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75¢ ■ FEB. 1975

Radio-Electronics®

THE MAGAZINE FOR NEW IDEAS IN ELECTRONICS

R-E EXCLUSIVE TV TYPEWRITER II
It's A Computer Terminal

INSIDE DIGITAL ELECTRONICS
What Digital Really Is

3-UNIQUE DIGITAL CLOCKS
Build Them Today

NOISELESS DISCS AT LAST
New Noise-Reduction System That Really Works

TAMING THE BASS REFLEX
Get The Most From This Design

NEW IC BREADBOARD SYSTEM
Build It For Your Bench

Jack Darr's Service Clinic

A GERNSBACK PUBLICATION

Circle 3 on reader service card

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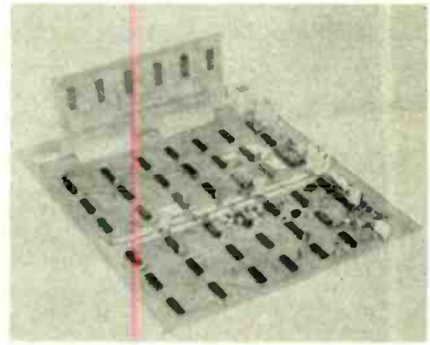
THE MAGAZINE FOR NEW IDEAS IN ELECTRONICS

More than 65 years of electronics publishing

FEBRUARY 1975 Vol. 46 No. 2



HEART OF TV TYPEWRITER II is this printed-circuit board assembly. It's the heart of a computer terminal that does almost everything . . . see page 27

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looking ahead

Deadline blues

An item in this column about a year ago celebrated the first commercial launching of videodisc sales by Telefunken of Germany. It was later modified with the comment that marketing had been delayed because a technical problem had cropped up in the player. Bearing in mind that there is a certain lead time in writing this kind of a column, I now report that by the time you read this, videodisc system sales to the public may have begun. At press time, Telefunken had announced that all technical problems had been resolved and it would start sales to the public in Germany of its videodisc player during the first two months of 1975. The Telefunken player (TeD system) uses a mechanical pickup and provides 10 minutes viewing time on a floppy eight-inch disc. In Germany, the videodisc players are priced at $600, including 25% tax. Discs are four to ten dollars, depending on subject matter.

Fax of life

Mail service has deteriorated so much that one major newsletter publisher is seriously considering electronic distribution as an alternative. F. W. Dodge, a subsidiary of McGraw-Hill, which publishes daily newsletters for the construction industry, has let it be known that it is looking for 65,000 facsimile terminals. Now when you consider that there are only about 130,000 fax terminals in the whole country now, this begins to look like a major order. Dodge is seeking receive-only equipment which can be hooked to phone circuits to bring its newsletter to subscribers during the wee small hours when phone charges are low. This would be the first major publication to be distributed by fax. Of course, F. W. Dodge may have overestimated the quality of our telephone service. What happens when 65,000 construction industry executives arrive at their desks, open up their favorite daily newsletter and read, "I'm sorry, but the number you have reached is not a working number . . .?"

All-electronic news

Television networks and stations are experimenting with "total electronic journalism" as the result of the development of a new family of broadcast equipment. Each of the three networks has spent more than $2 million recently to purchase miniature color TV cameras weighing 14 to 18 pounds, made by Fernseh of Germany and Ikegami of Japan as a substitute for film cameras. Hitachi Shibaden and Toshiba are also developing super-small cameras.

These cameras are often combined with miniature, battery-driven video-cassette recorders to produce on-the-spot newstape coverage. The development of highly efficient time-base correctors makes it possible to feed the output of a video-cassette directly onto the air or into a broadcast-type VTR with minimum picture degradation. The advantages are speed (since tape requires no editing) and economy (tape is reusable).

Quadradio

The FCC has concluded its field tests of discrete quadraphonic FM broadcasting systems. Using the facilities of KIOI, the pioneer FM stereo station in the San Francisco area, the Commission monitored tests of systems proposed by General Electric, RCA, Zenith, Quadracast Systems, and Nippon Columbia. The FCC must now determine whether it is necessary to authorize a discrete system, and, if so, which one. Matrix systems, such as SQ and QS, may now be broadcast without special authorizations. No action is expected in the near future.

Audio's new image

The sound may be the same, but there's a new look to audio amplifier ads. Blurb-writers have been working overtime to bring them into conformance with the tough new government requirements for describing audio equipment. The net result is a distinct benefit for the audio shopper—all published power claims may at last be directly compared.

Although the Federal Trade Commission rules went into effect in November, some audio advertisers weren't complying in their December ads, but much of the problem seemed to be a result of misunderstanding of the FTC rules and manufacturers were working hard to comply.

Under the new regulations, if any manufacturer makes any claim for power, it must prominently state power in rms watts per channel, maximum distortion, load in ohms and bandwidth—all measured according to specific procedures. Such claims as "super power" and "big sound" are now forbidden. The manufacturer or dealer must present standard figures to tell just how super or how big. The FTC is sticking to the letter of the rule, firing letters off to manufacturers telling them that such phrases as "2 X 20 watts per channel" are unacceptable (it should be "20 watts per channel").

What is "proper disclosure?" This is how an amplifier should be described to conform with the rules: "Minimum 20 watts per channel RMS power, both channels driven into 8 ohms from 40-20,000 Hz, 0.8% total harmonic distortion." Abbreviations and symbols, such as Ω for ohms and THD for total harmonic distortion aren't permitted.

While manufacturers generally are complying with the new rules in their magazine advertising, dealers are having more trouble and newspaper ads show widespread violations — obviously because many retailers are unaware of the new rules. The FTC says it will crack down if it doesn't stop.

Another home VTR

Home VTR systems crop up with amazing regularity, but none has actually made its way to the home since Cartridge Television Inc. folded its tents and liquidated its shop in bankruptcy proceedings. This month's home videotape system is strictly one-of-a-kind and holds promise of great tape economies. Developed by American Videonetics in Sunnyvale, CA, it employs neither helical or longitudinal scan principles.

It uses ¾-inch tape at a speed of 2.88-ips. The signal is deposited and read out by a group of eight heads on a bottlecap-sized wheel which revolves at 7200 rpm perpendicular to the movement of the tape (the audio tracks are longitudinal). The picture produced by this technique is very good, and an hour of recording can be stored in a single-reel cartridge 3.5 inches in diameter. With thinner tape, American Videonetics hopes to make possible a two-hour cartridge not much larger. That's the good news. Now the bad news—no prospect of any production before 1977. At least it's refreshing to see a new videoplayer system which isn't ready for production the day before yesterday.

by DAVID LACHENBRUCH
CONTRIBUTING EDITOR

new & timely

Searcher for Martian life to radio Earth via S-band

July 4, 1976, will be a big day for Mars as well as the United States. On that day a NASA Viking Lander—an unmanned laboratory—is scheduled to touch down near the mouth of the 4-mile deep gorge, Chryse. Its instruments

A HALFWAVE ANTENNA ON 3 GHz, this 4-inch high antenna will be the link to Earth for the NASA Lander due to touch down on Mars July 4, 1976. The Earthling studying it is RCA secretary Carol Safford.

are designed to discover signs of existing or former life on the planet.

It will take color, infrared and panoramic pictures—to be radioed to Earth for map making—burrow into the soil and analyze samples, analyze the atmosphere and check pressure, wind velocity and quake activity (if any). A special instrument will look for organic content in the soil specimens, and an X-ray fluorescent spectrometer will analyze them for chemical composition.

The communications system—designed by RCA for the purpose—can beam signals direct to Earth or relay information via its mother ship, the Orbiter, circling Mars. The Lander will have a narrow-beam steerable antenna, which will send signals in the 1.5-to-5 GHz band direct to Earth. Since the antenna must point directly at Earth, it will have to be adjusted continuously, during transmission, and can be used during only a part of the planet's rotation. At other times it will send scientific information back to the Orbiter on uhf. During favorable periods, the information will be sent via the S-band.

Two of the antennas look strictly out-of-this-world—as if they may have been made on Mars. The 4-inch-high low-gain S-band antenna is intended to receive command and control signals from Earth. A broad-band type, it need not be pointed directly at Earth to receive signals from the high-power Earth transmitters. The uhf low-gain antenna, which resembles an 18-inch high tree with tin can hanging from it, radios data to Orbiter for Earth relay. The hi-gain S-band antenna is the more conventional parabolic dish.

While the system is equipped to receive commands from Earth, most of the Lander's functions are automatic. This is necessary because the travel time for a radio signal from Mars to Earth is 20 minutes. Thus it would take 40 minutes for an Earth base station to react to a Martian condition and transmit a command to cover it.

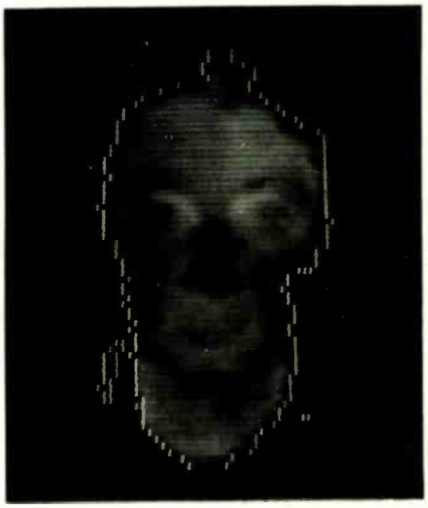
ANTENNAS FOR THE VIKING LANDER. In the background is the big high-gain S-band antenna. RCA technicians Schleeter and Kane are inspecting the little low-gain S-band antenna, only four inches high and three across, which receives signals from Earth. The antenna at right is the UHF communications link between Lander and Orbiter. The "cans" on the ends of the rods contain a protective foam that prevents high-power arcing in the Martian atmosphere.

Thermography—a new medical aid

Taking "heat pictures" (infra-red thermography) is not new. It was used for defense purposes during World War II. In 1956, thermography was used in Canada to locate possible breast cancer. Later, it was employed in Britain, at London's Middlesex Hospital in the early '60's, using a type of thermograph (known as the Smith Pyroscan) which was originally developed for docking ships in bad fog.

The main development of scanners for medical purposes took place in Sweden and the U.S.A. In the early '70's, Britain's Rank Industries produced a machine that is now used at the Bath hospital along with another machine manufactured by the A.W.R.E. (Atomic Weapons Research Establishment at Aldermaster, England). This combination is probably the best for medical purposes as it has a digital print-out facility, thus preventing possible misinterpretations.

The machine works by focusing infrared onto a very sensitive thermo-couple (Indium-Antinomide) cooled with liquid



THERMOGRAPH OF A HEALTHY FACE. The interesting "border" of bright spots is due to a presetting that permits electrons to reach the cathode-ray tube screen only above a certain heat level, causing surges on the scan line as the current is switched on and off.

nitrogen to between minus 200 to 400 degrees, which increases its sensitivity to infrared emissions. The infrared is picked up by an optical system which scans the relevant area of the patient and directs the infrared onto the thermocouple. The signal is then amplified and made visual on a gray-scale basis and can be seen on the instrument's cathode-ray tube. Black represents cold, and white represents hot. The result is a "heat picture". In cases of stroke prevention, one focuses on the face. The warning sign would be a relative coolness over one, or both, eyebrows.

"It should prove a useful initial screening test for a person who has complained of weakness, dizziness, one-sided headaches and transient blurring of vision," says Dr. Barbara H. Phillips, M.B. (Bachelor of Medicine), a member of the research staff at the Bath hospital. "These can be the warning symptoms that a stroke is on the way. Most strokes are triggered by a partial blockage of

(continued on page 12)

Your sure-fire smoke detector is here...the Mallory SDA3 Alarm.

Automatically, 'round the clock, when hazardous smoke fumes threaten, it sounds a life-saving intermittent blast—so loud it can break through the deepest sleep.

The Mallory Smoke Detector Alarm is completely self-contained, battery-powered. It installs easily on ceilings—in hallways, bedrooms, wherever warning for escape from lethal combustion products (visible or invisible) is needed.

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All for a price so affordable, every home, apartment, trailer, office can have sure-fire smoke-alarm protection.

For details, see your Mallory distributor.

The SDA3 Alarm is compact, unobtrusive—only 6" x 1$\frac{9}{16}$".

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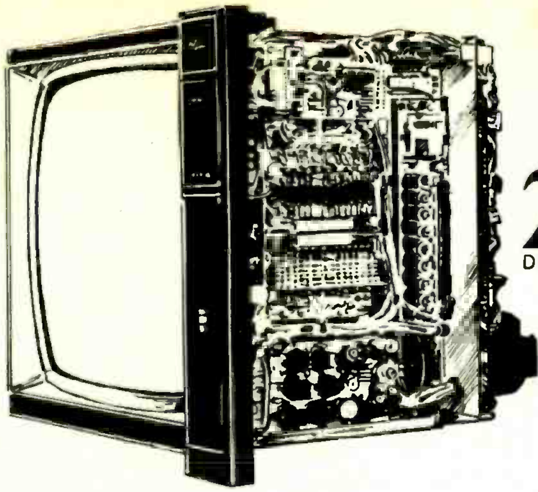


You get the same 25" hobby-kit color TV from three different schools.

DIAGONAL

You get this designed-for-learning 25" color TV only with NRI training.

DIAGONAL

No other home-study school gives you a TV like the one you build with NRI's Master Course in Color TV/Audio servicing. Some schools give you three or four plug-in sub-assemblies off the production line to put together a commercial set. Others give you a hobby-kit bought from outside sources. And because neither type was originally designed to train people for TV servicing, lessons and experiments must be "retro-fitted" to the set as it comes.

That's why we went to the trouble to engineer our own, exclusive solid-state TV. It's the only way a student can (1) get the feel of typical commercial circuitry, (2) learn bench techniques while building a complete set from the "ground" up, (3) perform over 25 "in-set" experiments during construction, and (4) end up with a 25″ diagonal solid-state color TV with console cabinet and all the modern features you'll find on sets you'll service. Nobody else can give you this combination of advantages because nobody else invested the time and money to design a set with learning in mind.

More know-how per dollar

That's what it all boils down to, the quality of training you get for the money you spend. In our 60-year history, more than a million students have come to NRI and we're fully approved for career study under the G.I. Bill. We must be teaching something right.

Some of those "right" things are bite-size lessons to ease understanding and speed learning . . . personal grading of all tests, with comments or explanations where needed . . . a full-time staff of engineer/instructors to help if you need it . . . plenty of "real-life" kits and experiments to give you hands-on training . . . and fully professional programs oriented to full- or part-time career needs.

NRI passes the savings on to you

You don't pay a big premium to get this unique TV as part of your training, because NRI engineering eliminates the cost of buying from an outside source. And we pay no saleman's commission. We enroll students by mail only. We pass the savings along to you in the form of low tuition fees, extras like a cabinet for the TV, a solid-state radio you learn on as you build, and actual instrument kits for servicing TVs . . . triggered sweep oscilloscope, integrated circuit TV pattern generator, and 3½ digit digital multimeter. You can pay hundreds of dollars more for a similar course and not get a nickel's worth more in training and equipment.

Widest choice of career opportunities

NRI offers not one, but five excellent TV/Audio servicing courses so you can tailor your training to your budget. Or, you can study other opportunity fields like Computer Electronics, Communications, Aircraft or Marine Electronics, Mobile Radio, and more. Free catalog describes them all, showing lesson plans, equipment and kits, and career opportunities. There's no obligation and no salesman will ever call, so send for your copy today. See for yourself why NRI experience, selection, and exclusives give you something no other school can.

If card is missing, write to:

NRI McGraw-Hill

NRI SCHOOLS
McGraw-Hill Continuing Education Center
3939 Wisconsin Avenue,
Washington, D.C. 20016

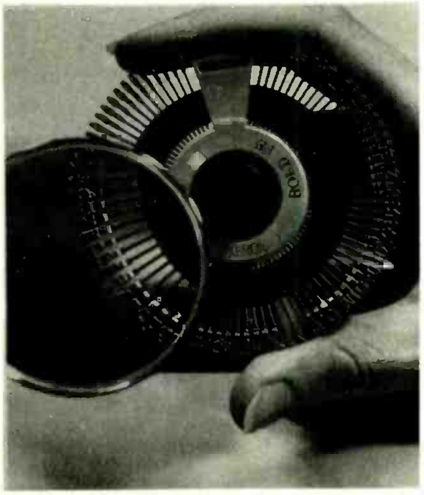
 (continued from page 6)

one of the two major blood vessels which feed the brain. The blockage, sometimes in an accessible place in the neck, can give off clots, which when swept upwards toward the brain cause a stroke. The aim is to discover and operate on the initial blockage before the stroke can occur".

Heat pictures are also showing promise as a useful tool in screening for breast cancer and for locating operating sites for varicose veins. Because the thermograph reads temperatures of the skin, body tumors can also be readily seen, as hot spots (white areas) against cold areas (black).

New electronic typing system turns out 350 words per minute

A high-speed electronic typewriter system, the Xerox 800, uses a typing wheel reminiscent of an old child's toy typewriter, and operates from magnetic tape or cards. It has a memory system that permits it to type one line in the regular manner, then the next line from the end to the beginning, saving the time normally lost in carriage return, thus increasing typing speed.



THE COMPLETELY NEW TYPING WHEEL is, however, reminiscent of two very old methods—one the child's typewriter in which each letter was rotated into position, then pressed down to print; the other a drum type in which a hammer behind the paper printed the character. The wheel will be available in 17 different type faces, easily interchangeable.

The operator types a draft which is automatically stored on tape or cards. Corrections can be typed directly over errors, or revisions can be inserted (as many as 78 characters per line). There are three spacing alternatives: elite (12 characters per inch), pica (10 characters) or proportional spacing, which, with right-hand justification, greatly improves the appearance of a document. The carriage returns automatically while the operator is typing a draft. When the draft—corrected and revised—is finished, the machine types it at the 350-word speed. Meanwhile the tape—or card—permits typing exact duplicates, if required.

In reproducing multiple documents, such as a single letter to several or many addresses, a dual-tape machine can type the names and addresses from one tape or card and the body of the letter from another.

The new machine, which has its own microprocessor, is leased by Xerox for a little more than $200 per month for the single-tape to about $300 per month for the dual-tape system.

The typing wheel, which Xerox uses instead of type bars or a ball, consists of 88 flexible spokes around a hub. Each character is brought into position electronically, then a hammer brings it up against the paper to print the character. The microprocessor can move carriage and paper to place any word or character in any desired place on the sheet.

FCC relaxes "beep" rule to protect phone users

The FCC has instituted proceedings with the American Telephone and Telegraph Co. (ATT) that would lead to suspending—under certain circumstances—the rule requiring a warning "beep" tone when telephone conversations are recorded. Such suspension would apply when a subscriber is being harassed by illegal or obscene telephone calls and wants to obtain evidence to that effect without warning the offending caller.

The case that led to the FCC ruling was that of a Maine man, Richard Maller. He complained to the New England Telephone Co. that a Massachusetts-based collection agency, Federated Credit Corporation, was making numerous abusive and harassing debt-collection calls to him. Such calls are not only against telephone company rules, but also violate the Federal Communications Act.

Mr. Maller made a tape of one of the calls to prove to the company that he was being harassed as he stated, but the company objected that Mr. Maller had also violated company rules by making the "unbeeped" recording.

The Commission was concerned about any company rule that would require a warning to be "transmitted to the offending party before the call could be recorded by the innocent party." The proper procedure in cases of abusive phone calls, the Commission pointed out, "is for the carrier to suspend service" to the offending party, and to restore it only when assured that illegal practices have been or will be discontinued.

Computerized efficiency reaches US Post Office

For the first time in the history of the Post Office, an automated system is serving customers, who—also for the first time—will receive printed receipts for their transactions. The system is being tried out in three stations in the San Jose, CA area, and its success has been such that it will probably be widely adopted.

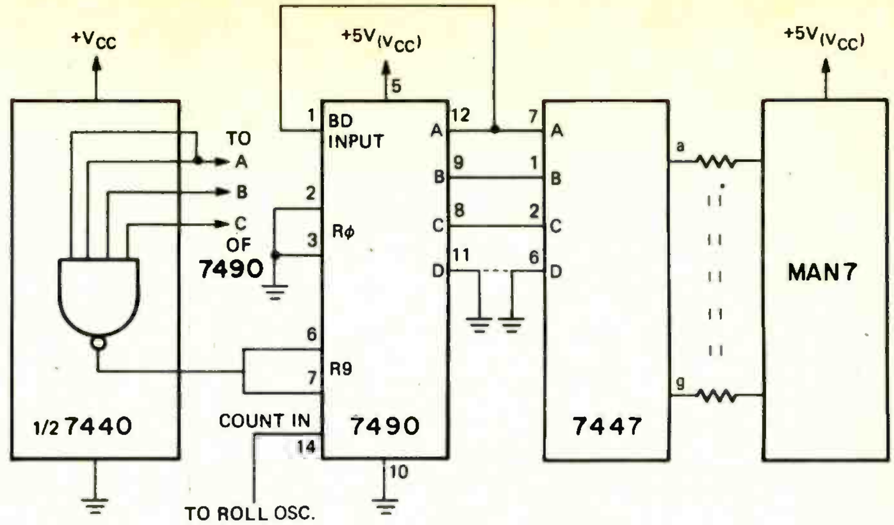
DIGITALLY ENCODED ZIP LABEL that looks like a bulls-eye is pointed out by RCA engineer Dan Siryj, engineer for the Parcel Post Coding Equipment Project. The system automatically encodes, generates and applies the label to the parcel. Read by the laser, as shown above, the zip code is verified by a computer that then generates a command signal to route the parcel to its proper destination.

POST (Point Of Sale/Transaction) consists of a microprocessor, a special function keyboard, a 5-inch CRT display, a built-in card reader and printer. The clerk inserts information into the system via the keyboard. The type of transaction, charges, money received and change due are then computed and displayed on the screen.

Two copies of the data are printed—one for the customer, one for Postal Service records. The system also records the transaction on tape for later processing.

RCA has also in the works a Parcel Post Encoding Equipment system, to speed up parcel handling with the help of digitally encoded zip labels. **R-E**

letters



ANOTHER WAY TO ROLL

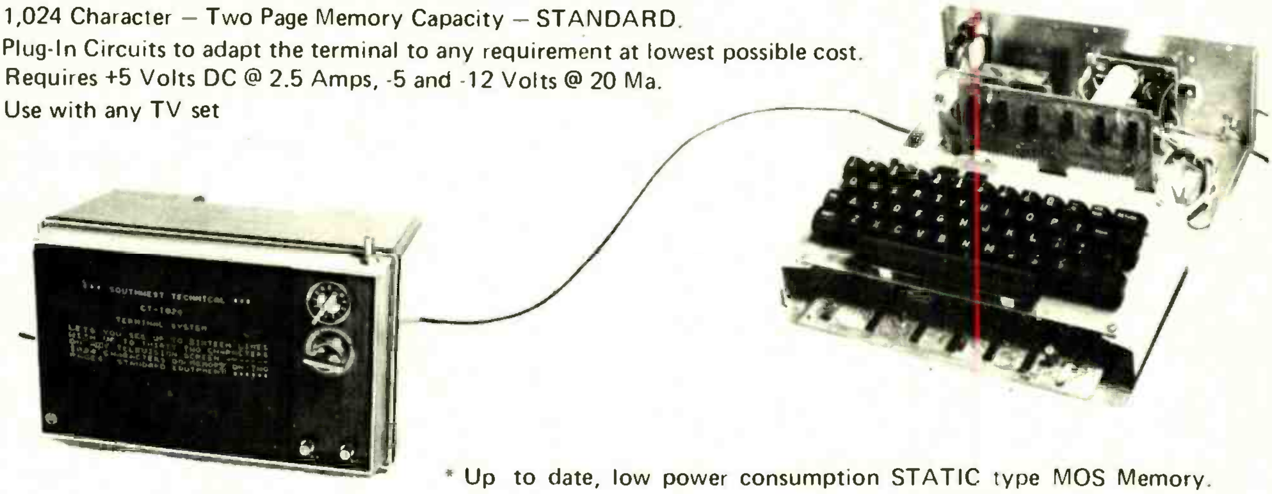
This letter is in regard to the article which appeared in the March 1974 issue of **Radio-Electronics** describing an electronic casino and asked for comment. Last summer I was interested in both an electronic dice-roll circuit and a roulette-type game. The attached reprint from Wireless World (August 1973) describes a much simpler method of generating the dice display. Their method uses only 2 IC's per counter/decoder as compared to 4½ and is simpler to wire. Using a similar oscillator to drive the dice and LED's in the standard pattern, the circuit gave excellent results. Also, I designed a circuit to give a digital readout of the dice values, using a 7490, ½ of a 7440 and a 7447. The 7447 is hooked up normally, but with the "D" input grounded. The 7490 counter has the "D" output grounded which does not harm it because the D FF is an RS type, but when the reset to 9 function is used, the counter resets to 1 instead since D is grounded. The 7440 Nand is used to detect the 7 state of the counter and is connected to the reset to 9 input. When the 7 state appears, the 7490 is reset to 1 so fast that it appears to be counting from 1 to 6 only. For a display, I used a MAN 7 readout. Another variation to save on parts count is to cascade the two counters to make a divide by 36. This will save one oscillator and will eliminate any problems caused by two oscillators locking in phase due to stray coupling.

I also have a simpler circuit for the roulette game—by using the self-correcting ring counter which is described in the following article from Electronic Design #9 (April 26, 1973) and non-inverting buffers such as the 7407 and 7417 which would decrease package count by 8 and simplify the wiring. By using the other half of the 7474 and a shift register of only 19 stages, the package count is cut by 13 packages for the shift register and by three buffers. This method is essentially to multiplex the LED's—the first one string of 19 would be on and when #19 was reached, the next pulse would (a) toggle the 7474 FF and (b) the shift register would return to 1 which is now the first lamp in the second string. The

(continued on page 16)

SWTPC IS PROUD TO ANNOUNCE: THE CT-1024 TERMINAL SYSTEM

* DISPLAYS UP TO 16 LINES (of 32 Characters) AT ONE TIME.
* 1,024 Character – Two Page Memory Capacity – STANDARD.
* Plug-In Circuits to adapt the terminal to any requirement at lowest possible cost.
* Requires +5 Volts DC @ 2.5 Amps, -5 and -12 Volts @ 20 Ma.
* Use with any TV set



* Up to date, low power consumption STATIC type MOS Memory.
* No complicated refresh or power-down circuits needed.

At last we can tell you about the most versatile, video-display terminal kit available anywhere; the Southwest Technical CT-1024. Our terminal is designed around a basic mother board and a 6,144 bit memory that will display two pages of data on any standard television set, or monitor. The two pages consist of 16 lines with 32 characters on each line. Input may be any source of parallel ASCII code; keyboard, computer, etc. If the system is to be used for a display, teaching aid, deaf communicator, or other similar purpose; this is all you will need.

Other applications of a terminal system such as remote time share, RTTY, etc require an interface having a serial output. For these applications you add our # CT-S plug-in UART card to the mother board. This allows you to transmit and receive ACSCII coded data in serial form at a rate of 110 baud. (300 and 600 baud options are available). The standard RS-232 type interface connects directly to your transmitter FSK modulator, modem system, or what have you.

If you are going to use the CT-1024 directly with a computer I/O port that requires a parallel ACSCII input, then you will want our parallel interface card, #CT-P which allows either the keyboard, or the computer to access the terminals memory and display data on the screen.

For those applications where it is useful, we also have an "off line edit", or "screen read" plug-in circuit #CT-E. This allows you to compose a program, or message on the terminals display screen and transmit it out a line at a time when you are finished and satisfied that everything is correct.

If you would like the convenience of complete cursor control, we have our #CT-CM plug-in board. This gives you Move Right, Move Left, Move Up, Move Down, Home Up, Erase to end of line and Erase to end of frame functions. These are operated by keyswitches, or any other type switches you may wish to use, giving you complete manual control of the cursor.

If the terminal is to be part of a computer system, you might prefer our automatic cursor control circuit #CT-CA. This plug-in not only allows you to control the cursor and to perform the functions listed above, but makes possible computer control of these same functions through the machines software.

# CT-1024 Terminal System Kit with 1024 Memory Card—less cabinet or power supply	**$175.00 PPd**
# CT-E Screen Read Plug-in Card Kit	**$ 17.50 PPd**
# CT-M Manual Cursor Control Plug-in Card Kit	**$ 11.50 PPd**
# CT-P Power Supply for CT-1024—115-230 Volt Primaries	**$ 15.50 PPd**
# KBD-2 Keyboard Kit – 53 Keys	**$ 39.95 PPd**

FREE—1975 Catalog—Circle our number on the "Bingo" card.

SOUTHWEST TECHNICAL PRODUCTS CORPORATION

219 W. RHAPSODY

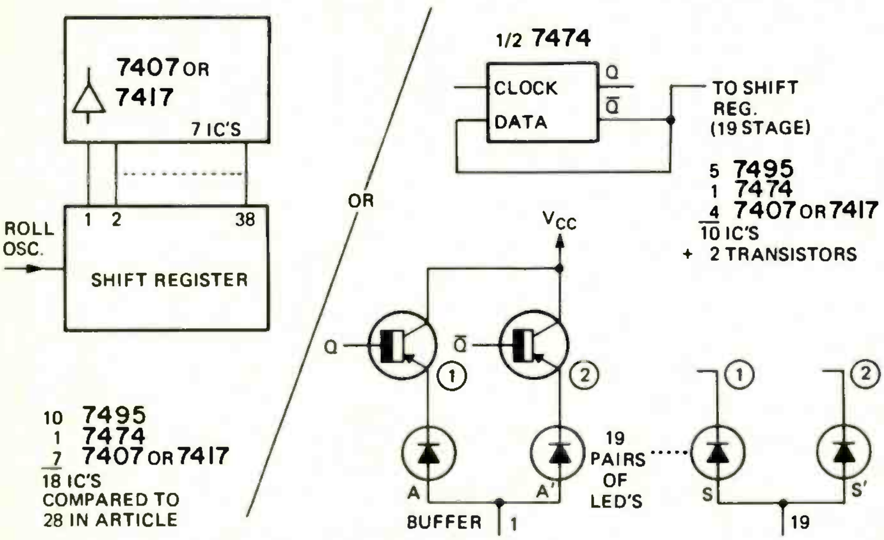
SAN ANTONIO, TEXAS 78216

Circle 7 on reader service card

LETTERS

(continued from page 14)

Q and the $\bar{Q}$ outputs of the 7474 would control which string was "on," with the control element being an npn transistor such as the 2N697. The type 7474 flip-flop has the $\bar{Q}$ output connected to the data input to use it as a divide-by-2. The



divide-by-2 can be placed before or after the shift register; if before, adjacent LED's will be on the same buffer and if it is placed after, the LED's will be in two separate strings as described above.

I hadn't included sound effects in my own versions and I added the ones suggested in the article—with fine results.

