 ...1.60
7412 ... .55	7454 ... .65	74121... .65	74192 ...1.55
7413 ... .85	7460 ... .40	74122... .90	74193 ...2.95
7420 ... .45			

MICROPROCESSOR

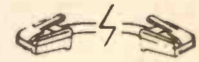
74LS00... .85	74LS32... .80	74LS109... .80	8080 ...8.95
74LS04... .60	74LS33... .60	74LS125...1.00	8212 ...3.00
74LS08... .65	74LS38... .80	74LS132...1.40	8216 ...3.50
74LS10...1.50	74LS74... .70	74LS151...1.60	8224 ...8.95
74LS11... .75	74LS75...1.10	74LS155...1.10	8228 ...6.25
74LS20... .70	74LS86... .70	74LS247...1.18	8255 ...8.95
74LS30... .65	74LS90... .95	Z80 ..14.95	4116 ...7.95

PLUG TO FOUR SPADE TIPS, FLAT CORD



542-7 – 7 ft. 3.95
542-25 – 25 ft. 7.95

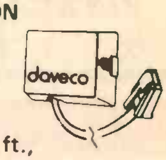
PLUG-TO-PLUG FLAT CORD



541-7 – 7 ft. 4.95
541-25 – 25 ft. 8.95

MODULAR EXTENSION

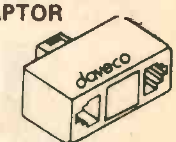
11.95



No. 538 25 ft., modular plug to dual modular jack.

MODULAR "Y" ADAPTOR

4.95



No. 548 - two modular jacks to one modular plug.

FLUSH MOUNT MODULAR JACK

3.95

No. 549 - flush mount wall type single modular jack.

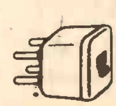
DUAL MODULAR WALL JACK

4.49

No. 547 - surface mount jack for 2 telephones. Easy to install.

WALL PLUG ADAPTOR

4.49

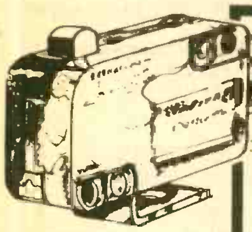


No. 544 - converts standard 4-prong wall jack to new modular jack.

DOMINION RADIO & ELECTRONICS COMPANY
535 YONGE STREET
TORONTO, ONTARIO
M4Y 1Y5

Micro, Slide, Push Button Switches

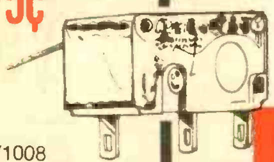
NORM ON/ OFF MICRO SW.



75¢

V1005

LEVER TYPE MICRO SW.



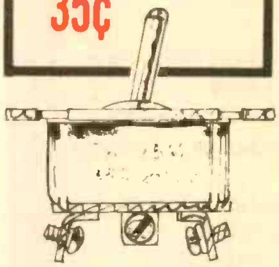
75¢

V1008

BAT HANDLE TOGGLE SW.

U1447

35¢



Heavy Duty

S.P.D.T. ILLuminated

Has nice snap action.

S.P.S.T. WIRED TOGGLE SW.

U1444

$1.19

Rated 3A-250 V AC

CHERRY KEY BOARD SW.

75¢

V1020

Miniature Push Button Switches.

29¢

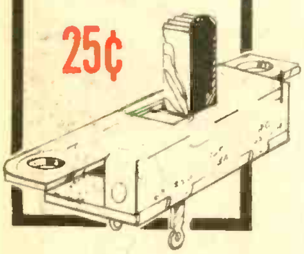
V1085

1951 Prices in 1981

SPRING RETURN S.P.S.T. SLIDE SW.

V1011

25¢



rated 3A-125 V AC

SLIDE SWITCH D.P.D.T.

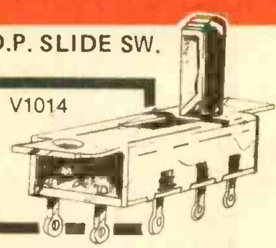
25¢

3P.D.T. SLIDE SWITCH

25¢

3POS. D.P. SLIDE SW.

V1014



Position (1) A & B and E & F are shorted

Position (2) B & C and F & G are shorted

Position (3) C & D and G & H are shorted

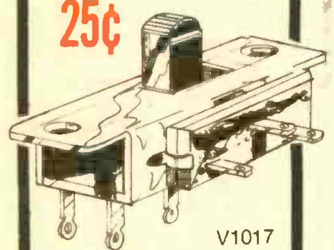
rated 3A-125 V AC

A.	B.	C.	D.
BOTTOM VIEW			
E.	F.	G.	H.

Very usfull see diagram

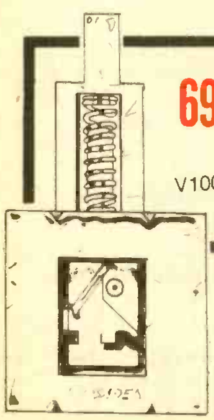
3P.D.T. SPRING RETURN SW.

25¢



V1017

PUSH ON/PUSH OFF SW.



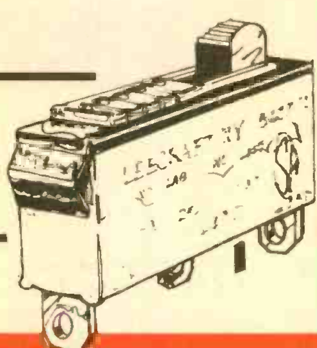
69¢

V1004

Illuminated S.P.S.T. SLIDE SW.

59¢

V1046

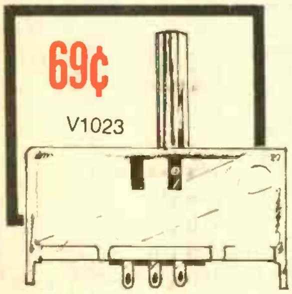


Built in neon indicator red lens, black bezel snap in mount

SLIDE SWITCHES

69¢

V1023



Rated 3A-250 V AC

30th Anniversary Sale

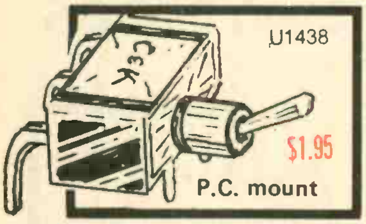
DOMINION RADIO & ELECTRONICS COMPANY

535 Yonge Street, Toronto, Ontario, M4Y 1Y5

Switches

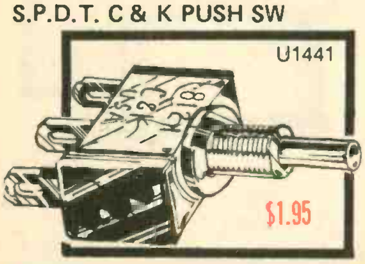
30th Anniversary Sale

MINIATURE CARD EDGE
P.C. S.P.D.T. SW.



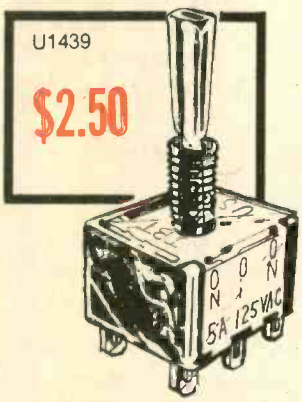
U1438
$1.95
P.C. mount

S.P.D.T. C & K PUSH SW



U1441
$1.95

D.P.D.T. SW.
No' CENTREOFF.



U1439
$2.50

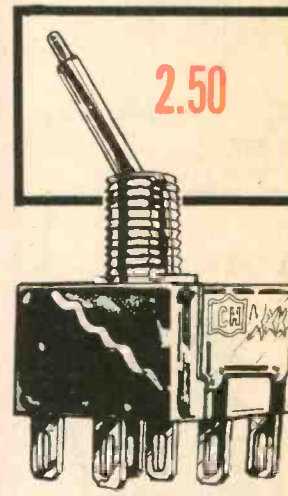
Mounts in 1/4" hole
Extends 5/8" behind panel
Rated 3A-125 V AC

MINIATURE D.P.D.T.
CENTRE OFF

U1440
$2.50

Fit 3/8" hole chrome lever

SPRING RETURN ONE SIDE



2.50

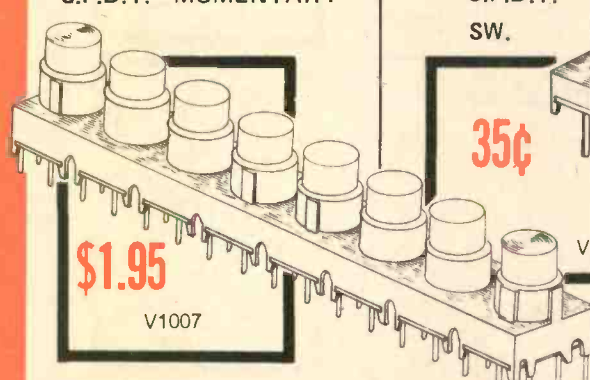
Push on terminals

Special Bargains

C & K SPRING RETURN
D.P.D.T. MINIATURE SW.

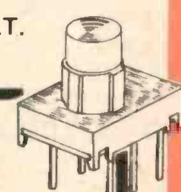
$2.50
U1445

8 GANG PUSH SW.
3.P.D.T. MOMENTARY



$1.95
V1007

MOMENTARY PUSH
3.P.D.T.
SW.



35¢
V1022

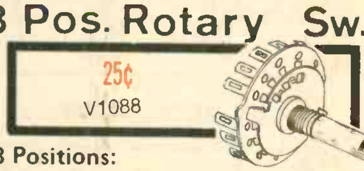
MINIATURE TOGGLE SW.
3.P.D.T. P.C.

U1449
$3.25

Size: 17 mm x 23 mm
P.C. mount pins 1/4" spacing
Gold flash contacts

1951 Prices in 1981

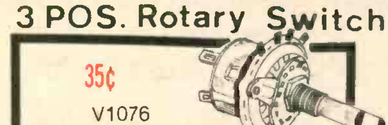
3 Pos. Rotary Sw.



25¢
V1088

3 Positions:
(1) 3 shorting/select
(2) 2 shorting circuit and shorting circuit 2
(3) 2 shorting circuit and 2 select.
Shaft length 7/8" fits 1/2 round knob

3 POS. Rotary Switch



35¢
V1076

3 Positions: On Ceramic Wafer
(1) 2 pole select
(2) 1 pole short select
(3) 2 pole select
(4) separate ON/OFF sw.

3 POS. Rotary Switch

25¢
V1061

3 Position Wafer Sw.
(1) In select one 2 in select one
(2) In select two 2 in select 1
Shaft 2" length 1/4" dia.

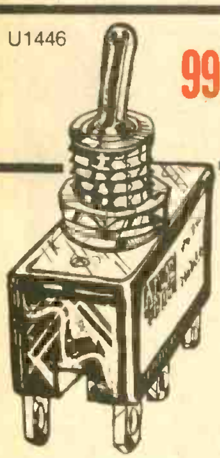
30th Anniversary Sale

REGULAR TOGGLE SW.
S.P.S.T.

U1442 $1.39

Rated 3A-125 V AC

BAT HANDLE
D.P.D.T. TOGGLE SW.

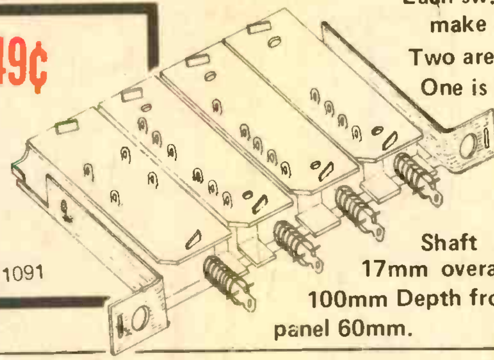


U1446 99¢

Standard Size
Very Popular

Multi-Function Sw.

NEW MULTI GANG BAR SWITCHES

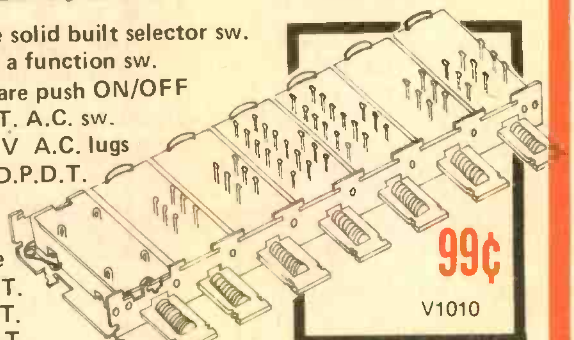


49¢ V1091

Each sw. push to make or break
Two are S.P.S.T.
One is D.P.D.T.

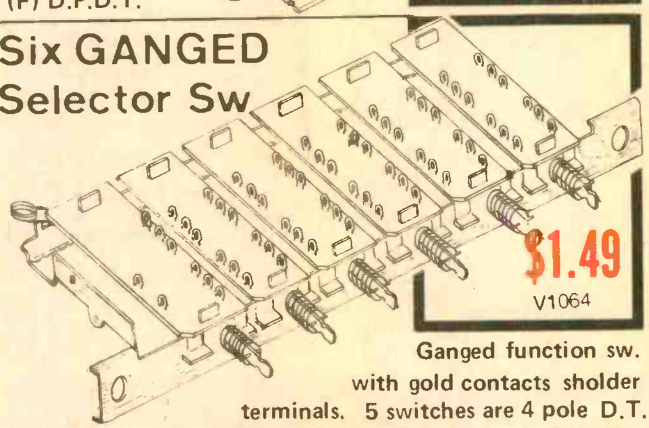
Shaft centres 17mm overall length 100mm Depth from front panel 60mm.

Low profile solid built selector sw. was used as a function sw.
4 switches are push ON/OFF
(a) D.P.S.T. A.C. sw.
5A 250 V A.C. lugs
(b) & (c) D.P.D.T.
(g) 3 pole D.T.
Cancel Type
(D) S.P.D.T.
(E) S.P.D.T.
(F) D.P.D.T.



99¢ V1010

Six GANGED Selector Sw

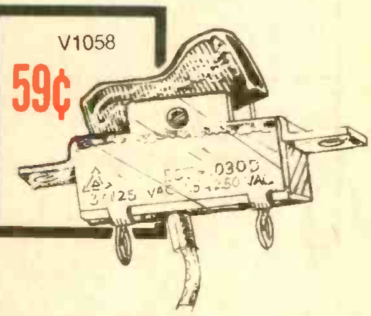


$1.49 V1064

Ganged function sw. with gold contacts sholder terminals. 5 switches are 4 pole D.T. Each cancelling the other when pressed. 6th is D.P.D.T. Push ON/Push OFF power sw. 3A-125V.A.C. These switches have been used for speaker selectors, tape deck selector, tape soarce selector, and unit selector knobs available on request 20mm shaft centres. Over all length 160mm.

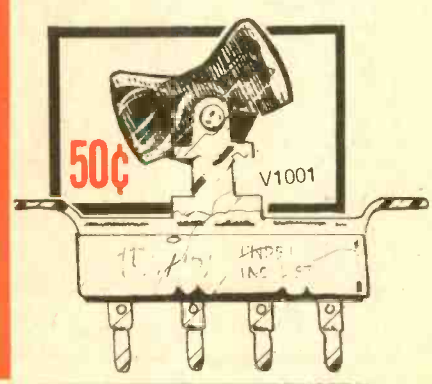
Rocker Switches

1.49 V1034



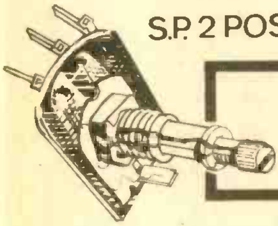
V1058 59¢

3POS. D.P. ROCKER SW.



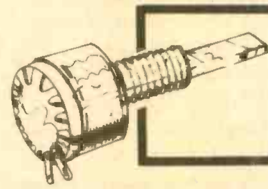
50¢ V1001

S.P. 2 POS. ROTARY SW



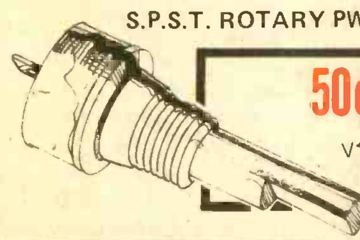
25¢ V1019

S.PD.T. ROTARY SPEAKER SW.



50¢ V1073

S.P.S.T. ROTARY PWR. SW.



50¢ V1016

DOMINION RADIO & ELECTRONICS COMPANY
535 Yonge Street, Toronto, Ontario, M4Y 1Y5

PLUGS JACKS & ADAPTERS

RCA PHONO PLUG	$.10	A1	
INSULATED RCA PHONO PLUG	$.20	A2	Red or Black
INSULATED RCA PHONO PLUG	$.35	A4	
SHIELDED RCA PHONO PLUG	$.45	A5	
RCA PHONO JACK	$.15	A6	
CHASSIS MOUNT RCA PHONO JACK	$.30	A7	
INLINE RCA PHONO JACK	$.35	A8	
DUAL RCA PHONO JACKS	$.30	A9	
SHIELDED INLINE RCA PHONO JACK	$.45	A10	
ULTRS MINI ATURE PLUG	$.15	A11	
ULTRA MINIATURE LONG BARREL PLUG	$.25	A12	
MINIATURE PLUG	$.20	A13	
MINIATURE PLUG	$.35	A14	
CHROME MINIATURE PLUG	$.50	A15	
ULTRA MINIATURE INLINE LONG BARREL JACK	$.35	A17	
ULTRA MINIATURE CHASSIS MOUNT JACK	$.15	A15	
CHASSIS MOUNT JACK	$.20		#901 Closed Circuit #902 Open Circuit
MINIATURE INLINE JACK	$.35	A19	
CHROME MINIATURE INLINE JACK	$.50	A20	
STANDARD PHONE PLUG	$.55	A21	Black
SHIELDED PHONE PLUG	$1.49	A22	
SHIELDED INLINE PHONE JACK	$1.49	A27	
INLINE PHONE JACK	$.55	A26	
CHASSIS MOUNT PHONE JACK	$.40	A28	Closed Circuit
CHASSIS MOUNT PHONE JACK	$.40	A29	Open Circuit
STEREO PHONE PLUG	$.89	A31	

VARIABLE SPEED SWITCH

$4.95 ea.

Originally from an electric drill, this trigger control device is 120vac, 4 amp and has a locking switch. Limited quantity available.

30th Anniversary Sale

SHIELDED STEREO PHONE PLUG	$1.89	A33	
STEREO PHONE JACK CIRCUIT CLOSING	$.50	A34	
INLINE stereo PHONE JACK	$.99	A35	
STEREO PHONE JACK	$.55	A36	
SHIELDED STEREO INLINE JACK	$1.49	A37	
EPOXY STEREO PHONE JACK	$.99	A38	CIRCUIT CLOSING
STEREO Y ADAPTOR	$3.95		
MALE CHASSIS MOUNT MIKE CONNECTOR	$.59	A45	5/8 - 27 thread
PHONO JACK TO PHONO JACK ADAPTOR	$.89	A43	
PHONO PLUG TO PHONE PLUG ADAPTOR	$.99	A47	
PHONO JACK TO PHONO JACK ADAPTOR	$.99	A48	
FEMALE INLINE MIKE CONNECTOR	$.89	A50	5/8-27 thread
PHONO JACK TO MINIATURE PLUG ADAPTOR	$.89	A52	
ULTRA MINIATURE JACK TO MINIATURE PLUG ADAPTOR	$.99	A53	
MINIATURE JACK TO ULTRA MINIATURE PLUG	$.99	A54	
MINIATURE JACK TO PHONE PLUG ADAPTOR	$.99	A55	
PHONE JACK TO ULTRA MINIATURE PLUG ADAPTOR	$.99	A57	
MINIATURE JACK TO PHONO PLUG ADAPTOR	$.99	A56	
PHONE JACK TO MINIATURE PHONE PLUG	$.99	A59	
PHONE JACK TO PHONO PLUG ADAPTOR	$.99	A60	

DOMINION RADIO & ELECTRONICS COMPANY

535 Yonge Street, Toronto, Ontario, M4Y 1Y5

A DIVISION OF DREECO ELECTRONICS LTD.