All in all, I did enjoy the article and I would like to see more of this type in print.

I am currently a student a UCI in Irvine, CA and I am majoring in computer science. **Radio-Electronics** has been on my reading list for the last 9 or 10 years, a long time when you consider that I am 21 years of age.

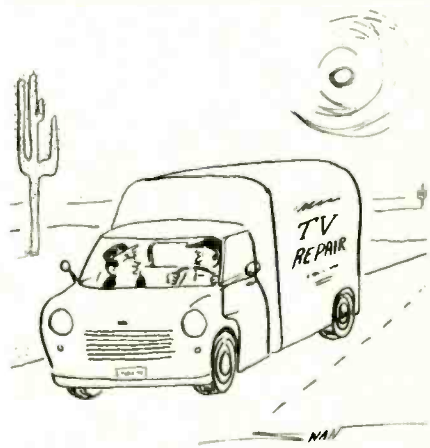
BRIAN SULLIVAN
Alhambra, CA

TV REVIDEO CORRECTIONS

Several errors crept into the TV Revideo Unit story and board layouts ("Put Time on Your TV Screen," September 1974, p. 33):

1. Resistor R14 should be 10K on the schematic. It is correct on the parts list.
2. Pins 1 and 2 of IC14 should go to +5V on the foil layout. They are correct on the schematic. Cut the ground foil to these pins and jumper them to pin 14 of the same IC.
3. A conductor is needed on the foil pattern between R31 and C13. The schematic is correct.
4. R8 should go to the other end of CONTRAST control R7 on the foil. Schematic is correct.

DON LANCASTER **R-E**



Suppose we ought to check that address again?

Now, 23v black matrix in an economy line.

From Sylvania, of course.

Replacing a black-matrix tube has usually meant buying a brand new tube because rebuilts just didn't exist. Now, Sylvania has changed all that.

We've added five black-matrix tube types to our low-cost Color Screen 85 line, and that even includes the popular 23-inch diagonal size.

That means you can offer your customers two different price ranges.

And increase sales opportunities by offering a low-price replacement.

With Sylvania, you not only have one of the broadest lines of replacement tubes in the industry.

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Read what the experts say about Heathkit Digital-Design Color TV

"The picture on the GR-2000 can only be described as superb. The Black (Negative) Matrix CRT, the tuner and i-f strip, and the video amplifier provide a picture equal to that of many studio color monitors."
(Popular Electronics, April, 1974)

"The picture quality of the GR-2000 is flawless, natural tints, excellent definition, and pictures are steady as a rock. It's better than any this writer has ever seen."
(Family Handyman, June, 1974)

"The plain truth is, with service and repair costs soaring even for the most insignificant in-home repair, the GR-2000 is the way all color TV sets will have to be made in the near future...."
(Elementary Electronics, May-June, 1974)

25" (diagonal) Heathkit GR-2000

Widely reviewed and acclaimed for its outstanding picture and years-ahead engineering. At the touch of a button, the channel number appears on the screen. The optional clock module displays the time right under the channel readout. The totally solid-state varactor tuner eliminates noisy "clunkers" with contacts that can wear out. Instead, pressing a button silently selects any of the 16 pre-programmed UHF or VHF stations. The unique fixed-filter IF never needs instrument alignment, so pictures retain unmatched clarity and brilliance year after year. And for the ultimate in convenience, add the optional wireless remote control. The GR-2000 can be custom mounted and optional cabinets start at $119.95*.

Kit GR-2000, less cabinet, 147 lbs., Exp./frt. **669.95***
Kit GRA-2000-1, Digital clock module, 1 lb., mailable **29.95***

Now–a new generation of Heathkit small-screen color TV with digital readout

GR-500
19" (diagonal)

GR-400
17" (diagonal)

GR-300
15" (diagonal)

Simulated TV pictures

Famous Heathkit quality in your choice of screen sizes — 15, 17 or 19" (diagonal). They all have GR-2000-inspired digital channel readout and optional plug-in clock modules. And in the tradition of the GR-2000, these TV's feature dozens of design innovations. Each uses a precision in-line gun in the picture tube and a slotted shadow mask for a bright picture. The GR-400 and 500's negative-matrix screen provides superior contrast while luminance and video circuits with black level clamps maintain the true brightness of televised scenes.

A factory-sealed static toroid yoke and magnet assembly completely eliminates convergence and purity adjustments — and the picture is superior to sets requiring manual adjustments.

The list of significant advances goes on and on — dual gate FET mixer, FET RF amplifier, 4 tuned circuits (instead of the 3 most sets have), automatic fine tuning and preset picture control, hi-fi output jack, slide out chassis. The GR-300 and 400 come complete with walnut veneer cabinets, cabinets for the GR-500 start at $39.95.

Kit GR-500, less cabinet, 88 lbs., Exp./frt. **499.95***
Kit GR-400, with cabinet, 104 lbs., Exp./frt. **489.95***
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6 unique new Heathkit products you can build yourself

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The GR-1075 is no ordinary clock radio. Big, bright Beckman planar gas discharge tubes display the time. The readouts adjust their brightness automatically as room lighting changes.

A standby battery power supply keeps the clock on time (without the display) if the electricity is interrupted. When the power is restored, the 24-hour alarm will be on time—and so will you. You can wake to your favorite station or a gentle electronic "beep" with adjustable volume. And the radio section uses the same design philosophy as our famous AR-1214 stereo receiver including fixed ceramic filters in the AM and FM circuits and a factory-assembled and aligned FM front-end with 5 μV sensitivity. With 4 IC's, 41 transistors and 35 diodes, the GR-1075's design is years ahead of ordinary clock radios.

Kit GR-1075, less batteries, 10 lbs., mailable, **129.95***

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The GC-1093 is an accurate timepiece for your car, boat or plane. It's an electronic clock and a 20-hour rally timer, both with quartz-crystal accuracy. Bright ½"-tall digits dim automatically at night. 12 VDC, mounts on or under the dash.

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At last, a sliderule calculator that's big enough to use. The IC-2100 has finger-sized keys and a bright, ½"-tall 8-digit display. Cumulative memory and register exchanges virtually eliminate scratchpad work. Performs arithmetic plus trig and arc trig in degrees or radians, common and natural logs, powers of e, square roots, inverses, pi and exponential functions.

Kit IC-2100
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119.95*

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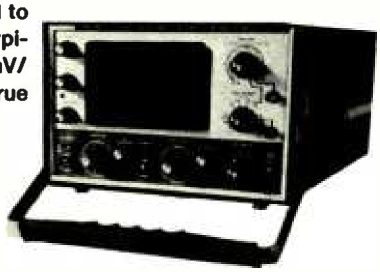
A professional scope at kit-form savings. DC-15 MHz frequency response, post-deflection accelerated CRT, vertical amplifier delay lines, time base up to 100 nsec/cm, guaranteed to trigger up to 30 MHz (typically up to 45 MHz), 1 mV/cm vertical sensitivity, true X-Y capability.

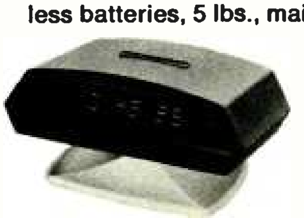


Kit IO-4510
34 lbs., mailable
549.95*

Digital Electronic Clocks with standby power

The GC-1092A is a digital clock with a snooze alarm; the GC-1092D reads the time in 6 digits, the month and date in 4 digits. Both have standby power supplies to keep the clock on time (without the display) even during power interruptions.

GC-1092 A & D,
less batteries, 5 lbs., mailable . . . . **each 82.95***



GC-1092A Time/Alarm

GC-1092D Time/Date

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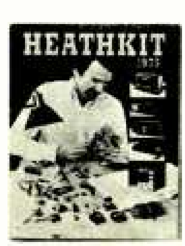

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CL-551

Circle 100 on reader service card

equipment report

Sencore PS29 Minute-Man Auto Trigger Oscilloscope

Circle 57 on reader service card

AT FIRST GLANCE, THE NEW SENCORE PS29 Minute-Man Automatic Triggered Oscilloscope looks like the others. Then you notice that something has been added, and something's missing. The new thing is a set of six (nice BIG!) pushbuttons right in the middle of the panel. What's missing is the TRIG-LEVEL and STABILITY controls. This smart little "green-line-indicator" triggers itself automatically.

If you want to look at a horizontal frequency waveform, just hook up the probe, push the TV HORIZ button and bang. Two lines of horizontal, locked tightly in. Vertical frequency; push the TV VERT button and there you are again; two frames. The only thing you might have to do is move the +SYNC− switch. (While testing this instrument, I actually made it lock on a horizontal output tube grid waveform with the SYNC switch deliberately set to + which is wrong for this type of waveform. It has a very high negative pulse. The slope of the top makes it hard to lock, but the Minute Man held it, with only a little twiddle of the horizontal frequency variable control.)

It'll also lock nicely on one of the hardest waveforms we have to work with; the comb pattern from a color-bar generator. This waveform has ten pulses of exactly the same amplitude, and it's hard to hold. The trigger circuits in the PS29 will lock on a pattern that is only one-half of a centimeter high on the screen. (I checked; it will do it.) This makes it very useful for doing things like digging out an intermittent in the color bandpass stages, which is the job I was testing it on.

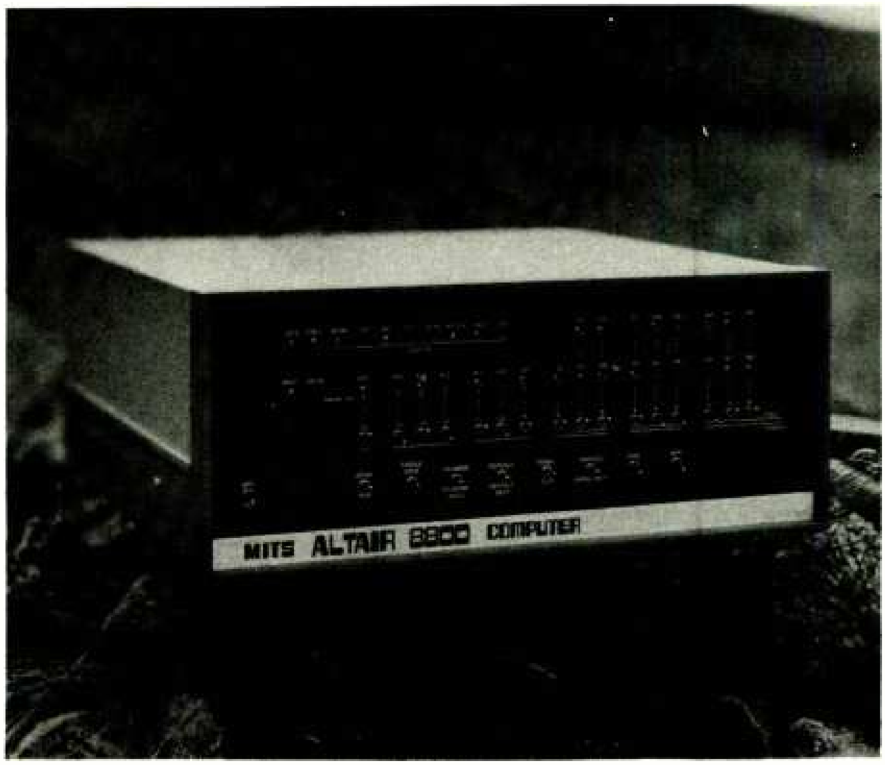
If you do find a waveform that is hard to hold, just plug a test lead into the EXT TRIG jack, and throw it in the chassis near the yoke leads. You'll get pulses of ample size to lock either horizontal or vertical signals. It takes only 400 mV of external-trig signal for a solid lock. [You do move the switch to EXT from INT (trigger) of course.]

The PS29 Minute Man has a bandwidth from dc to 8 MHz (usable response to 15 MHz). Together with the tremendously high input impedance of 10 megohms shunted by 11 pF, this makes it easy to see signals that would be hard to spot otherwise. The instrument comes with a specially designed low-capacitance probe, and has a FET input stage. The probe is rated at 5000 volts p-p ac, and 1000 volts dc so that there's no danger of blowing the front end. The vertical attenuator is calibrated "directly" in the actual voltage present at the probe tip. You don't have to multiply by 10 any more.

The sensitivity and input impedance makes it easy to use this for alignment of bandpass amplifiers, etc., with only a color-bar pattern. The comb patterns are clean and sharp, without the need for using a crystal detector probe. (One is available if your work needs it, of course.) You can do vectorscope analysis right from the front panel. Hook the probe to the R-Y output, and hook the B-Y output (using the test lead provided, which is color-coded *blue.*) to the jack on the front panel. Push the VECTOR B-Y button and there you are. Two ranges are provided for the horizontal (B-Y); 2 volts per division and 20 volts/div. "Fine adjustments" if needed can be made with the center knob of the horizontal sweep control. A special vectorscope graticule lights up when you push this button.

(continued on page 24)

MITS



A COMPUTER CONCEPT BECOMES AN EXCITING REALITY.

Not too long ago, the thought of an honest, full-blown computer that sells for less than $500 would have been considered a mere pipe dream.

Everyone knows that computers are monstrous, box-shaped machines that sell for 10's and 100's of thousands of dollars.

Pipe dream or not, *MITS*, the quality engineering oriented company that pioneered the calculator market, has made the *Altair 8800* a reality. It is the realization of that day when computers are accessible to almost anyone who wants one.

The heart (and the secret) of the *MITS Altair 8800* is the *Intell 8080* processor chip. Thanks to rapid advances in integrated circuit technology, this one IC chip can now do what once took thousands of electronic components (including 100's of IC's) and miles of wire.

Make no mistake about it. The *MITS Altair 8800* is a lot of brain power. Its parallel, 8-bit processor uses a 16-bit address. It has 78 basic machine instructions with variances up to 200 instructions. That's more than enough to program all the street lights in a major city.

And the *MITS Altair 8800 Computer* is fast. Very fast. It's basic instruction cycle time is 2 microseconds.

Combine this speed and power with the *Altair's* flexibility (it can directly address 256 input and 256 output devices) and you have a computer that's competitive with most mini's on the market today. And sells for a fraction of their cost.

The Altair 8800 has been designed to fullfill a wide variety of computer needs. It is ideal for the hobbyist who wants to get involved with computers. Yet, it has the power and versatility for the most advanced data processing requirements.

It's basic memory of 256 words of static RAM memory can be expanded to 65,000 words of directly addressable memory. Static OR dynamic memory. OR PROM or ROM memory. OR a floppy disc system. All supplied by *MITS*.

Using standard *MITS* interface cards, the *Altair 8800* can be connected to *MITS* peripherals (computer terminals, line printers, audio-cassette interface) to form the core of a sophisticated time-share system.

The *Altair 8800* can be a process controller. It can be an educational device. Or it can be expanded to be an advanced, custom intrusion system. A programmable scientific calculator. Automatic IC tester. Automated automobile test analyzer. Complete accounting system. "Smart" computer terminal. Sound and light system controller.

OR it can be all of these things *at the same time*. It could be the beginning of new business opportunities. The list of applications is literally endless.

MITS wants to service your individual computer needs.

You can buy an assembled *Altair 8800*. Or you can start by building the computer yourself. The *MITS Altair 8800* is the ultimate kit. Its assembly isn't much more difficult than assembling a desktop calculator.

OR you can start with an *Altair 8800* complete data processing system. *Altair Systems* come in 4 basic configurations.

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Warranty: 90 days on parts and labor for assembled units. 90 days on parts for kits.
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For those users who are not familiar with computers, *MITS* offers free consultation service. Just describe your requirements to our engineering staff and we will specify the additional cards and the system configuration you need to do the job.

The MITS Altair 8800 is backed by complete peripheral and software development programs. There is even a high level language available.

Order your Altair 8800 Computer today. As a special introductory offer, *MITS* is offering the *Altair 8800* at a discount of $100. This offer is good on all orders postmarked prior to March 1, 1975.

PRICES:

Altair 8800 Computer (assembled with complete operation instructions) **$750.00**
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EQUIPMENT REPORT

(continued from page 22)

Push the 3.58 MHz & VARISPEED button, and you have a standard variable sweep-speed scope. The TIME/DIV selector has a range from 100 ms/div up to 0.2 μs/div. In the last position, you can count cycles of the color burst or the 3.58-MHz oscillator. For your convenience (and mine, I can *never* remember what "time" corresponds to what frequency.) they have calibrated the sweep-speed dial with the frequency range for each time. To use this in the calibrated position, just turn the center knob all the way clockwise until you hear the detent click.

The vertical gain control is also calibrated, in volts/div. This too has a fine adjustment in the center. To calibrate it, same thing. Turn center knob clockwise until it clicks, and read the scale directly. A total of 12 ranges are available, from 0.1 volt/cm up to 500 volts/cm. Usable range for full-scale deflection (10 lines 1.0 cm apart) is thus 1.0 volt to 5,000 volts. The vertical amplifier can be used as an ac or dc amplifier by the input switch. A GROUND position in the middle makes it easy to set the line for calibration, on dc.

You can use this for sweep alignment too. Just push the SWEEP GEN 60 Hz. button. This connects a 60-Hz line sweep; for correct phasing of the sweep curve, if needed, a recessed screwdriver adjustment is provided on the front panel. The last button is a 5X EXPAND, which increases the width of the trace 5 times, for examination of certain parts of a waveform.

A Z-AXIS jack is on the back panel if you need it. Also, a sawtooth pulse output is provided, for pulse-testing of flybacks, yokes and similar coils. This is taken from the sweep, decoupled by an emitter-follower stage for safety. A good flyback will show a long decay time or ringing; a shorted winding will show a very few rings. No special setup is needed; this is another "Automatic" test.

I was quite impressed by the ease of operation. This should make things a lot faster for the technician who already knows how to use a scope, and will be *very* helpful indeed for the trainee, or new boy who doesn't really have the speed as yet. The calibrated sweep and vertical attenuator will make this one useful for many other classes of work in addition to radio and TV.

If you're going to branch out into computer servicing, etc., this will do the job. If you're going to use pulse counting, and similar jobs, the negligible overshoot and 45-ns rise time of the PS-29 will make it helpful indeed.

Hickok Model 215 Pocket Semiconductor Analyzer

Circle 58 on reader service card

HICKOK HAS HAD TWINS! THIS MIGHT sound odd for a big test-equipment maker, but they have. The new-borns are a pair of miniature test instruments that will sit on the palm of your hand (one on each, that is), and they're really precocious kids. They can do tricks that are almost unbelievable.

First is the model 215 Pocket Automatic Semiconductor Analyzer. It will fit in a good-sized shirt-pocket and it will "analyze" practically any kind of semiconductor device; bipolar and FET transistors, darlingtons, UJT's, diodes, diode bridges and Zeners. These tests can be made in or out of circuit with few restrictions.

The heart of the unit is actually a mini-computer (and I do mean "mini"). Practically the whole works are in MOS FET IC's. The readout is about as simple as you can get. If a device is good, an LED on the panel lights up and says GOOD. Others tell you that it is BAD, PNP or NPN, and one of the three LED's along the bottom tells you which terminal the base or gate is connected to.

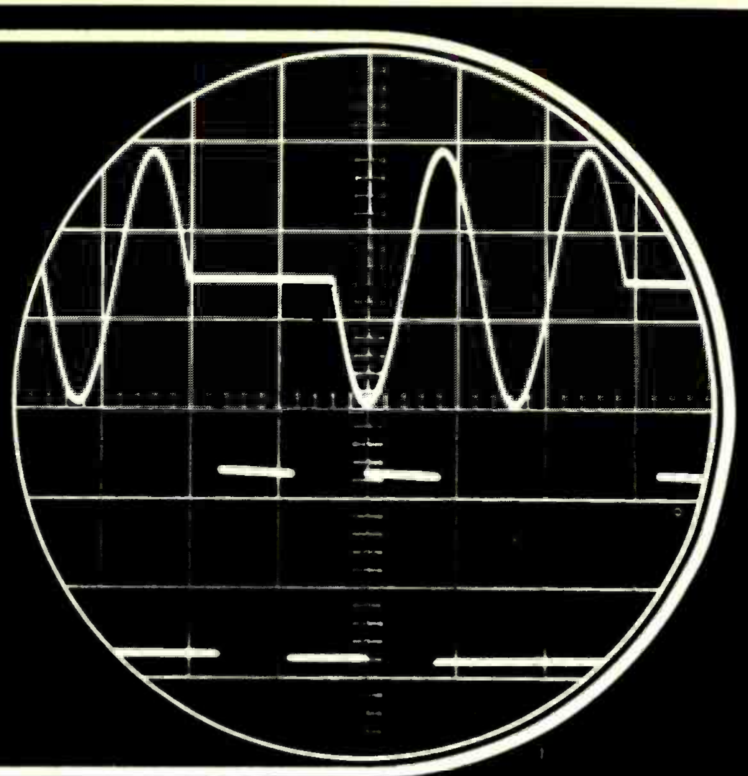
When testing diodes, one of the lights tells you which lead or terminal is connected to the cathode. This is very handy for some of those hard to identify diodes we run into. I've had one of those blobs on my bench for a long time, and finally found out which was the cathode. Marked it, too, for future reference.

The actual operation is far beyond me, but using the instrument isn't. Even I can tell what it's saying. When you hook it to a device, the computer circuitry scans all possible combinations of connections. When it finds one that gives the right output, it stops, and the LED's light up to show you what the busy little thing found. The scanning cycle repeats at intervals of about 4 seconds. If the thing you're testing is either open or shorted, the BAD, GOOD, PNP and NPN lights blink rapidly. To see exactly how this looks, just turn it on without a transistor hooked up. Since this is an open circuit condition, it sits there and blinks at you.

A standard 3-pin transistor socket is provided on the panel for out-of-circuit tests of small transistors. For in-circuit testing and transistors that won't fit in the little socket, such as TO-3's, etc, a set of test leads with clips plug into three banana jacks on

(continued on page 62)

how 80% of $2,000 is only



$580.00

Oscilloscopes for most production, inspection, QC and lab applications are not used to their full capability.

In fact their full capability in bandwidth may even need to be limited by an external bandpass filter for easier trace readability. In one electronics manufacturing facility a survey of 22 applications discovered 19 applications which were appropriately served by our least expensive $179.95 oscilloscope with recurrent sweep and 2MHz bandwidth. A survey of your facility may reveal similar opportunities for saving. Our triggered sweep scopes with 10MHz bandwidth and 35 nanosecond rise time answer the needs of more than 80% of all applications. Sensitivity of 10mV/cm offered by both our single and dual trace triggered sweep scopes is similarly suitable for over 80% of all applications.

Why overspecify your oscilloscopes? It's not necessary if the intent is to be sure you get the repeatability, reliability, ruggedness and versatility that is characteristic of every B&K oscilloscope. Move your ultra-wide bandwidth scopes to other applications where you need them. You'll find the B&K scopes easier to use with their simplified, human-engineered panels and controls.

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Model 1470

CONDENSED SPECIFICATIONS

B&K Model 1470 Dual Trace Triggered Sweep Scope
DC to 10MHz at 10mV/cm. Two separate vertical amplifiers. 35 n sec rise time. Six dual pattern modes including chopped, alternate, add and Channel 2 inverted. Auto and triggered sweep 1 usec/cm to 0.1 sec/cm. 5X magnification. **$580.00**

B&K Model 1460 Triggered Sweep Scope
DC to 10MHz at 10mV/cm. 35 n sec rise time. 0.5 usec/cm to 0.5 sec/cm auto and triggered sweep. 5X magnification. 5V p-p 1 KHz calibration voltage. **$450.00**

B&K Model 1431 3" Triggered "Mini-Scope"
As above, but ⅓ the size. **$399.00**

B&K Model 1403 Portable 3" "Mini-Scope"
3" solid state scope only 5¼"x7⅜"x11¼". DC to 2MHz bandwidth and 20mV/cm sensitivity. Recurrent sweep 10Hz to 100kHz. Weighs only 8½ pounds. **$189.00**

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Circle 16 on reader service card

BUILD THIS

This new TV Typewriter is primarily designed around TTL logic and provides the builder with many plug-on option boards. The options include a manually operated cursor control, computer operated board and much more

by ED COLLE

TV TYPEWRITER II

AFTER SEEING THE OVERWHELMING response shown for the TV typewriter story featured in the September 1973 issue of **Radio-Electronics** magazine, it is obvious that there are many readers interested in these units. As described in the previous article, there are many uses for a display such as this with the possibilities limited only by the imagination of the user.

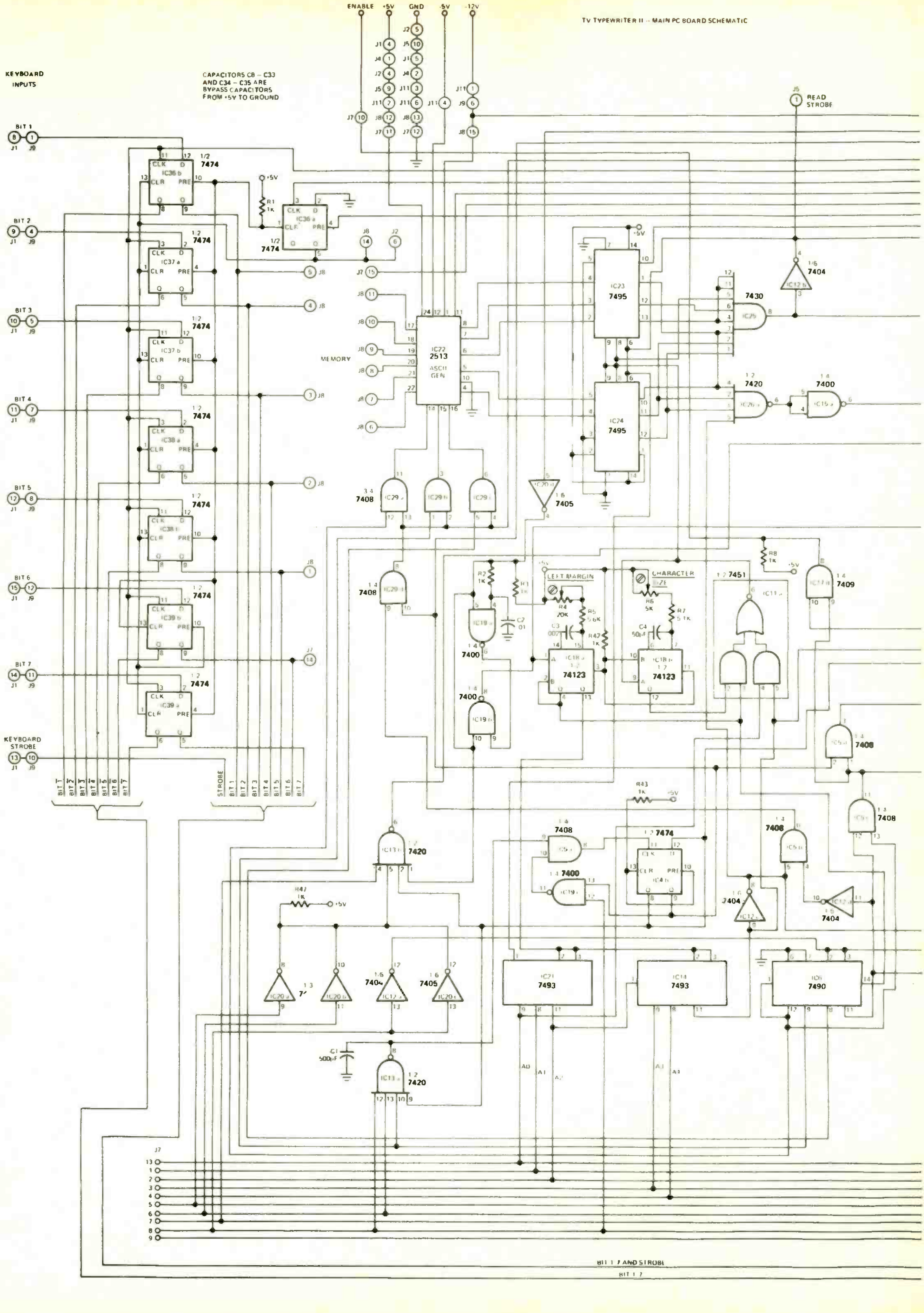
One of the biggest applications of these units, however, is for data communications with computers. Combined with a keyboard, we have one of the fastest and most efficient means for an individual to communicate with a machine. An excellent example is the Mark-8 minicomputer shown on the front cover of the July 1974 issue of **Radio-Electronics** magazine. You can be sure that more powerful and more economical units will follow. Then of course, if you don't have or don't want your own machine, you can always tie into a full size time-shared system, assuming you have access to one.

If you tried to build the terminal in the September 1973 issue, you probably discovered as many did that although the printed circuit boards were commercially available, some of the semiconductor chips were rather difficult to get. For this reason, this terminal has been built using 74 series TTL IC's that are common, easy to get, and inexpensive. The only MOS chips used are 2102 RAM's (Random Access Memories) and a 2513 character generator. And just to make things really easy, the unit is available as a complete kit including circuit boards, IC's, discrete components, interconnectors and optional power supply. A cabinet, however, is not being made available at this time. Since in most cases you will want to use the TV typewriter in combination with a keyboard of some kind to enter messages, the supplier of the TV typewriter is making available a low-cost compatible keyboard/encoder too.

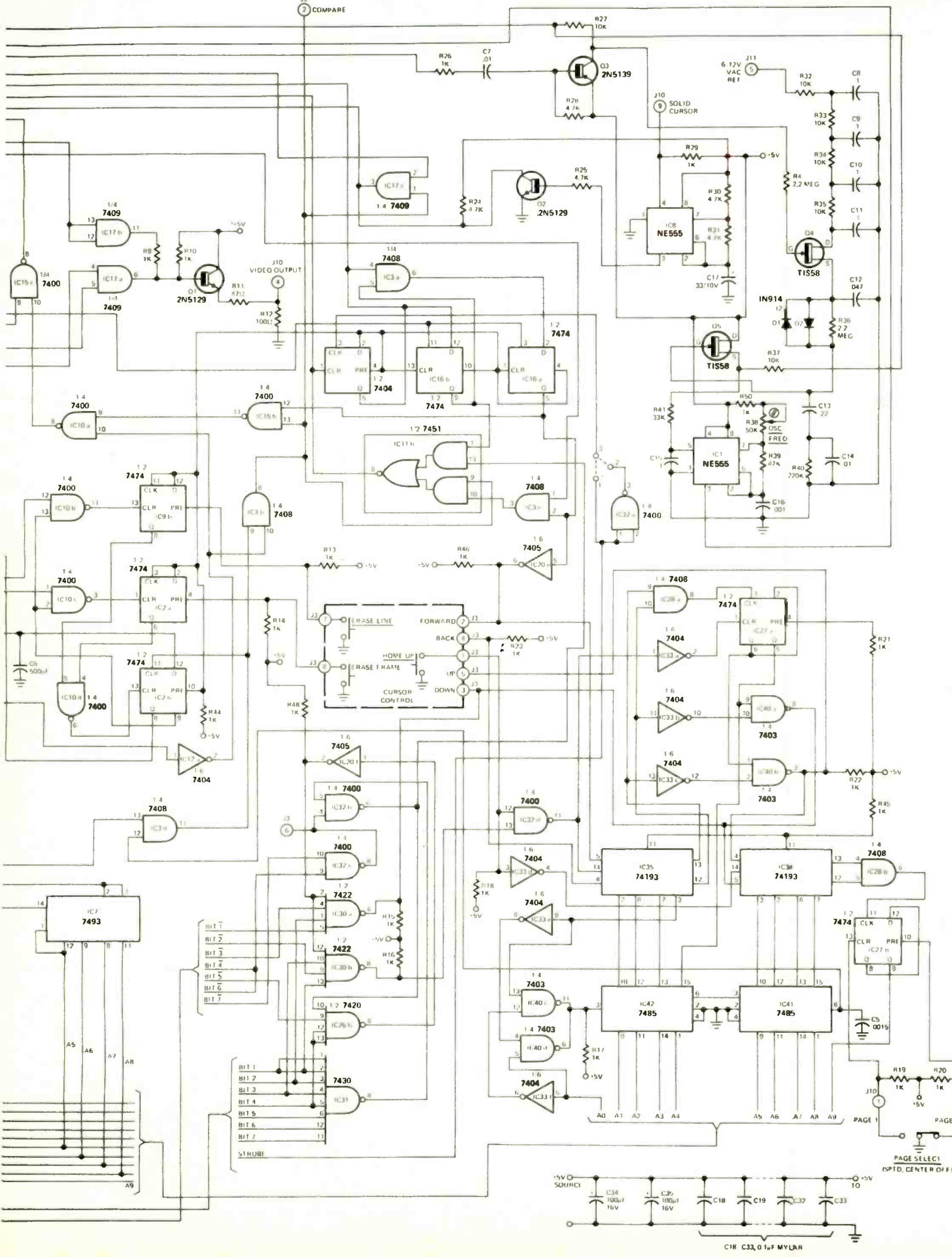
To make the unit as flexible as possible, extra effort has gone into designing plug-on options including a manually operated cursor control board, a computer operated plug-on board, screen read board and a URT communications board.

(text continues on page 30)
(complete schematic on pages 28 & 29)

TV TYPEWRITER II — MAIN PC BOARD SCHEMATIC



COMPLETE SCHEMATIC of the TV Typewriter is shown. The circuit is primarily designed around TTL logic.



SPECIFICATIONS

DATA FORMAT	1024 characters arranged as 2 pages of sixteen lines of 32 characters each.
OUTPUT	2.25-volt video pulse — 1-volt sync pulse compatable with the video input of a standard television or video monitor. The display's response must be to 1.6 MHz for maximum character size and to 3 MHz for minimum character size and should be flat to 4.5 MHz for best appearance.
INPUT	7 bit parallel ASCII positive logic with a key-press strobe that may be either positive or negative going.
CONTROLS	Page select Home up (moves cursor to upper left hand corner) Erase to end of line Erase to end of frame Cursor on off Line feed Carriage return Adjustable left hand margin positioning Adjustable character size
POWER REQUIREMENTS	5 Vdc, 2A, 5% regulation; —5 Vdc, 15mA; —12 Vdc, 20mA.
SIZE	12" long × 9¾" wide × 3½" high.
ACCESSORIES	Manual cursor control board. Computer cursor control board. Screen read board (allows transfer of accumulated data to an outside device — should be used with the cursor control and URT boards). URT board (receives and transmits data in RS 232 format using 7 bit ASCII code at 110, 220, 440, or 880 baud or if a different crystal is used 150, 300, 600, or 1200 baud).

1. **Cursor control (manually operated)** allowing the operator to position the cursor anywhere on the screen by using a set of switches similar to the keyboard switches.
2. **Cursor control (computer operated)** allowing the operator to position the cursor on the screen by sending commands to the display through software.
3. **Screen read** allows the user to edit all of the information on the screen using the cursor control board and then to send all of the accumulated data out to some external device using URT board, or as parallel data directly to a computer.
4. **URT board** receives and transmits data in RS 232 format using a seven-bit ASCII code. Baud rates can be multiples of either 110 or 150 depending upon a choice of crystals, up to 1200 baud.

The basic character organization is very similar to the original TV Typewriter, in that there are sixteen lines of 32 characters, however, this unit has a second page of memory as part of the basic unit rather than as optional accessory, providing a total character memory of 1024 characters.

Since the FCC is very rigid in their requirements for transmitters in the television frequencies, the unit has been designed to be connected directly to the input to the video amplifier of a standard television set.

Although any set may be used, the small-screen black and white portables give the best picture. The connections are simple and a jack can be provided to allow switching between terminal and normal television operation.

Automatic carriage return is provided after the last character of each line, returning the cursor to the beginning of the next line. Unless switched off, a blinking cursor always shows where the next character is to go and you have the option of writing on either one of two pages of memory which are independently selected and displayed on the screen, through the PAGE SELECT switch. This same switch also provides automatic carry-over of the cursor from one page to the other when the end of frame is reached; or when selected, automatically performs a "home up" (return to line 1— column 1) of the same page. Erase to end of line (EOL) and erase to end of frame (EOF) functions are also provided. When enabled, they perform the erase function from the cursor location on the page selected. Line feed and carriage return are provided as well; with a line feed being a binary 0001010 or a control J, and a carriage return as a binary 0001101 or a control M.

Next month's issue will contain the construction details and foil patterns plus a detailed description of how the unit works.

PARTS LIST TV TYPEWRITER

PARTS LIST — MAIN BOARD

IC1, IC8 — NE555 timer
IC2, IC4, IC9, IC16, IC27, IC36, IC37, IC38, IC39 — 7474 dual "D" flip flop
IC3, IC5, IC28, IC29 — 7408 quad AND gate
IC6 — 7490 decade counter
IC7, IC14, IC21 — 7493 4 bit binary counter
IC10, IC15, IC19, IC32 — 7400 quad NAND gate
IC11 — 7451 dual AND-OR-INVERT gate
IC12, IC33 — 7404 hex inverter
IC13, IC26 — 7420 dual NAND gate
IC17 — 7409 quad AND gate (open collector)
IC18 — 74123 dual one shot
IC20 — 7405 hex inverter (open collector)
IC22 — 2513 ASCII character generator
IC23, IC24 — 7495 4 bit shift register
IC25, IC31 — 7430 8 input NAND gate
IC30 — 7422 dual NAND gate (open collector)
IC34, IC35 — 74193 4 bit up/down counter
IC40 — 7403 quad NAND gate (open collector)
IC41, IC42 — 7485
R1, R2, R3, R8, R9, R10, R13 to R23, R26, R29, R42 to R49 — 1000 ohms, ¼-watt carbon
R4 — 20,000 ohms, trimmer
R5 — 5600 ohms, ¼-watt
R6 — 5000 ohm trimmer resistor
R7 — 5100 ohms, ¼-watt, 5%
R11 — 47 ohms, ½-watt
R12 — 100 ohms, ½-watt
R24, R25, R28, R30, R31 — 4700 ohms, ¼-watt
R27, R32 to R35, R37 — 10,000 ohms, ¼-watt
R36, R50 — 2.2 meg ohms, ¼-watt
R38 — 50,000 ohm trimmer
R39 — 47,000 ohms, ¼-watt
R40 — 220,000 ohms, ¼-watt
R41 — 33,000 ohms, ¼-watt
C1, C6 — 500 pF
C2, C7, C14 — 0.01 μF
C3 — 0.002 μF
C4 — 50 pF
C5 — 0.0015 μF
C8, C9, C10, C11, C15, C18 to C33 — 0.1 μF
C12 — 0.047 μF
C13 — 0.22 μF Mylar
C16 — 0.001 μF
C17 — 33 μF, 10V, tantalum
C34, C35 — 100 μF, 16V, electrolytic
Q1, Q2 — 2N5129 silicon
Q3 — 2N5139 silicon
Q4, Q5 — TIS58 field effect transistor
D1, D2 — 1N914 silicon

PARTS LIST — MEMORY BOARD

IC1 to IC6 — 2102 1024 bit static RAM
C1, C2 — 0.1 μF, 10V

The following items are available from Southwest Technical Products Corp., 219 W. Rhapsody, San Antonio, TX.

#CT-1024 Terminal System Kit with 1024 Memory Card — less cabinet or power supply. $175.00 postpaid.

#CT-E Screen Read Plug-in Card kit. $17.50 postpaid.

#CT-M Manual Cursor Control Plug-in Card kit. $11.50 postpaid.

#CT-P Power Supply for CT-1024 — 115-230 Volt Primaries. $15.50 postpaid.

#KPD-2 Keyboard Kit — 53 Keys. $39.95 postpaid.

Noiseless Discs At Last

New noise reduction system can be carried right up to and including the finished disc. For the first time, noiseless discs may become a reality.

by LEN FELDMAN
CONTRIBUTING HIGH FIDELITY EDITOR

IN A RECENT ISSUE OF RADIO-ELECTRONICS (October, 1974), we summarized some of the techniques currently being used in the recording and high-fidelity industries to overcome one of the few remaining impediments to "total fidelity" — noise. We pointed out that a company called *dbx, Incorporated*, though in existence barely four years, was devoting its primary efforts to the development of a variety of noise-reduction products for professional recording use and for audiophile use and promised to tell you more about the *dbx* processors in the future.

Between the time we wrote that article and now, *dbx* has announced and demonstrated yet another breakthrough in the noise-reduction battle and the results are so startling as to warrant a complete look at the *dbx* approach. Instead of confining their compression-expansion system to master tapes only (which are then used in the cutting of a master disc), they have carried the process right up to and including the finished disc itself, thereby offering the audio enthusiast the potential of records free of audible surface noise and capable of reproducing wider musical dynamic range than ever before.

Noise and dynamic range

Musical dynamic range can be defined as the difference between the maximum recorded peak musical signal and the minimum significant program material, expressed in decibels. As residual or background noise level is reduced, the available dynamic range increases proportionately. This is illustrated in Fig. 1, where the loudest sounds to be reproduced are limited by one or more of such factors as tape saturation, amplifier power output limitations, loudspeaker power input limits, and the like. Lowest level of sounds, on the other hand, are limited only by ambient noise conditions which may include residual tape hiss or noise (from the master tape), residual surface noise determined, even in a fresh disc, by the smoothness of the vinyl compound from which the disc is pressed and even the ambient noise conditions in the listening room (usually not the limiting factor). As can be seen in Fig. 1, any device that serves to reduce the "lower noise limit" relative to the fixed, loudest sounds, improves the overall signal-to-noise ratio directly.

In live concerts, loudest musical passages may well be 100 dB above quietest passages. Unfortunately, even the very best tape recorders, operated with some safety margin so as to keep peak distortion levels at a low value, have a usable dynamic range of approximately 60 dB. A common method of reducing musical dynamic range is for the recording engineer to alter instantaneous levels with manual gain controls while the recording is being made. This requires the recording engineer to be somewhat of a musical expert so he can study the musical score and anticipate sudden crescendos and compensate for them by reducing recording level and then deliberately increase levels when quiet passages occur to record them "above" the level of tape noise.

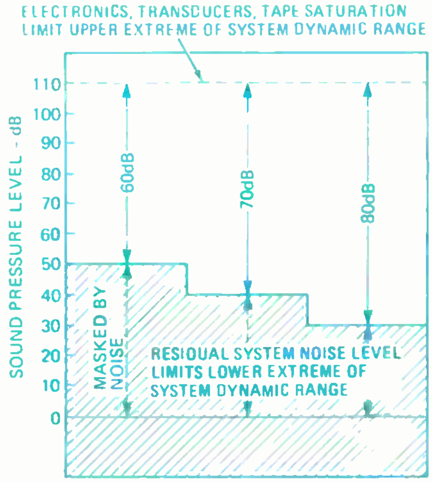


FIG. 1—IF NOISE LEVEL could be lowered, dynamic range can be increased.

Automatic gain controls, such as compressors and limiters are also often used in professional recording studios. Compressors work by gently or gradually reducing gain in the presence of loud signals while increasing gain as signal levels are diminished.

The result of the various forms of dynamic range reduction through signal tampering is that while soft sounds are recorded on tape above noise level and crescendos have been reduced in relative scale, the excitement of the performance has also been compromised. The use of professional noise-reduction systems (such as Dolby "A" or the professional versions of *dbx* compress-expand systems designed for recording studio use) on individual tracks of a 16- or 24-track master tape and on the subsequent mix-down tape (each successive mix-down would normally add to the residual noise problem) at least partly eliminates the need to restrict the dynamic range of the program to prevent tape-noise buildup. Even if the finished master tape recording had a 100-dB usable dynamic range (a condition which cannot be fulfilled by conventional recording tapes) the music must be transferred to a conventional disc which has, at the very best, a 65-dB dynamic range. Thus, there is still the problem of a musical dynamic range which is 30 to 45 dB too great for the recording medium.

The dbx system applied to tape

Since the *dbx* system was first applied to professional tape recording situations, it will be helpful to understand how this system works in that medium. A linear decibel compressor-expander can be set up as shown in Fig. 2. Voltage-controlled amplifiers control the input and output gain. Input and output level-sensors control gain with an appropriate control polarity to produce compression in section

A and expansion in section B. While it would appear that a compress-expand ratio of 2:1 could produce results having a 120-dB signal-to-noise ratio when used with a 60-dB (dynamic range) recorder, the behavior of noise sources in tape recording and human perception of these noises requires that the simple system shown must be mod-

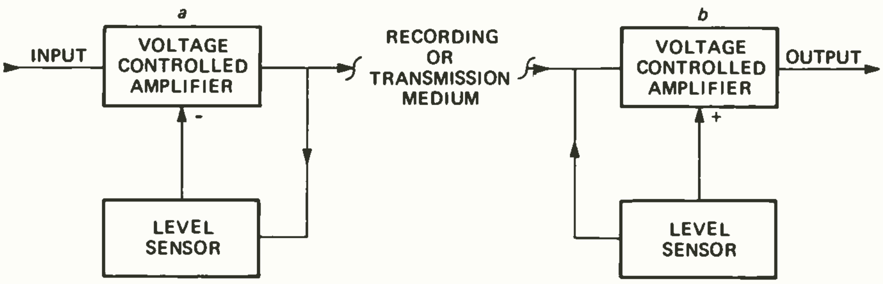


FIG. 2—BASIC COMPRESSION/EXPANSION SYSTEM.

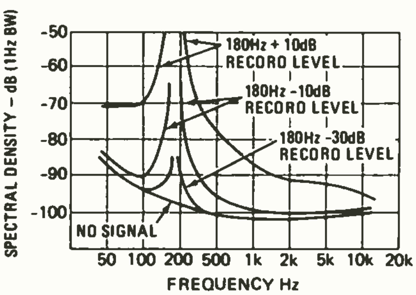


FIG. 3—AUDIBLE TAPE NOISE increases in level when recorded tones are applied to tape.

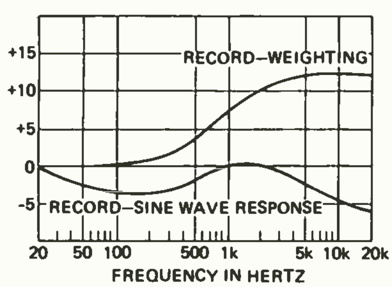


FIG. 4—HIGH-FREQUENCY HISS changes accompanying signal envelope level changes may be rendered virtually inaudible with high-frequency pre-emphasis.

ified. We all know and can recognize the sound of background tape hiss in the absence of a recorded program signal. Typically, this noise has the spectral distribution shown by the lower curve of Fig. 3. When a signal is recorded, however, the noise increases, especially in the vicinity of the recorded tone or frequency. This is illustrated in the upper curves of Fig. 3 and causes an apparent increase in the high-frequency content of tape recorded signals.

High-frequency hiss changes, accompanying signal envelope level changes, can be made nearly inaudible by using high-frequency pre-emphasis. Since such pre-emphasis is added in addition to that already "built-in" to the recorder in the form of equalization, however, its addition to the system might increase the system's susceptibility to high-frequency saturation or self-erasure, already a problem with many tape recorder products.

This problem is solved by *dbx* by introducing high-frequency pre-emphasis *before* the level-sensing circuits. Twenty dB worth of pre-emphasis, beginning at 1600 Hz was chosen, which produces the sine-wave response curve shown in Fig. 4.

Rms level sensing

A compress-expand system such as the one described only works if it has good tracking capability between the "encode" and "decode" processes. It might at first appear that the best type of level sensors to use in the set-up of Fig. 2 would be those that are responsive to peak signals. Unfortunately, peaks fully 20 dB or more above VU meter readings are quite common during studio recording and mix-down sessions. Tape recording levels are often adjusted so that such peaks are flattened. While this flattening does not result in serious audible distortion (it is more "rounded" than the clipping associated with overload of solid-state audio amplifiers), it does, nevertheless distort overall signal amplitudes and the "expansion" or playback circuits would not be able to track properly in relation to the original program material.

By the same token, "averaging" level sensors, used in the configuration of Fig. 2, would be far too slow. Furthermore, most tape recorders have significant time-delay dispersion in that frequency-dependent phase-shift changes do not produce constant time delay. Neither the peak nor the average value of a signal remains unchanged with non-constant time-delay errors. The one function that remains unchanged is the root-mean-square value of the signal. The rms value is the sum of all the energy of all frequency components present—without regard to their phase relationships. Recent advances in analog computation circuits have made it possible to devise a level-sensor circuit that is responsive to rms values of complex signals. The circuit shown in Fig. 5 squares the signal by doubling the logarithm of it and then taking the anti-log. This squared signal is averaged and used to derive the needed control signal for adjusting the instantaneous gain of the voltage-controlled amplifiers.

Complete compress-expand system

The final system for tape record and playback is shown in the block diagram of Fig. 6. A bandpass filter attenuates frequencies outside the audio spectrum which would not pass through the recorder. The input pre-emphasis network boosts the high-frequency content of the signal as previously described. The voltage-controlled amplifier alters signal gain in response to the output of the level sensor. The output buffer amplifier drives the tape recorder and the network feeding the rms level sensor. Compression is set at 2:1. The control buffer shifts the output voltage from the detector by means of the level-match control and determines the input signal level required for unity gain.

The decoder section has an identical level-sensing circuit which gives the same control signal to the expander as that used in the input compressor. The low-pass filter used in this case blocks tape recorder bias frequencies which might otherwise introduce decode errors. Control polarity to the voltage-controlled amplifier is reversed this time, to give a 1:2 expansion ratio. A de-emphasis network at the output of the system restores uniform frequency response.

Applying the system to discs

Noise-reduction systems, such as this one, if applied directly to disc cutting, would be very attractive to record manufacturers for a number of reasons. With the shortage of vinyl compounds now prevalent throughout the world, somewhat poorer or noisier vinyls could be used while still achieving better signal-to-noise ratios than those possible with the very best vinyl compounds recorded conventionally. Even if top-grade vinyl is used, there are still many advantages. For ex-

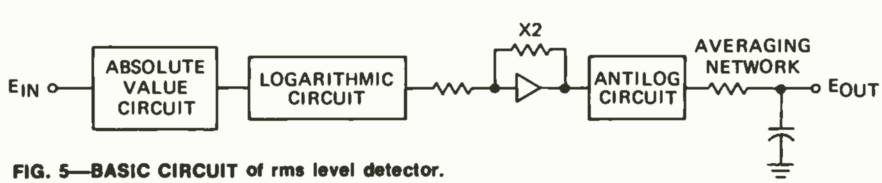


FIG. 5—BASIC CIRCUIT of rms level detector.

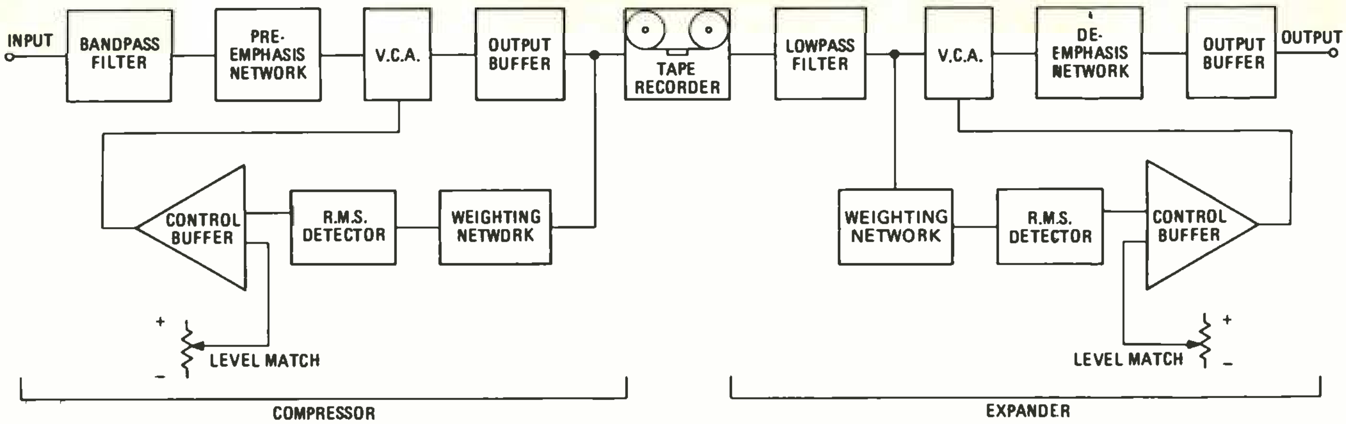


FIG. 6—COMPLETE TAPE NOISE reduction system block diagram.

ample, discs could be cut, say, 10 dB lower in level permitting increased program time (grooves can be spaced closer together without running into each other because of extremes of groove modulation). Even at such reduced level, it is estimated that at least 25 dB of noise reduction (or increased dynamic range) would be available!

Ordinary compress-expand systems (also known as companders) had potential drawbacks for direct disc applications in the past. If the given system is sensitive to level changes and must be referenced to some threshold of encoded level, variations in playback or pressings might cause noticeable "mistracking". This type of problem would be even more severe if the noise reduction system is of the multiband type which "compands" different segments of the audio spectrum differently. This is one of the reasons why Dolby noise reduction—even Dolby "B" (used in consumer applications) requires such careful calibration if it is to work effectively. This problem does not exist with the *dbx* approach because level matching is not critical.

The encoding process used for direct application to disc cutting uses the same sort of rms responsive level sensor, voltage-controlled amplifier connected for a 2:1 linear decibel compression over a 100-dB range and frequency weighting to reduce master tape modulation noise as in the basic tape noise reduction system already described. Further weighting in the level-sense channel prevents over-recording of program material containing high energy, high-frequency components. The decoder uses the same sort of component to form a 1:2 linear decibel expander and no matching of levels is required for accurate decoding. The overall compress-expand process is best illustrated by the diagram of Fig. 7 which shows that the record medium need be capable of only 50 dB of dynamic range to reproduce a full 100 dB of dynamic range during playback. The total process, from original recording session, through mix-down, application to disc master, final disc pressing and playback through a high-fidelity music system is illustrated in Fig. 8. Note that in this diagram other types of noise reduction systems may be introduced along the way and even greater benefits can be realized if noise reduction is used in all phases of the process, as shown.

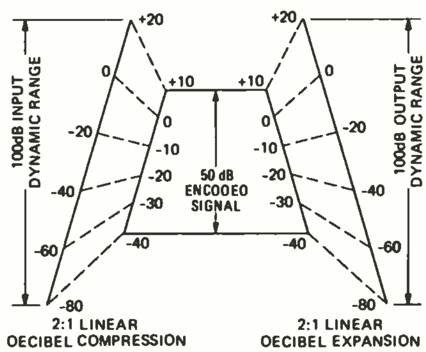


FIG. 7—THE dbx SYSTEM uses 50% compression and 50% expansion.

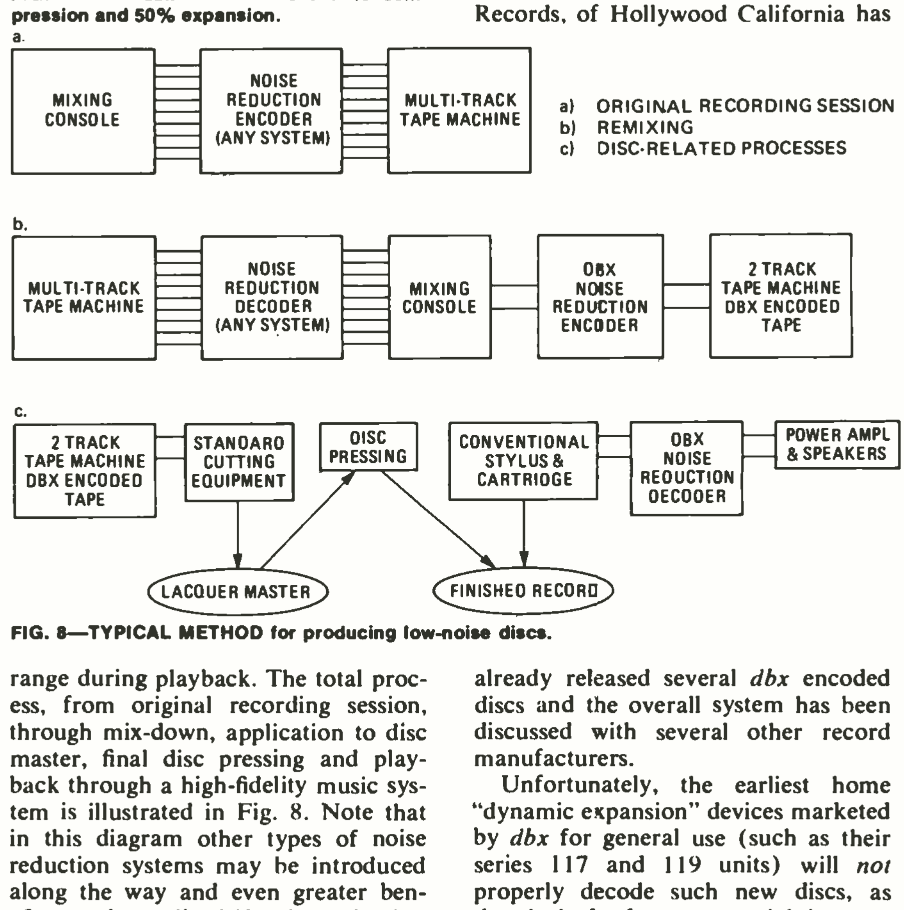


FIG. 8—TYPICAL METHOD for producing low-noise discs.

Incompatibility

The encoded disc prepared and pressed using the *dbx* disc system is, of course, incompatible in the sense that it requires a decoder for proper playback. The encoded master tape used to make such discs may also be used to cut compatible discs. This is done by simply decoding the tape prior to cutting—a process now being used by many record companies for noise reduction of master tapes. Studios already using *dbx* systems for this purpose could, if they desire, cut encoded discs without any further processing. At least one record company, Klavier Records, of Hollywood California has already released several *dbx* encoded discs and the overall system has been discussed with several other record manufacturers.

Unfortunately, the earliest home "dynamic expansion" devices marketed by *dbx* for general use (such as their series 117 and 119 units) will *not* properly decode such new discs, as they lack the frequency-weighting networks required in this refinement of the system. *dbx* has, however, introduced a new family of noise-reduction products, known as the 120 series, which are specifically intended for decoding these new discs and can also be used with all home tape decks (open-reel, cassette or even 8-track units having record capabilities) for improving dynamic range and signal-to-noise ratios of tape recordings you make yourself. How soon *dbx*-encoded records or pre-recorded tape will become available is unknown—of course you can use *dbx* gear now to do your own recording. The first two products in the series are the Model 122 and the Model 124, shown in the photo of Fig. 9. Model 122 is a two-channel record or playback unit which must be switched from one function to the other. Model 124 is a 4-channel record or playback unit which, when used in a two-channel system can record and playback at the same time (without making new connections), thereby permitting the recordist to monitor the decoded or normalized signal during recording. The units sell for $259.00 (for the Model 122) and $379.00.

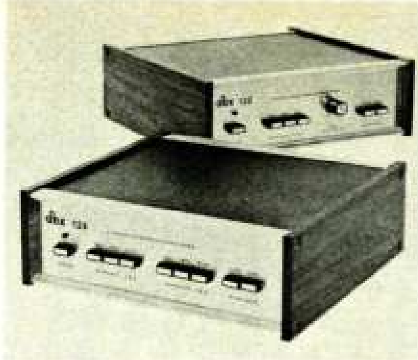


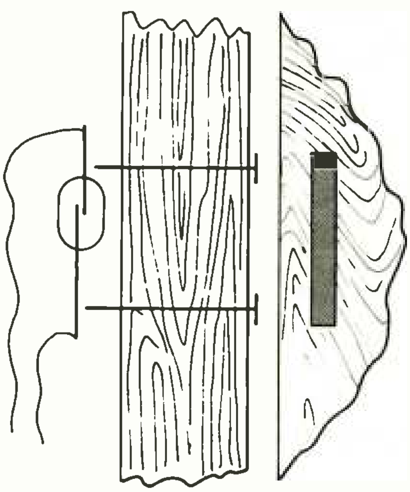
FIG. 9—TWO ENCODE-DECODE MODELS available from dbx for playback of dbx encoded discs and for use in home tape applications.

Future potential

The idea of yet another disc format requiring a special kind of accessory box for proper playback may not appeal to the average music listener. Still, the excitement generated during a recent demonstration of the system which I attended suggests that the totally noise-free reproduction of ordinary looking record discs and the incredible lifelike dynamic range heard while listening to a few of these discs may offset resistance to the purchase of additional hardware. Quoting Mr. David Blackmer, president of *dbx*, and the inventor and developer of this system, "We had intended the encoded disc as a limited distribution medium for the connoisseur. I am amazed at the overwhelmingly favorable response of disc recording specialists who have previewed this system. Many have expressed a conviction that this process will receive broad acceptance. . . . The emotional impact often exceeds that of the live performance." You count *this* listener, at least, among those optimists. I have never heard records reproduced with less noise or greater dynamic realism than those I heard at the recent *dbx* press conference I attended. **R-E**

REMOTE MAGNET CONTROL

Alarm circuits operated by reed switches and permanent magnets frequently present problems when the magnet and switch must be in close proximity, and yet remain concealed at all times.



Often the installation can be simplified by moving the switch farther away (such as on the other side of a door or window frame) and providing magnetic coupling.

Wire nails or soft iron wire adjacent to the poles of the magnet can be used to conduct the flux lines to the reed. If the nails make contact with the reeds the effect is enhanced.—*R. G. Cooper*

HV LOST ON TWO CHANNELS?