THE HOME OF RADIO & ELECTRONIC SUPPLIES

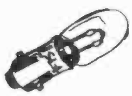
NO. 42 BULBS

15¢ ea.

3.2 Volt — 5 cp. 3000 hour average life. Base T-3 1/4 bulb screw type miniture.

Part No: U1400 Box 10 lamps 99¢

NO. 47 MINIATURE LAMPS 6.3 VOLT



15¢ ea.

U1401

6.3 volt —150 ma replacement for Auto & Home Stereo Receivers.

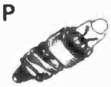
NO. 49 LAMPS

15¢ ea.

2 volt — .04 cp 60 ma. G4 - 1/2 Bulb. Miniture Bayonet Base.

Box of 10 pcs. 99¢ U1402

NO. 112 PRE-FOCUS LAMP



U1403 20¢ ea.

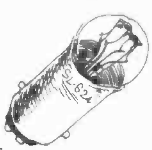
1.2 volt — 22 ma. 5 hr. average life style TL-3 Base miniature screw.

NO. SL-4T4 APPLIANCE BULBS

U1404 29¢ ea.

120 volts appliance S6 bulbs with cancelabra base. Clear bulb.

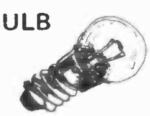
NO. 624 AUTO-LAMPS



U1405 29¢ ea.

28 volt — .37 amp. 6 cp. Type dual element style G-6.

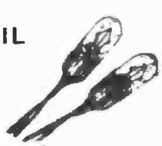
NO. 502 MINIATURE BULB



U1406 15¢ ea.

5.1 volt - .6 cp. 150 ma. Style G4 G4-1/2 bulb miniature screw base

MINIATURE PIG-TAIL LAMPS 6.3 VOLT

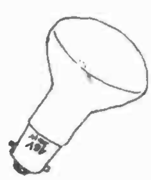


39¢ ea.

U1407

6.3 volt —150 ma replacement for Auto & Home Stereo Receivers.

NO. 1390 SPOT LAMP



59¢ ea.

U1408

48 volt — 20 watt 1500 hr. average life. Style R-12 single contact Bay Base

NO. NE-2 NEON LAMPS

U1409 10¢ ea.

For 120 V AC operation use 200k resistor.

NO. 6-7130 PUSH IN LAMP

U1410 79¢ ea.

6 volt Osram mini-Push In.

NO. 6A1 TELEPHONE LAMP

U1411 1.29 ea.

6 volt .14 amp type T-2 end ft. candles 900. Longlife telephone type.

MINIATURE 12 VOLT LAMPS

U1412 15¢ ea.

12 volt — 2cp miniature Bayonet Base.

12 VOLT-2CP MINIATURE BAYONET BASE

U1413 15¢ ea.

12 volt — 2cp miniature Bayonet Base.

NO. 1850 BULBS

15¢ ea.

U1414

28 volts — 70 ma T3-1/4 bulb with miniature Bay Base.

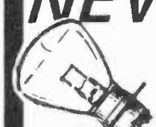
NO. 1829 BAY LAMPS

15¢ ea.

U1415

5 volt — 90 ma. 1500 hr. style T3 1/4 Bay Base.

NEW! PHILIPS Antique AUTO Bulbs

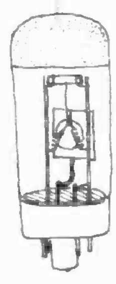


PREFOCUSED

ANY TYPE Your Choice 29¢ EA

Part No:		Style	Voltage:	Type:	Candle Power:
U1416	1009	D.E.	12V	Auto	
U1417	1252	D.E.		Auto	
U1418	1615	S.E.		Auto	
U1419	1829	S.E. Bay	28V	Auto	.07A
U1420	1850	S.E.	5V	Auto	.09A
U1421	SL2331	D.C. RPII	6V	Auto	32/32 C.P.
U1422	2336	DC	12-16V	Auto	32/32 C.P.

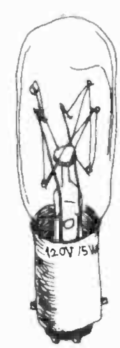
NO. G17Q PROJECTOR



U1423 $1.99

120 volts 150 watts pre focus built in reflector 4 pin locktal base.

DUAL CONTACT APPLIANCE LAMP

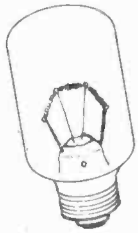


89¢

U1425

120 volt 15 Watt Bayonet Base dual contact base. Used in Vacum & Electric Brooms.

500W FOTO-FLOOD



U1424

99¢

MOGLE BASE

120 Volt 500 W.

30th Anniversary Sale

DOMINION RADIO & ELECTRONICS COMPANY

535 YONGE STREET
TORONTO, ONTARIO
M4Y 1Y5

BULBS, LEDS & LDRS

Special Bargains

NO. CHANDELIER BULBS

U1426 **25¢**

130 volt 15 watts torpedo clear lamp with candelabra base.

MINIATURE BASE CHANDELIER BULBS

U1427 **25¢**

130 volt 15 watts torpedo clear lamp with miniature screw base

NO. 7C7 APPLIANCE BULBS

Baynoet Base U1428 **25¢**

120 Volts 7W dual contact Bay Base style C7/7C7

NO. APPLIANCE BULB

Screw Base

U1429 **25¢**

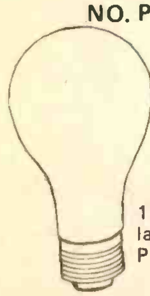
120 volts 7 Watt Candelabra Base style C7

AQUARIUM LIGHT BULBS

U1430 **49¢**

130 volts 40 watt frasted designed for quariums to bring out natural colours.

NO. PF 208E/60 PHOTO LITE



U1431 **99¢**

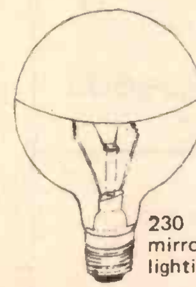
120 volts 500W photography lamp fits Reg. socket. Ideal for P.C. Board Developing.

NO. 57217E/25 PHOTO LAMP

U1432 **99¢**

115 volt 80 Watt lamp need balast to Ionize Gas Filled Lamp.

DECORATIVE LAMPS



U1433 **99¢**

230 volts 60 watts lamps with mirror non glare refector for back lighting. Standard Base.

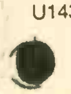
30th Anniversary Sale

CADMIUM SULPHIDE

U1434 **99¢**

500ohms-5k ohms

CLAIREX No. 705L



U1435 **99¢**

100ohms-3kohms

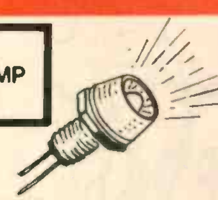
CLAIREX No. 505 L

99¢

1kohms-10k ohms

U1436 No. CSD3

RED LED LAMP

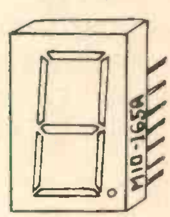


B1112 **49¢**

RED LED

SINGLE DIGIT DISPLAY

99¢

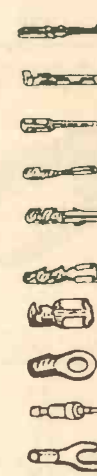


B1100	RED	.29
B1101	GREEN	.39
B1102	YELLOW	.39

B1103	RED	.29
B1104	GREEN	.39
B1105	YELLOW	.39

Hardware

PK. OF 10	Y1000	
PK. OF 10	Y1001	
PK. OF 10	Y1002	
PK. OF 10	Y1003	
PK. OF 10	Y1004	
PK. OF 10	Y1005	
PK. OF 10	Y1006	
PK. OF 10	Y1007	
PK. OF 10	Y1008	
PK. OF 10	Y1009	

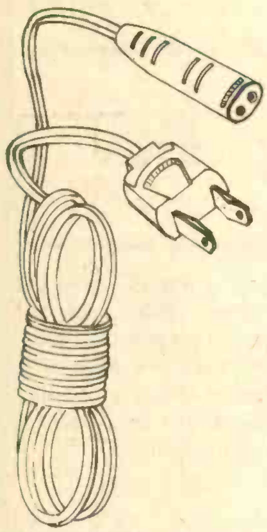


99¢ pk.

DOMINION RADIO & ELECTRONICS COMPANY

535 Yonge Street, Toronto, Ontario, M4Y 1Y5

Shaver Cords



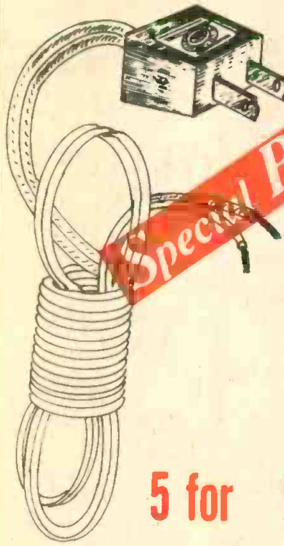
79¢

PURCHASED from a well known manufacture these portable shaver cords are always in demand. Pin spacing on cheater end 5 mm. Come in white, seven ft. rated 50 watts CSA.

Part No: U1450

Shaver cord . . . .

Lite Cords



Special Bargains

25¢

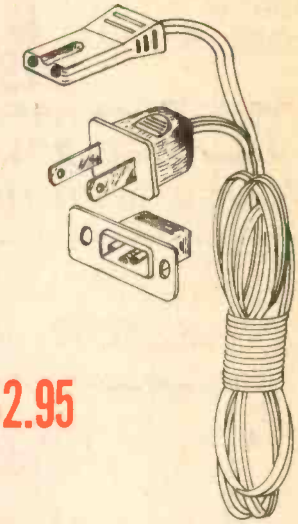
5 for $1.00

POWER line cords approx: 100,000 pcs in stock 20 ga. clear in colour with easy grip moulded plug. Ideal for small projects at school, lamp manufacture, or just as a replacement.

Part No: U1451

Clear cord . . . .

Cheater Cord



$2.95

PORTABLE equipment cord with key on cheater end. Used on cassette recorders of many types. Comes in black only with classis receptacle.

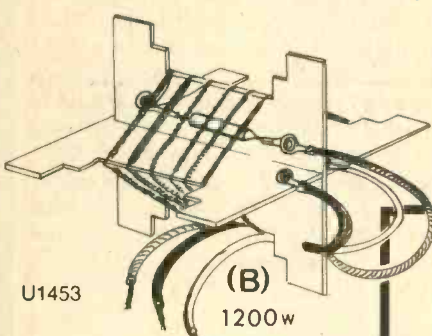
Part No: U1452

Cassette cord . . . . . .

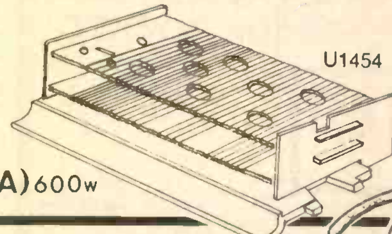
Brand New! HEATING ELEMENTS

For: ELECTRIC Styling Combs, Blowers & Mist Units

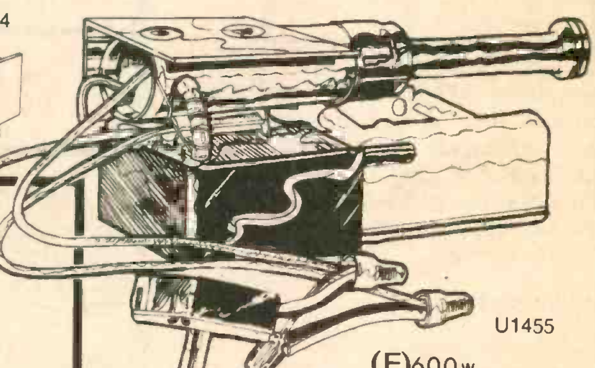
* WITH:DUAL HEAT RANGE
* 600w. 1000w. &1200w. all listed below:



U1453 (B) 1200w



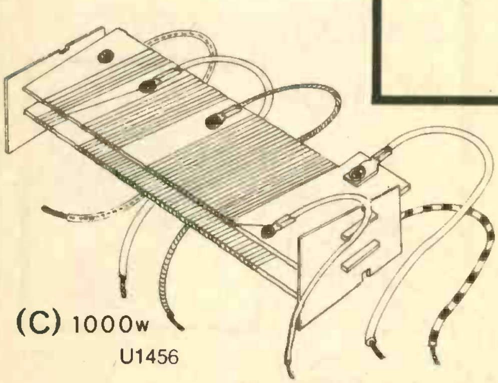
U1454 (A)600w



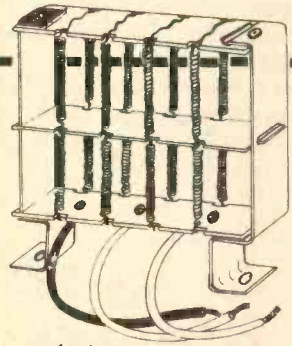
U1455 (E)600w

YOUR CHOICE

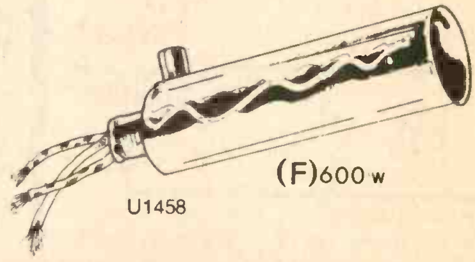
99¢



(C) 1000w U1456



(D)1000w U1457



U1458 (F)600w

30th Anniversary Sale

DOMINION RADIO & ELECTRONICS COMPANY

the men who operated them, encumbered as they were with homebuilt equipment and inadequate studio facilities. That they programmed at all and maintained a modicum of a schedule still makes one wonder.

For example, at one time the studio at Stratford were housed over a little used hotel annex. Whenever they unloaded beer kegs downstairs for weekend customers, the thumping on the floor caused the homebuilt turntables to jump, sending pickups sprawling and interrupting programs. These hazards, to me, typified early Canadian Radio where, often as not, studios were nothing more than a back room in a radio service shop and the associated transmitter was downtown, compared with the rural location of today with thin, vertical towers pointing to the sky.

Our own 10AK in '36 used wire strung between the chimney of the local steam laundry (the tallest point in the area) and the back of the Higgins Radio shop in downtown Stratford. It was an achievement, when kids, to be able to pick up old 10AK on a home-built crystal receiver. This station boasted a 50 watt transmitter, a carbon microphone and a phonograph.

Radio had been growing in a national way before 1930. Key stations were being opened right across Canada by the CNR, whose interest was illustrated by their early success in radios installed in Pullman cars. It soon became apparent Canada was developing two forms of radio; the local, independent station which, though commercials were still not able to maintain them, at least identified their character, as being apart from the CNR's operation, which was Government supported.

The inevitable question was asked: should Canada have its own national system or leave it to private enterprise to develop? Why couldn't we keep listening to U.S. stations which, since KDKA's early success in 1921, all but set the listening habits of thousands of Canadians, or, for that matter, use the local. But things had already been moving, national wise.

The Aird Commission was set up on December 6, 1928, to try to find an answer. Sending delegates to Europe for a start, they conducted enquiries throughout the continent and found countries there who were also searching for the same thing: a form of national broadcasting "in the public interest". Returning, they conducted hearings in Canada (like our past B & B Commission?) to pursue the question further.

Train Radio

Sir Henry Thornton, an early advocate of radio for Canadians and at the time President of the CNR, placed a private railway car at the Commission's disposal, facilitating their travels, which took in 25 Canadian cities. the conclusions of their findings was that a majority felt broadcasting should be on a public basis.

In the meantime, a growing rival who was to prove a difficult adversary of the majority's opinion, the CPR (with its extensive network wired facilities), felt broadcasting should be on a commercial basis. Championed by the Toronto Telegram and the old CKGW Toronto radio station (now defunct), they almost succeeded in having their way. This, despite the fact the CNR already had the basis of a successful network.

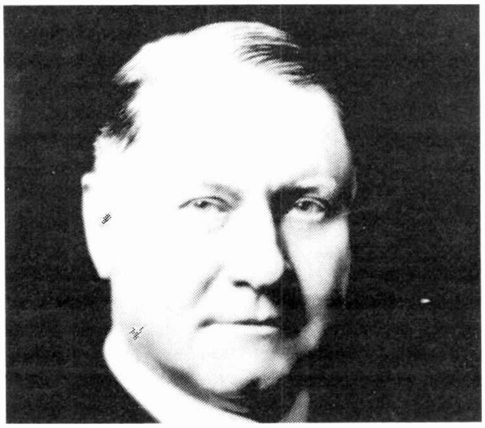


Fig. 1 Sir Henry Thornton

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Sir Henry Thornton, who did so much to promote early Canadian radio and who succeeded in fostering a sense of national identity, with the CNR network carrying the sound of the Peace Tower Chimes from Ottawa across Canada, for example, was caught in the middle of the growing controversy. In 1932, he recommended a Royal Commission to investigate all phases of the operation.

Two men appeared on the scene about this time Graham Spry and Alan Plaunt, both under 30 years of age and in the enthusiasm of youth saw what others failed to recognize in the possibilities existing for Canadian radio. Both had attended university in England and there had come in contact with the then young BBC. Together with eminent Canadians who shared mutual interests in Canada they formed the Radio League, out of which broadcasting in Canada, as we know it, had its genesis.

Spry appeared before the Duff Commission on behalf of the Radio League on January 14, 1932, arguing the railways were the principal program-builders in Canada (representing as they did half of all the coast-to-coast broadcasting at that time). He emphasized the value of the railways' wire services as indispensable to national programming, pointing out the many experimental stations could not hope to duplicate such a service. He made his point and the philosophy of a national system — augmented by comercial interests — followed. It was from this beginning that he enjoyed the assistance of Alan Plaunt and a man who proved their most impressive witness at hearings, Mr. Gladstone Murray from the BBC, who later became general manager of the CBC.

This new service was the first counter-force to the growing flood of programs now inundating Canada from the U.S.

The early forerunner of Canadian radio and the CBC — the Canadian Radio Commission — is lost in antiquity and never was resurrected, although it actually had the difficult and thankless task of taking over the vast network facilities of the CNR, suffering much abuse from politician and broadcaster alike. It laboured under much political acrimony, which involved both the Liberal and Conservative Parties under their respective leaders, W.L. Mackenzie King and R.B. Bennett. Sir Henry Thornton, who did so much to promote early Canadian radio, left Canada, and died in this native country.

Thornton's talks, heard by some of us at the height of his popularity over "his" CNR radio, were summed up by John Nelson writing in MacLean's of February 1925 and reported in Austin Weir's book "Struggle for National Broadcasting in Canada". Nelson said of Henry Thornton: "His talks, really fireside chats, were friendly, intimate, timely and dealt with a great variety of topics." He described how they were directed at acquainting employee and public alike of the CN's hopes, plans, successes and policies. Compliments received by customers, for example, about a certain porter, were relayed across the network, and every porter took pride in his work.

It was claimed at one time that it was the CNR's efforts in radio as ear-

RADIO STATION **CKBW** BRIDGEWATER N.S.
Station Engineer
James W. Essex 1947–49

ly as 1924 which was solely responsible for the success of immigration, helping, as it did, to quell the two greatest enemies of immigrants loneliness and isolation. The degree to which radio had become a vital part of the CN's operation in those distant days is illustrated by the fact that over an estimated 10 year period beginning 1923, the line spent over $2 million on radio, over half of it for programming and slightly less than half for transmitters and receivers on board trains.

Topping the Competition

There were many laughs interspersed with the pathos of those days. For example, that same 10AK which preceded CJCS had something of a record in another sense distance. For even with 50 watts, its radio voice far outweighed its own pecuniary circumstance. Perhaps out of pride in the achievement of being heard as far away as Detroit, Mich., over 150 miles distant, or merely being egged on by the desire to counteract the growing might of the U.S. stations now getting more powerful (in 1932 WLW Cincinnati went to 50, 000 watts and hammered into Stratford),10AK boasted a regular Saturday Night "Olde Tyme Show" over its 50 watts. Second to none, they proclaimed and to add emphasis the announcer said it originated from the 44th floor of their studios in downtown Stratford. Of course there were no buildings there over three stories, let alone 44! That the blarney had the necessary effect is evidenced by at least one intrepid fan from Detroit arriving in Stratford one day to ask where all the tall buildings were!

These earnest, if humble and comical efforts to add prestige to Canada's early broadcasts could not make up for the growing imbalance of power between Canada and U.S. stations. The total power of Canadian stations, even up to 1932, was less than a present day 50 kW transmitter, compared to a total of 680, 000 watts for American stations 30 years later! And more than a third of our stations were concentrated in Toronto and Montreal, leaving great isolated areas served from the U.S. It is to the credit of the early visionaries who doggedly pursued the argument of a national broadcast system for Canada that this has been changed. Their success is attested by the fact that nearly 90% of Canada now enjoys Canadian coverage.We are also in second place (next to the U.S.) for density of number of receivers, having approximately 58 receivers per 100 population, according to G.A. Codding's book "Broadcasting without Barriers", published by UNESCO. The U.S. have 88 receivers per 100 population, while the United Kingdom have 28.5 per 100. The USSR have about 16.5 per 100 population, with a bottom, in India, of only 0.3 per 100, though with its large population this still represents over 1 million sets.

Through the efforts of men of the calibre of Thornton, Spry, Plaunt, Austin Weir (commercial Manager, CBC, 1937-50), A.R. McEwan, Canada also set a record of "firsts" in communications. Amng these was the experimental use of radio on trains as early as October 13th, 1902, ten months after Marconi's epic first trans-Atlantic wireless message, when Dr. Ernest (later Sir Ernest) Ruthford and Dr. Howard Barnes successfully demonstrated the transmission of radio signals to a moving train with receivers located on board the "Internation Limited".

On October 9, 1923, the British Prime Minister, David Lloyd George, touring Canada at the time, was shown how newscasts could be picked up, via radio, aboard a moving train.

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7405	0.37	7492	0.48	74246	1.74	74LS02N	0.29	74LS55N	0.31	74LS148N	1.75	74LS240N	1.16	74LS352N	1.70	74LS443N	6.08
7406	0.45	7493	0.49	74247	1.59	74LS03N	0.29	74LS63N	2.21	74LS151N	0.55	74LS241N	1.16	74LS353N	2.10	74LS444N	6.08
7408	0.37	7495	0.68	74248	1.49	74LS04N	0.29	74LS73N	0.42	74LS153N	0.46	74LS242N	1.16	74LS362N	12.50	74LS445N	4.62
7410	0.35	7496	0.75	74249	2.02	74LS05N	0.29	74LS74AN	0.42	74LS155N	0.86	74LS244N	1.16	74LS365N	0.67	74LS447N	1.12
7413	0.50	74107	0.56	74251	0.98	74LS08N	0.32	74LS75N	0.45	74LS156N	0.93	74LS245N	2.09	74LS366N	0.67	74LS640N	2.66
7414	0.51	74121	0.59	74259	2.40	74LS09N	0.31	74LS76N	0.48	74LS157N	0.61	74LS247N	0.99	74LS367N	0.67	74LS641N	4.06
7417	0.45	74122	0.61	74265	1.70	74LS10N	0.32	74LS78N	0.38	74LS158N	0.61	74LS248N	1.40	74LS368N	0.67	74LS645N	1.21
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7475	0.65	74193	0.82	74390	1.20	74LS40N	0.39	74LS126N	0.56	74LS193N	0.83	74LS323N	6.00	74LS321N	3.78		

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4020	1.22	4175	1.05
4023	0.21	4194	1.41
4027	0.64	4409	13.32
4029	0.88	4410	10.38
4044	0.85	4411	11.69
4046	0.98	4419	8.80
4049	0.48	4422	—
4050	0.64	4433	16.03
4051	0.99	4501	0.45
4069U	0.21	4502	1.23
4071	0.28	4503	0.95
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4006	1.18	4516	1.17
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4008	1.06	4519	0.68
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4015	1.23	4522	1.34
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4022	1.02	4528	0.94
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4028	0.70	4530	1.21
4030	0.48	4531	1.99
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4040	0.84	4539	1.07
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4066	0.61	4557	4.43
4068	0.30	4558	1.96
4070	0.30	4561	1.75
4072	0.25	4566	1.58
4073	0.31	4568	4.86
4075	0.36	4572	0.51
4076	0.83	4580	6.53
4077	0.39	4583	1.90
4078	0.30	4584	0.64
4082	0.30	4585	1.34

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1N749	0.12	1N3214	6.24	1N4735A	0.16	1N4747A	0.16	1N5339B	2.02	1N5354B	2.02	1N5370B	2.02
1N751	0.13	1N4001	0.05	1N4736A	0.16	1N4748A	0.16	1N5340B	2.02	1N5355B	2.02	1N5375B	2.02
1N753	0.12	1N4002	0.06	1N4737A	0.16	1N4749A	0.16	1N5342B	2.02	1N5356B	2.02	N5378B	2.02
1N754	0.12	1N4004	0.08	1N4738A	0.16	1N4750A	0.16	1N5343B	2.02	1N5357B	2.02	1N5379B	2.02
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1N757	0.12	1N4007	0.11	1N4740A	0.16	1N4752A	0.16	1N5346B	2.02	1N5359B	2.02	1N5384B	2.02
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1N3208	1.98	1N4730A	0.16	1N4743A	0.16	1N4755A	0.22	1N5349B	2.02	1N5363B	2.02	1N5402	0.46
1N3209	2.40	1N4732A	0.16	1N4744A	0.16	1N5333B	2.02	1N5350B	2.02	1N5364B	2.02	1N5404	0.26
1N3210	3.08	1N4733A	0.16	1N4745A	0.16	1N5335B	2.02	1N5351B	2.02	1N5365B	2.02	1N5405	0.25

Transistors

2N697	2.62	2N3053	0.91	2N3716	2.48	2N4124	0.13	2N4898	2.04	2N5088	0.22	2N6073A	2.08
2N706	0.80	2N3054	1.14	2N3725	1.48	2N4125	0.13	2N4899	2.70	2N5089	0.28	2N6075A	4.26
2N708	0.46	2N3055	1.00	2N3738	2.62	2N4126	0.13	2N4900	2.60	2N5179	1.84	2N6081	17.64
2N718	0.80	2N3114	0.88	2N3739	3.10	2N4221	3.28	2N4901	2.48	2N5191	3.46	2N6082	19.86
2N718A	0.58	2N3117	1.04	2N3740	1.76	2N4223	1.76	2N4903	3.80	2N5193	1.72	2N6084	25.74
2N918	0.80	2N3134	1.88	2N3741	2.92	2N4231A	1.78	2N4904	2.70	2N5207	0.18	2N6121	0.80
2N930	0.46	2N3251	0.48	2N3766	2.02	2N4234	1.62	2N4905	3.24	2N5210	0.58	2N6122	0.90
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2N2221	0.41	2N3567	0.52	2N3790	2.92	2N4348	3.36	2N4920	2.14	2N5401	0.60	2N682	4.70
2N2222	0.41	2N3568	0.54	2N3792	2.16	2N4360	0.48	2N4921	1.75	2N5550	0.43	2N685	7.98
2N2222A	0.33	2N3569	0.52	2N3866	2.12	2N4400	0.13	2N4922	2.02	2N5589	11.96	2N690	12.80
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2N2857	2.70	2N3638A	—	2N3905	0.26	2N4403	0.13	2N5033	1.62	2N5655	1.42	3N141	1.65
2N2894	3.16	2N3642	0.34	2N3906	0.19	2N4410	0.68	2N5060	0.76	2N5657	1.96	3N246/MDA100A	2.08
2N2904	0.58	2N3643	1.04	2N3964	1.16	2N4416	1.35	2N5061	0.78	2N5771	0.28	3N247/MDA101A	2.24
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2N2906A	4.46	2N3713	2.26	2N4036	1.00	2N4442	3.36	2N5064	1.00	2N6045	3.04		
2N2907	0.89	2N3714	3.72	2N4037	0.90	2N4443	4.62	2N5086	2.58	2N6070B	1.84		
2N3019	0.88	2N3715	2.26	2N4123	0.13	2N4444	7.22	2N5087	2.28	2N6071B	2.00		

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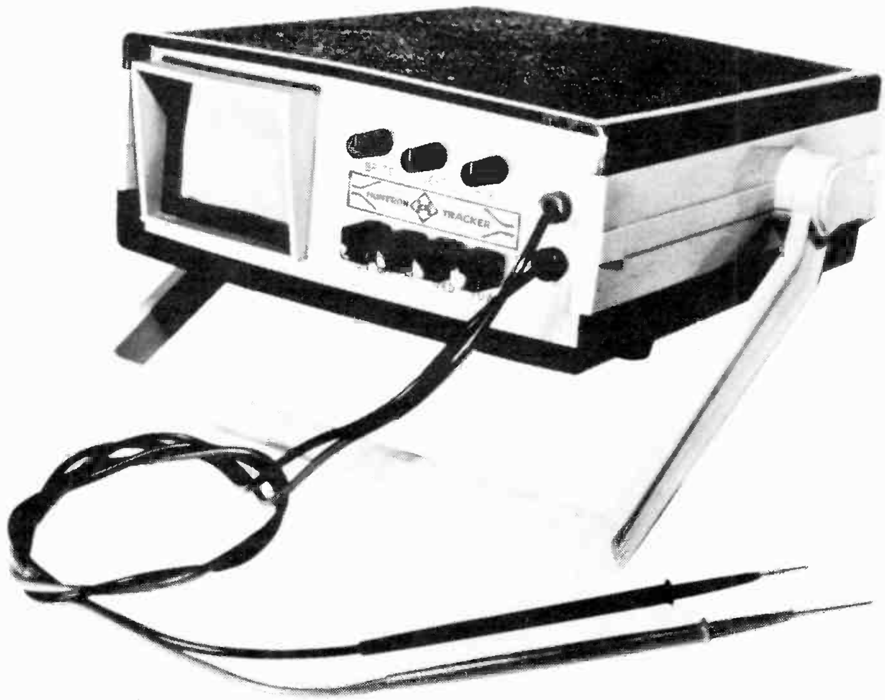

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Circle No. 3 on Reader Service Card.

The first trans-Atlantic broadcasts were begun by CNR radio in 1928, which saw the beginning of the "Empire" broadcasts over the same system in 1932, facilitated by The Canadian Marconi Company (without any remuneration) from its stations at Yamachiche and Drummondville, Quebec.

The concept of a bi-lingual network was begun in Canada with the first recorded program in language (French phonetics) being aired in 1931.

The early use of "Multiplex" (whereby more than one program could be sent over a pair of wires) was pioneered by the CNR in Canada to accommodate the growing demand for program carrying network facilities.

For sheer drama the coverage, in 1930, of the arrival of the R-100, Britains's huge dirigible which crossed the Atlantic in that year, can't be beaten. A leviathan nearly 800 feet long, its arrival in Quebec City was carried by the network in fact both, as the CNR and CPR had wires prepared with coverage from Montreal (where the mooring base was located at St. Hubert's) by a little known announcer named Foster Hewitt. Andy Ryan handled the CN network, and described the R-100's arrival in nearly inspired words, as the giant hovered over the city at dusk to the sound of every ship whistle, bell, and siren in the city.

Culture-wise, Canada registered a landmark with an early history series designed to acquaint Canadians with their own exciting past (the centennial efforts were something new?) and securing one of the top men of the day to run the series — Tyrone Guthrie who later became Sir Tyrone Guthrie of Stratford Shakespearean fame.

The establishment of the CBC in 1936 saw the residue irritants of the old Canadian Radio Broadcasting Commission removed, and Canada moved into a new era of broadcasting with the parallel growth of the CAB (Canadian Association of Broadcasters) the commercial arm of radio broadcasting. How many, for example, can forget the early "Good-Morning Sherriff's Hour", with their bright music and fun early each morning; or the "Happy Gang" whose lighthearted entertainment helped counteract the otherwise sombre war years?

Perhaps the great men of Canadian Radio are as the voices of radio itself — ghosts if you will — who speak even now. Many had died, like Alan Plaunt, still young at 37, with years of service unfulfilled. Plaunt was subsequently remembered by the "Alan B. Plaunt Memorial Lectures", established by Carleton University in 1958 and delivered annually.

Graham Spry — after leaving Canadian Radio — retained an active interest in it from his post in London, England where he served as Agent-General for Saskatchewan. Later, he frequently wrote on the subject for the Queen's Quarterly Review, retiring in 1968. As Austin Weir said of these two men who did so much for early Canadian radio, "it was commonplace for Plaunt and Spry to dig into their own pockets to provide needed funds for that early organizational work".

And perhaps this is as good an epitaph for the legions of men and women who, in a thousand different ways and varying capacities of service, have contributed to the growth of a once struggling child to the giant that is Canadian Radio today. ETI

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INTO LINEAR IC's (Part One)

Now that Into Electronics has finished, Ian Sinclair again puts pen to paper and tackles the awesome task of describing the habits of that family of ICs known as Linear ICs.

IF YOU'RE JUST GETTING INTO THIS ELECTRONICS CAPER, perhaps you think that you'd better avoid ICs. Can't say we blame you — ICs are small, with lots of connecting pins laid out a bit too close for comfort, and the circuits which use ICs look strange in comparison to the more familiar circuits which use transistors. Just to make life a bit more difficult for the unfortunate beginner, books for beginners very often don't mention ICs at all, and books which do mention ICs seem to assume that you know all about them already.

This series is designed to change all that. We're going to start off by introducing you to the types of IC which are classed as *linear* — and we'll explain what that means in a moment. Later — much later — we'll look at the other type of IC, the digital IC. In addition, the series will be built around practical work — we're not going to spend too much time on the theory of ICs. Reason is that what goes on inside an IC is not of so much interest as what goes on outside — it's not like a transistor circuit in which we can change any component we like. That doesn't mean we won't explain how the circuits work; we will, honest, but we won't explain the details of the circuits inside the ICs.

IC THE DIFFERENCE

What is an IC anyway? The letters stand for Integrated Circuit, which doesn't tell you much more than the phrase 'silicon chip' which you read in the papers — and they usually manage to add an 'e' to silicon as if it were a furniture polish. What the IC means is that a complete electronic circuit can be made on a small piece of silicon as easily and as quickly as a single transistor. Transistors are made from thin silicon pieces, called wafers, measuring about 1.25 mm square, by a set of manufacturing processes which include heating in various gases and evaporation of silicon and metals. Now as it happens, we can make resistors and capacitors by the same processes in a different sequence, so by using shields (or *masks*) over the silicon we can control what sort of component we make on each part of the wafer. By evaporating metal, we can then make connections between different sections, so constructing a complete circuit.

What's the advantage? It's not just that the whole circuit is smaller to an incredible extent, though that can be handy. The big, big advantage is that all the connections are made during the manufacturing process. Let's explain that. Suppose we made up a 5 transistor circuit (Fig. 1a) using separate components — the name for a circuit made this way is *discrete* circuitry. There are a lot of connections to make in this discrete circuit. Making each connection takes time, and each one is a possible source of trouble, like dry joints. mistakes, short circuits, the lot. Even if you get all of these connections right, there's a fair chance that one out of all these components may break down and fail at some time, and the more components you use, the greater the chance of at least one of them failing. An electronic circuit is like anything else — the more components it uses, the less reliable it is.

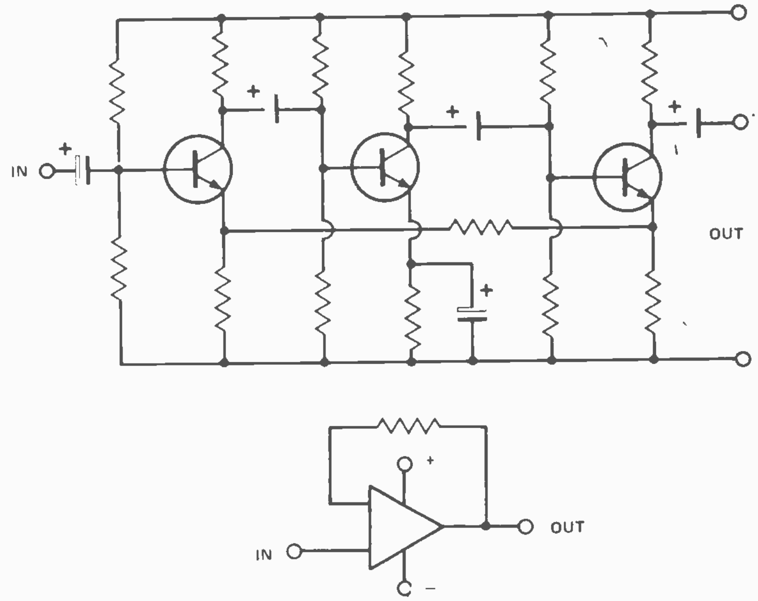


Fig. 1. A transistor amplifier circuit (a) and an IC circuit (b) with the same performance.

PINNED DOWN

Now if we make the same circuit in integrated form, as an IC Fig. 1b, there's just one component — the IC. All the components which make up the circuit are there, but because they were made in one operation and at the same time, they behave with the reliability of one component. There are now fewer connections to make; in the example shown, we've replaced 21 components and 42 connections by two components, the IC and resistors and seven connections. That's a big improvement, and because the IC is a single component, it can be tested more easily and more quickly than would be possible if we had to test each component of a discrete circuit separately, then the whole circuit once it was assembled.

That's not all, either. The IC is produced by the same sort of factory methods as are used to make transistors, so that making one IC costs about as much, once we get production going, as making one transistor. Because of that, the IC is usually cheaper than the components it replaces. Just to complete the list of advantages, the IC is not so easily damaged by mechanical shock (he means they still work after you've dropped them, lad) as a complete circuit made from separate components.

Any snags about all this? Well, yes, there's one. If you make up your circuits from separate components, you can make any circuit you like. Using ICs, aren't you limited to what the manufacturers think is worth providing? The answer is yes and no! A readymade circuit is a bit of a restriction, but the types of circuits that are made as ICs are so designed that they can be used in a huge number of ways, making them practically as versatile as separate components, as you'll see when we get round to trying out some circuits. To keep prices low, ICs have to be made in very large quantities, so that an IC must be useful for a lot of applications so as to earn a bit of bread for all the people who make it.

LINEAR AND DIGITAL

So far, so good. Now we come to the two main types of IC. Apart from a few specialised ICs, they're all either linear ICs or digital ICs, so now we have to explain what the difference is. Any electronic circuit usually has an input and an output, and we put a signal into the input and take a signal from the output. If the output signal is a copy of the input signal then the circuit is a linear circuit, an amplifier in fact. Why linear? If we plot a graph of the output signal voltage against the input signal voltage, the graphs shown in Fig. 2, then the graph shape is a straight line for a linear circuit — and that's where the word *line*-ar comes from. When an amplifier is perfectly linear, the graph line plotted as we've just described, is perfectly straight, and the output signal is a perfect copy (though to a different scale) of the input signal.

ICs that are designed for use as amplifiers are linear ICs, each part of the circuit inside the IC is a linear amplifier. A few other types of ICs are also classed as linear ICs, even though their output signals look nothing like their input signals, just because they contain linear amplifier circuits. We'll be looking at one of these ICs, the 555 timer, later in this series.

LINEAR ICs

How about digital ICs, then? Very briefly, because there's another series on digital ICs coming up, these ICs use the same types of signals for both input and output, and what we are interested in is what combination of signals or sequence of signals we have. Much more of that later, in the next series but for now we're concerned only with linear ICs.