I've just finished a course in TV servicing but it didn't say anything about this. We've just moved and we're on cable-TV. All stations except Channels 5 and 9 come in fine. These two? The raster blooms, goes out of focus and I lose high voltage. I've checked all the tubes in the high-voltage circuits, the waveforms on the horizontal oscillator, and everything I can think of. What is causing this?—W.T., Victorville, CA.

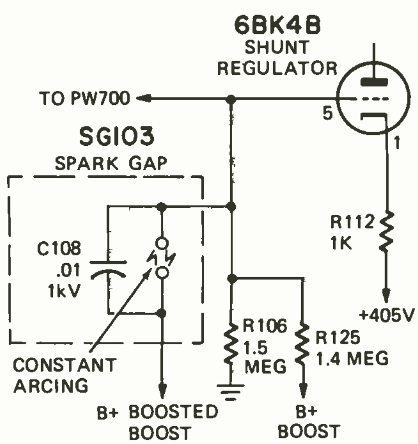
Right at the moment, I can't tell you exactly what *is* causing this phenomenon, but I can tell you what *isn't*. The high-voltage stage, including the oscillator. If this works on even *one* channel, it is OK. It's common to *all* channels so it should work. Something else is the cause of this screwball reaction.

For a pure guess, I'd say something in the agc; *or*, something "on the cable". If Channels 5 and 9 were much *stronger* than the rest, they could be making the agc cut the set off. This is very rare but has been known to happen. (This would tell you two things: one the cable isn't set up correctly, and two, your agc isn't working properly either!)

Check other sets and, if possible, get a field-strength reading on the cable. All stations should be set at about the same level. Second check; when this trouble happens disconnect the cable lead in; if the raster comes back, then check the agc, etc.

RCA CTC 31

The complaint was a constant snapping sound that origiated at the base of the 6BK4 high-voltage shunt regulator. This was found to be caused by arcing in the spark-gap-capacitor combination in the 6BK4 grid circuit.



Clean any dirt or dust from around the capacitor and spark gap. Lower the high voltage to 25 kV and tune the horizontal efficiency coil for minimum current plus 1 or 2 mA through the cathode circuit of the 6JE6 horizontal output tube.— *Homer L. Davidson*

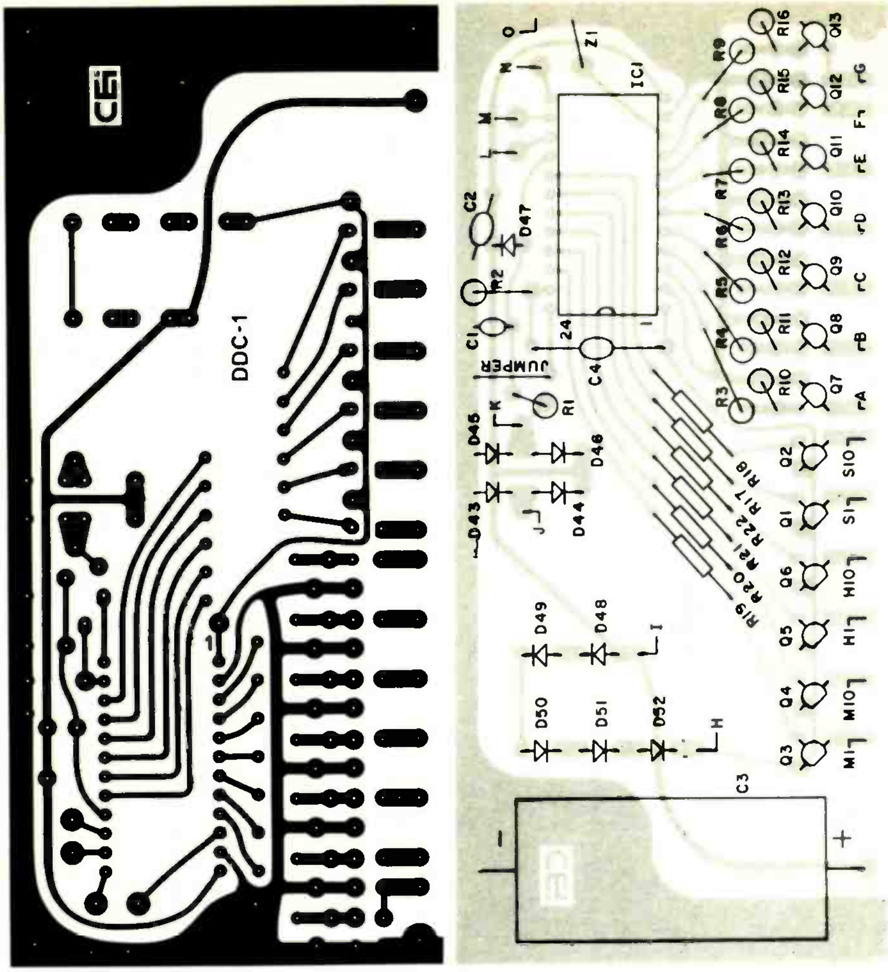


FIG. 10—(a) ACTUAL SIZE PATTERN OF THE NUMITRON DESK CLOCK CONTROL BOARD as viewed from the foil side. (b) X-ray view of the same board showing the location of all components mounted on the top side of the board.

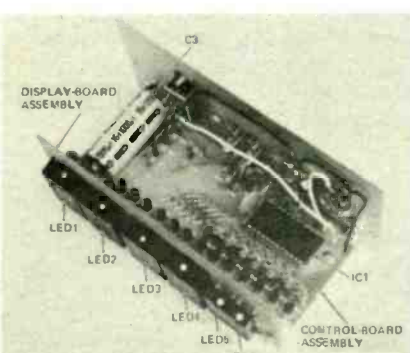


FIG. 12—INSIDE VIEW of the LED desk clock. The diplay board is attached directly to the control board with small angle brackets, and the control board is attached to the rear panel in the same manner.

REAR VIEW of the LED desk clock showing the location of the various controls and power terminal-strip.

This forms the complete electronics assembly for the LED desk clock, which then slips into the simulated-walnut cabinet from behind. All of the switches and the terminal strip, TS1, are mounted on the rear panel. S1, the display BRIGHT-DIM switch, is not used in this version of the desk clock. The *same* control-board assembly, (as used in the Numitron desk clock) is used in the LED desk clock.

Fig. 13 shows the LED display PC board pattern. First, install the three jumpers on the copper-foil side of this PC board. Use short lengths of *insulated* hook-up wire for the three jumpers. Make sure the insulation covers the entire length of the jumpers and that none of the copper conductors on the board are shorted to the jumper wires. Next, install resistors R1 to R7 flat against the PC board, on the copper-foil side. Now flip the board over and install the LED readouts, LED1-LED6.

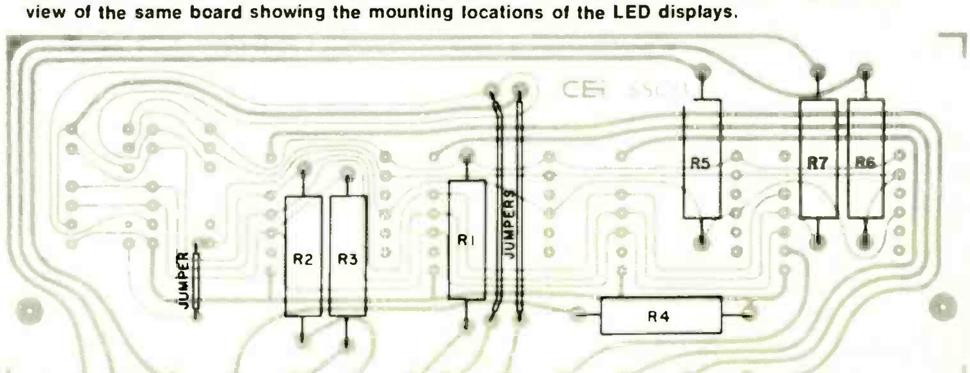
After the LED display-board assembly has been mounted at right angles to the control-board assembly, the two boards are interconnected directly, point to point, with short pieces of bare copper wire. Connect holes *A* through *G* on one board directly to holes *A* through *G* on the other board. Likewise, connect holes *S1* through *H10* on one board to the corresponding holes on the other board. This completes the wiring of the two PC boards that make up the LED desk clock.

Using and setting the clocks

The time setting controls are located on the rear panels of the digital clocks. To set the time, use the following procedure on the Numitron desk clock and the LED desk clock.

Set the HOLD-RUN switch to HOLD. Press the FAST SET pushbutton for at least one full minute, so the hours and minutes digits run through several complete cycles. This allows the clock chip to cycle completely, getting rid of any "illegal" numbers or blank digits. Release the FAST SET pushbutton as soon as the desired hour(s) are indicated on the first two digits. Now press the SLOW SET

FIG. 13—(top right) ACTUAL SIZE PATTERN OF THE LED DISPLAY BOARD as viewed from the "foil" side. (below) Seven resistors and three insulated jumpers are soldered on the "foil" side of the display board mounting the displays on the opposite side. (bottom right) X-ray view of the same board showing the mounting locations of the LED displays.



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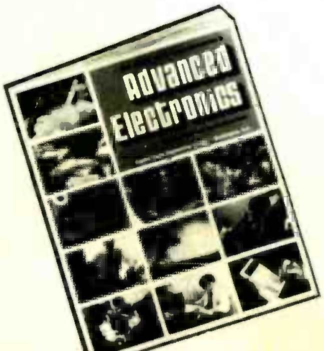

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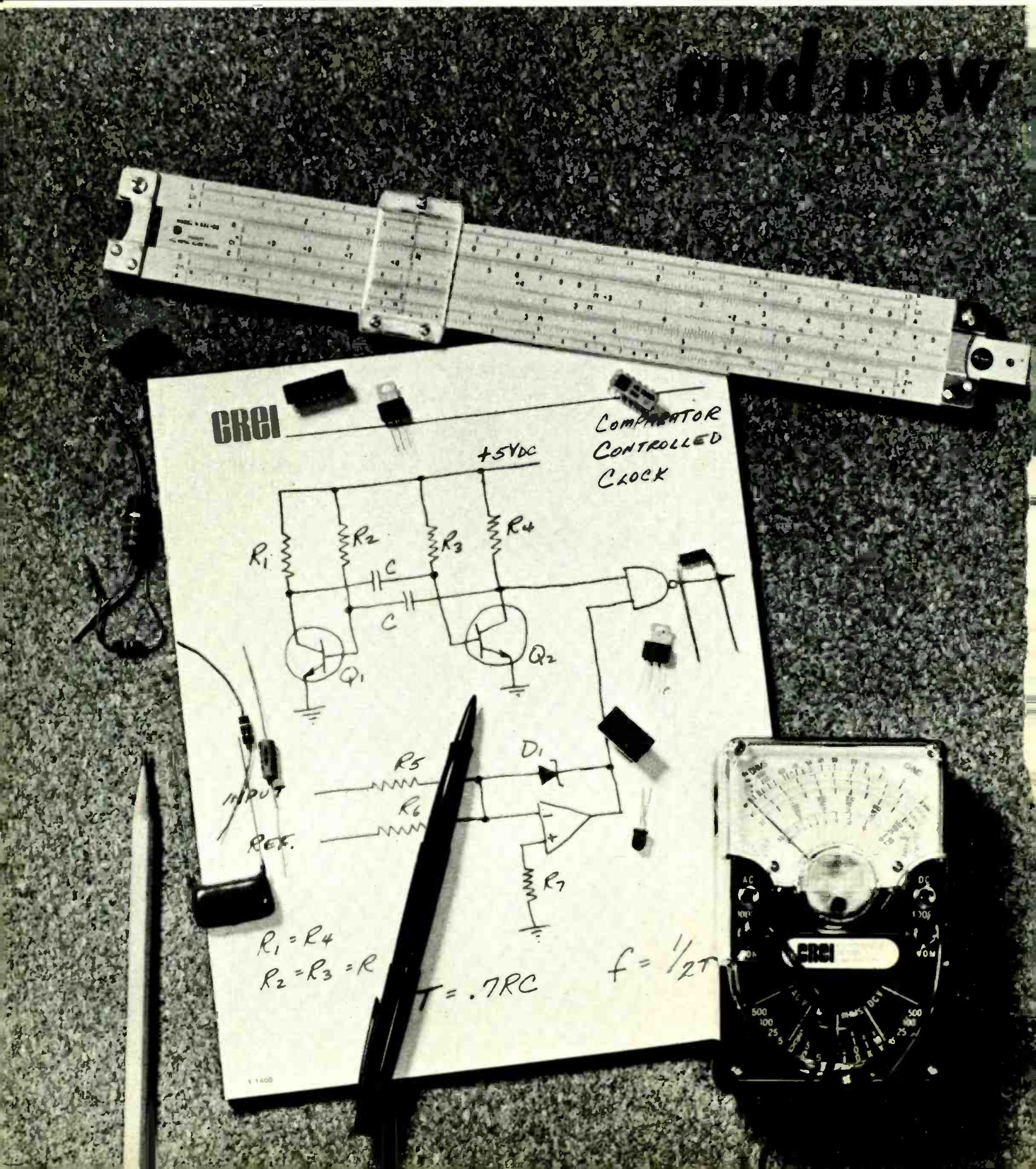


BUILD 3 UNIQUE CLOCKS

This month we present the construction details for two desk clocks. One clock uses a numitron display, the second clock features an LED readout.

by CHARLES CARINGELLA and MICHAEL ROBBINS

LAST MONTH WE PUBLISHED THE SCHEMATICS of the three digital clocks and described how they worked. The parts list for all three clocks was also given. This month we will examine the construction details for the two desk clocks.

Building the clocks

The Numitron desk clock is housed in an attractive cabinet measuring 7 inches wide, 4 inches deep and 3 inches high. Oiled walnut is used for the sides, while a formed piece of 1/16-inch thick sheet acrylic serves as the sloping front as well as the top of the cabinet. If you want only the digits in the display to show, use a piece of smoke-gray acrylic, or if you want all of the internal "clock works" to show, then use a piece of clear acrylic. The latter makes for a real conversation piece!

An inside view of the Numitron desk clock is shown in Fig. 9. The chassis serves as the front edge, bottom, and rear panel of the clock cabinet. The Numitron display-board assembly is attached to the chassis bottom on 1/8-inch spacers using suitable screws, while the control-board assembly is mounted on the rear panel with 5/8-inch spacers and suitable screws. The 5/8-inch spacers allow the control board to clear all of the switches, as well as the terminal strip, TS1, which are mounted on the rear panel of the cabinet.

Figure 10 is the control PC board, which greatly simplifies construction of the clock. Install all jumpers on the PC board first, then install a set of Molex pins on the board to serve as the socket for IC1. *CAUTION: Do all of your soldering with a small pencil iron and use only a good grade of rosin-core solder. Use a small 1/2-turn loop of insulated hook-up wire as the jumper at Z1. Do not install Z1 if you desire the 24-hour time format. D48 is not used. Install a short jumper wire in its place.*

Carefully observe the orientation and polarity of the diodes, transistors, and the electrolytic capacitor. Mount all diodes vertically on the PC board. Resistors R17 to R22 are installed flat against the board. All of the remaining resistors are mounted vertically.

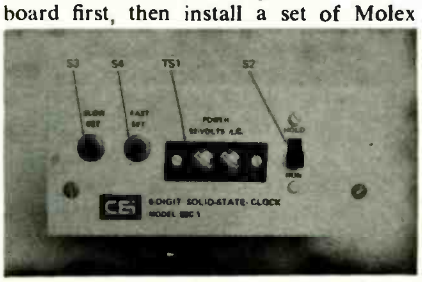
Should you want to operate the clock from a 50-Hz power-line source, unground pin 11 of IC1. This can be done by cutting off pin 11 of IC1, or removing the corresponding Molex pin from the PC board, before installing IC1 on the board.

Figure 11 is the display PC board. Silicon rectifiers, D1 to D42, are mounted flat against the board, and they should be installed first. Next, mount the PC sockets for V1 to V4. Remove pin 1 from each socket before installation. V5 and V6 are smaller tubes and are soldered directly into the board. You will have to lengthen all of the leads of V5 and V6 with 1/2-inch lengths of bare copper wire. This will elevate the display tubes so that their bottom segments line up with the bottom segments of display tubes V1 to V4.

The Numitron display-board assembly is wired to the control-board assembly with two interconnecting wiring harnesses. One wiring harness is used to connect holes *A* through *G* on one board to the corresponding holes on the other board. Likewise, the other wiring harness connects holes *S1* thru *H10* on one board, to the corresponding holes on the other board. This completes the wiring of the two PC boards necessary to complete the Numitron desk clock.

The LED desk clock is housed in a smartly styled simulated-walnut cabinet that is 5 3/4 inches wide by 3 inches deep by 2 3/4 inches high. The window is red sheet acrylic so only the illuminated digit segments show.

An inside view of the LED desk clock is shown in Fig 12. The display-board assembly is attached, at right angles, directly to the control-board assembly with small angle brackets. Likewise, the control-board assembly is attached to the rear panel using small angle brackets.



REAR VIEW OF THE NUMITRON DESK CLOCK showing location of the various controls and the power terminal-strip.

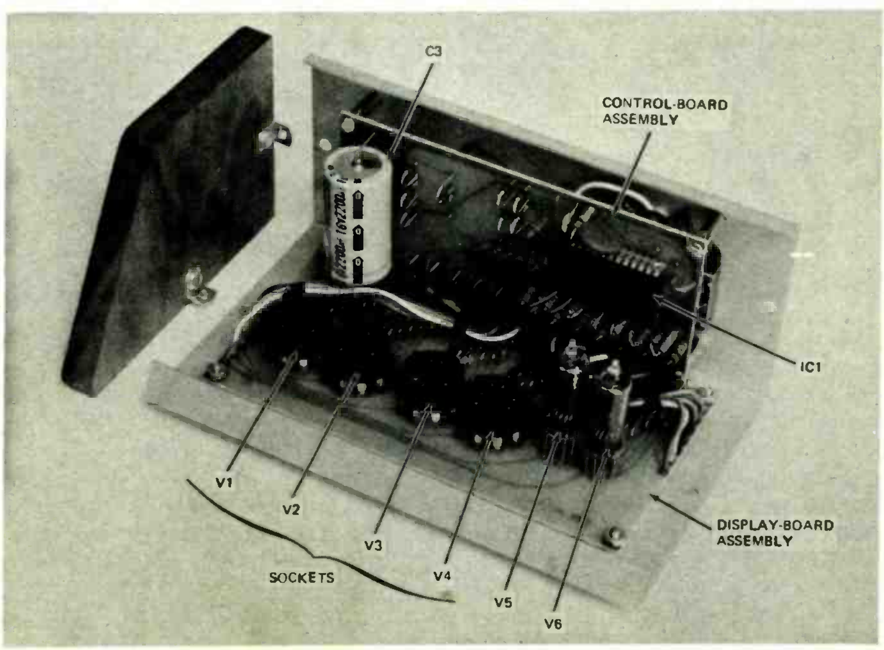


FIG. 9—INSIDE VIEW OF THE NUMITRON DESK CLOCK. The chassis serves as the front, bottom, and rear panel of the cabinet. The Numitron display board is attached to the chassis bottom, while the control-board assembly is mounted on the rear panel.

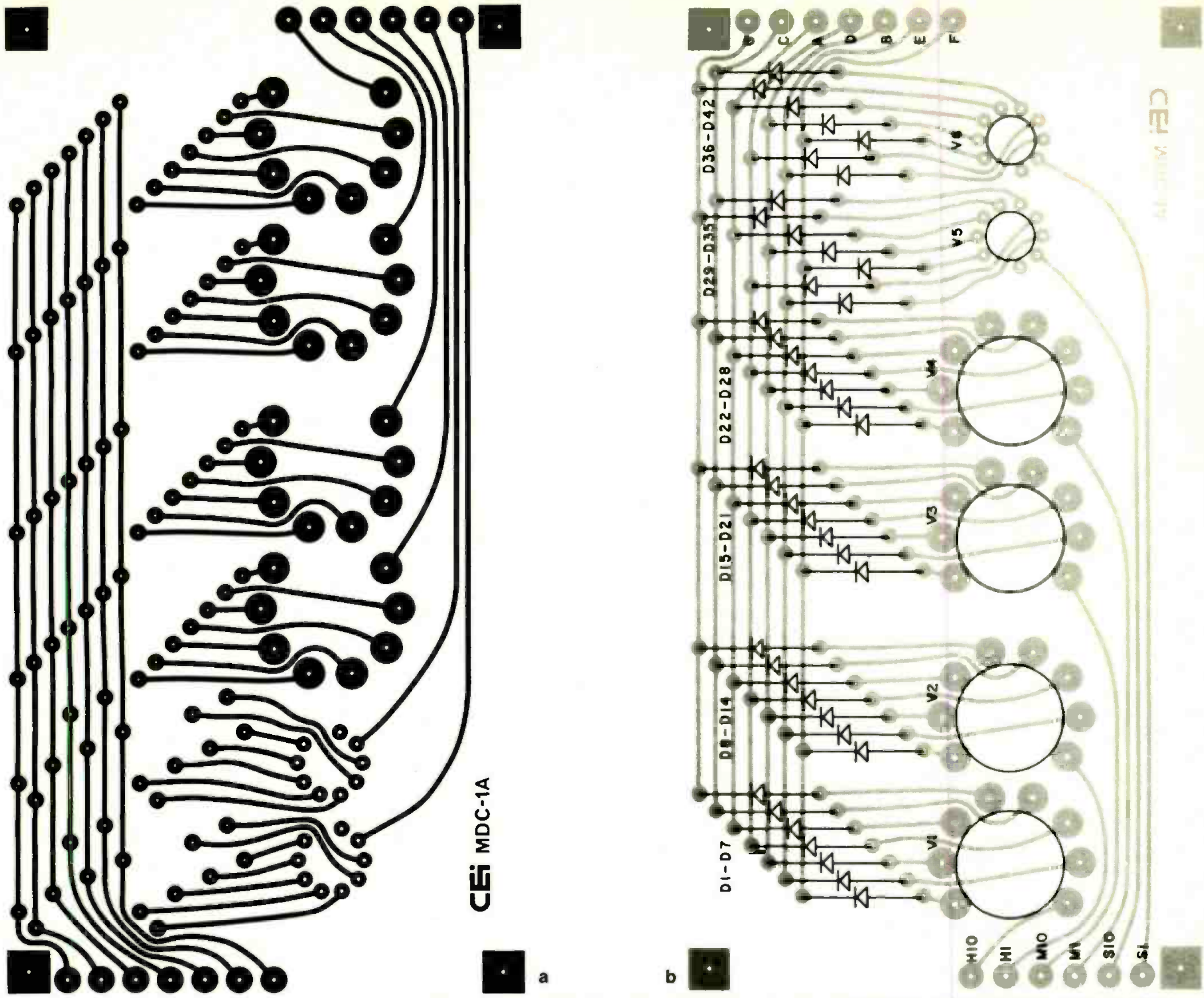
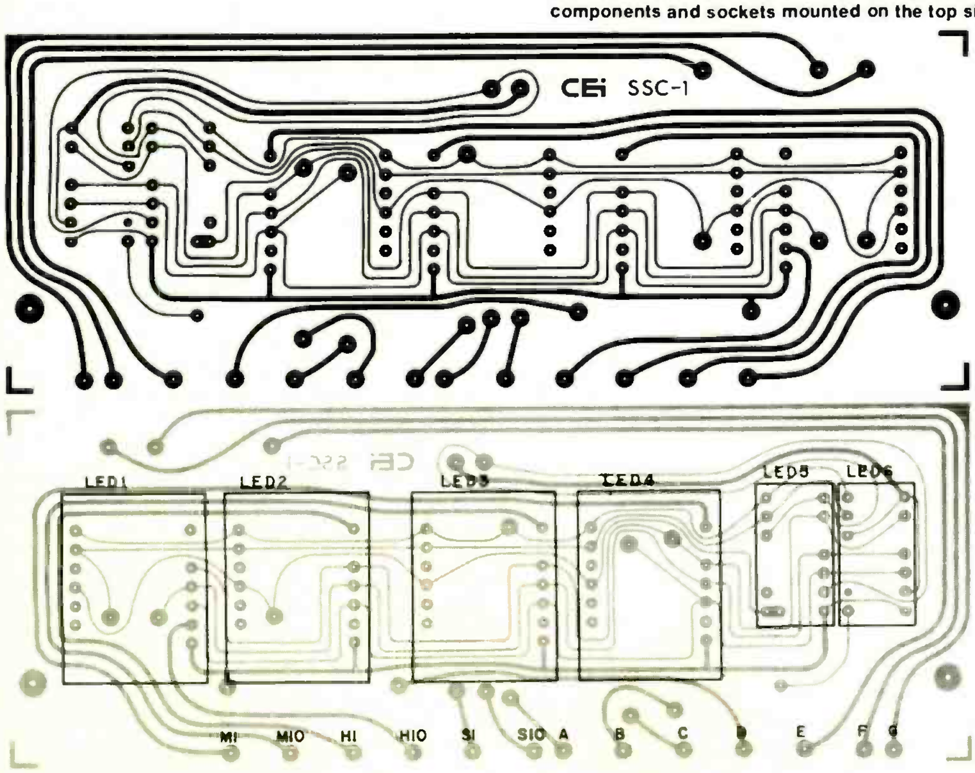


FIG. 11—(a) ACTUAL SIZE PATTERN OF THE NUMITRON DESK CLOCK DISPLAY BOARD as viewed from the foil side. (b) X-ray view of the same board showing the location of all components and sockets mounted on the top side of the board.



pushbutton to cycle the minutes. Release the pushbutton as soon as the desired minute(s) appear on the second two digits. To start the clock, simply flip the HOLD-RUN switch to the RUN position. The clock will now indicate the time. Should the clock be unplugged, or should the power fail at any time, repeat this procedure to again set the time.

With these clocks, it is possible to precisely synchronize the time (accurately to the second) with any source of accurate or "standard time", such as WWV. To do this, follow the procedure outlined above, however, set the time so it is one or two minutes fast. Now, allow the clock to run. When the seconds digits read "zero-zero", flip the HOLD-RUN switch to HOLD. As soon as the "announced" time corresponds to the time indicated on the clock display, flip the HOLD-RUN switch to RUN. The time should now track accurately to the second. Long-term accuracy of the clock, is, of course, determined by the accuracy of the power-line frequency.

The article will conclude next month with the construction details and the foil patterns for the wall clock. **R-E**

TECHNICAL TOPICS

by **ROBERT F. SCOTT**
TECHNICAL EDITOR

WE RECEIVED QUITE A BIT OF "FLACK" on the circuit (November 1973 issue) that turns on a car's parking lights whenever the headlights are turned on. Several readers called the circuit "a typical case of over-design," claiming that the diodes were not needed. I see these remarks as "typical cases of second-guessing a design without thinking through the problem." The diodes were included to isolate the parking lights so they can be used for their original purpose without having the headlights on.

Electronic donkey

Several readers submitted ideas and suggestions to Craig Pearce for generating the two-tone "electronic donkey" or "hee-haw" siren used on European police cars. One suggested a device made from two inexpensive code-practice modules turned on alternately by a 6-volt automobile directional flasher. The oscillator outputs to be fed to an IC power amplifier. He, in turn, asked for help in finding a circuit to duplicate the sound of guns used on the "Star Trek" TV show. Anyone know what these guns sound like and how the sound can be produced? Help!

C. L. Holland, an Enginering Technologist for RCA, sent in a modification of a circuit he designed as an alarm for a digital clock. The alarm uses two gates of a 7400 IC cross-connected to form an astable multivibrator driven by the 1-pulse per second output of the digital clock IC. The hee-haw circuit (Fig. 1) has a low-frequency astable modulator added to make a self-contained European-type siren. Tone and rate can be varied as desired by changing capacitor values. If the tone is too harsh, a simple R-C filter will remove the harmonic content—the multivibrator output is almost a square wave. With the resistor values shown, no start-up problems occur; but if the 2.2K or 2.7K resistors are changed too much, latch-up can be a problem. The cost of the "electronic donkey" will be hard to beat with 7400 quad 2-input NAND-gate IC's as low as 25¢ each.

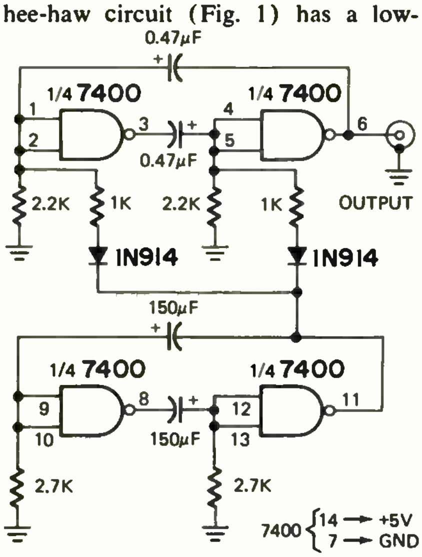


FIG. 1 — "HEE-HAW" TWO-TONE SIREN uses two 7400 IC's. The upper two gates form a multivibrator that controls the tone.

Taped sound for home movies

Several of you have asked for information on synchronizing taped sound with a home movie projector. An excellent series of three articles on this subject appeared in the November and December 1973 and January 1974 issues of *Electronics Australia* (PO Box 163, Beaconfield 2014, Australia). The author, N. Labordus, points out that while the speed of a film can be varied, within limits, without being detected by the eye, even slight changes in tape speed is quickly noticed as distortion in the sound. For these reasons, synchronizing designs are based on a constant tape speed with the projector's speed being variable in response to sync signals from the recorder. He gives theoretical and construction details on three control methods: A *non-discriminating* system does not discriminate between "just right," "too fast" and "too slow" and only acts to slow down the projector when it is running too fast. A *discriminating* control is better in that it can speed-up or slow-down the projector. However, both of these control systems have a disadvantage that requires manual control of the recorder and projector speeds to correct. A momentary loss of sync causes the picture to lead or lag the sound for the duration of the film reel.

The *integrating* control system compares integrated digital reference signals from the projector and recorder and develops a feedback signal that controls the instantaneous speed of the tape recorder. Block diagrams of non-discriminating, discriminating and integrating control systems are shown in Figs. 2, 3 and 4, respectively.

Add-on scope triggered sweep

A triggered sweep in an oscilloscope is a decided advantage when viewing some types of signals. Until a few years ago, a triggered sweep was a feature found only on laboratory-type instruments. Now, you can add this feature to your service-type scope for around $10. The circuit in Fig. 5, from *Electronics* magazine, is designed around a simple op-amp and a type 555 IC timer.