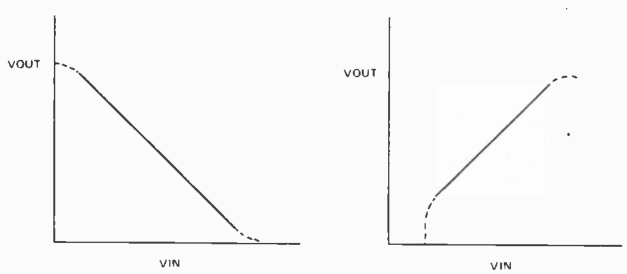


Fig. 2. Linear graphs (a) Inverting amplifier, (b) non-inverting amplifier. The graph lines usually bend noticeably at the ends, hence the use of bias to use only the straight portions.

SHAPES AND SIZES

The first ICs were made quite a fair time ago; the idea was first hawked around in 1952, but it wasn't until silicon was being used on a large scale to make transistors that the first serious attempts to make ICs started. In those days of the late 50's, only fairly simple circuits, two or three transistors and a resistor or two, could be made, and these first ICs didn't need many connecting leads, very often only four or five. These were input, output, supply positive, supply negative and perhaps an additional feedback connection.

Now the silicon wafer slice, or chip, which is used for an IC is the same chip as we use for a transistor, and it will fit into the same size of can. As a result the first ICs were mounted in the same TO-5 cans as were used for most transistors at the time, but with a few more leadout wires added. Because the TO-5 can is a fairly large one (by transistor standards), it was possible to use up to 9 leadout wires from one TO-5 can, and most of the early ICs were so mounted. You can still get these TO-5 ICs, but it's not the most convenient method nowadays. The kind of 'Package' that's most often used nowadays is the rectangular block of plastic with a row of pins on either side. This is called the dual-in-line package (shortened to DIL or DIP), and all ICs are obtainable in this form. The actual silicon chip takes up only a small part of the block, and the plastic is simply a convenient way of protecting the IC chip and its leadout wires.

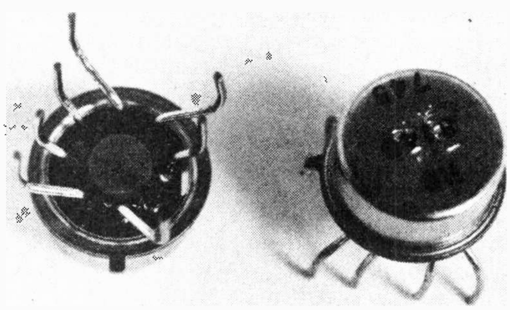


Fig. 3. An IC in a TO-5 can.

To make life simpler, a number of standard DIL packages are used, some with 8 pins, some with 14, some with 16. Larger pin numbers are used, but these numbers are the most common, particularly for linear circuits. The spacings of the pins are designed to fit a 2.5 mm grid (0.1" if you are unconverted), so that the distance between pins is always a multiple of 2.5 mm. The 8-pin, 14-pin and 16-pin types, for example, have the pins of each line set at 2.5 mm apart, and the lines 7.5 mm apart. Some of the bigger types of linear or digital ICs have the lines spaced 15 mm apart, but the spacing between pins on one line is always 2.5 mm.

Sometimes not all of the total number of pins in a DIL package are used, and in any case we need to know how the pins that *are* used are to be connected. To make it a bit easier, the pins are numbered, but the numbers aren't printed on the ICs — there isn't room. What is done is to mark the IC package so that we can find pin number 1, and then go on from there to find all the others. Fig. 5 shows how the pins are numbered. The index mark is a notch at one end of the IC, or a small dot at pin 1, sometimes both. When the small dot is used, it locates pin 1; the notch shows which end of the IC has pin 1. Looking down on the IC, pins *down*, with the notch at 12 o'clock, pin 1 is always at around 11 o'clock. The pins are then numbered in sequence down one line and up the next one, with the last pin at the notch end of the IC, around 1 o'clock. A few ICs, incidentally, look as if they have a notch at each end — the correct one to use is the one which is more deeply cut into the plastic.

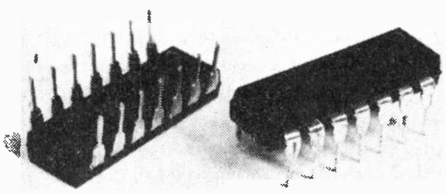


Fig. 4. Typical DIL packages.

PRACTICALITIES

Let's be practical for a moment. If all of your construction has been with transistors up to date, you're going to notice a difference. Transistors have thin leadout wires which can be bent and shaped to suit your circuitboard. ICs have thicker, flattened pins, and the circuit board has to be shaped, with solder pads 2.5 mm apart in lines 7.5 mm apart, to take the IC *without* bending the pins. On most solderboards, this presents a few problems because with lines spaced only 2.5 mm apart, your soldering has to be pretty neat if you're to avoid shorting tracks together with the solder. It's a great advantage to have a soldering iron with a really small bit, and to use fine-gauge solder — more of this in Part 2.

SYMBOLS

Good ol'fashioned transistor circuits use a symbol for each component and most of these symbols have been around for a long time. There aren't many standard symbols for linear ICs, mainly because so many linear ICs would need special symbols, and it takes longer these days to get a symbol accepted than it does to design and produce the IC! The symbol which is most often used is the triangle (Fig. 6) with input(S) at the flat end and output from the sharp end. This symbol is used to represent an amplifier, and since most linear ICs contain amplifiers or *are* amplifiers, it's the most useful thing to have a symbol for. Other linear ICs simply use a square or rectangular block symbol, with, input, output and power supply lines going in and out of the block. What goes on inside the IC then remains a mystery until we take a long hard look at the data sheet — and until you've finished this series it may remain a mystery even after you've seen the data sheet.

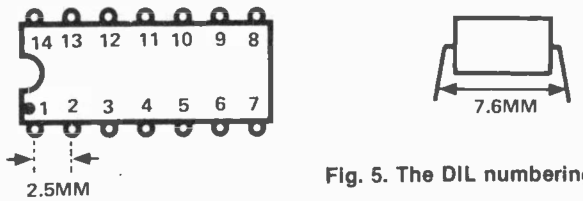
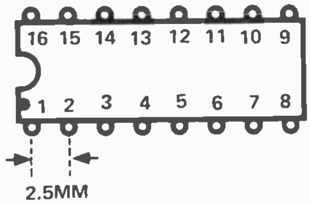


Fig. 5. The DIL numbering system.



One feature of the amplifier symbol needs a bit of explaining, though. A lot of IC amplifiers have two inputs, marked + and —. This has nothing to do with power supplies, but with feedback connections. Remember feedback? It means taking some of the output signal and connecting it back to the input of the amplifier. Feedback comes in two main types; positive, which increases gain and distortion, and causes amplifiers to oscillate; and negative which decreases gain and distortion and makes amplifiers more stable if we use it correctly. The + and — symbols at the input of the IC amplifier refer to feedback connections. A feedback connection from the output to the + input is a positive feedback connection, and a feedback connection from the output to the — input is a negative feedback connection. We can't get inside the IC, so we need some way of making these connections as and when we need them. We'll see how these two connections can be used later on when we look at the uses of the 741 IC amplifier chip.

BIAS AND FEEDBACK

One feature of an IC amplifier which looks as if it might be a source of trouble is the fact that we can't make large-value IC capacitors — they would take up too much room on the chip. IC amplifiers are directly coupled, meaning that the collector of one transistor in the amplifier circuit is connected directly to the base of the next one. Now if you recall anything about coupling signals from one transistor to another, you'll remember that direct coupling is a very odd business indeed. To use a transistor as a linear amplifier, the bias current has to be correct. What amount is correct, then? It's the amount which ensures that a normal input signal will not cause any transistor to cut off (no current) or to bottom (when the collector voltage is almost zero and can't go lower). If the transistor cuts off, the collector voltage reaches supply voltage and can't go higher — result is no more amplification until the voltage drops again. If the transistor is allowed to bottom, the collector voltage gets down to about 0.2 V higher than the emitter voltage, and can't go lower; again this means no more amplification until the voltage can rise again. If any transistor in an amplifier cuts off or bottoms, then the amplification certainly isn't linear. We usually ensure correct bias by setting the current through each transistor so that with no signals at the input, the collector voltage of each transistor is about half-way between the supply voltage and the emitter voltage.

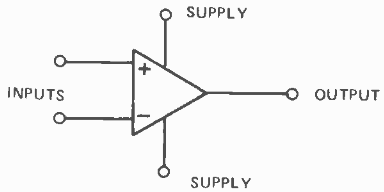


Fig. 6. Symbol for an amplifier IC.

DC COUPLING

Now the odd business about direct coupling is that we can't bias each transistor in an amplifier separately by itself. If all the transistors are connected together, collector to base, without the use of capacitors to isolate the DC, then the collector voltage of one transistor is the base bias voltage for the next one, and the only way we can control all of this is to have the bias for the first transistor in the amplifier set correctly, and design the amplifier so that setting the first one will ensure that all the others are correct also.

The only way we can bias a linear IC, then, is by applying a steady bias voltage at an input terminal. We can't take the circuit apart to get to any of the transistors inside, we simply have to assume that the designer of the IC knew what he was doing (and they do, folks, they do) and arranged things so that with the correct bias on the input each stage of the IC would be correctly biased.

We can ensure that we have the correct bias for linear action by using negative-feedback bias. As we've seen, a signal fed back from the output of an amplifier to the + input is positive feedback, but a signal fed back to the — input gives negative feedback. A linear amplifier IC can be correctly biased by connecting a resistor to act as a

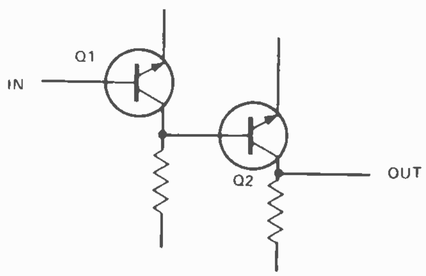


Fig. 7. Direct coupling — the base voltage of Q2 is equal to the collector voltage of Q1.

feedback path between the output and the — input terminal. This feeds back DC, and works only because the amplifier is completely direct-coupled.

How does it work? Let's take a look at a typical circuit (Fig. 8) which uses two separate batteries to operate a linear IC amplifier. Now using two batteries as this circuit does may look a bit complicated, but in fact it makes amplifier circuits a lot simpler, as we'll see later. In the

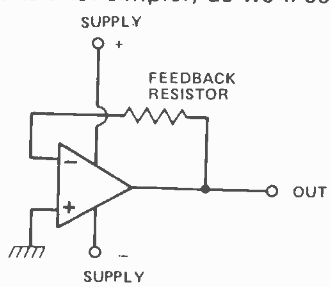


Fig. 8. Negative feedback bias — this is the bias system which is used for all linear amplifier circuits.

diagram, the + input of the amplifier is connected to earth, which is also the return path for both batteries, and the output of the amplifier is connected through a resistor (any size, 10K to 10M) to the — input. This automatically sets the amplifier to the correct bias.

HOW IT WORKS

Here's how it works. Remember that the circuit inside the linear IC is quite an elaborate one, containing a lot of transistors and with a very large voltage gain, 100 000 or more. In addition, the voltage that is amplified is not just the voltage at one input but the voltage *difference* between the inputs — if both of the inputs are at the same voltage there's nothing to amplify. We've shown the + input connected to ground, so unless the — input is also at ground voltage (give or take a bit, as we'll see), there will be some voltage difference between the inputs and this will be amplified to appear at the output. If the voltage at the + input is higher than the voltage at the — input, the output voltage goes high (to +9 V in the diagram) and if the voltage of the — input is higher than the voltage of the + input, the output voltage goes low (to —9 V in the diagram).

So far, so good, now we have to get back to the negative feedback. If we raise the voltage at the — input above earth voltage (which is the voltage of the + input), then the voltage at the output will drop below ground voltage. If we lower the voltage at the — input below ground voltage, then the output voltage will rise well above ground voltage. The output voltage is free to swing either above or below ground voltage because we've used two power supplies in this example.

With the output connected to the — input, the only thing that can happen is for both the — input and the output to settle at ground voltage. Why? Imagine that the—input voltage rises to 0.00001V above ground voltage. With a voltage gain of 100 000, and the usual inversion, this would cause an output voltage of — 0.00001 × 100 000 = —1 V. This amount of voltage at the output, connected back to the — input by a resistor, would whip the input voltage back to zero pretty quickly. Imagine it the other way round — that the — input voltage has dropped to —0.00001 V. Once again, the combination of high gain and inversion produces a voltage, this time of +1.0 volts, at the output, and the feedback ensures that the voltage drops back to zero again. If the — input voltage is exactly zero, the same as the voltage that the + input has been set to, then there's no difference between the input voltages, nothing to amplify, and the output voltage remains at zero — which is exactly halfway between the supply voltages, just the condition to ensure that the amplifier is correctly biased.

INPUTS AND OUTPUTS

Why can't we just connect both inputs to ground? The reason, once again, is the very high voltage gain of the IC amplifier. The slightest voltage difference between the inputs, as small as 10 microvolts, will cause an output of a volt or so, and so and slight differences between the transistors inside the IC will cause a change of output voltage even with both inputs grounded. This sort of difference is called an offset. We can't, even in an IC make transistors which match each other prefectly, so that this offset always exists. Using negative feedback for bias solves this problem, because the feedback action

Continued on page 62

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4-INPUT MIXER

Four into one will go with this mini-mixer. Why not build one for your band today?

IF YOU ARE IN A BAND and your PA has a range of inputs you may wonder why you need a mixer. Well one of the advantages is that when your bass player thinks he is not loud enough to be heard over the rest of you, it's up to someone else to turn him up! Otherwise, you can so easily get that snowball effect where one musician turns up the volume only to be followed by all the rest and so on until every sentient being within earshot suffers premature deafness (pardon?).

Many bands these days seem to have started on nothing and are maintained on a shoe string. If yours falls into this category, then this is the project for you. No-one is going to claim it's hi-fi but it is cheap. Using 741 op-amps will produce plenty of power versus cost.

Construction

We built our unit into a small plastic case and mounted all the pots on the aluminium top cover, making the required connections with shielded cable. Take care not to produce a ground loop when connecting up. The remaining components can be mounted on our PCB; only three wire links are required to supply the op-amps negative supply. We used polycarbonate capacitors mostly, taking advantage of their small size and good characteristics,

HOW IT WORKS

The heart of the circuit is IC2, an op-amp connected as a conventional virtual ground summing amplifier. This stage mixes the input signals and also has a gain of 10 to compensate for the insertion loss of the passive tone control network. There are three high level inputs and one low level which is input to IC1. This stage provides non-inverting amplification with a gain of about 20. Independent volume controls are provided for each input and the signals are mixed in IC2 before being passed to the tone control network. This provides a 40 dB range of control with an insertion loss at midband of — 20 dB.

This output from the tone control is AC coupled to unity-gain voltage follower IC3. AC coupling avoids the problem of wiper 'track noise', which would result from the irregular capacitor charge and discharge currents. R16 is inserted in the output of IC3 to isolate the op-amp from the large capacitive load presented by a long length of screened cable. Potentiometer RV7 provides overall volume control and capacitors C14 and C15 decouple the power supply lines. Two 9V batteries provide power for the unit and current consumption will be just a few milliamps.

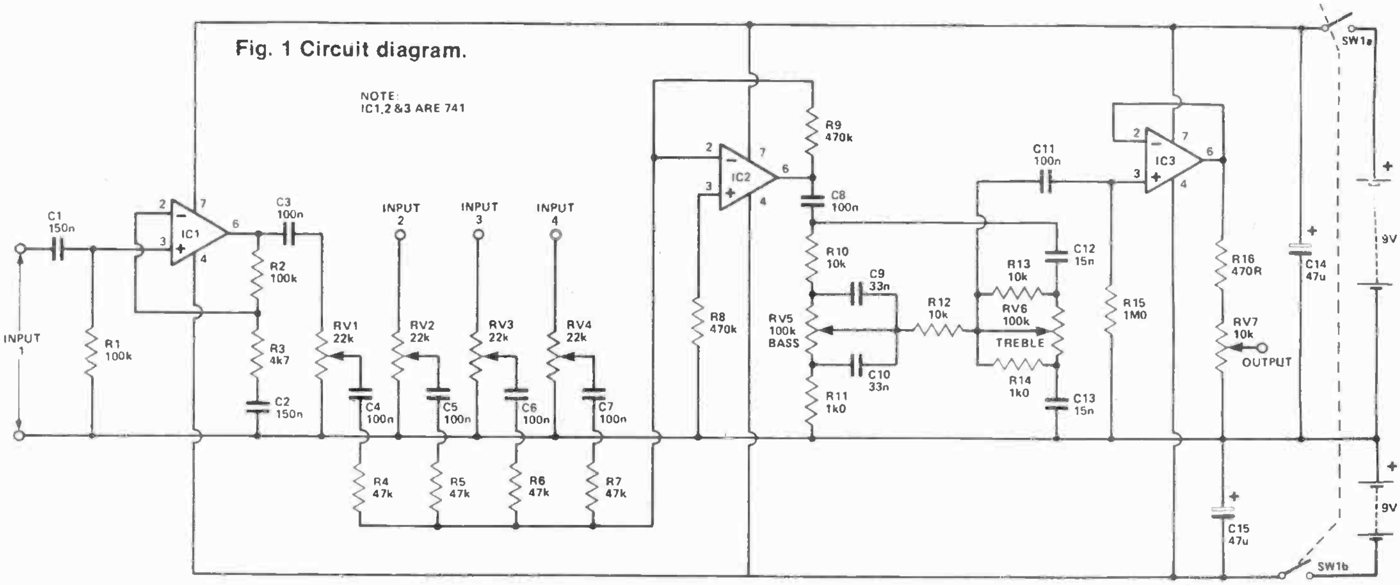


Fig. 1 Circuit diagram.

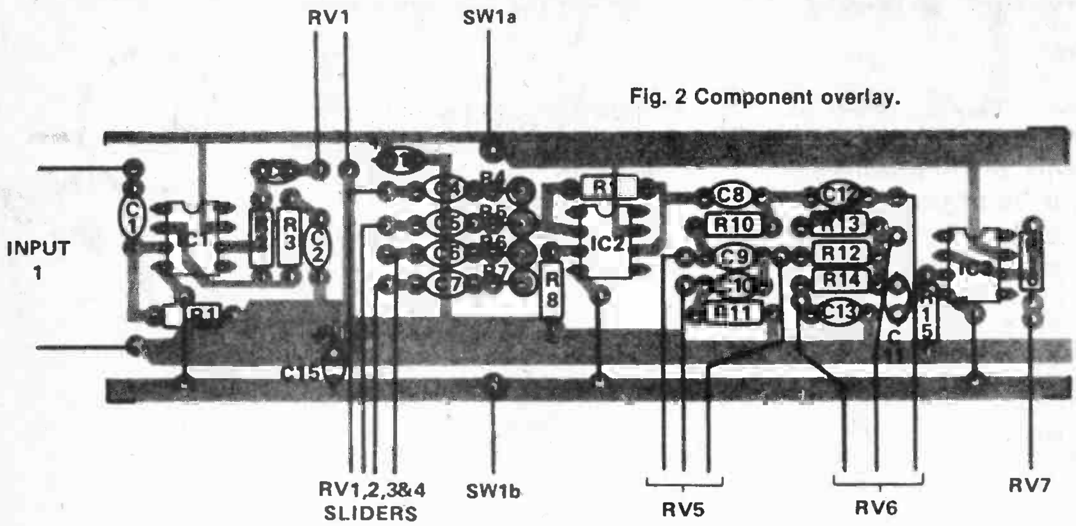


Fig. 2 Component overlay.

though polyester types can be substituted. There are no special precautions to take. Just make sure you put the ICs in the right way up and get the polarity of the two tantalum capacitors right.

Remember, if you ever reverse-bias a tantulum cap by more than about 3 V it's dead certain that you'll have blown it up and it'll no longer be a capacitor; more a low-value resistor with the inevitable effect on circuit operation. No problems with this project, though. Simply build it, fix it and mix it!

PARTS LIST

Resistors all ¼W 5%

R1,2	100k
R3	4k7
R4,5,6,7	47k
R8,9	470k
R10,12,13	10k
R11,14	1k0
R15	1M0
R16	470R

Potentiometers

RV1,2,3,4	22k logarithmic
RV5,6	100k logarithmic
RV7	10k logarithmic

Capacitors

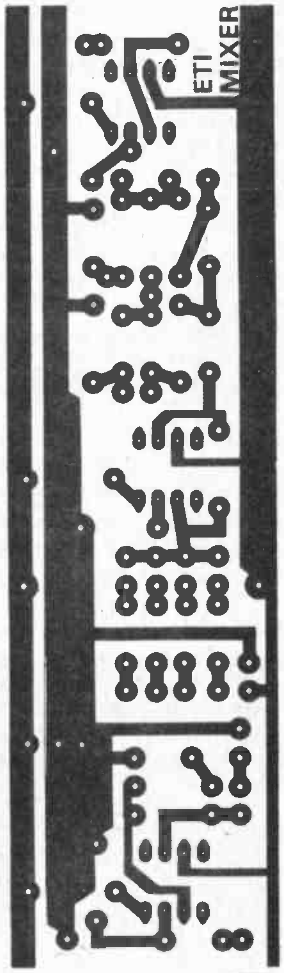
C1,2	150n polycarbonate
C3,11	100n ceramic
C4,5,6,7,8	100n polycarbonate
C9,10	33n polycarbonate
C12,13	15n polycarbonate
C14,15	47u 16V tantalum

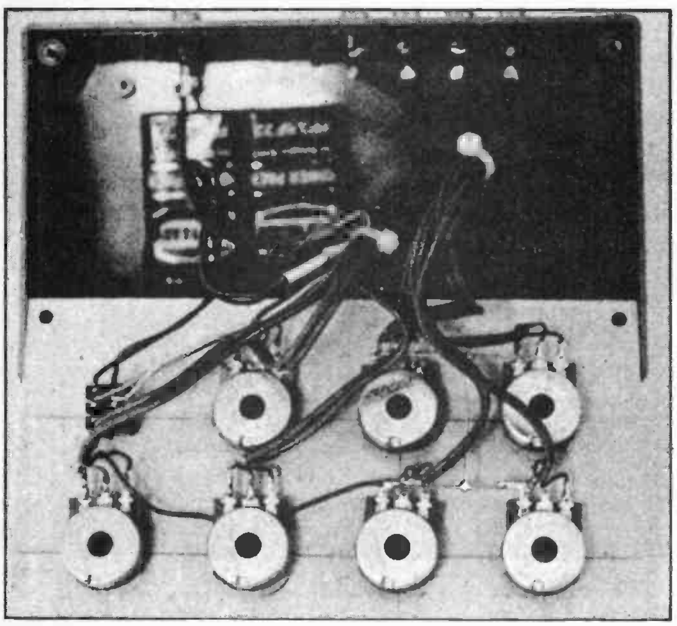
Semiconductors

IC1,2,3	741

Miscellaneous

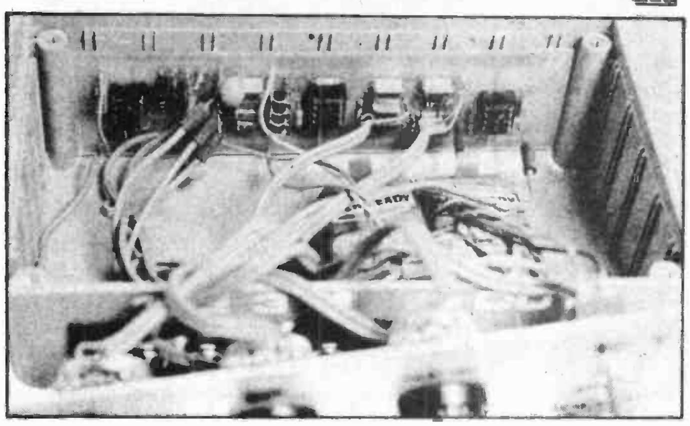
Case, connectors, batteries, DPDT switch, etc.





The PCB (above) tucks neathly away at one end of the case. Make sure the case is deep enough to allow clearance of the batteries and potentiometer bodies.

Front panel control layout (left).



SPEAKER DESIGN Part One

If you ever wanted to know, in a practical fashion, what is involved in the design of a loudspeaker system, then here's a down-to-earth insight — ending in a real design. By David Tilbrook.

MORE MONEY can be saved by the construction of a pair of loudspeakers than any other single component of the hi-fi system. Unfortunately, they are also the most important hi-fi component! Unless the turntable or amplifier is particularly poor, the loudspeaker will undoubtedly determine the overall sound of the system. For this reason it is disappointing there are so few really good kit loudspeakers.

The fact that a "correct" loudspeaker doesn't exist is to be expected, since the principles of loudspeaker operation are enormously complex. Every loudspeaker model makes certain assumptions to simplify the mathematics and to make the model manageable. If these assumptions are overdone the model rapidly loses relevance, becoming incapable of making worthwhile predictions about the real loudspeaker. While it is true that a detailed understanding of loudspeaker operation is not necessary to enable a kit loudspeaker to be built, some understanding will enable the optimum to be obtained from the loudspeaker and is essential for those brave experimenters who would like to get involved in modifying the loudspeaker drivers. Only then can the best choice of driver, enclosure type and crossover be established. Although loudspeaker design is as much an art as it is a science, the loudspeaker that has been created with a motley assortment of drivers placed in a box with some "general purpose crossover" is more likely to sound like a dropped saucepan than a good loudspeaker!

The most common loudspeaker consists of several moving-coil direct-radiating drivers mounted in an enclosure. These cover different frequency bands within the audio spectrum. A crossover is used to separate these frequency bands and feed them to the appropriate driver.

If the drivers used had perfectly flat frequency responses, were constant eight ohm loads with infinite power handling, and the crossovers represented lossless transfer characteristics with no untoward interactions with the drivers, and if nature did not object to the reproduction of low frequencies in confined volumes (i.e. if the speed of sound was one tenth the speed it is) loudspeaker design would be a simple matter.

Most of these problems can be summarised with one work . . . inertia. This is that property of nature whereby things resist change. We can't really complain too strongly about inertia since it is responsible for much of the order that exists in the universe. Nevertheless, in loudspeaker design it causes real problems. The signal voltage from the power amp, the magnetic field around the voice coil, the movement of the coil and loudspeaker cone, all resist change. Since the objective of loudspeaker design is to convert an electrical signal into its exact acoustic counterpart, these sources of inertia cause errors resulting in distortion. The effects of inertia don't stop at just slowing down the system. The resistance to change of motion by the cone for example results in some parts of the cone moving before others. Sound waves start to travel along the cone itself, travelling radially out from the voice coil. Depending on the nature of the flexible surround between the cone and the chassis this sound wave will be partially reflected back down the cone. This causes constructive and destructive interference with the original sound wave propagating up the cone

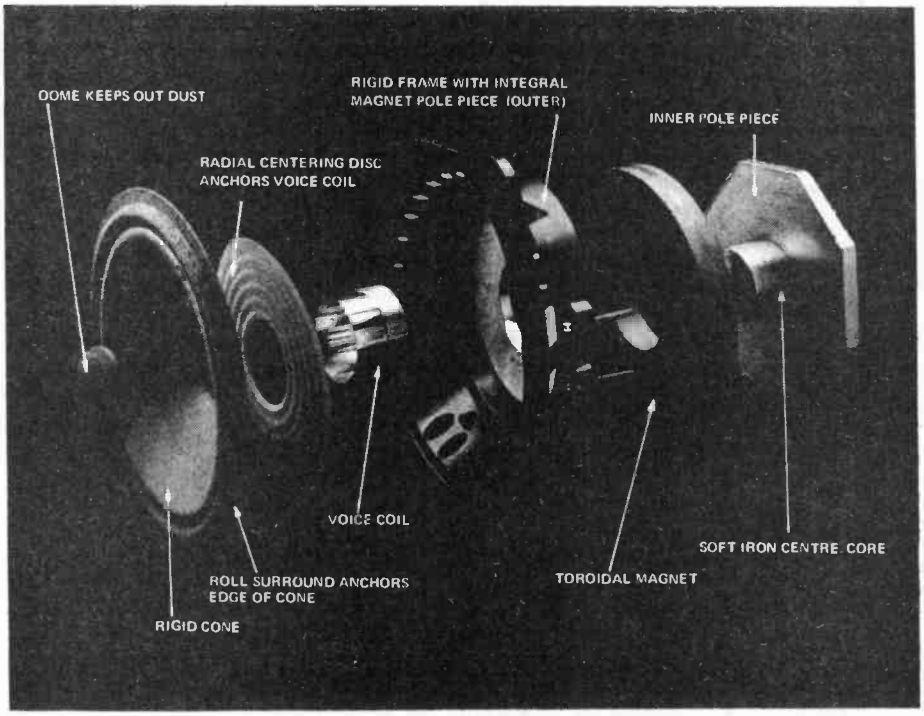
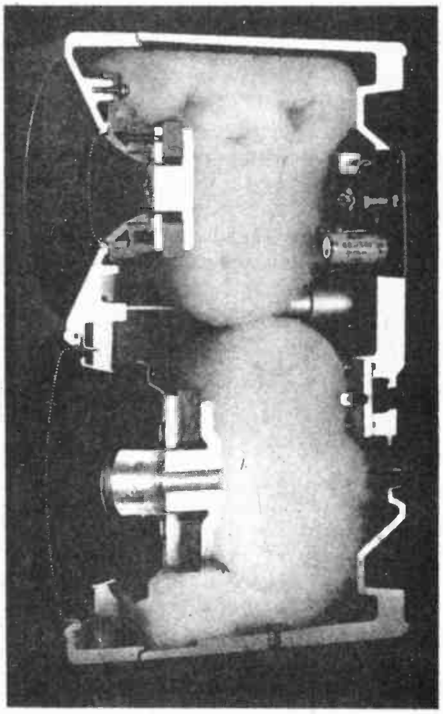


Figure 1. **An exploded view of a moving-coil loudspeaker showing the various components in its construction. Compare this with the cutaway view of a speaker at right (Pic: courtesy Bose).**



Cutaway view of a speaker unit showing internal construction (Pic: National).

resulting in colouration. Clearly, this is not something the home constructor can do much about, since it depends on the manufacture of the particular driver concerned, but it indicates the sorts of problems that will be encountered.

The Moving-Coil Direct-Radiating Speaker

The vast majority of drivers used in loudspeakers are of the moving coil type and as such all operate in a very similar way. Fig. 1 shows a typical moving coil loudspeaker. Signal voltages from the power amp give rise to signal currents that flow through the voice coil. This is simply a coil of wire wound on a hollow circular former. In normal 8 ohm drivers the dc resistance of the voice coil is around 8ohms, but the driver will only represent this resistance to the power amp at one specific frequency, the actual impedance of the driver varying widely as the frequency is varied (see Fig. 2). A given signal voltage level will therefore produce different signal currents for different frequencies. The signal current causes a varying magnetic field to be produced around the voice coil. This field interacts with an intense magnetic field from the drivers' pole piece and magnet assembly causing a force to be exerted on the voice coil and loudspeaker cone.

As the cone moves it will compress or rarify the air immediately in front of it, creating an area of either increased or decreased pressure. These pressure variations comprise a sound wave that travels from the driver to our ears.

The electrical impedance of the driver is caused by several phenomena each one dominating in a specific frequency band. One of the most significant mechanisms is the back EMF (EMF stands for electromotive force, i.e: voltage) of the driver. The movement of the voice coil in the magnetic field acts as a generator causing a current to flow in the voice coil. This current is of opposite polarity to the applied signal current (another natural application of the principle of inertia) causing decreased current flow in the voice coil for a given signal voltage. This is seen by the amplifier as an increase in the drivers' impedance.

EMF is given by the simple equation:

EQUATION 1

$e = Blv$ where 'e' is the back EMF in volts
'B' is the magnetic flux
'l' is the length of wire in the magnetic field
and 'v' is the velocity of the cone

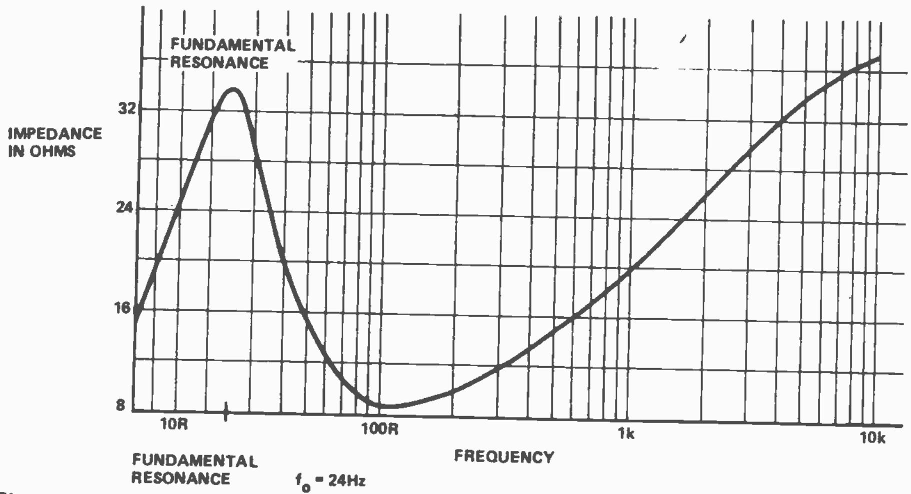


Figure 2. **Typical impedance versus frequency characteristics of a moving-coil loudspeaker**

Since the magnetic flux and the length of wire in the magnetic field can be considered as constants, the equation shows that the amount of EMF generated is directly proportional to the velocity of the cone.

So the electrical impedance is a secondary phenomenon, is certainly not constant, and does not relate directly to the radiated acoustic power. The amount of back EMF will be determined by the velocity of the cone, and this is a function of nearly every major parameter of the loudspeaker box.

The force exerted by the voice coil on the loudspeaker cone is given by the equation:

EQUATION 2

$F = Bil$ where 'F' = force on the voice coil
'B' = Magnetic field intensity
'i' = current in the voice coil
and 'l' = length of wire in the field

Again, regarding 'B' and 'l' as constants, the equation shows that it is current and not voltage that determines the force on the voice coil. Since the voltage contains the signal information from the power amp, it would be necessary for a perfectly linear relationship to exist between applied voltage and resulting signal current flow if a distortionless signal is to be produced. The impedance would have to be a constant and this is not the case. Fortunately the movement of the cone is not directly related to the current in the voice coil in the simple way shown above or the frequency response of a loudspeaker would simply be the inverse of its rather lumpy impedance curve.

In order to understand the parameters that determine the acoustic power actually radiated, it is necessary to look at the sources of mechanical rather than electrical impedance.

Converting Energy

In the operation of a moving-coil direct-radiating driver there are really two energy conversions going on simultaneously. First the electrical energy is converted into mechanical energy of the voice coil and cone. Secondly this mechanical energy is converted into acoustic energy by the interaction of the cone with the neighbouring air molecules. Both these conversions must be accurate if the final result is to be a low distortion replica of the input voltage waveform.

The laws that apply to mechanical and acoustic forces are directly analogous to those of electrical forces and for this reason we can represent what happens in any acoustic or mechanical problem by a circuit diagram. In mechanics and acoustics there are direct and simple relationships like Ohm's law in electronics. It is only the complex arrangement of mechanical or acoustic circuit elements that makes the picture look complicated. Just as an electronic circuit can look complex, but can be broken down into smaller and simpler circuits, so too can any acoustic or mechanical problem.

We can represent a complete picture of a dynamic loudspeaker by a circuit diagram showing electrical/mechanical and mechanical/acoustic conversions (see Fig. 3a).

The power amplifier is connected via a net series resistance Rg, to the terminals of the loudspeakers. This resistance is the result of the internal resistance of the power amplifier and connecting cables. Since the voice coil is a coil of wire it possesses both inductance and resistance. The applied electrical signal sees these two in series and we represent this by the resistance R_E and the inductance L_E. The "E" simply implies that these are electrical quantities. Current flowing in the voice coil

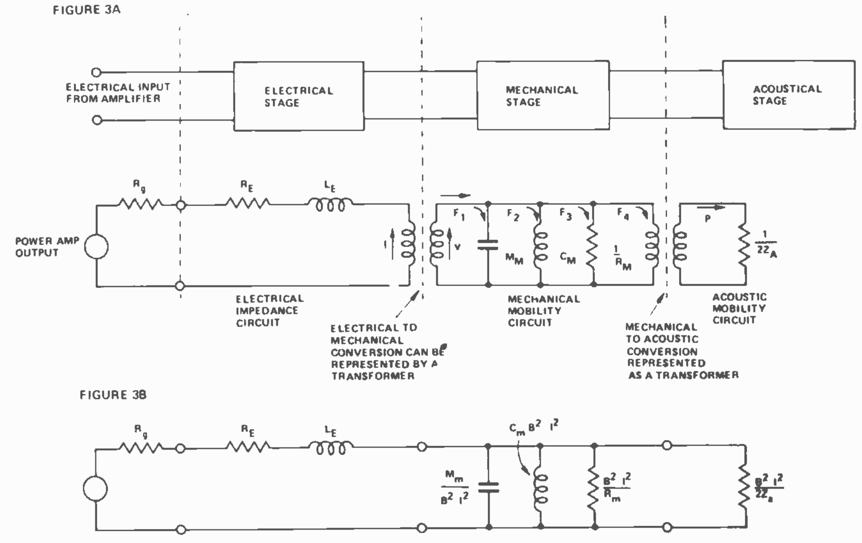


Fig. 3 Equivalent circuit for a typical moving coil direct radiating driver in an infinite baffle

gives rise to the magnetic field that causes mechanical movement of the voice coil and cone assembly. This conversion of electrical to mechanical energy is represented in the circuit diagram as a transformer. Voltage across the primary is represented by the letter "e" and gives rise to velocity 'v', of the voice coil and cone assembly at the secondary of the transformer.

The total force applied by the voice coil ("F") is shown in the mechanical stage as "flowing" through the "wires" just as current would flow through the wires of an electrical circuit. This force sees three mechanical components in parallel, a mechanical capacitance M_M, a mechanical inductance C_M and a mechanical resistance, $1/R_M$. The mechanical capacitance M_M is caused by the mass of the cone. As frequency rises inertia comes into play and it becomes increasingly difficult for the

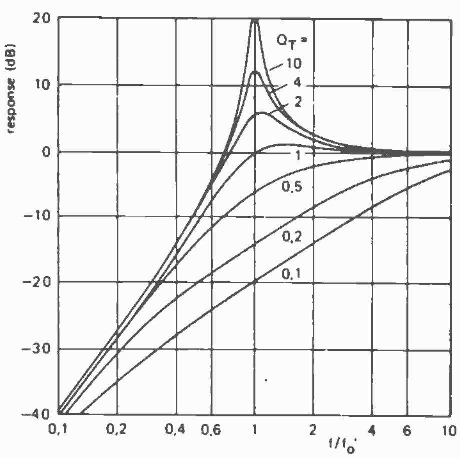


Figure 4. **Normalized frequency response of a typical low frequency loudspeaker for different values of Q_T (after Hermans & Hull, Electronic Applications Bulletin, Vol. 35, No.2., Feb. 1978, Philips).**

cone to follow the input voltage waveform. The mass of the cone causes a frequency response roll-off at higher frequencies. This could be represented either by an inductance in series or a capacitancein parallel with the load. In Fig. 3 this has been shown as the parallel capacitance, M_M.

A loudspeaker cone has a certain springiness, due to the nature of the cone's suspension and the overall construction of the particular driver. We specifiy this springiness by a spring constant, which is simply a number, represented by the letter 'k'. In loudspeaker technology we more often use the term compliance rather than spring constant. Compliance C_M, is defined as:

$$C_M = \frac{1}{k}$$ where 'k' is the spring constant.