A signal from the scope's vertical amplifier is fed to one input of the op-amp and a reference voltage for setting the trigger level is fed to the other. The op-amp's output swings from $+V_{cc}$ to $-V_{cc}$ each time the signal on the SENSITIVITY control exceeds the voltage on the inverting (−) input. The abrupt changes in the op-amp output are differentiated into spikes and fed to the trigger input of the 555 timer IC. The capacitor selected by the RANGE switch begins to

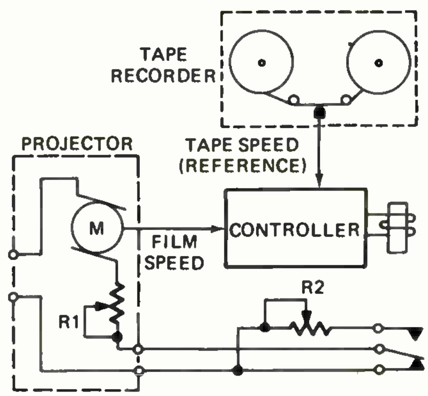


FIG. 2 — NON-DISCRIMINATING CIRCUIT used for synchronizing taped sound with a movie projector.

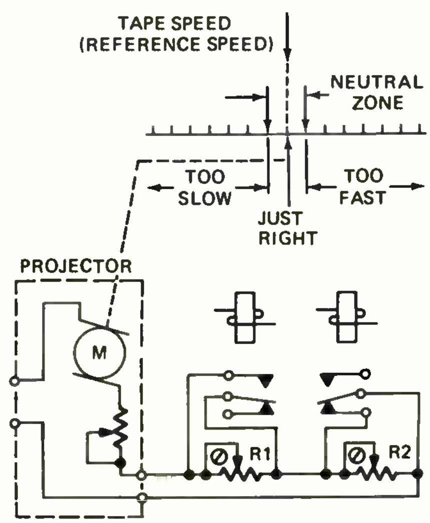


FIG. 3—DISCRIMINATING SYNC CIRCUIT controls the speed of the projector in either direction.

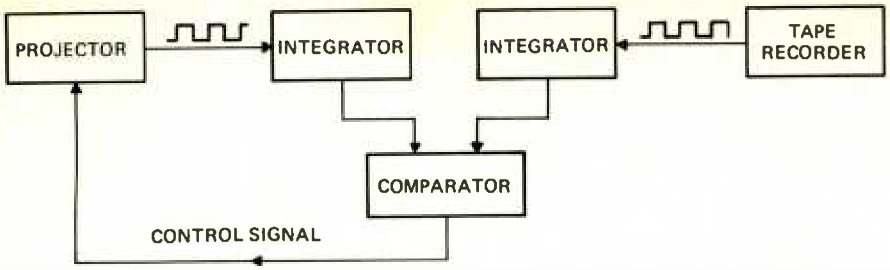


FIG. 4—INTEGRATING SYNC control circuit uses digital reference signals from the projector and recorder for controlling speed.

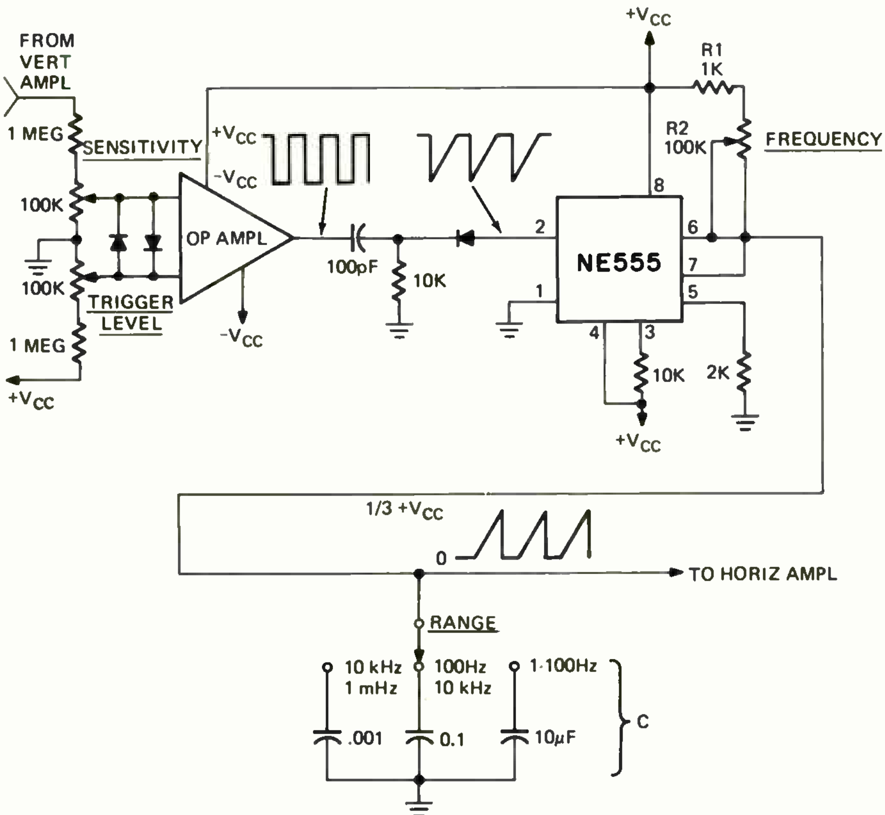


FIG. 5—TRIGGERED SWEEP circuit can be added to your service-type scope for approximately ten dollars.

charge exponentially through R1 and R2 until it reaches about one-third V_{cc} existing on pin 5. The sawtooth voltage is applied to the scope's horizontal amplifier to provide horizontal deflection. The circuit resets after each sweep and awaits the next trigger pulse from the vertical amplifier. The sweep speed is determined by the settings of the RANGE and FREQUENCY controls.

Sleep switch for bedside radio

If you habitually listen to the late-night news or other programs on a bedside radio, you've undoubtedly awakened many mornings to find that the radio has been on all night. You can prevent this in the future by adding a delayed-turnoff switch like that described in the "Suggested Circuit" column in *Radio & Electronics Constructor* (London, England). The electronic switch, Fig. 6, is connected in series with the negative lead from the set's battery. It is switched in and out of the circuit by S1, and the timed period before turnoff begins when you press pushbutton S2.

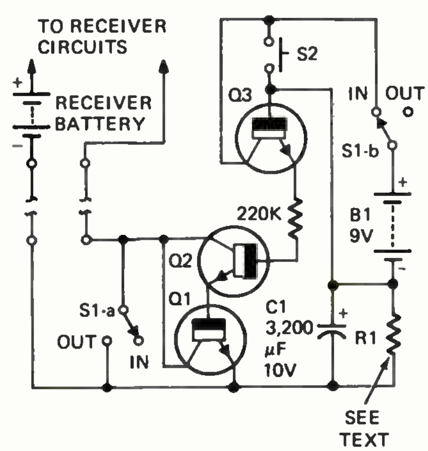


FIG. 6—SLEEP SWITCH provides delay for turning off your bedside radio. Delay is determined by resistance of R1.

Closing S2 charges timing capacitor C1 and turns on Q3, a switching transistor. About 8.4 volts appears on the emitter of Q3, which turns on Q1 and Q2 (connected as a Darlington pair.) Q1 is a silicon power transistor that acts as a switch to open and close the set's battery circuit. When Q1 is turned on and saturated, there is a 0.65-volt drop between its emitter and collector.

As soon as S2 is released, C1 starts discharging through R1 and the bias on Q3 starts to fall. In about one hour, or a time interval determined by the values of C1 and R1 and C1's leakage resistance, the voltage on Q3's emitter falls below the level required to keep the Darlington pair turned on. The drop across Q1 starts to rise sharply and the receiver turns off. A second timed period can be initiated by pressing S2 again.

Timing capacitor C1 should especially be selected for a very low leakage current. To do this, connect a 9-volt battery across the capacitor for about 1 minute. Disconnect the battery, wait 1 hour and then measure the voltage remaining on the capacitor with a high-impedance voltmeter. The capacitor used in the prototype had a residual charge of 7.5 volts after an hour.

In the prototype, a 430K resistor used for R1 provided a delay of about 52 minutes. You can select a suitable value for R1 by temporarily substituting a 10K resistor and monitoring the voltage across the emitter and collector of Q1. Using a watch with a sweep second hand, see how long it takes for the voltage to start rising from the normal 0.65 volt. To find the factor by which 10K must be multiplied to get the final value of R1, take the total number of seconds in the desired delay period and divide this figure by the number of seconds it takes for the voltage across Q1 to begin to rise.

For example, assume that the voltage across Q1 starts to rise in 60 seconds and you want a 1-hour delay (3600 seconds). The final value for R1 is $10{,}000 \times 3600/60$ or 600,000 ohms. A 620K resistor—the closest standard value—is adequate.

Q2 and Q3 are BC107 silicon npn transistors similar to the Motorola HEP-56, Sylvania ECG123A; RCA SK3124 and Zenith ZEN103. Q1, a BD124 npn silicon power transistor, is similar to the HEP-S5000, SK3054 and ECG152. The nominal power dissipated in Q1 is very low, so heat sinking is not needed. The timer can be connected to the receiver through a closed-circuit jack wired in series with the negative battery lead.

That's all for now. So long, this time, 'til next time. **R-E**

Build This IC Breadboard System

by C. D. WADSWORTH

Use it to design your own circuits. It contains its own power supplies, signal generator and LED monitor. It's a lab-quality instrument that can save many hours of tedious design time

HERE IS A VERSATILE "LAB QUALITY" BREADBOARDING system that will save you many hours, hundreds of components, and actually help you in your design of circuits. I tried to make this unit a complete and self-contained system so I could assemble and test any proposed design without the need for other equipment, except perhaps the indisposable oscilloscope. As you will see later, this is a pretty elaborate system, so you may wish to do a little at a time. You will also note that there are several approaches to each section of the system, so you have a choice and can construct the breadboarding system that suits your needs.

The total system is broken down into 7 sections to make it easier to explain, understand and assemble. These 7 sections are:

- **Two separate dual power supplies** ± 5 volts to ±18 volts, fully adjustable and tracking and with a conservative 1 amp capability on each side.
- **Two meters** (one each for voltage and current) that can be switched to monitor any of the four outputs of the power supplies. The current meter can be switched to read 150 mA or 1.5 A full scale.
- **A function generator** which provides sine, square, triangle, and ramp outputs with the frequency adjustable from 100 Hz to 1 MHz. The output is adjustable to 3 volts peak-to-peak.
- **A single pulse generator** or switch controlled flip-flop which can be utilized as a bounceless switch or a single pulse generator with complimentary outputs.
- **Twelve LED displays** (and drivers) so you can determine the condition of any point in your breadboarded circuit.
- **Internal power supplies** for the function generator, LED's and drivers, etc. so the other power supplies will have no internal load and the meters will read only the voltage and current supplied to your breadboarded circuit.
- **Breadboarding sockets** to provide sufficient space for extensive and intricate design and testing.

This breadboarding system has one additional feature which can, in time, pay for the cost of the entire system, and that is the fact that it can be used to test most active components. By using the LED's and the function generator, transistors can be checked for response from 100 Hz to 1 MHz. The signal from the function generator can be varied to 3 volts peak-to-peak, so you can check for large and small signal response. Digital IC's (TTL) can be checked using the single pulse generator. Voltages are available for testing CMOS and, using a little imagination, even linear IC's can be checked.

How the circuit works

Let's start with the ± 5 volt to ± 18 volt dual power supplies. The schematic is shown in Fig. 1. The positive side of the supply is controlled by the μA723 voltage regulator which consists of a temperature-compensated Zener, a voltage-reference amplifier, error amplifier, a series-pass transistor and current limit circuitry.

The supply voltage for the μA723 IC (pin 8) is supplied through D5 which isolates the IC from the rest of the input circuitry. In this manner, IC1 is isolated from the output load. The lower voltage limit (± 5 volts) is determined by the input to pin 3 and is derived from a reference voltage which appears at pin 4 of IC1. This reference voltage is divided down by the divider network consisting of R5 and R7.

IC1 contains an error amplifier to maintain the output voltage at the desired level. Pin 3 is the non-inverting input to the error amplifier and pin 2 is the inverting input to this amplifier. The output of the amplifier controls an internal pass transistor which in turn controls pass transistors Q1 and Q2. The input to pin 2 is derived from the output of the regulator by the divider network consisting of resistors R8, R9, and R10. By adjusting R9, pin 2 senses a varying amount of the output voltage which causes the output of the error amplifier (controlling the internal pass transistor) to change in a direction that will cause the input to pin 2 to be equal to the input to pin 3.

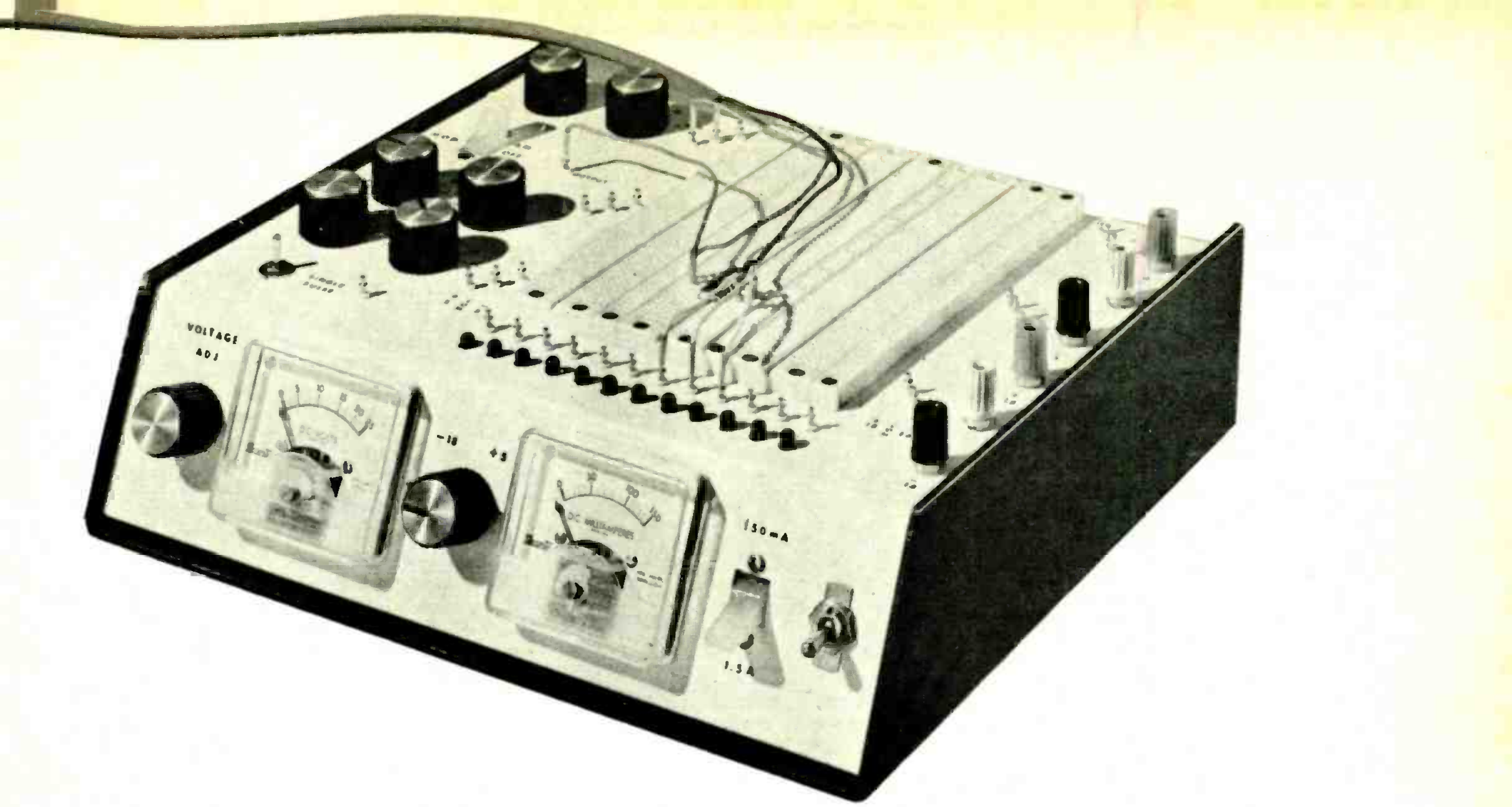
IC1 contains internal current sensing elements which monitor the voltage drop across the two resistors R3 and R4. The voltage drop across resistors R3 and R4, which is fed to pin 10 of IC1, is directly proportional to the output current through the pass transistors. When an overcurrent condition occurs, the voltage drop across R3 and R4 will exceed a predetermined level. This will trigger the internal current sensing elements which in turn will clamp the output of the error amplifier. The outboard transistors Q1 and Q2 are additional pass elements to increase the current capability of this supply to more than 1 amp.

The negative side of the supply is controlled by using a 741 op-amp, which merely tracks the positive supply and inverts the output to provide drive for the pass elements. The divider network of R15, R16, and R17 is used to trim the negative side of the supply to exactly match the positive side. Q5 is the current-sensing element for the negative side of the supply.

Because the negative side of the supply always tracks the positive side, I decided to build two of these supplies so I could get any combination of + and − voltages I wanted or I could get + and − voltages for op amps and a + 5 volt supply for TTL digital circuits at the same time.

The wiring diagram for the meters is shown in Fig. 2. This circuit is straightforward, so no further explanation will be given here. However, you should be sure the switch you use is the non-shorting type and it is preferable to use a four-deck (2 poles, 4 positions each deck) switch rather than an eight-deck switch, this is because of cabinet space. If you do not use the meter specified, then the value of the shunt resistor will have to be changed. The value of the shunt resistance can be determined by multiplying the meters internal resistance by 0.11.

I have found these meters to be a very important must when breadboarding a particular circuit. By using the meters, you can determine the power requirements in both the active and quiescent states. Some circuits are more stable at a particular voltage and sometimes excessive current drain can indicate a defective component or improper wiring.



I strongly suggest that you include the meters in the unit you build. The cost of the meters will be offset many times in the information gained through their proper use.

The internal power supplies (+ 12 volt and + 5 volt) are detailed in Fig. 3. This + 12 volt supply provides a well regulated voltage with low ripple, and this circuit can provide up to 1 amp with the components specified, however, this far exceeds the needs of all the internal circuitry shown here so a lower power pass transistor can be substituted for Q6. I decided on the 1A capability here, so that in the future, additional internal circuitry could be added without the need for replacing the power supply.

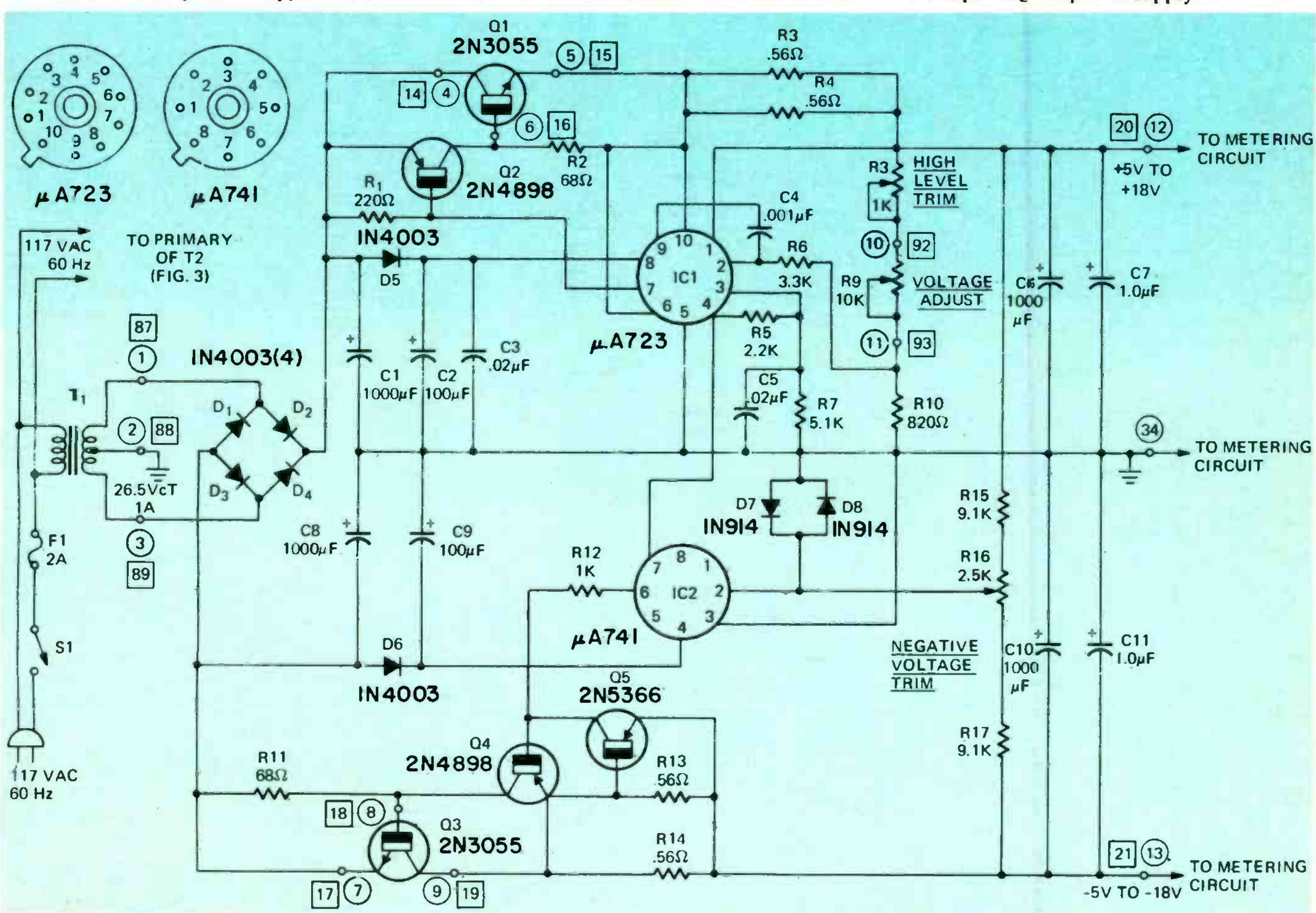
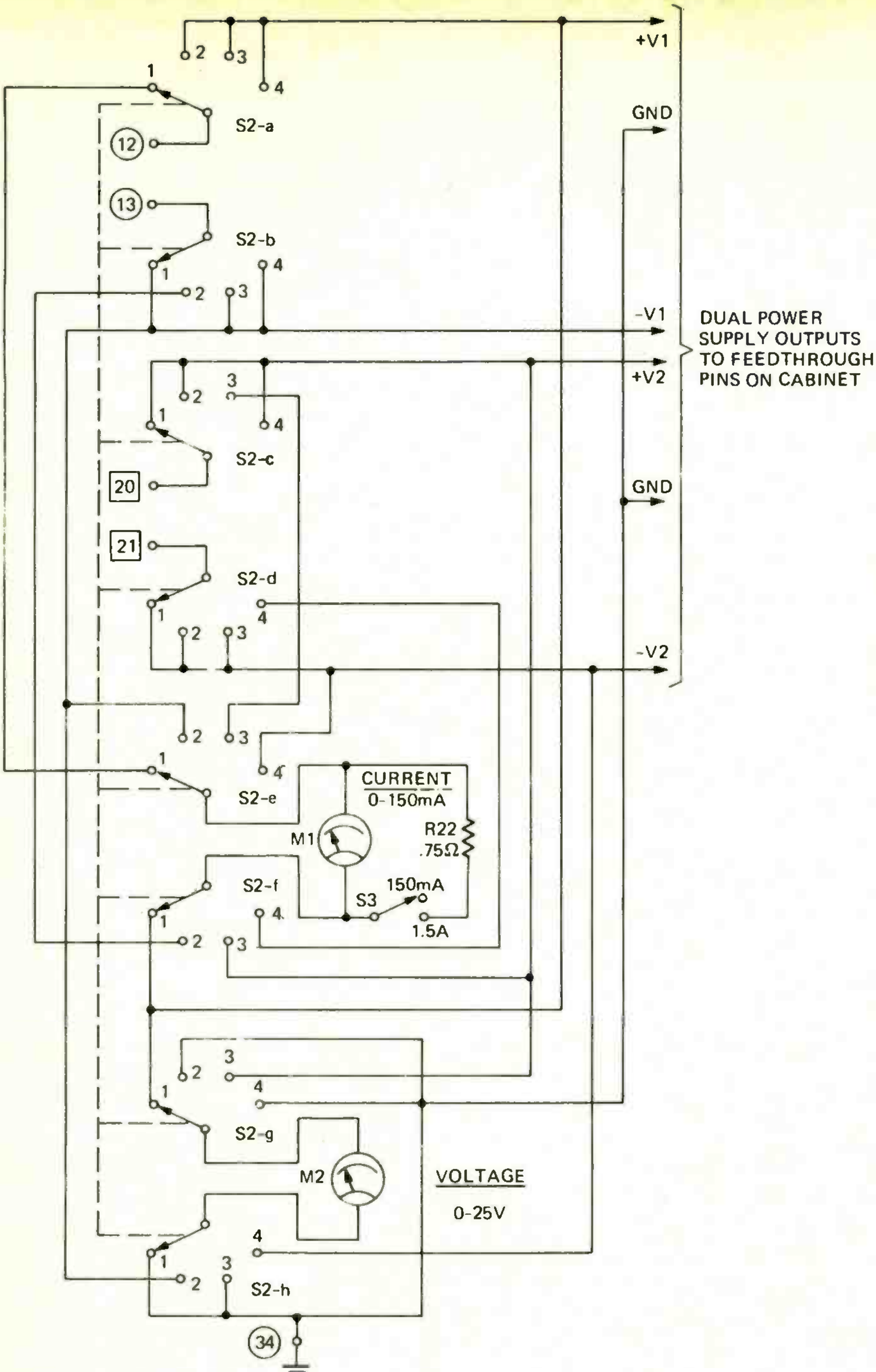


FIG. 1—DUAL POWER SUPPLY can provide between 5 and 18 volts at 1 amp. The negative side of the supply tracks the positive side. Two dual supplies are used. Interconnections for dual supply #1 is shown with circles. Squares denote the interconnections for dual supply #2.



NOTE:

SWITCH POSITION - S2	MEASURE
1	DUAL SUPPLY #1 - POSITIVE OUTPUT
2	DUAL SUPPLY #1 - NEGATIVE OUTPUT
3	DUAL SUPPLY #2 - POSITIVE OUTPUT
4	DUAL SUPPLY #2 - NEGATIVE OUTPUT

FIG. 2—METERING CIRCUIT measures the voltage and current output of the two dual supplies. Switch S2 selects the output to be measured and switch S3 selects the current meter range—150 mA or 1.5 A.

This circuit can be made adjustable by placing a 10K potentiometer between resistors R20 and R21 with the variable leg of the potentiometer connected to the base of Q3 transistor Q8. The value R20 should be changed to 1K. The low level output is limited to the Zener voltage of D11, so if you want the supply adjustable down to +5 volts, then D11 will have to be changed. Remember also the dissipation that the pass transistor must handle is $(V_{in} - V_{out}) \times I$, so the lower the output voltage the less current the supply can provide (with the same pass transistor) without the possibility of burned out components. We have used this circuit at 12 volts and 1 amp without a heat sink for the pass transistor but the case temperature reaches the 110° to 115° range, so care should be taken if you go much beyond this point.

The +5 volt supply is simply a standard (309K) regulator receiving it's input from the regulated 12 volt supply. This increases the current demands of the 12 volt supply but eliminates a high-value capacitor (and subsequent board space) from the 5-volt supply. This circuit will provide about 725 mA so it can power all the LED's and the single pulse generator at the same time without strain.

Next, let's tackle the LED's and their drivers. The circuit is shown in Fig. 4. The drive transistors are connected in a Darlington configuration to provide a very high gain so that almost any input will turn on the associated LED. The 22K resistors provide current protection for the transistors while the 56-ohm resistors provide current limiting for the LED's. There are a number of sources of surplus LED's at very attractive prices which are quite suitable as a substitute, but keep the following in mind:

a. Not all LED's provide the same viewing angle and can range from 30° to 140°. The easier they are to see the less chance of missing an important indication.
b. Stick to plastic encapsulated LED's, they are a lot easier to mount.
c. Remember that LED's are essentially current devices and excessive current can send them up in a puff of smoke. Be sure your current-limiting resistor provides proper protection.

The bounceless pushbutton or the single pulse switch is shown in Fig. 5. This circuit uses one half of a quad 2-input NAND gate to form a bistable multivibrator. The cross coupling eliminates the "bounce" experienced on the conventional mechanical switch. Both a positive-going square wave and its compliment are available. If you use a spring-return toggle switch or a

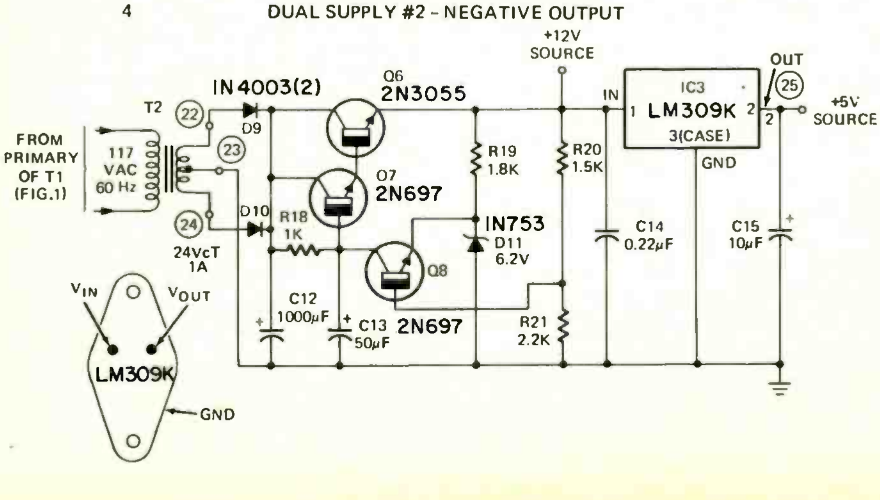


FIG. 3—+5 AND +12 VOLT POWER SUPPLIES provide the supply voltages to the internal circuits.

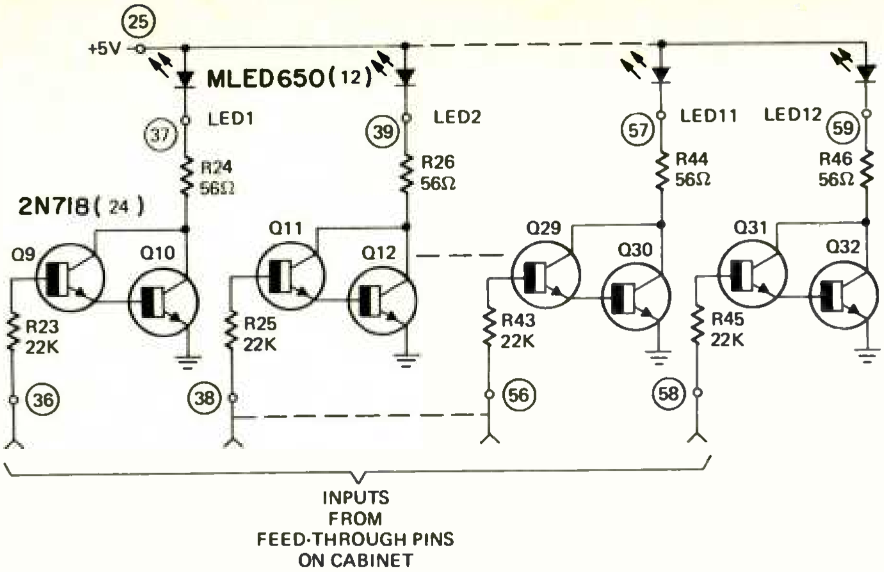


FIG. 4—LED INDICATORS use Darlington drivers to give sensitive indications.