The compliance impedes large movement of the cone. Since bass frequencies require longer cone excursions the compliance of the driver causes a frequency response that falls as frequency decreases. This can be represented as a capacitance in series or an inductance in parallel with the load. In Fig. 3 the compliance C_M is represented as an inductor in parallel with the load.

The remaining term in the mechanical part of the loudspeaker circuit diagram is the mechanical resistance. Just as all circuit elements in an electronic circuit have resistance, so too does the mechanical circuit. The resistance is seen in series with the whole mechanical circuit and could be represented as a series resistor or a parallel inverse resistance. If R_M is the mechanical resistance of the circuit, an inverse resistance is defined as:

$$\frac{1}{R_M}$$

In Fig. 3a force is shown as 'flowing' in the mechanical 'wires'. The total available force is shared into four major parts; the forces needed for the mass M_M, the compliance C_M, the mechanical resistance R_M and the load. If we define these four forces as F_1, F_2, F_3 and F_4 respectively, we can say that

F (the total force available) = $F_1+F_2+F_3+F_4$, and this has been shown in the mechanical circuit diagram. We have to represent the series resistance as an inverse resistance, $\frac{1}{R_M}$ and place it in parallel with the load, to illustrate the way it obtains its part of the total available force (F).

In this case the load is the primary of the mechanical/acoustical transformer. Of course this transformer doesn't actually exist. It is merely a way of representing the conversion of mechanical energy to acoustic energy by the interaction of air molecules with the surface of the loudspeaker cone. Mechanical force in the primary of the transformer is converted into sound pressure 'p', in the acoustic circuit.

In Fig. 3a it is assumed that the loudspeaker is mounted in an infinite baffle. This is a partition that extends to infinity in all directions, cutting the universe into two halves, with a hole in which the loudspeaker is mounted. This is just a little impractical, but the only important thing is that no sound produced by the back of the speaker cone can interact with the sound from the front.

In order to move air molecules, the cone must do work so the air impedes movement of the cone. This impedance is called the acoustic impedance and is represented in the circuit diagram by Z_A. Since the loudspeaker is mounted in an infinite baffle the acoustic impedance is the same on both sides of the cone and becomes $2Z_A$.

We are now in a position to understand the causes of variations in the electrical impedance and acoustic radiated power. As was shown earlier, the back EMF is one of the dominant forces acting to increase the driver's impedance. It is related to the velocity of the loudspeaker cone as was indicated by Equation 2. If the motion of the cone is impeded, i.e: if the cone is held, the velocity must decrease, causing a decrease in the amount of back EMF. The decrease back EMF will cause a drop in loudspeaker impedance. So an *increase* in mechanical impedance causes a *decrease* in electrical impedance. With this in mind the electrical/mechanical/acoustic circuit diagram of Fig. 3a can be converted into the all electrical circuit diagram of Fig. 3b.

This circuit predicts the impedance characteristics of the driver. A generally increasing impedance with frequency is caused by L_E, while M_M, C_M, and R_M form a damped parallel resonant circuit. We would expect a sharp increase in impedance at one frequency, dropping to the dc resistance of R_E and R_G and then slowly rising as frequency increases. This is exactly the response as shown in Fig. 2 which is the measured impedance response of a typical 12 inch (300 mm) woofer. This resonance point is called the fundamental resonance of the driver, and being a function of the compliance of the driver, can be expected to decrease in frequency a little as the driver wears in. This is the reason some loudspeaker experimenters "run in" the driver before measuring resonant frequency.

A more accurate model

The model of the loudspeaker developed so far has assumed that the shape of the loudspeaker cone remains unchanged and moves as a "rigid piston", following the input signal. This rigid piston theory works well at predicting the characteristics of drivers at low frequencies. At high frequencies inertia again comes into play and the cone can no longer be considered as a rigid piston. If the driver remained a rigid piston throughout the audio spectrum its frequency response would fall off at a rate of 12dB/octave at high frequencies, range.

The equation showing the relationship between the frequency of a sound and its associated wavelength is

$\lambda \nu = V_A$ where V_A is the velocity of sound in air
λ is the wavelength in meters
and ν is the frequency in Hertz.

The equation shows that the wavelength of sound decreases as frequency is increased. It should be noted that the velocity of sound depends on the medium in which the wave is propagating. The velocity of sound in the loudspeaker cone will be substantially different to that in air. Using this equation we can calculate the frequency at which the wavelength of sound approaches the radius of the loudspeaker cone. For a 300 mm (12 inch) loudspeaker this frequency is around 400 Hz and it is at this frequency that the rigid piston theory starts to come unstuck. Above this frequency the sound wave propagates up the cone, hopefully to be damped in the rubber surround. The sound wave is attenuated as it moves through the cone, and this attenuation effect increases with increasing frequency, causing a decrease in the effective cone diameter. This is the effect that enables a single cone loudspeaker to operate over a wide frequency range, since the decreasing effective cone diameter decreases the inertia presented to the coil assembly at higher frequencies. It should be noted that, in this range of the frequency spectrum, the rim and the cone will be radiating in antiphase with the coil assembly. The way the cone material and suspension react to this multiple wave propagation is one of the biggest differences between a good driver and a poor one. It is for this reason that metal cones for instance are so often unsuccessful. Their ability to damp multiple resonances is generally poor in comparison to materials like paper or plastics.

Damping and Q-factor

In midranges and tweeters the drivers can be operated in frequency ranges that exclude their fundamental resonances. The crossover points are usually chosen so that at least one full octave exists between the crossover point and the fundamental resonance. In the case of bass drivers however it is necessary to operate the driver at the below the resonance of the woofer.

This is the main reason so many different bass loading principles have been developed. The fundamental resonance of the basss driver must be damped so that an acceptably flat frequency response can be established. If the resonance is not damped adequately, the all too common 'one note bass' sound results. This is a particularly noticeable and fatiguing loudspeaker fault and considerable effort must be spent on obtaining a smooth bass end response.

Since the loudspeaker is a resonant circuit the amount of damping can be specified by quoting the Q or quality factor. Q is defined by:

$Q = \frac{f_o}{f_1 - f_2}$ where f_o is the frequency of the fundamental resonance.
and f_1, f_2 are the 3 dB points.

Figure 4 shows a graph of bass-end frequency responses at a variety of Qs. Although the flattest response appears to be given by the case when the Q = 1, this is not the optimally damped case and some boomy bass often occurs in bass systems with Qs around unity. The best Q is probably about 0.5. The bass is not boomy but is also not over-restricted which can happen if the Q drops to around 0.2 or 0.3. The best damping for any specific case needs to be established by experiment and ultimately, as always, the ear must be the final test.

Loudspeaker compliance, the total mass of the cone and the net series resistance with the voice coil, all determine the response of any loudspeaker system and any or all of these can be adjusted in order to achieve the optimum damping and frequency response. In practice, adjustments to the Q of the system are done by modifying the compliance and acoustic mass and resistances caused by the loudspeaker enclosure rather than modification of the driver itself.

The enclosure

The circuit in Figure 3 has been developed assuming that the driver is mounted in an infinite baffle. The air load on the cone of the loudspeaker is represented by an impedance of value:

$$\frac{1}{2Z_A}$$

When the driver is mounted in a practical loudspeaker enclosure, this acoustic impedance becomes a little more complicated and the circuit in Figure 5 replaces the simple resistor of Figure 3. This new impedance is made up of two major components. The radiation impedance from the front of the box ($M06AR$, R_{AR}) is related to the size of the baffle and is independent of the volume of the box.

The volume of air that the driver has access to is related to the effective radiating area of the cone and to the size of the baffle. Since bass frequencies have a greater dispersion than higher frequencies the volume of air accepting the radiated sound increases at lower frequencies. So the impedance on the front of the cone will be greatest at high frequencies. If the size of the baffle is large in comparison to the radiating size of the driver the box approximates an infinite baffle down to a lower frequency than it would otherwise, and the frequency at which the driver has access to a 360° radiation pattern is decreased. This is represented by the series combination of the inductance M_{AR} and R_{AR}, which gives an impedance characteristic that increases with frequency like the front radiation.

The second component of the radiation impedance is caused by the enclosed volume of air within the box. If we consider a sealed enclosure the volume of air within the box will be compressed by the driver. So the enclosure volume will affect the overall compliance of the loudspeaker system. This acoustic compliance is represented in Figure 5 by the capacitance C_{AB}. The effect of this is to increase the stiffness of the loudspeaker cone resulting in an increase in the fundamental resonance of the enclosure.

The volume of air in the box will also have an equivalent mass represented by the inductance M_{AB}. This mass will also affect the resonance of the system by increasing the overall mass of the cone. The acoustic resistance with the enclosure is shown in Figure 5 as R_{AB}.

The final resonant frequency of the driver in the box is a function of the total effect of all the compliances and masses in the system. If the total mass is represented by M_a and the total effect of the compliances is C_a then the resonant frequency of the system will be given by the equation

$$f_o = \frac{1}{2\pi\sqrt{M_a C_a}}$$

the equation shows that a decrease in either the total mass or compliance will cause an increase in the resonant frequency of the loudspeaker system.

Resonances

The acoustic circuit in Figure 5 represents the reactances caused by the enclosure around the resonant frequency, but as usual in loudspeaker science things get more complicated as frequency increases. As the wavelength of the sound wave produced inside the enclosure becomes shorter the box no longer acts as a simple spring. The produced wave travels from the back of the driver towards the rear and sides of the cabinet, where it is reflected back towards the driver. This sound wave will interact with the cone, either reinforcing or impeding the motion of the cone depending on the particular frequency. This results in successive rises and dips in the frequency response and for this reason it is important that this reflected wave is damped as much as possible. In order to absorb this unwanted energy the enclosure is usually lined with an absorptive material such as bonded mineral wool, acetate fibre or bonded hair felt.

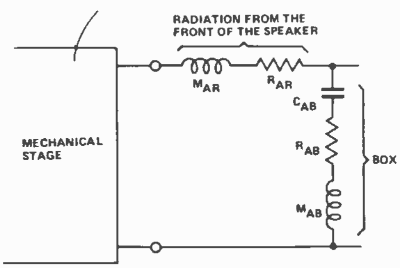


Fig. 5 Equivalent circuit diagram for the acoustic stage of a direct radiating moving coil driver mounted in a sealed enclosure.

The most important parameter of an y of these materials is that they are reasonably open. If the material is too dense it will not only have little absorption but it will decrease the total available volume within the box. Generally a layer of 25 mm speaker innerbond on the back, sides, top and bottom is about right.

Lining the box also has the effect of altering the acoustic resistance on the back of the cone. This effect is often used to increase the damping and thereby decrease the Q of the system resonance. Usually the necessary damping can be only partially achieved and it is necessary to partially fill the box with an absorptive material as well. If the enclosure is completely filled sound waves within the enclosure are converted into heat in the filler material. Normally this overdamps the box resulting in a Q sometimes as low as 0.1.

Filling the box has one other major effect. Owing to the heating of the material inside the box and its different density to that of air, the velocity of sound within the enclosure is reduced dramatically. The speed of sound in air is around 344 m/s and this could drop to as low as 292 m/s. This has the effect of increasing the compliance of the enclosure and thereby decreasing resonant frequency in the same way as increasing the box volume would. As optimally filled box could appear some 30% to 40% bigger than it really is.

Throughout this article we have discussed the sealed enclosure, leaving explanations of other bass loading techniques to a later time. One of the most common enclosures is the bass reflex, which uses a port cut in the baffle to augment the bass radiation of the driver. The acoustic circuit diagram must show the effects of the mass, compliance and resistance of the port in addition to those shown for the rest of the box, making the loudspeaker equivalent circuit even more complicated. Both the bass reflex and the sealed enclosure are capable of very good results and it is not possible to state simply which is better. We have omitted a detailed discussion of the principles of the bass reflex loudspeaker simply for the sake of simplicity.

Next month we will deal with the problems of mating a collection of drivers to form a completed loudspeaker.

Dont' miss it!

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Hi-Fi speaker systems; D. Hermans and M.D. Hull, Phillips applications bulletin 35/1 and 35/2.

Vibration and sound radiation of loudspeaker diaphrams; A.J.M. Kaizer.

Loudspeakers in vented boxes: A.N. Thiele.

To be continued.

COMPUTING TODAY

If you have a computer, would like to have a computer, or feel like you work for a computer sometimes, ETI has a new column for you.

Edited by Steve Rimmer

HEY! SOMETHING NEW.

This month, we're inaugurating a column to deal with micro-computers and micro-computing for the users of the popular small systems. In the months to come, we're going to be looking at both hardware and software for TRS-80s, PETs, VICs, APPLEs, OSIs, and a really neat, if incredibly slow, way to play space invaders on an abacus. At the moment, we're planning future bits on speech synthesis, machine language programming and computer music, plus a lot of other stuff even we haven't though up yet.

ETI readers are invited to contribute to this column. If you have a favourite bit of computing you'd like to share, we'd be most interested in checking it out, and, of course, we'll pay for anything we use. Complete fine print is at the end of this column.

VIC With Character

One of the things that we touched on in the VIC review last month was the capability of the machine to produce programmable characters, that is, for the user to decide what the letters on the CRT should look like. This is a capacity not found in the PET computers, which preceded the VIC, and, as well, not even mentioned in the VIC's manual. However, it can be done, as we shall see.

You are probably familiar with the basic notion of character generation, but, if not, heretofore, (or hereto forethirty in Newfoundland) is a brief explaination. Skip ahead if it's already lodged in your brain.

The characters you normally see on the screen live in a ROM, or Read Only Memory. This is a chip that spews out a pre-defined pattern of bits for any given input code. The input code, in this case, would be a function of the character code being called up, i.e., the ASCII value of the character, plus the position of the CRT beam at the moment in question. Obviously, the bit pattern changes as the beam scans downward. In the case of the VIC, with characters being defined by an 8x8 dot matrix, each character in the ROM can be thought of as being eight eight-bit words, or eight bytes.

When the VIC wants to generate characters, all it does is to vector over to the location in memory where the ROM lives, add to this the character code, and call up the required pattern of bits, which thereupon modulates the CRT beam. A bit simplified, but that's about it. On sequential lines, as the beam decends, it must be constantly adding to the character code to get the required bytes out of memory.

Now, changing the characters is actually pretty easy. All you have to do is change the bit patterns in the ROM. Gad zooks! Hardware modifications . . . never. Okay, how about making the computer thing you've done it. Ya, that sounds better.

The VIC's character generator ROM lives at 32768 decimal (oddly enough, the screen location in old PETs). Among other things, location 36869 holds the address of this ROM, so the computer can find it. When it wants to get the bit patterns for characters, it simply goes to this location, and vectors over to wherever it tells it to go. A bit complicated, I suppose, but there is a perfectly good reason for doing it this way. You see, while the ROM up at 32768 cannot be changed under software command, the number in this address location can. It can be set such that the VIC chooses as its character ROM a chunk of RAM, which can be loaded with whatever data we choose . . . including, of course, character patterns.

The way to get basic programmable character capability in the VIC is, first off, to define some RAM as exclusive character pattern RAM. Actually, we need quite a lot of this. The only place where there's enough is in the user RAM (which, yes, is small enough as it is). We must make sure that BASIC doesn't interfere with the character codes . . . and BASIC is noted for trampling over things. Thus, what we needs do is to make the VIC think that the top of its BASIC RAM is somewhat lower than it actually is. The difference will be used to contain the characters.

The top of memory ponter is at locations 55 and 56 in page 0. The way this works is that the top of memory is defined by PEEK(55) + 256*PEEK(56). In order to reserve enough memory to produce a programmable character set of useful proportions, we're going to need at least a K, and preferably a K and a half. The register at location 56 adjusts the pointer in increments of 256 bytes, or ¼K, which is convenient. It is usually at 30: we'll POKE it to 24 (6 * 256, or 1.5K).

The beginning of this new ersatz character ROM will now be at 6144 decimal.

Next, we want to change the address of the character ROM to fool the computer into looking at the RAM block at 6144 instead of its ROM at 32768. This is done by POKing the address register at 36869 with 254.

This, as you will know if you've just tried it, will produce a screen full of garbage. This is because there is just random stuff in the RAM at this point, which the VIC is presently using for character codes. Hit RUN and RESTORE simultaniously to get out of this condition.

With the memory location reserved, before or after changing the vector (probably easier to do before, although it's less fun to watch) the characters must be moved from ROM into the character code RAM. This is just a matter of writing a simple FOR-NEXT loop to PEEK each location in the ROM and POKE the resulting data into the appropriate RAM locations, beginning at 6144.

Program 1 shows the basic mechanism for doing all of the above in its first subroutine. It takes about a minute to complete, and looks really wild, as it fills the screen up with garbage, and then gradually replaces it with letters.

Now, although the screen may not look any different, it actually is being filled by a completely different set of characters. Only thing is that they're the same ones as in the character ROM.

To figure out where any particular character lives in this RAM, do the following. Clear the screen and home the cursor. Type the character in the first location on the screen. This is location 7680 decimal in RAM. PEEKing this location will give you the PET ASCII code for the character. This differs a bit from real ASCII, so don't just use the ASC function. The code for "A" for example, is 1. The location of the first byte for the letter "A" in RAM is given by 6144 + 1*8, with the next consecutive seven bytes being the rest of the character.

Numbers

If you PEEK the first byte of the character "A", you will get 24 . Now, how do these numbers correspond to the bit patterns, you cry forlornly. Well, you could if you tried. Oh, very well; be upper crusty and dignified about it.

If you check out figure 1, you'll see an eight by eight matrix that contains the letter "A". The top line is the byte that happens to be 24. Now, if you were to weight each vertical column of the matrix in ascending powers of two, as in a hexidecimal format, you'd get some of the bits in that line off and some on. Add 'em up: they do actually come out at 24.

The numbers from 0 to 255, expressed as powers of two, can produce every possible combination of eight bits. Thus, poking this byte with the appropriate number will turn on any desired dots in the matrix. If you POKE it with 255, the top line in the "A" will become a bar, with all the dots on.

POKing the character codes in by hand is something of a pain, but, fortunately, there is an easier way. You can store the codes as DATA, and use a program to load them in for you. The second subroutine in program 1 handles this. It begins at 6664, the location of the spade symbol, or shifted "A", and POKEs the RAM with all the data it finds until it READs a 999. The DATA is located from statement 1000 on.

The DATA which is contained in the program listing will produce a treble cleff using the shifted "A" through "G".

Generating the codes can be done with 8x8 graph paper, but this, too, is a royal pain, and, happily, not all that necessery. Program 2 is offered by Paul Higginbottom of Commodore. It can be used to figure out the character codes, which can be written down, and later included in program 1 as data. When changing the data in program 1, just be sure you don't omit the 999, or you'll get an "OUT OF DATA" error.

When you run this program, it will produce a garbage screen just like before, and then clean it up. Thereafter, it will display the matrix of any character you like, with dots for the "O"s and asterisks for the "1"s. Using the screen editor controls, it's possible to replace the dots with asterisks, or vice versa, and modify the character matrix. The thing's pretty well self explanitory.

Applications

It's possible, but not all that advisable, to reprogram the upper case alpha characters; the hassle being that if you do it you probably won't be able to read text. However, there's still all the shifted (graphics) symbols, which should give you enough for any reasonable application. Keep

Continued on Page 70

Program 1

```
 10 GOSUB100:GOSUB200:END
 100 REM MOVE THE CHARACTER ROM INTO RAM AND CHANGE THE LOOKUP VECTOR.
 110 POKE56,24:POKE36869,254
 120 FORX=32768TO34303
 130 POKE(X-26624),(PEEK(X))
 140 NEXTX
 150 RETURN
 200 REM POKE IN GRAPHICS CHARACTERS
 240 READA:IFA=999THEN280
 250 POKE(6664+X),A
 260 REM 6664 IS 6144 (START OF CHARACTER RAM)+65
     ,SCREEN ASCII OF SHIFTED "A" *8.
 270 X=X+1:GOTO240
 280 RETURN
 1000 REM THE DATA AREA
 1010 DATA 0.0.0.0.1.1.1.1
 1015 DATA 0.0,0.192.32,32,32,32
 1020 DATA 1.1.1.1,7.9,17,33
 1025 DATA 32,32,64.128,0,0,0,0
 1030 DATA 35,37,37.33.33.17,9,7
 1035 DATA 192.32,16.16,16,16,16,224
 1040 DATA 1.1.13.13.9,15,0,0
 1999 DATA 999
READY.
```

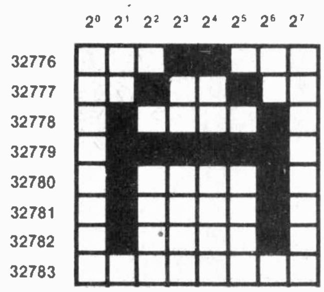
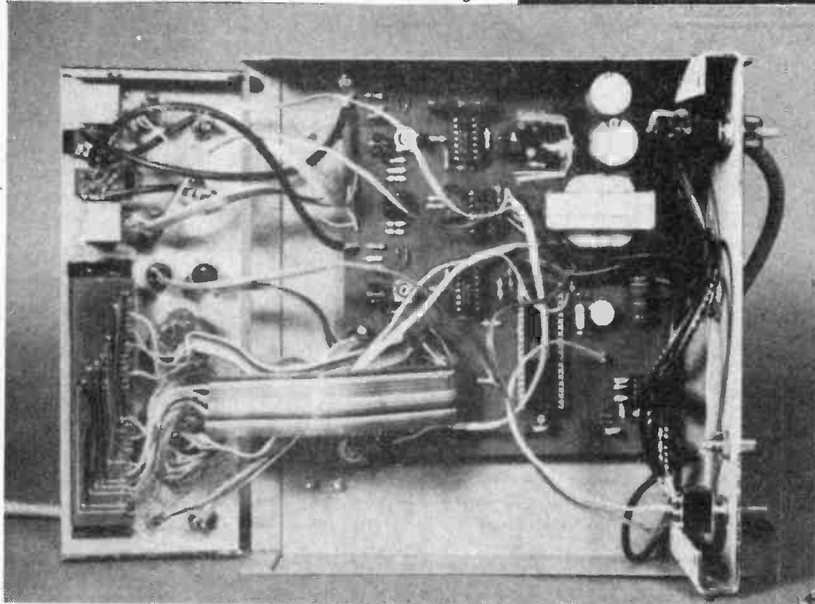


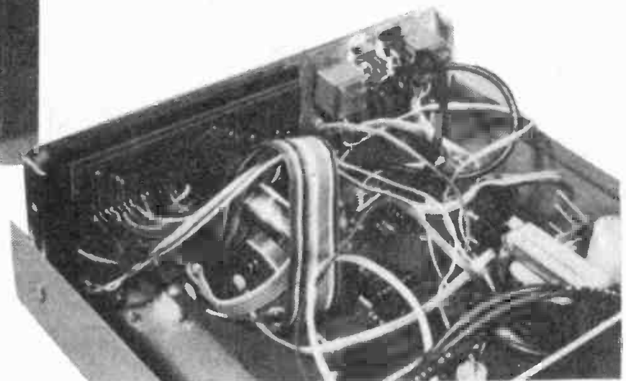
Fig. 1

Program 2 (by Paul Higginbottom)

```
 1000 POKE56,24:CLR:GOSUB9000
 1010 REM
 1070 PRINT"■DISPLAY MATRIX OF ?   (RETURN FOR NOTHING)":X=0:Y=0
 1073 GOSUB9100:GOSUB9200:IFA=32THENFORI=0TO7:A$(I)="........":NEXT:GOTO1080
 1076 FORI=0TO7:A$(I)="":FORJ=0TO7:A$=".":IFPEEK(P+I)AND2↑(7-J)THENA$="*"
 1077 A$(I)=A$(I)+A$:NEXTJ,I
 1080 PRINT"■";:FORI=0TO7:PRINTA$(I):NEXT
 1085 PRINT"■■■■'←' FOR NEW MATRIX":PRINT"■'RETURN' TO ENTER"
 1086 PRINT"■'*' TO WRITE PIXEL":PRINT"■'SPACE' TO ERASE PIXEL"
 1090 PRINT"■";:IFYTHENFORI=1TOY:PRINT:NEXT
 1100 PRINTLEFT$(A$(Y),X)"■"MID$(A$(Y),X+1,1)"■"MID$(A$(Y),X+2):OY=Y
 1110 GOSUB9100:IFA$="■"THENY=(Y+1)AND7
 1130 IFA$="■"THENX=(X+1)AND7
 1140 IFA$="■"THENX=(X-1)AND7
 1150 IFA$="■"THENY=(Y-1)AND7
 1170 IFA$="■"THENX=0:Y=0
 1175 IFA$="←"THEN1070
 1180 IFA$="■"THENX=0:Y=0:GOTO1073
 1190 IFA$="*"THENA$(Y)=LEFT$(A$(Y),X)+"*"+MID$(A$(Y),X+2):X=(X+1)AND7
 1200 IFA$=" "THENA$(Y)=LEFT$(A$(Y),X)+"."+MID$(A$(Y),X+2):X=(X+1)AND7
 1400 PRINT"■"A$(OY):IFA$<>CHR$(13)THEN1090
 1500 PRINT"■■■■■■■■■■■■OK?■■■■";
 1510 GETA$:IFA$=""THEN1510
 1520 PRINT"    ■■■■"::IFA$<>"Y"THEN1090
 1530 PRINT"■■■■■■■■■■■■REPLACE ?  ■■";
 1540 GETA$:IFA$=""THEN1540
 1550 PRINTA$
 1555 IFPEEK(7910)=32ANDA$<>" "THEN1530
 1560 GETB$:IFB$=""THEN1560
 1570 IFB$=CHR$(20)THENPRINT"■";:GOTO1530
 1580 IFB$<>CHR$(13)THEN1560
 1590 GOSUB9200
 1610 FORI=0TO7:T=0:FORJ=0TO7:IFMID$(A$(I),7-J+1,1)="*"THENT=T+2↑J
 1620 NEXTJ:POKEP+I,T:PRINTT:NEXTI
 1630 GETA$:IFA$=""THEN1630
 1640 GOTO1010
 5000 END
 6000 PRINT"■WHICH CHARACTER ?
 6010 GETA$:IFA$=""THEN6010
 6020 PRINT"■"A$:A=PEEK(7680)
 6030 P=6144+A*8
 6040 FORI=0TO7:PRINTPEEK(I+P):NEXT
 6050 GETA$:IFA$=""THEN6050
 6060 GOTO 1010
 9000 IFPEEK(36869)=254THENRETURN
 9005 POKE36869,254:PRINT"■MOVING THE CHARACTERS":F=26624
 9010 FORI=6144TO7679:POKEI,PEEK(F+I):NEXT
 9020 RETURN
 9100 GETA$:IFA$=""THEN9100
 9110 RETURN
 9200 PRINT"■"A$:A=PEEK(7680):P=6144+A*8:PRINT"■WORKING !!":RETURN
READY.
```



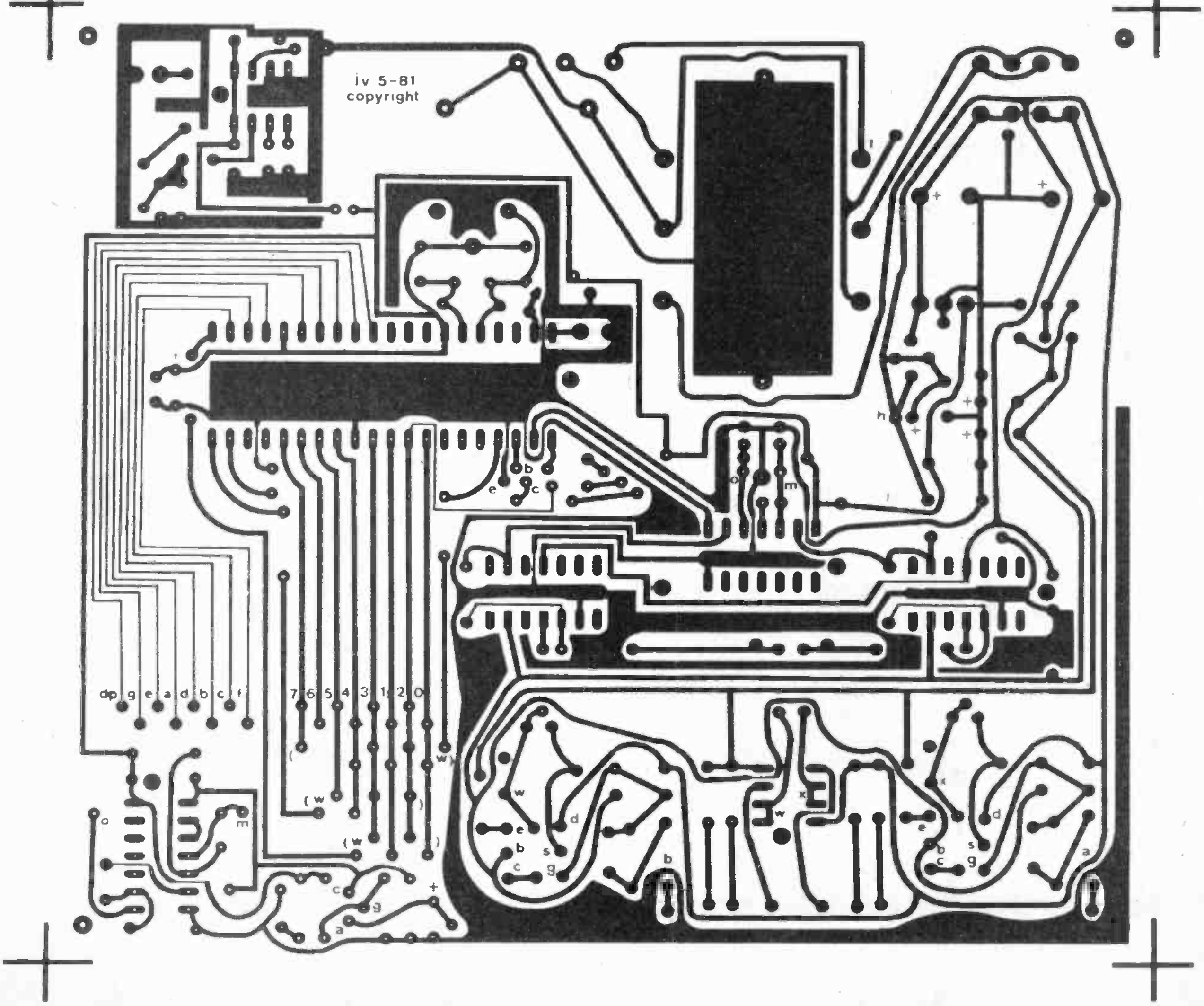
Interior view of Universal Counter



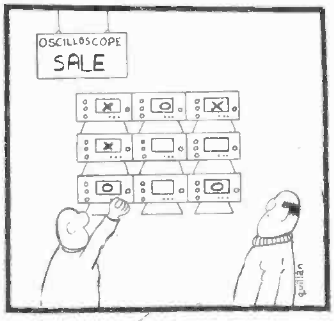
Front panel wiring of Universal Counter

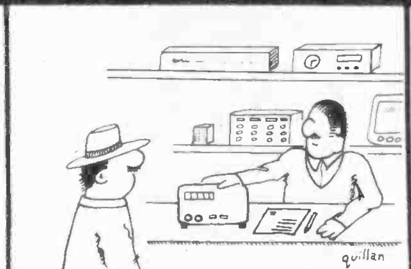
There is a very strong 500Hz multiplex signal on the function switch lines so this distance must be at least 2 in.

Fig. 5 The PCB



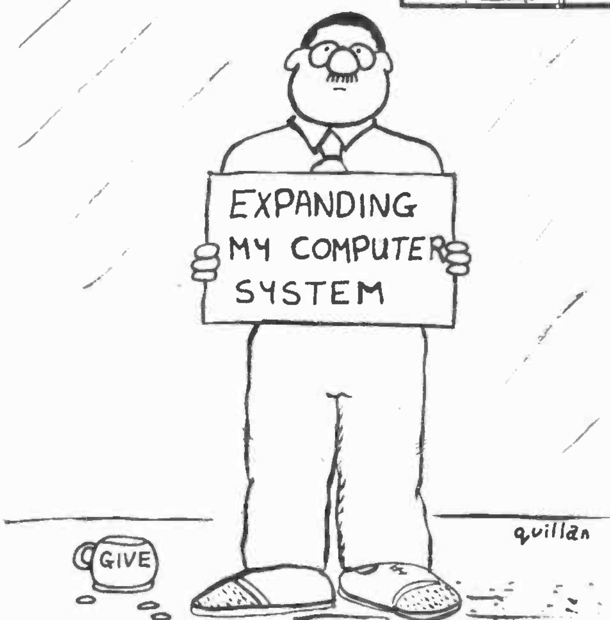
The Fun of Electronics

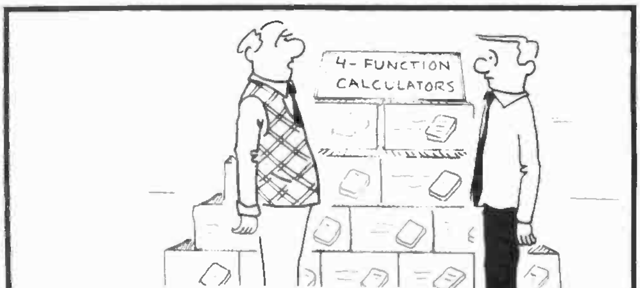




This is a very good logic state analyser and it also solves crossword puzzles.

Can we visit it?





If you can possibly avoid it, try not to mention to the customers that we count "on" and "off" as two functions.

It says "Warning – this is a low profile socket and can only be used with incognito IC's."

Yes I am "into Electronics" how did you guess?

Well if you can't get me a 5 megahertz triggered-sweep, solid-state oscilloscope with Z-axis modulation, trace rotation and 10X sweep magnification, then how about a teddy bear?

AUDIO TODAY

Wally Parsons

You've probably been thinking that speaker wire is nothing more complicated than an extension cord with the plugs cut off. Wally Parsons dispells your delusions.

IN MUCH OF AUDIO design we see a great deal of preoccupation with big things.

For example, with amplifiers we are often concerned with circuit topologies, the kind of output stage used, the input circuit, amount of feedback, which active devices are better than others, and so forth.

Similarly, speaker designers make mush of such parameters as driver size, type of enclosure, box size, number of drivers, magnet weight, total Q, even the number of elements in the dividing network, to the point of counting fuses as elements.

Turntable platter weight, type of drive, speed control system, pickup operating principle, cantilever material, all of these are frequent topics of discussion.

To be sure, all these are important matters. After all, it wouldn't do to try to build a bass reflex speaker without consideration of driver Q and driver/box compliance ratios. And certainly the shape of a stylus is a matter of some significance whether you're a pickup designer or simply setting out to buy one.

But all too often we tend to give so much attention to the big things that we leave little details to look after themselves. Or we take them so much for granted that we never bother to learn their function, and so never maximize their usefullness.

Consider, for example, the ubiquitous Zobel network!

An Exercise In Simplicity

The Zobel (or Zoebel) network, so named after its inventor, is a deceptively simple little circuit consisting of a capacitor in series with a resistor, which is connected across either the output or input terminals of a circuit or device (Fig. 1). Its primary function is load stabilization and the neutralization of inductance. Although it has applications in other areas, such as servo control systems, in audio it is usually found in audio amplifiers where it is used to provide a phase lag in the output circuits of amplifiers which must drive long lines at low impedances, and across the input terminals of loudspeaker drivers.

Its importance in the latter application was brought home quite clearly to me many years ago and, considering its ease of application, I'm amazed that so few speakers feature this means of impedance correction. Instead, too many designers seem to proceed on the simplistic assumption that driver voice coil inductance can be allowed for in the design of the dividing network.

Unfortunately, such efforts usually result in an impedance curve which looks like a roller coaster, a characteristic which seems all too common with the bulk of the speakers on the market today.

Several years ago, while working on a particular speaker, I discovered that the cross-over network didn't work. Each driver, bass, midrange, tweeter appeared to delivering a smooth wide range signal. It was my first try at a first order network, which is supposed to be inherently phase linear.

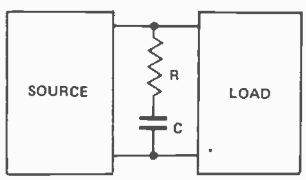


Fig. 1. R & C form a Zobel network.

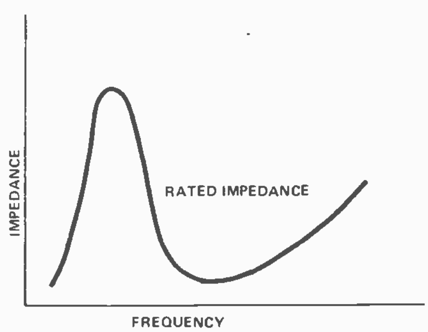


Fig. 2. Driver impedance curve.

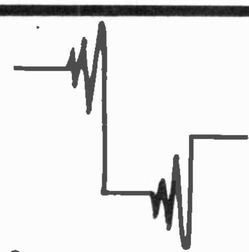


Fig. 3. Square wave across inductive load.

This Is Eight Ohms?

Examination of Fig. 2 will disclose the cause of the difficulty.

Fig. 2 is an impedance curve representative of what is usually encountered with a dynamic unit. This is alleged to be an eight ohm unit, but at what frequency does it exhibit this impedance? Why, at the lowest point on the curve, that's where. As you can see, this is a very narrow band.

In addition, the only frequencies at which the impedance is resistive are the minimum impedance to which I just referred, and the low frequency fundamental resonance. At all other frequencies the impedance is reactive.

Of particular interest to us is the high frequency rise. This is due largely to voice coil inductance and if you know its value it's a simple matter to neutralize it. To find the value of inductance, simply connect a suitable value of capacitance across the voice coil terminals and measure the frequency at which the combination resinates. Inductance can be calculated from the formula:

$$L = \frac{1}{2} X F^2 C,$$

where F = Voice Coil inductance, and r_e = Voice Coil DC resistance, and $R_{Zobel} = r_e$.

The final network may not be entirely correct, either because of inaccuracies in measuring the inductance, or the fact that the inductance may actually vary with frequency because of acoustical loading effects. Nevertheless, it can yield excellent correction.

This network can be fine-tuned by driving the driver/network combination from a square wave generator, and observing the waveform on an oscilloscope. The capacitance can be varied to obtain the nearest approximation to a square wave. In any case, it will be a vast improvement over Fig 3, which shows what a square wave looks like across an uncompensated driver.

In case you think that such a network will roll off the highs, try connecting a corrected and uncorrected driver directly to an amplifier. A reactance does not dissipate energy; it takes energy from the source, then returns it. The resulting phase angles of the inductive and capacitive elements exactly balance each other, so that no phase shift occurs, the condition which exists if the network is resistive.

Testing The Whole Network.

A constant resistance dividing network only performs as specified when each output is terminated at its design resistance. An inductive load does not provide for this condition. It is, therefore, essential that each driver behave as a resistance, even in its stop band.

It follows from all this that a correctly designed and terminated dividing network can be connected across a signal source without deforming a square wave. This provides a useful test of such a network.

To test the network itself, each output should be terminated by a resistor of the required value. Deformation of the leading edge of a square wave indicates problems in the high frequency network, while deformation of the trailing edge indicates problems in the low frequency network.

A hump or trough in the flat top region indicates mid-range problems, while any sign of ringing indicates oscillation.

Examination of the pass band with sine waves will pin-point the frequency at which problems are occurring and appropriate measure can be taken.