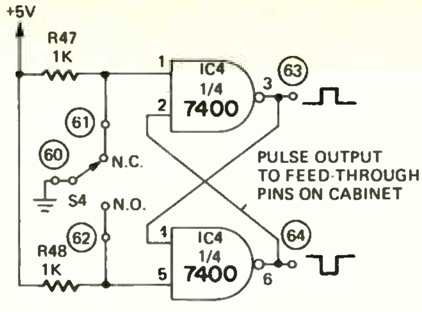


FIG. 5—SINGLE PULSE GENERATOR is operated by a switch. This eliminates the noise due to contact bounce normally encountered with mechanical switches. Both the inverted and non-inverted output is available.

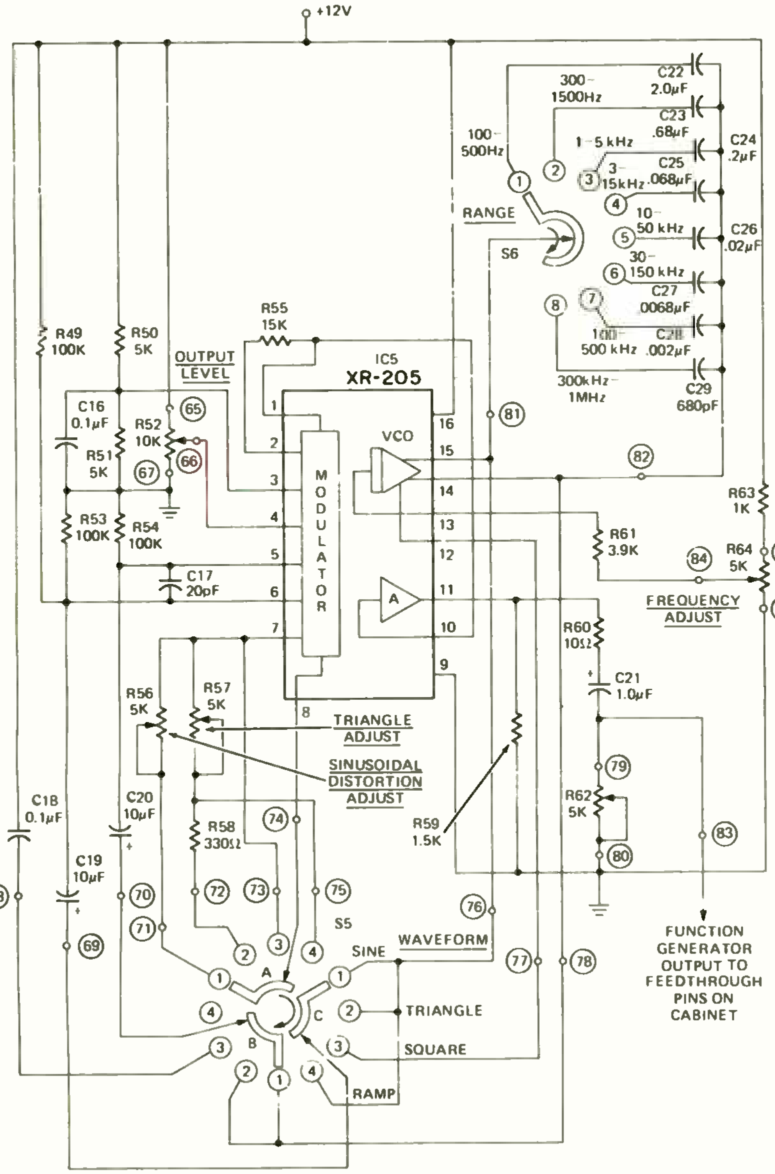


FIG. 6—FUNCTION GENERATOR can provide sine, square, triangle, and ramp output waveforms over a frequency range of 100 Hz to 1 MHz.

pushbutton switch, then you have a single pulse function. If you use a standard toggle switch then each operation of the switch will invert the output without bounce.

The function generator is shown in Fig. 6. This is a somewhat simplified version using a single IC, the XR-205, operating from a single 12-volt supply. It provides 4 functions over a wide frequency range and, if good wiring practice is followed and good quality passive components are used, the sine wave distortion can be as low as 2.0%.

This IC has 3 basic sections, a voltage-controlled oscillator (VCO) for generating the basic waveforms, a modulator section for waveform adjustment through amplitude or phase modulation, and a buffer amplifier.

The basic input to the modulator section is the Y inputs (pins 5 and 6), and is controlled by switch decks S5-b and S5-c. Waveform adjustment is effectively controlled by the amount of resistance between pins 7 and 8 through switch deck S5-a. Trimmer R56 is adjusted to minimize the harmonic content of the sine-wave output and R57 provides the proper trimming for the triangle output.

The X modulator inputs (pins 3 and 4) control the effective gain of the modulation section and R55 provides the amplitude control for the outputs from the modulation section at pins 1 and 2.

Frequency is controlled by the selection of the timing capacitor (pins 14 and 15) through RANGE select switch S6 and with the proper dc bias applied to the VCO through pin 13 by R64. With the capacitor values shown, there will be an overlap of frequencies so that, even with fairly high tolerance (10%) capacitors and even after aging, you should still have a full frequency range. It is suggested, however, that you use Mylar or tantalum capacitors.

About the breadboarding sockets. These sockets are what initiated the design of the total system and have provided a savings to date that far exceeds the system cost in just components and man hours alone. The parts list indicates two different suppliers for these sockets—we decided on one over the other only because we thought it would fit our cabinet layout better.

Next month the article will conclude with the construction details, foil patterns, parts list and calibration details. R-E by RICHARD A. KARLIN and GARY F. COMISKEY

What Can DIGITAL Do?

What is the difference between analog and decimal? Binary, what and why? What is binary-coded decimal? Here are the answers.

DIGITAL AND ANALOG ARE THE HEAVENLY Twins of electronics. Twin techniques which together embrace the whole field! The key-and-relay dc telegraph system—that ancient electronic equivalent of the jungle drum—was digital. After that, things went pretty much analog. The telephone, the talking machine, radiotelephone, amplifiers, modern receivers and transmitters (AM, FM, SSB), television, analog computers, oscilloscopes and VTVM's!

Now we are in the middle of a ferocious digital revolution. Digital techniques have taken command of most areas of computation, have captured large areas of the instrument and measurements market, are making rapid inroads in communications systems, and are threatening to invade virtually all areas of electronics. The TV technician who does not understand digital techniques may some day find that he can no longer service TV sets. Even the basic audio amplifier can be made a digital instrument. Join us in examining the reasons for this digital explosion and in learning the techniques which make it so powerful.

Before we compare analog and digital techniques, let's make sure we agree on what the words mean. Analog can be traced back to the Greek *analogos:* something that is like something else. Suppose we wish to represent the temperature of a room. Some circuit parameter must be caused to be similar (proportional) to the room temperature. What parameter?? We could use the voltage between some two points, the current through some circuit leg, the frequency of an oscillator, or the width of pulses in a pulse train. The key idea is that of a *proportionality* between the information and the circuit parameters chosen to represent it.

Such a proportionality is limited by both the accuracy limits of the circuit and by noise. An accuracy of 10% is easy, 1% requires some care and a bit of expense, and 0.1% is possible but very expensive.

Digital can be traced back to the Latin *digitus:* finger. The concept is that of *units* of measure. Information is rendered into some *number of units.* A flock of sheep is counted by matching them against the fingers (digits) and scratching symbols in the soft earth. But sheep come in units by nature. What do we do with room temperature, which can be any fraction of a degree? We use fractional units, but we will get to that eventually.

Analog systems are proportional, as smooth as the noise will allow; digital processes are inherently grainy. They go stepwise, and we count the steps. This sounds like a tremendous disadvantage, but fortunately we can make the steps as small as we wish. The steps can be voltage steps, current steps, width (of a pulse) steps, etc. In this sense, analog and digital systems are alike in one respect—they both can use any parameter available in a system. The mathematician or physicist might describe the analog system as *continuous* and the digital system as *discrete* or *quantized.*

Consider two systems for recording data. In each case, the data will be the height of a man above a base level. In the analog system, the man climbs a ramp until he is at the proper height, and then stands there. In the digital system, the man climbs a flight of stairs until he reaches the proper height, then he too stands there. But these men become restless, and they shuffle their feet. Shuffle as he must, the man on the staircase will not reduce the accuracy of any measurements that are made, as long as his shuffles do not change the step he stands on. But each little shuffle will move the man on the ramp upward or more likely downward, spoiling the accuracy shuffle by shuffle.

Here then we have the differences between analog and digital systems:

The analog system can represent data smoothly and continuously, but is subject to error from any component change or drift no matter how small. Its accuracy can be improved only by improving the accuracy of the components, a process which becomes progressively more costly and difficult.

The digital system is quantized, and thus can only approximate continuous data, but the approximation can be as close as we wish, and is subject to error only if component change or drift is large enough to exceed one digital increment. The accuracy of a digital system can be improved by assembling a greater number of digital circuits, each alone having only moderate accuracy and cost.

Digital systems differ from one another in two important ways: the parameter chosen to represent the data (voltage, current, frequency, pulse width, et cetera), and the number of quantized levels used. Our decimal number system uses ten numerals, 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9. Thus we can represent any one of ten levels with one decimal digit. With two decimal digits we can range from 00 to 99, a total of 100 levels. For data less than one we add a decimal point and place digits to the right of it: 27.356. The value of each position to the left increases tenfold, the value of each position to the right decreases tenfold. Now suppose we had a circuit which could be set to have an output of any integral voltage from

TABLE I

MOST SIGNIFICANT (Decimal) DIGIT (MSD)	1,000,000,000	100,000,000	10,000,000	1,000,000	100,000	10,000	1000	100	10	1	1/10	1/100	1/1000	1/10,000	1/100,000	1/1,000,000	1/10,000,000	1/100,000,000	1/1,000,000,000	1/10,000,000,000	LEAST SIGNIFICANT (Decimal) DIGIT (LSD)
	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	

MOST SIGNIFICANT BIT (MSB)	512	256	128	64	32	16	8	4	2	1	1/2	1/4	1/8	1/16	1/32	1/64	1/128	1/256	1/512	1/1024	LEAST SIGNIFICANT BIT (LSB)
	1	1	1	1	1	1	1	1	1	1 •	1	1	1	1	1	1	1	1	1	1	

Positional values for ten columns each side of the decimal (binary) point for the decimal and binary number systems.

TABLE II

BINARY	DECIMAL
0	0
1	1
10	2
11	3
100	4
101	5
110	6
111	7
1000	8
1001	9
1010	10
1011	11
1100	12
1101	13
1110	14
1111	15
10000	16
100000	32
1000000	64
1100100	100
10000000	128
11001000	200
1111101000	1000
10000000000	1024

A comparison of some numbers in binary versus decimal form.

0.0 to 9.0. Each such circuit could represent one decimal digit. Five such circuits could be used to remember the data 27.356. Such a ten-state circuit is possible, however, because of economic and reliability considerations, modern digital circuits which use voltage to represent data are only two-state.

Two-state logic systems are called binary systems (binary: composed of two different parts). Each of the two logic states is assigned a name or symbol. The more common symbols and names are: Low——High, LO——HI, False——True, F——T, 0——1. When the data is represented by voltage, present practice is to use one of the left symbols for the more negative of the two voltages and the matching right-hand symbol for the more positive voltage.

If we choose one of the two symbols of a pair and write it down, we have a single *binary digit*. The term "binary digit" has been shortened to "bit." The bit is the smallest possible unit of information. It conveys a choice of one of two possible levels, symbols or values. This term is used throughout computer theory, information theory, and communications theory, so it is important to have a good grasp of it. Remember that it is a contraction of Binary Digit, and that it stands for one of two possible items.

Let us see what we can do with a single bit. Beginning with some statement logic, we will use one bit to represent the truth value of that statement. Let us identify this bit of ours (and thus the statement also) with the letter **A**. (Understand that **A** is not one of the two bit-values, it is simply an identifier so we can tell this bit from other bits). The statement will be: I am hungry. Thus, we write **A** = **I am hungry.** Mind, this is not an ordinary algebraic equation. It is shorthand for: "The truth value of the bit we call **A** represents the truth value of the statement we have equated with **A**." So if bit **A** has value **T**, then the statement is to be considered true, and if bit **A** has truth value **F** then the statement is to be considered false. To get down to brass tacks, if **A** = **T** (**A** is true), then I *am* hungry.

Next, we may ask, can the truth value of *any* statement be represented by one bit?

We must conclude that a single bit can represent any two-statement data provided that at any instant one and only one statement will be true. This is automatically true of any statement and its proper negation. For example: *I am hungry/I am not hungry. I am thirsty/I am not thirsty. It is raining/It is not raining.*

But beware. In English it is easy to form an improper negation: a pair of statements which, for example, cannot both be true, but which can both be false. Example: *It is hot/It is cold.* It cannot be both hot and cold . . . but it could be neither hot nor cold . . . it could be warm. A pair of statements when one and only one can be true at the same time are said to be *mutually exclusive*. In pure logic, only a statement and its negation qualify. However, in practical design, occasions arise where two statements may act like a mutually exclusive pair even though they are not. A good example is the AM-FM switch on a radio. AM and FM are certainly not naturally mutually exclusive. However, the radio designer has decided to make them so (in a given radio) by placing them on a single two-position switch. In the universe of that radio, you cannot have both AM and FM, and if you want neither then you must use another switch, the ON-OFF *switch*.

Having concluded that each independent statement requires one bit, let's turn to arithmetic. Again, we start with one bit. This time we assign the values 0 and 1. This is the same as 1 and not-1. In other words, the bit represents the truth value of the numeral 1.) To count beyond nine in a decimal system requires two digits. To count beyond one in a binary system likewise requires two digits. But where each added decimal digit increases the value tenfold, each added binary digit increases it two fold.

Table I compares the positional values of a binary and a decimal system. The decimal system is deeply ingrained in all of us. The binary system is not so well known, yet we have met it in the form of simple doubling (1, 2, 4, 8, 16, 32) and in the carpenter's rule which divides the inch into halves, then quarters, then eighths, then sixteenths. Table II compares some decimal and binary numbers.

Finding the decimal value for a binary number is simple. First, write the positional column values over the columns.

TABLE III

ASCII	SYMBOL	ASCII	SYMBOL
000000	SPACE	100000	@
000001	!	100001	A
000010	"	100010	B
000011	#	100011	C
000100	$	100100	D
000101	%	100101	E
000110	&	100110	F
000111	'	100111	G
001000	(	101000	H
001001	)	101001	I
001010	*	101010	J
001011	+	101011	K
001100	,	101100	L
001101	—	101101	M
001110	.	101110	N
001111	/	101111	O
010000	0	110000	P
010001	1	110001	Q
010010	2	110010	R
010011	3	110011	S
010100	4	110100	T
010101	5	110101	U
010110	6	110110	V
010111	7	110111	W
011000	8	111000	X
011001	9	111001	Y
011010	:	111010	Z
011011	;	111011	[
011100	<	111100	\
011101	=	111101	]
011110	>	111110	↑
011111	?	111111	←

The six-bit subset of the ASCII code assigns 64 symbols to the 64 possible six-bit characters.

Second, add all column values where 1 appears. For example, 100101 =

$$\frac{32\ 16\ 8\ 4\ 2\ 1}{1\ \ 0\ \ 0\ \ 1\ \ 0\ \ 1} = 32 + 4 + 1 = 37.$$

With practice it can be done without bothering to write the column values. Try the following and check your answers against those on the last page of the article.

A. 1101
B. 11011
C. 10001
D. 11100111
E. 110.101

On the other hand, to convert a decimal number to binary, using the same positional value columns, you must write a 1 in those columns which just add up to the decimal number and a 0 in all other columns. Those readers not familiar with this process may wish to try their hand with the numbers below, checking against our answers on the last page of the article.

F. 5, 7, 8, 15, 81

We have seen how each bit can represent an independent statement, and we have seen how groups of bits can constitute a positional number system, similar to our familiar decimal system, but using only two symbols and doubling or halving column values. Living as we do amidst so many signs, signals, and codes, we can easily see how anything can be represented by a group of bits. One particular bit pattern is assigned to each item to be represented. For example, The American Standard Code for Information Interchange (ASCII) uses a six-bit subgroup to represent all letters, the numerals zero through nine, and a number of punctuation marks and symbols. The assignments are shown in Table III.

To translate a text to ASCII, each letter, figure, or symbol in the text would be replaced by the six bits assigned to that letter, figure, or symbol by ASCII. The title of Hugo Gernsback's prophetic novel, *RALPH 124C 41 +* becomes: 110010 100001 101100 110000 101000 000000 010001 010010 010100 100011 000000 010100 010001 001011 in ASCII.

Now it's time to sharpen up our vocabulary. We have defined the bit as a single binary digit. And we have shown how a group of bits can represent a letter, a number, or a symbol. A group of bits used to represent a letter, a number, or a symbol is called a *character*. This is logical. Character is our term for a single letter, number, or symbol. Thus it is reasonable to call the associated group of bits a character. Most digital systems are built to handle characters of some specific size. Often a number of characters are handled together. Such a group of characters are called a *word*. But do not confuse this with the English term word. Digital systems group characters for convenience of handling. They may not be related in any way. They need not make an English word or anything like it.

The number of different numerals used in a number system is called the *base* or the **radix** (Latin for root) of the system. Thus our familiar decimal system is base (radix) ten, while the binary system is base (radix) two. Computer people often find base eight, called *octal*, very convenient for some purposes. When systems other than base ten are used, the base must be clearly indicated. This is done by stating the base in the text or through subscripts. Thus 27_8 indicates that the number 27 is in base eight (octal). This could be translated to 23_{10}, 23 in base ten. (27_8 means 2 eights plus 7 units = 16 + 7 = 23.)

The number of different characters which can be formed with N bits is 2^N. Thus, for example, 6 bits can form 2^6 (64) different characters. These can be used to count from 0 (000000) to 63 (111111), or to represent any group of 64 symbols or statements.

But sometimes we have good reason not to use all the available characters. For example, noise, dirt, or some momentary malfunction will occasionally cause a solitary bit to be transferred or interpreted incorrectly. It might seem that this would cause the character containing that bit to be changed. However, by making it a rule to use only some of the possible characters while making the others forbidden combinations, we can detect and even correct such errors.

Another example is of prime importance in the instrument field. When we buy a digital voltmeter, we expect the data readout to be in decimal form. After all, not many of us sight-read binary. $+1101.001_2$ may be the same as $+13.125_{10}$ volts, but we expect to see the easily read decimal form. If the data inside the voltmeter were generated and stored in binary form, the translation problem would be formidable. To see the problem, inspect Table I, showing the weights of the binary digits. In general, each bit contributes to many if not all decimal columns. The translator would require a fantastic amount of logic.

But by modifying the binary code, we can substantially reduce the problem. A group of four bits has 16 possible characters. Suppose we take such a group and assign ten of these characters to the numerals zero through nine, as in Table IV,

TABLE IV

DECIMAL	BINARY CODED DECIMAL (BCD)
0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001
10	0001 0000
11	0001 0001
12	0001 0010
13	0001 0011
14	0001 0100
15	0001 0101
16	0001 0110
17	0001 0111
18	0001 1000
19	0001 1001
20	0010 0000
30	0011 0000
40	0100 0000
50	0101 0000
60	0110 0000
70	0111 0000
80	1000 0000
90	1001 0000
100	0001 0000 0000
125	0001 0010 0101

Decimal coded into Binary Coded Decimal form. The four-bit combinations 1010, 1011, 1100, 1101, 1110, and 1111 are never used.

and never use the other six. These four bits now represent one decimal digit. We will use another four bits to represent the next decimal digit and so on. Now to translate from this code, which is called binary-coded-decimal (BCD), only four bits need be inspected for each decimal digit, and the translator problem becomes manageable.

We began with a comparison that revealed one of the key advantages of digital techniques: High accuracy at modest cost. Binary coding can represent any collection of data, numbers, letters, statements, et cetera, by using an appropriately large group of bits, each bit being realized by one basic two-state logic circuit. Further, we have seen the flexibility: how code groups (characters) can be left unused for error detection or for simplification in translating to decimal form.

But these advantages are only part of the story. Digital readout gives us fast, accurate data. Completely inexperienced personnel can read and copy a digital display. Compare this with reading the dial of a typical mirror-scale, multi-range VOM. Data can be entered on a numeric keyboard or numeric switches as opposed to multiturn potentiometer dials. Yet even these advantages are only a small part of the story. Unlike an analog system, a digital system maintains full accuracy until its maximum frequency limit is reached. Thus, while most analog systems begin to degrade above 10,000 hertz, digital systems hold full accuracy to 1, 10, or even 100 megahertz, depending on the specific circuits used. And even at 100 megahertz, the power dissipated is low.

The magic combination of reasonable power, modest cost, high accuracy, and high speed is an open door. This combination allows us to perform many hundreds of operations without loss of accuracy, or to time-share one assembly of equipment by switching it between a number of sources and outputs. Messages can be combined, transmitted, and split apart. Frequencies can be synthesized to unbelievable accuracies. Messages can be coded for security. Digital operations can be repeated to perform digital filtering with results almost impossible to achieve with ordinary filters.

Suddenly techniques that were difficult or impossible in analog systems are open to us. Our next article will explore the rules of logic that govern these digital techniques. **R-E**

ANSWERS

A. 8 + 4 + 1=13

B. 16 + 8 + 2 + 1=27

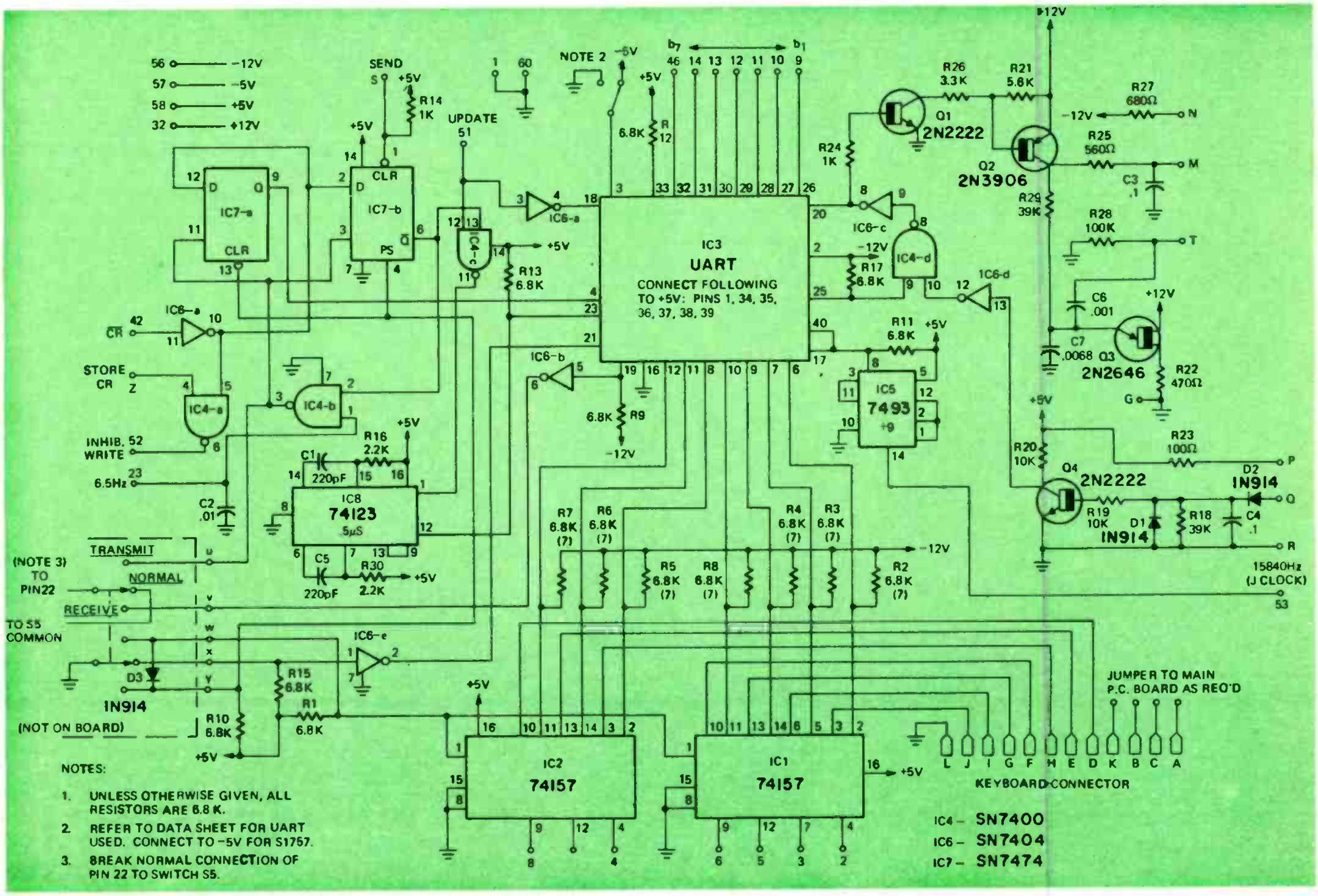
C. 16 + 1=17

D. 128 + 64 + 32 + 4 + 2 + 1=231

E. 4 + 2 + ½ + ⅛ =6⅝

F. 101, 111, 1000, 1111, 1010001

add this UART to your TV typewriter



You can connect it between your TV typewriter and a Teletype for a "hard print" copy. Or you can connect it between a cassette recorder and the Minicomputer for extended memory.

by ROGER L. SMITH

IF YOU OWN AN ASCII ENCODED KEYBOARD, Teletype®, 'TV Typewriter', (**Radio-Electronics**, Sept. 1973), or a Mark 8 Minicomputer, (**Radio-Electronics**, July 1974) you need a UART (Universal Asynchronous Receiver/Transmitter) to communicate with other such equipment or to record data on a tape. This article shows you how to add a UART and support circuitry to your 'TV Typewriter' so you can send your data to a Teletype for "hard copy" print out. The same circuit will also output data into or accept data from a regular cassette tape recorder. It is also possible to transmit data from Teletype to recorder and back (could be used to automatically type out mailing lists). When a cassette recorder is used with the Mark 8 Minicomputer, the result is a large bulk storage device.

Although it is not included on the PC board, we'll show you the circuits needed for a FSK (Frequency Shift Keyed) MODEM using the XR-210. The "Mark 8 Minicomputer", "TV Typewriter", MODEM, and DAA (Data Access Arrangement) together give you a powerful computer terminal.

How is all of this interfacing done? The communication problem boils down to this: characters in the form of 6 to 8-bit ASCII logic levels must be sent one bit at a time to a remote location and thereupon converted back to 6 or 8 parallel data bits. All of this requires an elaborate combination of AND gates, shift registers, start and stop bit generators and detectors, and timing circuits. Thanks to MOS-LSI circuits, most of this has already been done for you at a terrific saving of time, space, and money in the UART.

The size of a UART, a 40 pin package, may startle you, but the price is $15 or so, which can't be equalled by hardwired circuits. Several companies presently make UARTS including Western Digital, American Micro-Systems, General Instrument, Texas Instr., Signetics, and Intel (see UART Table). Detailed operation of a UART can be obtained from any of these manufacturers and won't be covered here. Basically, however, as each ASCII character is presented to the transmitter input, start, stop, and parity bits are added and the bits are sent out in serial fashion at a rate determined by an external oscillator. The receiver portion reverses the process for incoming serial data.

The transmitter output of the UART is a TTL logic signal that should be converted to a 20-mA current-loop signal for Teletype operation or to the standard EIA RS-232C interface signals. You could also use your own driver design, provided you are communicating to your own gear.

The main idea is to provide an error-free signal to the receiver with moderate rise and fall times (30 volts/μs or slower).

With the UART and additional circuits shown in the schematic, the output (Q2, pins **M** & **N** and input (Q4, pins **P** & **Q** are directly compatable with a Teletype. The oscillator input (pins 17 & 40) was adjusted to be Teletype compatable. The frequency should be 16 times the baud rate (110HZ $\times$ 16 = 1760HZ). STOP, START, and IDLE bits are generated by the UART. We found that communicating with a Teletype was made easier if we increased the TV Typewriter memory to 7 bits because the Teletype must receive CR (carriage return) and LF (line feed) signals. Adding the 7th bit is done by adding a 2524 memory IC to your memory board as described in the section titled "Changes to TV Typewriter." If you don't intend to use a Teletype, you should study only those circuits that suit your needs. Note that the serial output of the UART is normally high.

The rest of the circuit shown in the schematic provides the SEND signal to start the transmitter and data selectors (74157) to select either the keyboard or the UART to input to the TV Typewriter memories. The SEND signal can be a key on your keyboard or a special pushbutton that provides a ground signal to start the transmitter. We found it convenient to Stop the transmissions by detecting the carriage return (CR) signal and stopping any time it occurred (the CR is found on pin 42—see "changes to TV Typewriter"). Note that the entire circuit is built on a PC board that will plug on top of the board "stack" of your "TV Typewriter". The Transmit-Normal-Receive switch can be any DP3T switch conveniently located on the unit.

You will need 4 lines to connect the output of the board to the Teletype. Connect as follows:

I/O Board to Teletype

M	7	Refer to the section titled
N	6	"Teletype Information" for
P	3	proper connections on the
Q	4	Teletype.

If you plan to use your UART with only a keyboard to transmit data, you will need an oscillator on pins 17 & 40. You can change IC5 to an MC4024 and alter the wiring to provide 1760 HZ. Since you will be transmitting only 1 bit at a time, all you need is a one-shot for your KP signal (use IC8 connected to pin 51). Received data will appear in parallel form at pins 5 thru 12 of the UART which you connect to your particular output device. Note that when an output is available, pin 19 goes high and pin 18 must then be pulsed low to reset the output register. Also, when no input data is being received, input pin 20 must be held high.