Now For The Lines

After wiring up your system and verifying that all is well, using the above tests, try sending a square wave down the line which will be connected to the amplifier, only using a high impedance (say, 500 Ohms) generator, with the speaker attached at the far end. Observe the waveform at the generator output.

Surprise, surprise! It will bear a remarkable resemblance to our old enemy in Fig. 3.

What happened?

Simple. Wire has self inductance. When two conductors are close to each other and run parallel, serving both the send and return sides of a circuit, their magnetic fields oppose each other and tend to cancel. The closer the conductors the greater the cancellation and the less the net inductance.

Since this constitutes an inductance in series with a resistance (the load), the answer is a Zobel network at the input to the line, or the output of the amplifier.

In fact, most amplifiers incorporate the network in the equipment. However, since the manufacturer has no way of knowing exactly what is going to be connected to his product, the final circuit may not always be optimum, but will be satisfactory for an anticipated worst condition.

But, if you're building your own amplifier, or you don't mind tampering with a commercial product, it's quite possible to establish the optimum network values.

Usually you won't have enough data to compute the inductance of your line, so it's simpler to do so experimentally. Connect a dummy load to the receiving end equal to the intended impedance load. Send a square wave of sufficiently high frequency (around 10kHz) as to allow a clear view of the spike on the leading edge, from a high resistance generator, and observe the waveform on the scope. Connect across the line at the generator a Zobel network consisting of a resistor equal to the dummy load, and try various capacitors until the spike is eliminated, but without rounding the leading edge of the wave form. The value required will probably be between 33n and 200n.

Finally, you may have concluded that since the resistance in the Zobel network is equal to the load resistance, the importance of maintaining constant impedance in the load has been sadly neglected.

How very true.

INTO LINEAR IC's *continued from page 48*

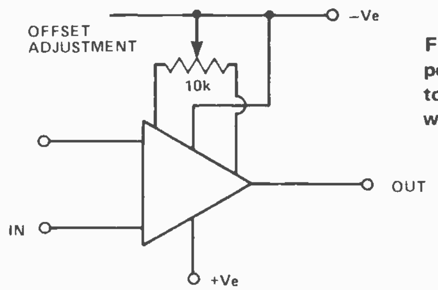


Fig. 9. Offset adjustment. The potentiometer can be adjusted to make the output voltage zero when both inputs are zero.

Finally, as far as this session is concerned, to matters practical. Reading about what ICs do is fine, but there's nothing like experimenting for yourself, and your understanding of what linear ICs do becomes a lot more complete when you've tried out some circuits and found out for yourself how they behave. There are going to be a lot of circuits shown in this series, and I wouldn't suggest that you tried out each and every one of them, but at least one or two from each part of the series is about par for the course, keeping you up to date in the practical side of using ICs. One of the pleasant things about working with ICs is that you quite often don't need many other components — the bias circuit of Fig. 8 demonstrates that. On the other hand, if you want to show exactly what a circuit is doing, you need some way of testing it. If you have access to such goodies as signal generators and oscilloscopes, great — you can check out any of the circuits completely. If you don't run to this sort of laboratory equipment, then we'll try always to include circuits which can be tested with simpler methods, like cheap crystal microphones and earpieces, old loudspeakers, LEDs and the like. One really useful aid, though, is a decent voltmeter or multimeter with at least 20 000 ohms per volt on its DC ranges.

Now the next thing is how to construct the circuits. You could, of course, solder up each one, spend a fortune on ICs, and end up with an awful lot of small bits of board, each with a different circuit on it. A much simpler way is to use one of these very useful devices, a solderless breadboard. This way there's no soldering problem, circuits can be assembled very quickly, taken apart afterwards, and the components re-used. We can even arrange our circuit diagrams (and we have, too) so that you can check each connection in the circuit — it's as near to electronics-by-numbers as you'll ever get. More about all that next month, and also about soldering and power supplies. We'll also take a brief look at how you can design a circuit layout for yourself — stay with us.

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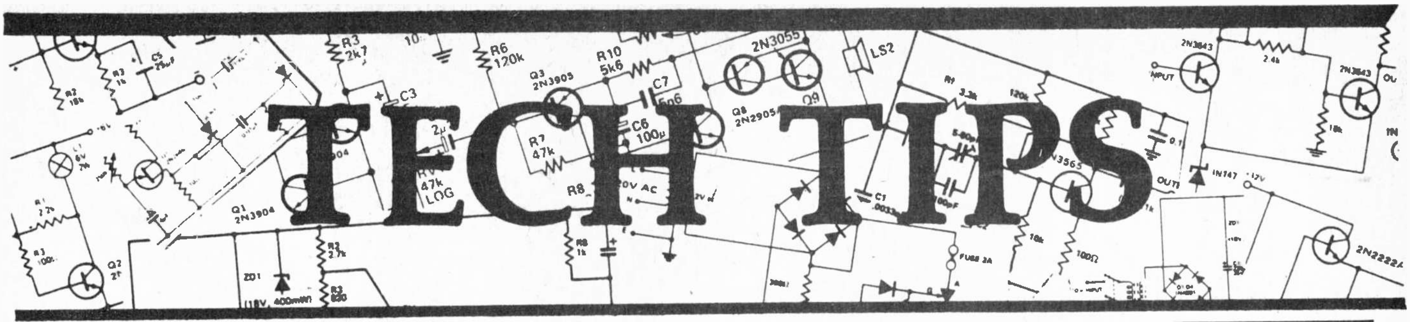
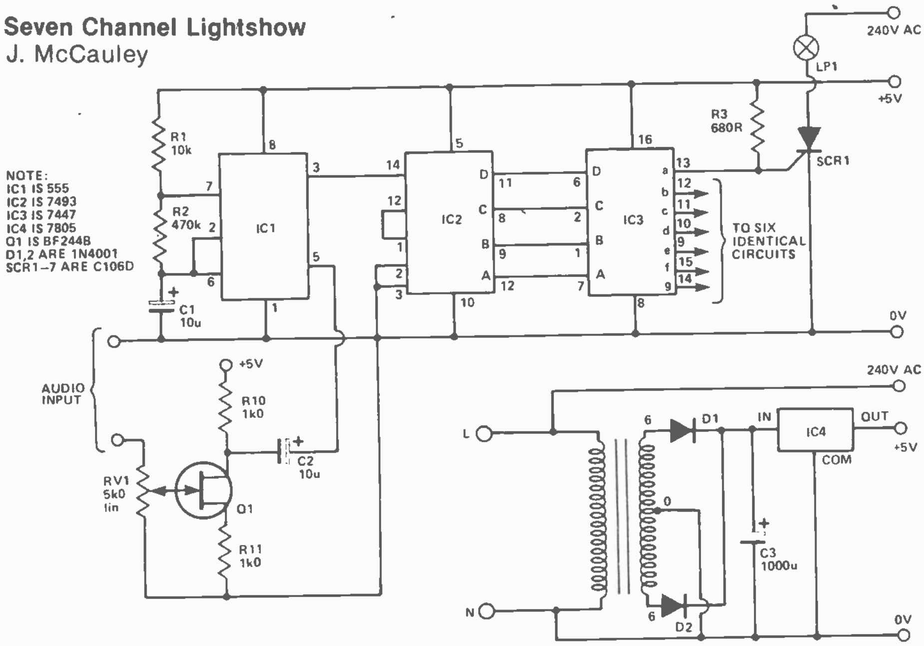


Seven Channel Lightshow

J. McCauley



COUNT	LP1	LP2	LP3	LP4	LP5	LP6	LP7
0		X	X	X	X	X	X
1					X	X	
2	X		X	X		X	X
3	X			X	X	X	X
4	X	X			X	X	
5	X	X		X	X		X
6	X	X	X	X	X		
7					X	X	X
8	X	X	X	X	X	X	X
9	X	X			X	X	X
10		X	X	X			X
11				X	X	X	X
12	X	X				X	
13	X	X		X		X	X
14	X	X	X	X	X		
15							

X LAMP LIT

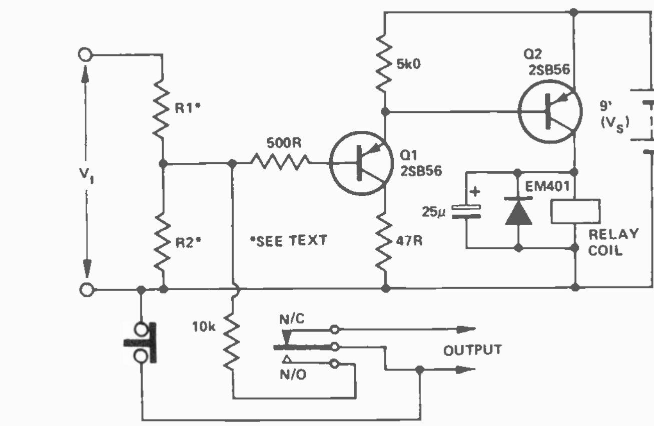
When used with an audio input this circuit gives a very effective display, using seven 75 W coloured spot lamps for disco work or smaller 'pygmy' bulbs when used as an addition to a home audio system. Alternatively the 7447, which is a display driver, can drive seven LEDs directly.

As can be seen from the truth table there are 16 different arrangements for the sequence of switching. This helps give the impression that the bulbs are randomly switched. The operation of the circuit is as follows.

The 555 timer is connected here as a VCO with the control voltage on pin 5 derived from the audio input via the FET input buffer circuit. The variable length pulses from the VCO are then used to clock the 7493 which is connected here as a binary counter.

The outputs from the 7493 are then decoded by the 7447 decoder (BCD to seven-segment). The outputs from this IC are used to trigger the SCRs, thus turning on the appropriate lights.

All that is necessary to operate the circuit is adjustment of the input level control (RV1) to give the best visual display. When switching low power loads ie 75 W, RFI suppression circuitry should not be required; however, with greater loads (absolute max 750 W per channel) such circuitry will be necessary.



Relay PSU Protector

This circuit may prove very useful when trying out a project for the first time. Any power supply shorts will pull the supply voltage (Vi) down, turning the transistors on and tripping the relay. This then causes the 10 k resistor to latch the circuit in the 'tripped' mode. The relay is connected so that it disconnects the supply to the circuit being tested. The circuit can be reset by pressing the momentary-contact switch shown.

R1 is selected so that Vi/R1 is greater than Vs/R2. R2 must be greater than R1 and Vs/R2 must be large enough to turn the first transistor on.

The circuit works with Vi ranging from 3 to 18 volts.

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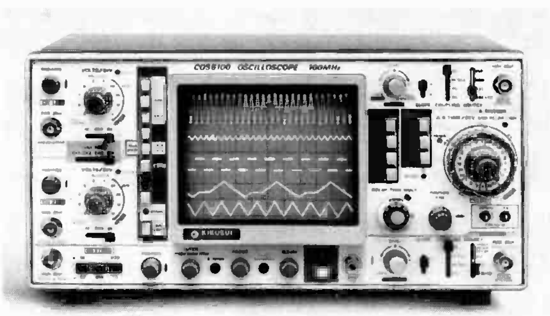

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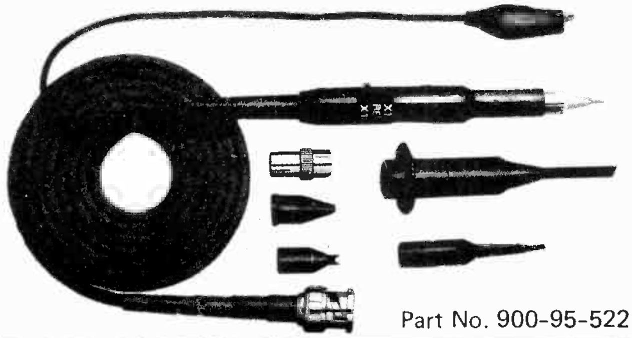
Oscilloscope Probes



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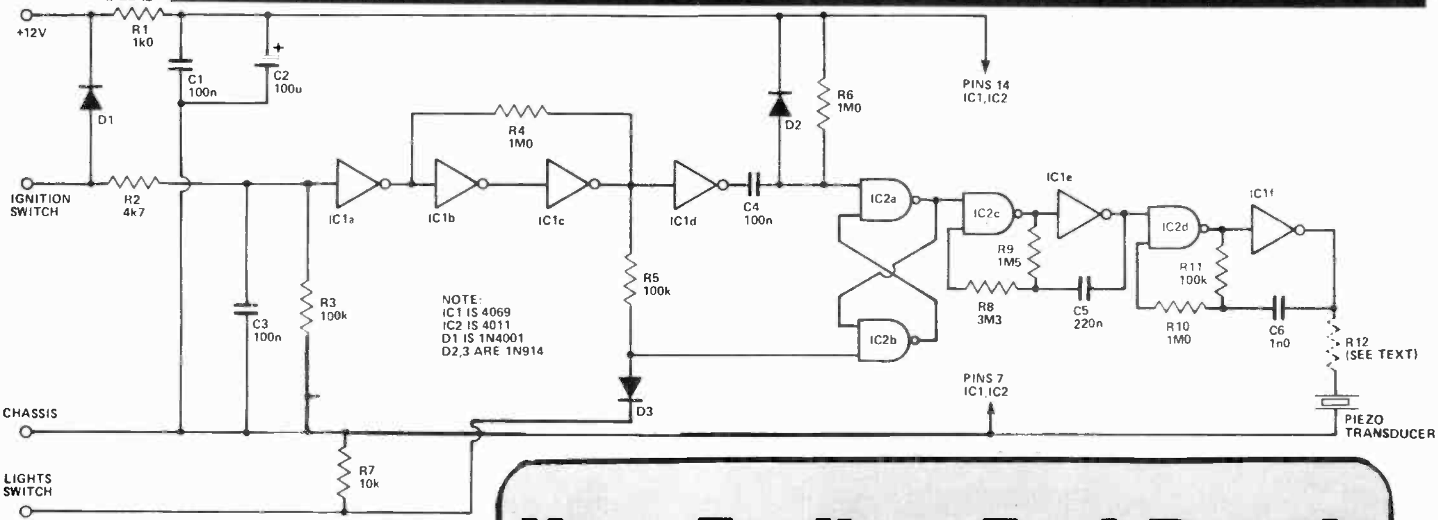


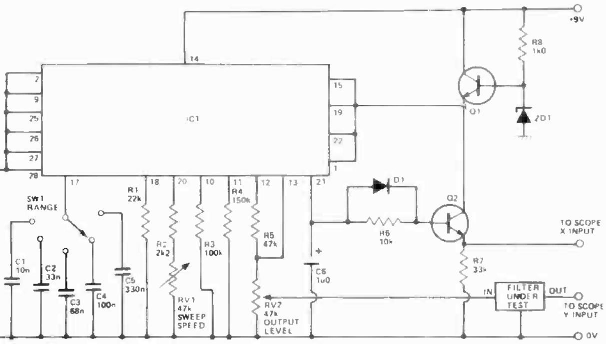
Car Lights Warning
A.M. Tucker

This circuit gives an audible warning if the car lights are left on when the ignition is switched off. If necessary, the lights can be switched off and then on again, and the alarm will be cancelled.

Operation is as follows: the ignition switch is connected to buffer IC1a, Schmitt trigger R4-IC1b-IC1b and inverter IC1d. R1-C1-C2 and R2-C3 are filters. If the lights are on and the ignition is switched off, a negative pulse is applied through C4 to IC2b and the junction of R5 and D3 goes high, causing the flip-flop to change over. This enables the slow oscillator IC2c-IC1e (approximately) 4kHz oscillator IC2d-IC1f, causing audible bleeps in the piezo-electric transducer. If the lights are off, the input to IC2a is held low via D3 and R7, inhibiting the oscillators. D1 and D2 deal with unwanted transients, while R12 is chosen to give the required warning level.

The circuit can be adapted for positive ground vehicles by reversing the diodes and electrolytic capacitor, reversing the connections to pins 7 and 14 of the ICs, and substituting a 4001 NOR IC for the 4011 NAND IC. With this modification, there may be a short bleep when the ignition is switched off and the lights are not on.

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



Simple Frequency Response Display

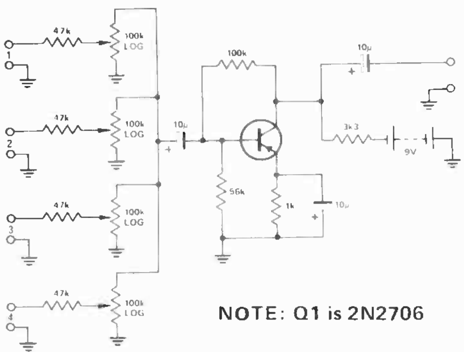
M. Harrison

This circuit was originally designed to test audio filter circuits, but has several other uses such as demonstrating the properties of tuned circuits, or testing graphic equalisers. The circuit consists of a low-frequency oscillator with a triangular wave output which is used to frequency modulate a VCO, while also being fed to the X input of a 'scope (the signal is about 2 V peak-to-peak, so further amplification may be needed for some 'scopes). The VCO output level against frequency, with the frequency decreasing from left to right. SW1 sets the frequency range of the display, and RV1 sets the scanning speed; it is adjusted to give a good display, and does not affect the actual shape of the display. As well as being simple this circuit is cheap, the 76477 only costing about $5. Q1 and Q2 are any NPN silicon transistors with a reasonable gain, for example 2N3904.

NOTE:
IC1 IS SN76477
Q1,2 ARE 2N3904 OR SIMILAR
D1 IS 1N4148
ZD IS 6V8 ZENER

Four-Input Mixer

D. Marzolla



NOTE: Q1 is 2N2706

This mixer circuit has very low current drain and can give an operating life of three to four months from a No. 216 9-volt battery with moderate use.

The input impedance is 47k and the gain of the mixer is 3 dB. Perhaps a good use for those old germanium transistors you were going to throw out but knew they would come in handy sometime!

Circle No. 24 on Reader Service Card.

 Continued from Page 58

in mind, though, that even if you reprogram the appearance of a character, it will still be interperted by the machine in the same way. For instance, if you convert a shifted "2" so it looks like half a Martian, it will still set the quote mode when hit, and, thereafter, all subsequent cursor control keys will be printed, instead of directly moving the cursor.

Programmed characters can be used to create special character sets for math, chemistry, electronic design, music, and, of course, games. The character loader program, program 1, can be run prior to actually loading the main program, as once the characters are in RAM and protected by bringing down the pointer, nothing can hurt them unless you RESTORE. You can execute NEW or CLR without any hassles, as these commands only refere to BASIC, and, by bringing the pointer down below the character RAM, we've put them outside the memory BASIC can deal with. It's worthwhile doing this two program approach, as it means you don't have to tie up useful working RAM with the loader, which isn't really much good for anything after it's been run once.

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. . .and we'll send you money. Actually, it's a bit more complex than that. If you're into computers, you may have a favourite program, utility, peripheral or hardware widget that other readers would be interested in checking out. Send it to us, and, if we think it's wonderful, we'll run it, and send you up to $30.00 on publication. The following are our criteria for thinking things are wonderful.

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2. Machine language utilities and other ML stuff with reasonably practical applications are generally wonderful.

3. We need listings. Don't send us cassettes, disks or paper tape, because, in the vast majority of cases, we won't be able to do anything with them. Hand written or typed listings are not all that wonderful, as they lead to errors. Printed listings are wonderful, especially when done with fairly new ribbons. If you haven't got a printer, you can usually harrass the store where you bought your computer into doing a listing for you.

4. Hardware add ons and mods are quite wonderful if they aren't too crazy.

5. The PDP 11 is not a home computer. Neither is the IBM 1130, even if you did get one at a junk sale. We're trying to restrict wonderfulness to reasonably well known small machines, as it will be applicable to the greatest number of readers. Obviously, if you're writing machine code for a bizzarre computer with a common CPU with a reasonably normal bus structure, it's still wonderful as it will work for anyone else having that CPU.

8. Please send your stuff along with a self stamped and addressed envelope. This is really wonderful, so we can tell you what's to become of it.