Recording data

Most cassette tape data recording is done by converting the bits ("O" and "1") to two tone signals. This is called FSK (Frequency Shift Keying) recording. Unfortunately, the need for error free FSK recording and reproduction requires precision equipment which to you and me translates into $$$. Since the data rates we are using here are quite low, it is possible to use a $20 cassette recorder *if* we record single frequency tone *bursts*. Note that we can't record the bits directly because they occur at a 110 bits per second rate—too low for most recorders.

With this tone burst method, the tape speed can vary considerably before any errors are introduced. This method can be called PPK for Pulse Position Keying and consists of recording a pulse of tone signal for a "1" and not pulse for an "0" during each 9.1-ms bit time.

On our Input/Output board, the tone bursts are generated by unijunction oscillator Q3. The tone signal (about 3.8 KHZ) is present during the "Mark" time ("1") and absent during the "Space" ("0") time. The output (pin T) is connected to the auxiliary input of the recorder (or thru 470K to the MIC. input). If you make a tape recording without a Teletype connected, you must ground pin **M** and connect pins **P** and **Q** together. Notice that we haven't provided any automatic START or STOP for the recorder. A dual monostable (74123) in the SEND line could be used (with a relay) but it is much easier to start and stop the tape manually with a switch.

When you play back the tape into the I/O board, you should connect the "earphone" output to pins **Q** and **R**. You could incorporate a switch arrangement to select the desired input/output device.

PARTS LIST

All resistors ¼ watt unless noted

R1, thru R13, R15, R17 — 6800 ohms
R14, R24 — 1000 ohms
R16, R30 — 2200 ohms
R18, R29 — 39,000 ohms
R19, R20 — 10,000 ohms
R21 — 5600 ohms
R22 — 470 ohms
R23 — 100 ohms
R25 — 560 ohms
R26 — 3300 ohms
R27 — 680 ohms
R28 — 100,000 ohms
C1, C5 — 220-pF disc
C2 — .01 μF
C3, C4 — .1 μF
C6 — .001 μF
C7 — .0068 μF
Q1, Q4 — 2N2222
Q2 — 2N3906
Q3 — 2N2646
D1 - D3 — 1N914
IC1, IC2 — SN74157
IC3 — UART (see table)
IC4 — SN7400
IC5 — SN7493
IC6 — SN7404
IC7 — SN7474
IC8 — SN74123

Misc.: P.C. board, molex connectors, 22Ga. wire, DP3T switch.

Add to TV Typewriter; Signetics 2524 IC, 2200-ohm and 6800-ohm resistors, 10-μF electrolytic (C9).

**Printed-circuit board is available from Techniques Inc.
235 Jackson St., Englewood, N.J. 07631
$6.50 postpaid (New Jersey residents add 5% sales tax).**

UART MANUFACTURERS

Western Digital Co., *(TR1602), (TR1402)*
19242 Red Hill Ave., Newport Beach, CA 92663

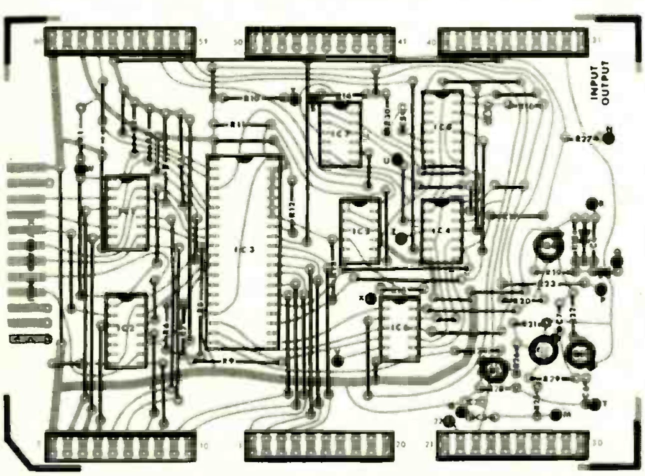
American Micro-Systems *(S1757; S1883* —the most available at this writing)
3800 Homestead Rd., Santa Clara, CA 95051

General Instrument *(AY-5-1013A)* Box 600, Hicksville, N.Y. 11802

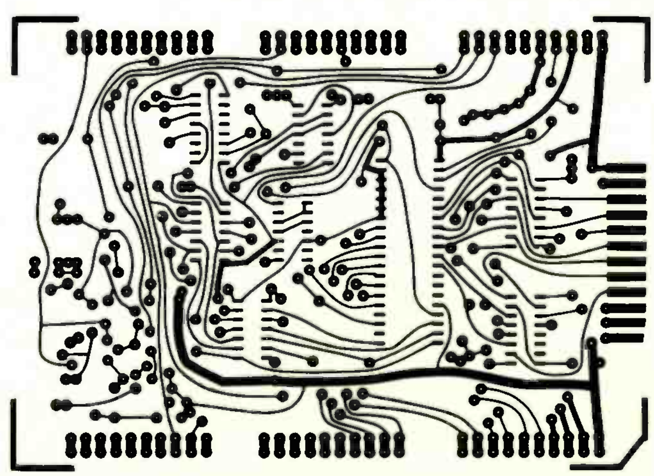
Texas Instruments *(TMS 6010NC; TMS 6012)* Box 5012, Dallas, Texas 75222

Signetics *(2536)*
811 E. Arques Ave., Sunnyvale, CA

Intel *(8201)*
3065 Bowers Ave., Santa Clara, CA



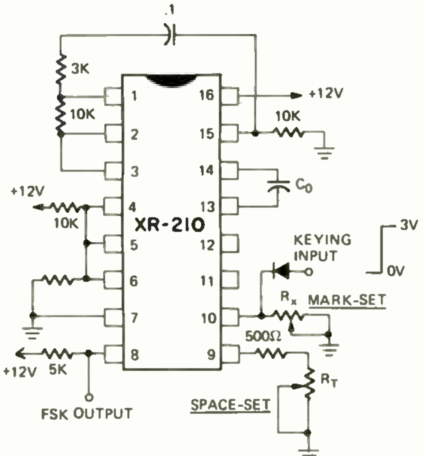
FOIL PATTERN FOR THE INPUT/OUTPUT BOARD shown half-size. The UART is a 40-pin dip package.



X-RAY VIEW OF THE FOIL PATTERN for the input/output board shows the component layout.

You may also want to use an 8 to 500-ohm transformer on the output of your recorder to help match it to the I/O board.

Although the Input/Output board was designed primarily with a Teletype and cassette recorder in mind, it represents a large portion of a MODEM. All that needs to be added are a couple of XR-210 IC's to provide modulation and demodulation of the serial data. For this application, you may want to increase the data rate to 150, 300, or 1200 baud. You would need to increase the oscillator input (pins 17 & 40) accordingly, to 16 times the baud rate.



Select C_0, R_T & R_X for desired frequencies.

$$C_0 = \frac{220}{f_0} \qquad R_T = \frac{.1f_0}{f_1 - f_0} \qquad R_X = \frac{.3f1}{f2 - f1}$$

where f_0 = 5% lower than f1, R_T & R_X in KΩ.

for f1 = 1070 Hz, f2 = 1270 Hz:

Co = .22 μf, R_T = 2K, R_X = 1.6K

FIG. 1—SCHEMATIC DIAGRAM FOR FSK MODULATOR shows how the XR-210 IC is connected. This circuit plus FSK demodulator is needed for MODEM.

The XR-210 circuits necessary for a MODEM are shown in Figs. 1 and 2. You can write to EXAR Integrated Systems, 750 Palomar Ave., Sunnyvale, Ca. 94086 for their 8 page brochure on the XR-210 for complete details.

Changes to TV Typewriter

1. The "blinking" of the cursor is used as a KP signal to send out each character, so its speed should be increased to 6.5 Hz by changing C9 on the timing board to 10 μF. Also, change wiring of pin 22 as shown in the input/output schematic. Note that the 1760-Hz UART oscillator input limits your maximum character rate to 10 characters/second.

2. Storage of bit 7 must be added to give Teletype a carriage return & line feed. Do this by adding a new 2524 IC to the *memory board*. "Piggyback" the new 2524 on top of IC4 by first bending pins 2 and 6 straight out from the new IC. Pinch remaining pins together slightly (1 toward 8, 4 toward 5, etc.) so the IC will make physical contact with IC4's pins and only pins 4 & 8 will need soldering (just a *very* light touch.) Tack on a 2.2K resistor from pin 6 to common of R1 thru R5 (+5V) and a 6.8K from pin 2 to bus on pin 4 (−5V). Add jumper wires from pin 6 of IC to pin 2 on pc board and another from pin 2 of IC to pin 46 of board.

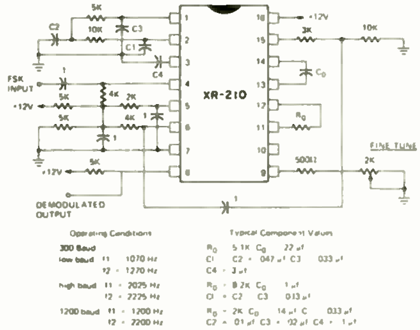


FIG. 2 — FSK DEMODULATOR schematic shows how the XR-210 is connected. This circuit plus circuit in Fig. 1 is needed for MODEM.

3. The TV Typewriter must distinguish between a line feed (LF) and carriage return (CR.) This is done by detecting bits 3, 6 and 7 (CR = $\overline{A}_6 \cdot \overline{A}_7 \cdot \overline{A}_3$). On the cursor board, cut a break in foil from IC6-13 to R12 and add jumpers to connect IC-8, 9 and 10. Cut break in foil from IC6-10 to pin 52 and add jumper from IC6-10 to pin 42 (this allows you the choice of storing or not storing the CR).

4. On the main "TV Typewriter" board, remove the wiring between switch S2 and pin 32 and add wiring to bring +12 volts to pin 32.

Notes: 1. When you elect to store CR and you type a CR on the TV Typewriter, an M will appear on the screen. Typing a LF (line feed) will produce a J. This is because the character generator is designed for only 6 bits. The Teletype printout will be OK.

2. If you wish to use the "TV Typewriter" *without* the input/output board, jump pins 42 and 52.

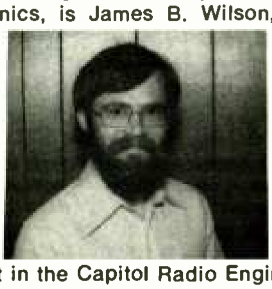
Teletype information

The input terminal strip of the Teletype must be connected to provide full duplex operation using the 20-mA loop signals. This is done by moving the blue wire on the current source resistor (the large wire-wound resistor) to the 1450-ohm position. Move the brown/yellow wire from terminal 3 to 5. Move the white/blue wire from terminal 4 to 5. Move the violet wire from terminal 8 to 9. Signal input will be to terminals 6 and 7 and the output at terminals 3 and 4.

It requires 9.1 ms for a Teletype to send or receive a bit. Each charcter transmission consists of a start bit, 8 data bits, a stop bit and an idle bit. The start bit is a "space" (no current), and the stop and idle bits are each a "mark" (current). **R-E**

Gernsback Award goes to Jim Wilson and Richard Mitchell

Another winner of the Hugo Gernsback Scholarship Award, a $125 check given annually to a student in each of eight leading home-study schools of electronics, is James B. Wilson, Jr., a



student in the Capitol Radio Engineering Institute (CREI). The Award is in memory of Hugo Gernsback, who throughout his life devoted much time and energy to encouraging young men in the study of radio and electronics.

Mr. Wilson, 24, a Nebraskan, has just moved to Lincoln with his wife Lorraine and three-month-old daughter Kyla, where he has been transferred to the Video Tape Duplication Center of the Nebraska Educational Network, as a recording engineer. Previously he was a transmitter engineer for the Network at KRNE-TV for six months, then was transferred to KLNE-TV, with remote of KHNE-TV, where he has been for the past year and a half.

During that time he completed CREI's Electronic Engineering Technology program, with a major in Television Engineering Technology, and gone on to additional majors. These were Communications Engineering, Automatic Control Engineering, and Computer Engineering technologies. Credits for these courses have been applied toward the New York Institute of Technology college credit program through CREI. He has now 47 semester hours at NYIT and is continuing his studies toward the Associate in Applied Science degree in electronic engineering technology.

Jim is an Associate Member of the Society of Motion Picture and Television Engineers (SMPTE) and of the IEEE. While at CREI he was also listed in *Who's Who Among Students in American Vocational and Technical Schools.*

The RCA WV-529-A "Service Special" VOM, given each month by RCA to the runner-up in the Scholarship Award contest, is won this month by Richard D. Mitchell, 35, of Deerfield, NJ. An ex-Marine, Mr. Mitchell began his study of electronics in the service, and later enrolled in the CREI Electronics Engineering Technology program. He has also taken courses in several other home-study schools, including Motorola, Cleveland, Jerrold, Grantham and Raytheon's training facilities.

Now confined to the house for several months following a serious auto accident, he is continuing his studies in his major of Missile and Spacecraft Guidance. Before the accident he was—and still is—employed with Control Data Corporation as a technical manager. He has held a First Class FCC license since 1959. **R-E**

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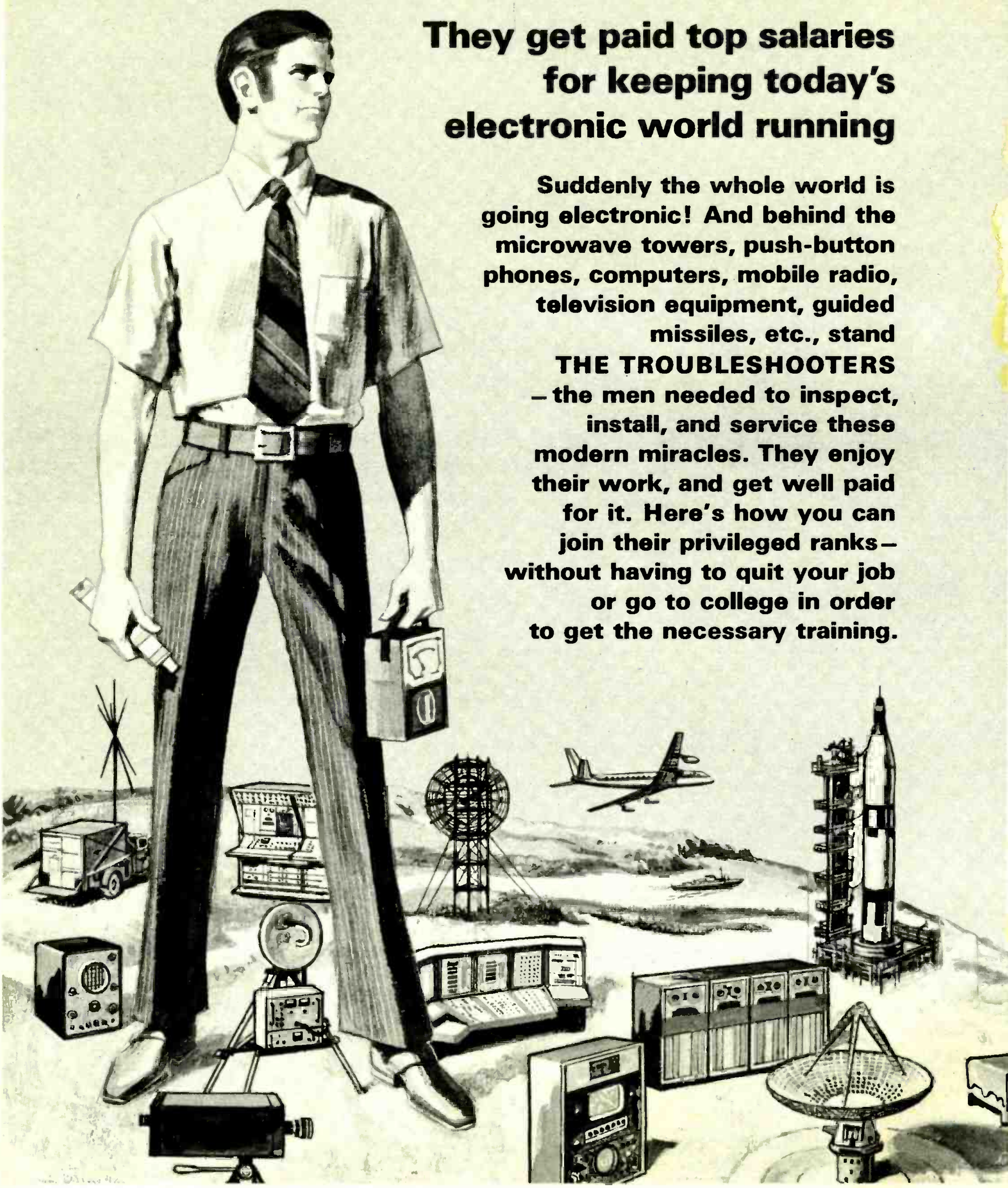

Taming The Bass

The bass reflex is still a popular speaker enclosure.
applied to it, however, is obsolete.
validity of those design goals and
be made when designing

ANY SPEAKER BOX SERVES ITS PRIME PURpose by isolating the out-of-phase backwave from the front. The more ambitious designs use the backwave to reinforce the sound from the speaker. The most popular and probably most useful of these designs is the bass reflex.

A good reflex enclosure shifts the phase of the sound waves so in-phase port radiation is effective over a specific selected band of low frequencies. The air in the port loads the speaker cone, controlling its travel at resonance. This results in lower distortion and a decrease in the peak electrical impedance of the speaker.

Each kind of speaker baffle has its own special problem. There's an old name for the one that is supposed to haunt ported enclosures; it's "boom box." Some critics see bass reflex enclosures as resonant devices that are now obsolete, but many speakers sold without enclosures are designed for bass reflex operation. These speakers offer greater efficiency and dynamic range than speakers designed for compact sealed enclosures. The only part of the bass reflex that is obsolete is much of the theory and practice applied to it.

A survey of enclosure design indicates that the perfect bass reflex would have:

1. **Box tuned** to the speaker's free-air resonance.
2. **Double impedance peaks** equal in amplitude.
3. **Double impedance peaks** equally distant from the free-air resonance.
4. **Port area equal** to the effective cone area of the speaker.
5. **Ratio of the frequency** of the two impedance peaks showing a value lower than 2.4:1.
6. **Largest possible cubic volume,** up to at least 9 cubic feet.
7. **Damping material** across the port.

Although each of these ideals are suggested by leading authorities, not one of them is valid in all cases. In all fairness, most of these statements were useful for the high-fidelity speakers being manufactured several years ago when these statements were published. Those speakers had lighter cones and a lower compliance than today's speakers. Unfortunately, boom-box folklore has not only preserved these ideas, but it has made some colorful interpretations.

Before we examine each of the seven points mentioned above, let's consider briefly how the ported enclosure works. The impedance curves of a speaker in free air, closed boxes, and ported boxes tells much of the story (See Figs. 1 and 2). We must admit that the impedance curve has no direct relationship to frequency response, but it does give us useful information. A peak in the low-frequency region of a speaker's impedance curve indicates increased cone movement at that frequency. The movement can be observed by making a frequency run with a bare speaker and watching the cone.

The frequency of maximum vibration is the fundamental cone resonance of the speaker (f_r). Frequency f_r is inversely proportional to the mass and compliance of the cone. When the speaker is installed in a closed box, the air in the box acts as a restoring force on the piston, reducing the effective compliance of the cone. The effect moves f_r to a higher frequency. The smaller the box, the greater the change in frequency (Fig. 1).

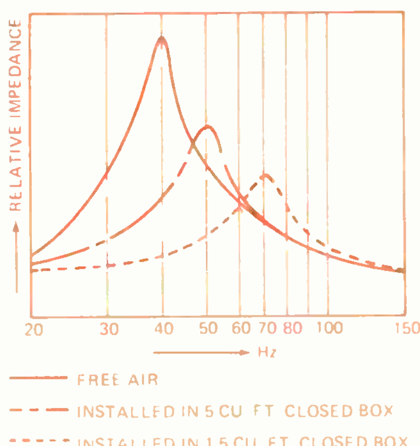

FIG. 1—IMPEDANCE CURVES of speaker used in tests described in this article.

If a port is cut in the box, the action is somewhat more complex. The air in the port moves back and forth, compressing and rarefying the enclosure air like another piston. It also radiates sound at a band of frequencies around box resonance. That resonance is determined by air volume and port area.

At vent resonance, the air velocity in the port is at a maximum. Here the system's acoustical impedance exerts the maximum load on the cone, restricting its motion. This point shows up in the impedance curve as the low point of a valley between the two new peaks (Fig. 2).

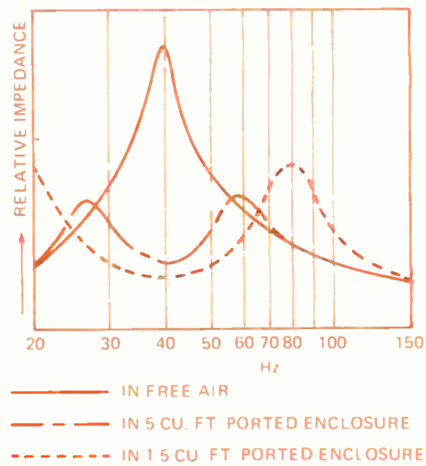

FIG. 2—IN FREE AIR and in ported enclosures, there is a marked difference in the impedance curves of the same speaker.

Tuning the enclosure

Now, to consider the first of the seven statements—Should the box be tuned to the speaker's free air resonance? Classic reflex theory say, "Yes!" The reason usually given is to control cone motion at resonance, but a contrary opinion is offered by some audio engineers. They cite the fact that a speaker's resonance changes the moment it is put into a box.

The attitude of various manufacturers on the question of tuning the box to f_r varies greatly. Jensen and Altec Lansing recommend it. University seems to favor it except for some special situations. But JBL asserts that there is no longer any good reason to follow the practice.[1] All

[1] JBL publication CF 802 *Loudspeaker Enclosure Construction Manual*, p. 8.

Reflex

Much of the design criteria
This article explores the
the considerations that should
your own bass reflex

by DAVID B. WEEMS

of these companies employ engineers who know what they are doing. The difference in opinion may arise from different design goals or differences in the speakers they manufacture.

An important consideration in some cases is to locate the vent resonance where the system will produce the best frequency response curve, although frequency response isn't everything. This requirement will put the box resonance at some point down to, but usually not below, the free-air resonance of the speaker. Tuning the box below f_r will extend the low-frequency range, but may, in some cases, increase distortion above system resonance where the load on the speaker falls off at a frequency that is too low for that particular speaker.

For speakers with a bass resonance between 40 and 60 Hz, tuning the box to f_r should produce good results. For speakers with a fundamental resonance very much below 40 Hz, it's a different problem.

To cite an extreme case, some low-resonance speakers with an f_r of 20 Hz or below are designed to be used in compact ducted enclosures. If a ported enclosure were tuned to such a low frequency, the middle bass response would suffer because the air in the port offers a reactance to high frequencies which begins to be effective 3 or 4 octaves above resonance. This reactance, which makes a ported enclosure act like a sealed box at high frequencies, would start cutting off response around 80 Hz in a box tuned to 20 Hz. This would leave a dip in the response curve up to some point, depending on cone size, where cone radiation is fully effective. Systems using these speakers might better be tuned to 40 or 50 Hz.

Some speakers have bass resonant frequencies between 25 and 40 Hz. While the dip in frequency response mentioned above might not be objectionable in a system tuned in the region of 25 to 40 Hz, a higher tuning may be more desirable.[2] One reason is that the danger point, for hangover, is the frequency of the upper impedance peak. By setting the box resonance above that of the speaker, the amplitude of the upper peak is reduced (Fig. 3). This does not automatically reduce frequency response at that point, but hangover trouble is not necessarily frequency-response trouble. For modern amplifiers, which may be considered constant-voltage devices, a rise in speaker impedance results in less power drawn from the amplifier. (This may be shown by applying Ohm's Law with a constant voltage.) The reduced power does not mean reduced sound output. The output of the cone and the port are exactly in phase at the upper peak. And a rise in impedance coincides with increased cone movement, so there is lower electrical damping on the speaker here and a greater tendency for hangover to occur.

It may be argued that what is gained in electrical damping at the reduced upper peak is lost in the increased amplitude of the lower peak (Fig. 3 again). At the range of frequencies cited above, the lower peak occurs too far down the frequency range to be noticeable. The objective of tuning to a frequency above f_r is twofold: to improve port radiation in a useful frequency range, and to control cone movement and improve transient response at a frequency band around the upper impedance peak. Looking back to number 2 of our seven points—equal peak amplitudes—we can say, "Not necessarily!"

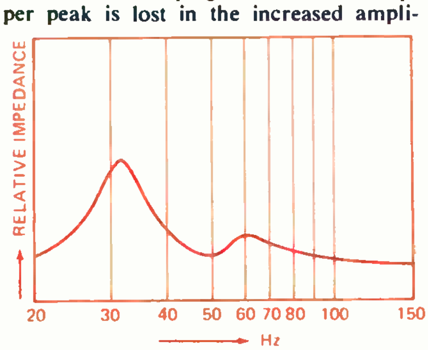

FIG. 3—SPEAKER'S IMPEDANCE CURVE WHEN installed in a 5-cubic foot enclosure that is tuned to a frequency above f_r when f_r is 40 Hz, and the enclosure is tuned to 50 Hz.

Going to point 3 on our list of cliches—Should the frequency of the double peaks be equally distant from the resonant frequency? Presumably, this point was meant to apply in those cases where the enclosure is to be tuned to f_r, so let's consider that situation.

The equal distance theory is often repeated and is true in one sense, that the distance is measured on a graph and the graph is plotted on semi-log paper. What should be equal is two *ratios* involving the peak frequencies. One is the ratio of the upper impedance peak to f_r, and the other is the ratio of f_r to the lower impedance peak. For example, in the 1.5 cu-ft box in Fig. 2, the frequency of the upper peak (f_2) is 80, f_r is about 40, and the frequency of the lower peak (f_1) appears to be 20. (The test equipment used here did not go below 20 Hz, but the amplitude appears to be equal to that at 80). The ratio of f_2/f_r is 80/40 or 2:1. The ratio of f_r/f_1 is 40/20 or 2:1. To tune to f_r, you can check to see if the two ratios are equal. It is quicker to locate a frequency than the impedance amplitude at that frequency. And some test equipment can't reliably measure an amplitude peak in the 20 to 30 Hz frequency range.

Easy tuning

Even if you know where to tune an enclosure, the mechanics of doing it can be a drag. The usual advice is to make the port too large and use an adjustable panel to narrow it down to the correct size. But compact enclosures usually require ducts behind the port (see Table I). These increase the mass of the air in the port and permit the enclosure to be tuned to a frequency low enough to be practical. In such cases, the tuning can be simplified by using mailing tubes or carpet roll tubes. Carpet tubes usually have a wall thickness of ¼ inch and an inside diameter of 3 inches, a useful size for many enclosures.

A hole in the baffle, cut to make a snug fit for the tube, will accept tubes of different lengths. The tubes may be tried from outside the enclosure. Tuning will be approximately the same as when the tubes are located behind the baffle.

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[2] Badmaieff and Davis: *How To Build Speaker Enclosures*, Sams, Bobbs-Merril, 1966, p. 65.

An assortment of different lengths can be tried until the proper length is determined. The setup is shown in the photo. This method has the great advantage that the testing can be done from outside without removing the back for each trial. When tuned, the proper tube can be permanently installed with wood glue.

The resonant frequency of an empty enclosure may be determined by mounting a panel with a small hole (about 3/16 inch) over the speaker opening. A small speaker can be installed over the hole, and fed from an audio generator or frequency test record (see Figs. 4 and 5). Box resonance can be detected by listening for a peak in output at the port. The small hole is needed to damp any resonances in the small speaker.

Enclosure size

Points 4, 5, and 6 can be considered together. All three statements are related to the cubic volume of an enclosure. The larger the enclosure, the greater the port area needed to tune the enclosure to a given frequency. The classic bass reflex usually sets the port area equal to the effective cone area of the speaker. Then the ideal cubic volume was chosen, that volume which would tune the enclosure to f_r with such a port. For modern speakers, this practice results in enormous enclosures. For example: to tune an enclosure with a 12-inch speaker to 40 Hz, with port area equal to effective cone area, the volume would be 15 cubic feet.

Aside from the chances of getting enclosures of such dimensions into the average home, their performance would not always be satisfactory. James F. Novak, senior design engineer at Jensen, is a leading exponent of the theory that an optimum volume exists for each loudspeaker. Novak says that a cabinet that is too big will add boom without extending the bass. He bases his choice of optimum volume on that enclosure which will give the best transient response. Novak says that the requirements of the optimum volume concept are met when the closed box raises the resonant frequency of the speaker to about 1.6 times the free air resonance.[3] For the speaker used in the tests reported here, with f_r of 40 Hz, the closed-box frequency should be about 64 Hz. A look at Fig. 1 shows that the 5 cu-ft box is too large (50 Hz), and the 1.5 cu-ft box (70 Hz) is too small for optimum performance.

Another way to locate Novak's optimum volume is by the ratio of the frequencies of the double impedance peaks. These peaks appear farther apart in a small enclosure than in a large one (see Fig. 2). According to Novak, the optimum volume enclosure, when tuned to f_r, would have the upper peak at 3.13 times the frequency of the lower peak. In the 1950's, the value 2.4 was given as the maximum allowable.[4] This lower value would indicate a much larger enclosure. But the reason for the change becomes more apparent when one considers the difference between loudspeakers of today and then. The typical speaker of the 1950's had a stiffer suspension and, consequently, a higher resonance. A small enclosure would have put the upper impedance peak too high in frequency, causing a severe loss of bass. Any system will cut off at some point below the upper impedance peak.

Perhaps not everyone would choose Novak's specific figures, but there is general consensus on the desirability of selecting a volume that is neither too large nor too small. The danger of the small enclosure has already been noted —a rise in the hangover frequency and loss of bass.

There is probably less agreement about maximum volume. But even if one's goal is extended bass, without consideration of optimum transient response, there is a point beyond which the enlarging process bumps into the law of diminishing returns. Here is a concrete example. Novak says that a Jensen SG80 loudspeaker, when mounted in a box of optimum volume (about 1 cubic foot), has a cut off point of 50 Hz. If the volume is doubled to 2 cubic feet, the cut off point is reduced to 46 Hz. Thus by doubling the volume, one gains only 4 Hz. This shows one of the most valuable features of the optimum volume concept. Every speaker system is a compromise between mutually

TABLE I. APPROXIMATE PORT AREA REQUIRED TO TUNE MODERATE VOLUME ENCLOSURES TO FREQUENCIES BETWEEN 40 TO 60 HZ.

VOLUME (cu. ft.)	PORT AREA (sq. in.)		
6	18	36	75
5	14	30	50
4	10	20	36
3	T-1½	12	22
2.5	T-3	8	16
2	T-4	T-1½	10
1.5	T-6	T-3	T-1½
	40	50	60
	Box Frequency (Hz)		

Numbers preceded by letter "T" indicate that a 3-inch I.D. tube must be used in the length mentioned. For example, to tune a 2 cu. ft. enclosure to 50 Hz., the tube should be 1½ inches long.

These figures tend to be high to allow for adjustment. Tune by decreasing port or trimming tube length for best results.

The above chart should be suitable for most modern speaker/box combinations. A good example of a more complete chart is the one published in Jensen Tech Note 1004A.

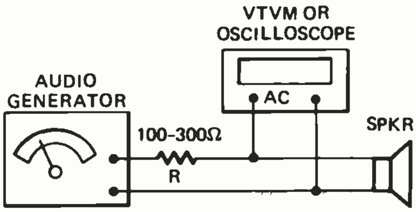


FIG. 4 — TEST SETUP TO TUNE ENCLOSURE. The variation in ac voltage across the voice coil with frequency is noted. Since voltage varies directly as impedance, the voltage readings may be used as relative impedance for the purpose of tuning the enclosure.

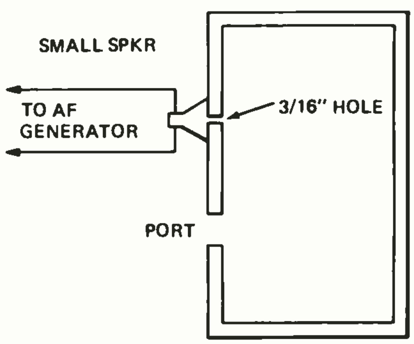


FIG. 5—SETUP FOR DETERMINING natural resonance of an empty ported box (see text for details). This method may also be used to tune an empty box to any desired frequency before a high-fidelity speaker is installed. Any change due to volume occupied by the speaker is insignificant. Unless a large speaker is mounted in a small enclosure. A frequency test record may be substituted for the audio generater and the resonance point estimated with a stop watch.

TABLE II. LITERATURE ON PORTED ENCLOSURES PUBLISHED BY LOUDSPEAKER MANUFACTURERS

ALTEC LANSING:	"Speaker Enclosures, Their Design and Use." $1.00 from Altec Lansing, 1515 South Manchester Ave., Anaheim, CA 92803.
ELECTRO-VOICE:	"Bass Reflex Design Handbook." Electro-Voice, Buchanan, MI 49107.
JBL:	"Loudspeaker Enclosure Construction Manual." 50c from JBL, 3249 Casitas Ave., Los Angeles, CA 90039.
JENSEN:	Jensen Tech Note 1004A, "How to Design and Construct Speaker Enclosures." Jensen Mfg. Div., The Muter Co., 6601 South Laramie Ave., Chicago, IL 60638.
UNIVERSITY:	Instruction sheets for various loudspeaker models. University Sound, P.O. Box 1056, Oklahoma City, OK 73101.

[3] James F. Novak: *"Baffle: Speaker-Air Interface"*; **Radio-Electronics, June, 1967, p. 51.**

[4] F. Langford Smith, *Radiotron Designer's Handbook*, 4th Ed; RCA, 1953, p. 847.

opposing factors. Novak's concept is a useful point from which to work in considering how large an enclosure should be.

Damping materials

Is the port a good location for damping materials (point 7)? One reason cited in favor of it, is that particle velocity is greatest in the port and is zero at the walls, the other popular location.

The answer to that argument has been hinted above, that the danger point in most reflex enclosures is at the frequency of the upper impedance peak, not the port frequency. Putting a resistance to air flow in the port defeats the action of the port in augmenting bass response and loading the speaker.

The most important function of damping material is to absorb reflected sound in the mid-range and high frequencies. Although the port tends to discriminate against the emergence of those frequencies, they will be reflected through the speaker cone if not damped.

The recommended thickness for damping material is usually 1 inch to 2 inches. It normally covers from about one-half to the whole interior wall surface, except for the speaker panel. When only part of the interior is covered, the damping material should be installed on one of each pair of opposite surfaces. For example, one side, the ceiling, and the back. The final amount depends upon the characteristics of the speaker, the room, and the personal taste of the listener. But the damping is more effective if the material is spaced a short distance away from the wall. Novak recommends the use of a fiberglass covering for the speaker itself.

If the enclosure is filled with damping material, the operation of the enclosed air is changed from adiabatic to isothermal. This decreases the velocity of sound within the box. Wavelength, which is proportional to velocity, is likewise reduced. The net result is to make the enclosure act larger with respect to wavelength. Although "stuffing" expands the effective volume, it uses up some audio power, and can lead to overdamping and loss of bass.

Stuffing can be used in some problem situations to good advantage. For example, in the case of a bad speaker/box mismatch, where major surgery is impractical, stuffing may improve the sound. The problem of how much stuffing can be solved by trial and error as can that of how much damping material to add to any enclosure. A simple listening test will probably give satisfactory results if one knows what to listen for.

Which brings us to one of the most overlooked sources of information, the manufacturer. Almost any of the name brand speaker makers will supply instructions for ported enclosures. Information sheets are free, but more complete bulletins are often available at nominal cost (see Table II).

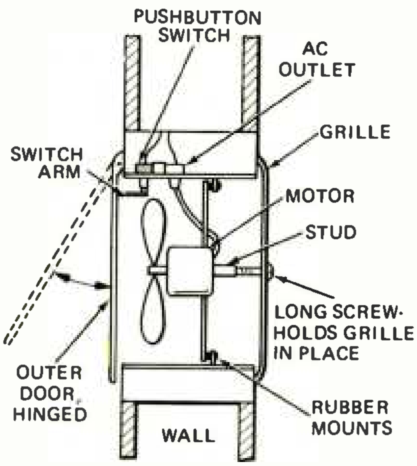
We must admit that the ported enclosure requires considerably more attention to detail than the sealed enclosure if its special virtues are to be realized. But given careful design and competent execution, it is worth the effort. **R-E**

appliance clinic

EXHAUST FANS

by JACK DARR
SERVICE EDITOR

ONE USEFUL ELECTRICAL APPLIANCE that is practically never seen, and ideally, not heard either, is the wall-mounted exhaust fan. Once used almost exclusively in the kitchen, they're found in interior bathrooms, laundry rooms, and at any place where forced ventilation is needed. The diagram is a side view of a typical exhaust fan installation.



These are standard electric fans of various sizes. They're mounted in a metal box, which is built into the wall. Covering the outside of the unit is a top-hinged lid to keep rain out and an ornamental grille is used on the inside for protection against the fan blades. The fan-motor is mounted on rubber bushings to hold down the noise. The on-off switch is usually operated by an arm on the outer door, which is opened and closed by a chain, lever, etc. from inside the house.

Medium-sized induction motors are used, without brushes. Most motors of this type are lubricated with good sized oil-wicks in the end bells. Very little lubrication is needed, and only if the fan sounds "draggy" or makes noise. When oiling, use a light oil and put only a few drops in each end.

To get at the fan for checking, take out the long screw usually found in the center of the inside grille. To check for lubrication, spin the blades with your fingers. They should turn freely and coast for quite a while. The motor housings of these fans are well-sealed, but after long use, some fine dust or dirt may have gotten in.

If the fan won't run at all, pull the plug; this will be plugged into a special outlet inside the housing. Push the door out to turn the switch on, and check for the presence of ac voltage in the outlet. If no voltage is present, check the switch. To do this, push the switch button with your finger several times and listen to the sound. It should make a clean "click". If it doesn't, the switch could be dirty. Try squirting some contact-cleaner into the edges of the box. Since it would be dangerous to use the fan itself to tell when the switch is working, plug your neon voltage-tester into the outlet. Push the switch and watch for the light.

Exhaust fans in kitchens often pick up quite a coating of grease from cooking vapors. This picks up lint and dust, and can even stick on the fan-blades thickly enough to unbalance them. The grille, if it has small openings, can clog up too. This is not hard to clean off. To clean the grille, take it off and wash it in a solvent. DO NOT use flammable solvents.

The easiest way to clean the grille is to make up a dish full of solution with any of the modern laundry detergents. Then, just drop the grille in it, and let it soak for about 15 minutes. This will soften the grease, enough so that it can be brushed off.

While you're waiting for the grille to soak, you can be cleaning the fan blades. The dirt may be scraped off these with a dull knife, and then soaked with detergent on a cloth. Don't use too much, which will make things very messy. If the fan has a heavy accumulation, it can usually be taken out by undoing the mounting bolts. When handling the fan, be sure that you do not bend the blades.

Before putting the fan back (or every time the fan is inspected and cleaned) check the condition of the short line-cord from motor to plug. Since the fan runs in fairly hot air, and high concentrations of oily vapor, this may have caused a deterioration of the insulation. If you see any signs of cracking in the insulation, take the fan out and replace the line cord. The vibration could cause the cord to hit the housing, resulting in a dangerous short. For safety, these fans should be wired up with the 3-wire "safety-ground" system. **R-E**

EQUIPMENT REPORT

(continued from page 25)

the bottom of the panel. An indicator light is mounted near each one of these. These lights tell you whether No. 1, No. 2 or No. 3 is the control element; base or gate, when it's lit.

For in-circuit testing on PC boards, a sharp pointed 3-pin probe is available. Since all you need do is make contact with all three terminals of the transistor, without hunting up the basing, this is fast and easy. The probe can be held in one hand while the other turns the switch on. For unidentified transistors, this gives you the base, and the other two are easy to find.

Diodes of all kinds are tested with the No. 1 and No. 3 terminals or leads. These can be checked in-circuit or out. The P or N LED lights indicate which lead is on the cathode of the diode. (The diode symbol is printed right on the panel, bless them.)

A two-way switch is used; center is off, one way is for transistor testing, the other for diodes. If you leave it in either ON position, several lights blink, so that there's no excuse for running the batteries down. Even if this switch is left on, an automatic switch turns it off when the case is closed. The unit is powered by two stock 9-volt transistor batteries or by two 9-volt NiCad batteries. The latter can be recharged with an optional plug-in charging unit. The jack for this is already on the case and hooked up.

We ran this unit through the mill, testing everything we could find, to try and catch it. It came through. It spotted bad, and good transistors, in such things as TV tuners (in a cascode mixer circuit), TV antenna boosters, avionics equipment, amplifiers and you name it.

As in all in-circuit transistor testers, there is always the chance that a circuit fault, or an oddball circuit, will make a transistor read bad when it isn't. But these are rare. They occur mostly in cases where there is a very low impedance, or a large capacitance, directly across the transistor. If you're in doubt, take the transistor out and recheck. If it reads GOOD now, there is something wrong in the circuitry.

The manual specifies "maximum in-circuit loads" from one lead to any other, as 500 ohms or 0.2 μF, or any combination having an equivalent impedance of 500 ohms at 1.0 kHz. You can usually spot this from the schematic, and/or circuit behavior. Any device that refuses to check, such as a programmable UJT, *can* be checked by checking it as a "set of diodes", very quickly and accurately. If all of these are good, then the thing is OK.

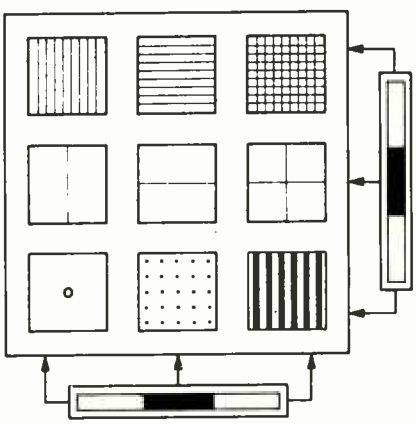
The Model 215 is fast, and it is most definitely automatic. It gives you test results that are unmistakable, in a hurry. Its miniature size makes it easy to take along. The tough plastic case will let you carry it in a caddy or even a toolbox. All in all, quite a little piece of test equipment.

Hickok Model 239 Pocket Color-Bar Generator

Circle 59 on reader service card

THE OTHER "INFANT" (SIZE-WISE only) is the Hickok model 239 Pocket Color-Bar Generator. Almost the same size (it's 1/8 inch narrower) it's a real smart kid for its age. Using the same MOS FET technology as the Model 215, this one generates every one of the standard color convergence patterns needed for setting up and servicing any color TV set. Beside the regular patterns, a few special ones come in very handy.

The model 239 provides a total of nine patterns: a standard 10-bar keyed rainbow (I should say "gated" rainbow, since this is more nearly correct), dot and crosshatch (15 x 21 pattern), vertical lines (21 of them) horizontal lines (15 of them), plus a single vertical, or a single horizontal line, a single dot, and a single crosshatch (one vertical and one horizontal line crossing at the center). Very useful for centering adjustment. These patterns can be selected by a novel "matrix switch", looking like a pair of three position slide-switches, one at the side and the other across the bottom (see diagram).



MATRIX SWITCH for selecting patterns, on the Model 239. In the position shown, the center pattern will be seen. Each switch has three positions.

A CHROMA-LEVEL control, also a slider type, is at the left side. It allows adjustment up to 150% of normal color amplitude. The ON-OFF switch is automatic; when you open the case, it's ready to go. An ample length of 300-ohm twin-lead, with clips, is permanently attached to the instrument. The model 239 can be tuned to any of three low-band TV channels: 2, 3 or 4. It comes from the factory set on Ch. 2, but can be instantly reset to any of the other two. The adjustment is made with a plastic screwdriver through a hole in the front pahel.

Like its twin, the 239 is powered by two 9-volt batteries, and can also be used with NiCad batteries, and the charger. The input jack is already on the case. As usual with MOS circuitry, the battery drain is very low.

A very comprehensive instruction book comes with the 239, covering all kinds of convergence adjustments, even purity. This book in itself should be very useful to novice technicians. **R-E**

R-E's Substitution guide for replacement transistors

PART XXIII

by ROBERT & ELIZABETH SCOTT

ARCH—Indicates the Archer brand of semiconductors sold only by Radio Shack and Allied Radio stores. Allied Radio Shack, 2725 W. 7th St., Ft. Worth, Texas 76107

DM—D. M. Semiconductor Co., P.O. Box 131, Melrose, Mass. 02176

G-E—General Electric Co., Tube Product Div., Owensboro, Ky. 42301

ICC—International Components, 10 Daniel Street, Farmingdale, N.Y. 11735

IR—International Rectifier, Semiconductor Div., 233 Kansas St., El Segundo, Calif. 90245

MAL—Mallory Distributor Products Co., 4760 Kentucky Ave., Indianapolis, Ind. 46241

MOT—Motorola Semiconductors, Box 2963, Phoenix, Ariz. 85036

RCA—RCA Electronic Components, Harrison, N.J. 07029

SPR—Sprague Products Co., 65 Marshall St., North Adams, Mass. 01247

SYL—Sylvania Electric Corp., 100 1st Ave., Waltham, Mass. 02154

WOR—Workman Electronic Products, Inc., Box 3828, Sarasota, Fla. 33578

ZEN—Zenith Sales Co., 5600 W. Jarvis Ave., Chicago, Ill. 60648

Radio-Electronics has done its utmost to insure that the listings in this directory are as accurate and reliable as possible; however, no responsibility is assumed by Radio-Electronics for its use. We have used the latest manufacturers material available to us and have asked each manufacturer covered in the listing to check its accuracy. Where we have been supplied with corrections, we have updated the listing to include them. The first part of this Guide appeared in March 1973.

	ARCH	DM	G-E	ICC	IR	MAL	MOT	RCA	SPR	SYL	WOR	ZEN
2N5245	NA	TF-0021	GE-FET-2	ICC-F0021	NA	PTC 152	HEP-F0021	SK 3116	RT-175	ECG 132	NA	NA
2N5246	NA	TF-0021	GE-FET-2	ICC-F0021	NA	PTC 152	HEP-F0021	SK 3116	RT-175	NA	NA	NA
2N5247	NA	TF-0021	GE-FET-2	ICC-F0021	NA	PTC 152	HEP-F0021	SK 3116	RT-175	NA	NA	NA
2N5248	NA	T-802	GE-FET-2	ICC-802	NA	PTC 151	HEP-802	SK 3116	RT-175	ECG 132	WEP-802	ZEN 123
2N5249	NA	NA	GE-62	NA	IRTR-87	PTC 121	NA	SK 3024	RT-114	ECG 199	WEP-243	NA
2N5252	NA	TS-3021	GE-32	ICC-S3021	NA	NA	HEP-S3021	NA	NA	NA	WEP-3021	ZEN 208
2N5253	NA	TS-3022	GE-32	ICC-S3022	NA	NA	HEP-S3022	NA	NA	NA	WEP-3021	NA
2N5254	NA	T-52	NA	ICC-52	NA	PTC 103	HEP-52	NA	RT-103	NA	WEP-52	NA
2N5255	NA	T-715	NA	ICC-715	NA	PTC 127	HEP-715	NA	RT-115	NA	WEP-715	ZEN 106
2N5256	NA	NA	NA	ICC-715	NA	PTC 127	HEP-715	NA	RT-115	NA	WEP-715	ZEN 106
2N5258	NA	NA	GE-FET-2	NA	NA	PTC 152	NA	NA	RT-175	NA	NA	NA
2N5262	NA	TS-3010	GE-66	ICC-S3010	NA	NA	HEP-S3010	SK 3529	RT-164	NA	NA	ZEN 207
2N5264	NA	T-707	NA	ICC-707	NA	PTC 118	HEP-707	NA	NA	ECG 162	WEP-707	ZEN 204
2N5267	NA	T-801	NA	NA	NA	PTC 152	NA	SK 3112	RT-175	ECG 133	WEP-801	NA
2N5268	NA	T-801	NA	NA	NA	PTC 152	NA	SK 3112	RT-175	ECG 133	WEP-801	NA
2N5269	NA	T-801	NA	NA	NA	PTC 152	NA	SK 3112	RT-175	ECG 133	WEP-801	NA
2N5270	NA	T-801	NA	NA	NA	PTC 152	NA	SK 3112	RT-175	ECG 133	WEP-801	NA
2N5272	RS276-2009	T-53	NA	ICC-53	NA	PTC 123	HEP-53	NA	RT-113	ECG 108	WEP-56	ZEN 102
2N5273	NA	SR-1473	NA	ICC-R1473	NA	NA	HEP-R1473	NA	NA	ECG 5683	NA	NA
2N5274	NA	SR-1475	NA	ICC-R1475	NA	NA	HEP-R1475	NA	NA	ECG 5685	NA	NA
2N5275	NA	NA	NA	NA	NA	NA	NA	NA	NA	ECG 5697	NA	NA
2N5277	NA	NA	GE-FET-1	NA	NA	PTC 151	NA	SK 3112	RT-175	ECG 133	WEP-801	NA
2N5278	NA	NA	NA	NA	NA	PTC 152	NA	SK 3116	RT-175	NA	NA	NA
2N5292	RS276-2015	T-720	NA	ICC-720	NA	PTC 131	HEP-720	NA	RT-113	ECG 108	WEP-56	ZEN 109
2N5293	NA	TS-5000	GE-66	ICC-S5000	NA	PTC 137	HEP-S5000	SK 3054	RT-152	ECG 152	WEP-S5003	NA
2N5294	NA	TS-5000	GE-66	ICC-S5000	NA	PTC 137	HEP-S5000	SK 3054	RT-152	ECG 152	WEP-S5003	NA
2N5295	NA	TS-5003	GE-66	ICC-S5003	TR-55	PTC 137	HEP-S5003	SK 3054	RT-152	ECG 152	WEP-S5003	ZEN 210
2N5296	RS276-2018	TS-5003	GE-28	ICC-S5003	IRTR-76	PTC 137	HEP-S5003	SK 3054	RT-154	ECG 152	WEP-S5003	ZEN 210
2N5297	NA	TS-5000	GE-66	ICC-S5000	NA	PTC 137	HEP-S5000	SK 3054	RT-154	ECG 152	WEP-S5003	NA
2N5298	NA	TS-5000	GE-66	ICC-S5000	NA	PTC 137	HEP-S5000	SK 3054	RT-154	ECG 152	WEP-S5003	NA
2N5301	NA	TS-7000	GE-75	ICC-S7000	TR-36	NA	HEP-S7000	NA	RT-149	NA	WEP-S7000	NA
2N5302	NA	TS-7000	GE-75	ICC-S7000	TR-36	NA	HEP-S7000	NA	RT-149	NA	WEP-S7001	NA
2N5303	NA	TS-7000	GE-75	ICC-S7000	TR-36	NA	HEP-S7000	NA	RT-149	NA	WEP-S7001	NA
2N5305	NA	NA	GE-64	NA	TR-69	PTC 153	NA	NA	NA	ECG 172	WEP-WS9100	NA
2N5306	NA	TS-9100	GE-64	ICC-S9100	IRTR-69	PTC 153	HEP-S9100	NA	NA	ECG 172	WEP-WS9100	ZEN 128
2N5307	NA	NA	GE-64	NA	NA	PTC 153	NA	NA	NA	ECG 172	WEP-WS9100	NA
2N5308	NA	TS-9100	GE-64	ICC-S9100	IRTR-69	PTC 153	HEP-S9100	NA	NA	ECG 172	WEP-WS9100	ZEN 128
2N5309	NA	T-713	GE-62	ICC-713	IRTR-87	PTC 121	HEP-713	SK 3024	RT-114	ECG 128	WEP-53	NA
2N5310	NA	T-713	GE-62	ICC-713	IRTR-87	PTC 121	HEP-713	SK 3024	RT-114	ECG 128	WEP-53	NA
2N5311	NA	TS-0001	GE-62	ICC-S0001	IRTR-87	PTC 144	HEP-S0001	SK 3024	RT-114	ECG 128	WEP-712	ZEN 125
2N5320	NA	TS-3002	NA	ICC-S3002	TR-25	PTC 110	HEP-S3002	SK 3512	NA	ECG 192	WEP-3002	NA
2N5321	NA	TS-3010	GE-28	ICC-S3010	NA	NA	HEP-S3010	SK 3512	NA	NA	WEP-3003	ZEN 207
2N5322	NA	TS-3003	GE-28	ICC-S3003	TR-30	PTC 111	HEP-S3003	NA	RT-126	ECG 106	WEP-3003	NA
2N5323	NA	TS-3003	NA	ICC-S3003	NA	PTC 141	HEP-S3003	SK 3513	RT-115	NA	WEP-S3003	NA
2N5324	NA	T-234	GE-25	ICC-234	TR-27	PTC 122	HEP-234	NA	NA	NA	WEP-235	NA
2N5325	NA	T-235	GE-25	ICC-235	TR-27	PTC 122	HEP-235	NA	NA	NA	WEP-235	ZEN 328
2N5332	RS276-2023	T-52	NA	ICC-52	NA	PTC 103	HEP-52	NA	NA	NA	WEP-52	NA
2N5333	NA	NA	NA	NA	NA	PTC 111	NA	NA	RT-155	NA	NA	NA
2N5334	NA	TS-3010	GE-66	ICC-S3010	NA	NA	HEP-S3010	NA	RT-154	NA	WEP-S3003	ZEN 207
2N5335	NA	TS-3002	NA	ICC-S3002	NA	NA	HEP-S3002	NA	NA	NA	WEP-S3002	NA
2N5336	NA	TS-3002	NA	ICC-S3002	NA	NA	HEP-S3002	NA	NA	NA	WEP-S3002	NA
2N5337	NA	TS-3002	NA	ICC-S3002	NA	NA	HEP-S3002	NA	NA	NA	WEP-S3002	NA
2N5352	NA	NA	NA	NA	NA	PTC 127	NA	NA	RT-126	ECG 106	WEP-52	NA
2N5354	RS276-2021	T-51	GE-22	ICC-51	TR-20	PTC 127	HEP-51	SK 3114	RT-115	ECG 159	WEP-51	ZEN 101
2N5355	RS276-2021	T-51	NA	ICC-51	TR-88	PTC 127	HEP-51	SK 3114	RT-115	ECG 159	WEP-51	ZEN 101
2N5356	RS276-2021	T-716	NA	ICC-716	NA	PTC 127	HEP-716	SK 3114	RT-115	ECG 159	WEP-716	ZEN 107
2N5358	NA	NA	GE-FET-1	NA	NA	PTC 151	NA	SK 3112	RT-175	NA	WEP-801	NA
2N5359	NA	NA	GE-FET-1	NA	NA	PTC 151	NA	SK 3112	RT-175	NA	WEP-801	NA
2N5360	NA	NA	GE-FET-1	NA	NA	PTC 151	NA	SK 3112	RT-175	NA	WEP-801	NA
2N5361	NA	NA	GE-FET-1	NA	NA	PTC 152	NA	SK 3116	RT-176	NA	WEP-801	NA
2N5362	NA	NA	GE-FET-1	NA	NA	PTC 152	NA	SK 3116	RT-176	NA	WEP-801	NA
2N5363	NA	NA	GE-FET-1	NA	NA	PTC 152	NA	SK 3116	RT-176	NA	WEP-801	NA
2N5364	NA	NA	GE-FET-1	NA	NA	PTC 152	NA	SK 3116	RT-176	NA	WEP-801	NA
2N5365	RS276-2021	T-716	GE-21	ICC-716	NA	PTC 127	HEP-716	SK 3114	RT-115	ECG 159	WEP-716	ZEN 107
2N5366	RS276-2021	T-716	GE-21	ICC-716	NA	PTC 127	HEP-716	SK 3114	RT-115	ECG 159	WEP-716	ZEN 107
2N5367	RS276-2021	T-716	NA	ICC-716	NA	PTC 127	HEP-716	SK 3114	RT-115	ECG 159	WEP-716	ZEN 107
2N5368	RS276-2009	T-736	GE-20	ICC-736	TR-21	PTC 136	HEP-736	SK 3122	RT-102	ECG 123A	WEP-736	ZEN 120
2N5369	RS276-2009	T-736	GE-20	ICC-736	TR-21	PTC 136	HEP-736	SK 3122	RT-102	ECG 123A	WEP-736	ZEN 120
2N5370	RS276-2009	T-736	NA	ICC-736	TR-21	PTC 123	HEP-736	SK 3122	RT-102	ECG 123A	WEP-736	ZEN 120
2N5371	RS276-2009	T-53	NA	ICC-53	TR-21	PTC 136	HEP-53	SK 3122	RT-102	ECG 123A	WEP-53	ZEN 102
2N5372	RS276-2021	T-708	GE-21	ICC-708	NA	PTC 103	HEP-708	SK 3114	RT-115	ECG 159	WEP-52	NA
2N5373	RS276-2021	T-708	GE-67	ICC-708	NA	PTC 127	HEP-708	SK 3114	RT-115	ECG 159	WEP-52	NA
2N5374	RS276-2021	T-708	GE-67	ICC-708	NA	PTC 127	HEP-708	SK 3114	RT-115	ECG 159	WEP-52	NA
2N5375	RS276-2021	T-716	GE-67	ICC-716	NA	PTC 103	HEP-716	SK 3114	RT-115	ECG 159	WEP-716	ZEN 107
2N5376	RS276-2009	T-736	NA	ICC-736	NA	PTC 123	HEP-736	NA	RT-109	NA	WEP-736	ZEN 120
2N5377	RS276-2009	T-736	NA	ICC-736	NA	PTC 136	HEP-736	NA	RT-109	NA	WEP-736	ZEN 120
2N5378	RS276-2021	T-716	GE-67	ICC-716	NA	PTC 127	HEP-716	SK 3114	RT-115	ECG 159	WEP-716	ZEN 107
2N5379	RS276-2021	T-716	GE-67	ICC-716	NA	PTC 127	HEP-716	SK 3114	RT-115	ECG 159	WEP-716	ZEN 107
2N5380	RS276-2009	T-736	GE-20	ICC-736	TR-21	PTC 136	HEP-736	SK 3122	RT-102	ECG 123A	WEP-736	ZEN 120
2N5381	RS276-2009	T-736	GE-20	ICC-736	NA	PTC 136	HEP-736	NA	RT-109	ECG 159	WEP-736	ZEN 120
2N5382	NA	T-716	GE-21	ICC-716	NA	PTC 103	HEP-716	SK 3114	RT-115	ECG 159	WEP-716	ZEN 107
2N5383	NA	T-716	NA	ICC-716	NA	PTC 127	HEP-716	SK 3114	RT-115	NA	WEP-716	ZEN 107

NA=NOT AVAILABLE

(turn page)

	ARCH	DM	G-E	ICC	IR	MAL	MOT	RCA	SPR	SYL	WOR	ZEN
2N5391	NA	NA	GE-FET-1	NA	NA	PTC 151	NA	SK 3112	RT-175	NA	WEP-801	NA
2N5392	NA	NA	GE-FET-1	NA	NA	PTC 152	NA	SK 3116	RT-176	NA	WEP-801	NA
2N5393	NA	NA	GE-FET-1	NA	NA	PTC 152	NA	SK 3116	RT-176	NA	WEP-801	NA
2N5394	NA	NA	GE-FET-1	NA	NA	PTC 152	NA	SK 3116	RT-176	NA	WEP-801	NA
2N5395	NA	NA	GE-FET-1	NA	NA	PTC 152	NA	SK 3116	RT-176	NA	WEP-801	NA
2N5396	NA	NA	GE-FET-1	NA	NA	PTC 152	NA	SK 3116	RT-176	NA	WEP-801	NA
2N5397	NA	NA	GE-FET-2	NA	NA	PTC 152	NA	SK 3116	RT-176	NA	WEP-802	NA
2N5398	NA	NA	GE-FET-2	NA	NA	PTC 152	NA	SK 3116	RT-176	NA	WEP-802	NA
2N5399	NA	T-718	NA	ICC-716	NA	PTC 133	HEP-716	SK 3039	RT-113	ECG 108	WEP-720	NA
2N5404	NA	T-S3003	NA	ICC-S3003	NA	NA	HEP-S3003	NA	NA	NA	WEP-S3003	NA
2N5406	NA	T-S3003	NA	ICC-S3003	NA	NA	HEP-S3003	NA	NA	NA	WEP-S3003	NA
2N5410	NA	SR-0134	NA	ICC-R0134	NA	NA	HEP-R0134	NA	NA	ECG 5876	NA	ZEN 403
2N5413	NA	TS-3001	NA	ICC-S3001	NA	NA	HEP-S3001	NA	NA	NA	NA	NA
2N5414	NA	TS-3001	NA	ICC-S3001	NA	NA	HEP-S3001	NA	NA	NA	NA	NA
2N5417	NA	TS-3008	GE-20	ICC-S3008	NA	PTC 136	HEP-S3008	NA	NA	NA	NA	NA
2N5416	NA	TS-0004	GE-20	ICC-S0004	TR-21	PTC 136	HEP-S0004	SK 3122	RT-102	ECG 123A	WEP-56	ZEN 127
2N5419	NA	TS-0004	GE-20	ICC-S0004	TR-21	PTC 136	HEP-S0004	SK 3122	RT-102	ECG 123A	WEP-56	ZEN 127
2N5420	NA	TS-0002	NA	ICC-S0002	TR-21	PTC 123	HEP-S0002	SK 3122	RT-102	ECG 123A	WEP-735	ZEN 126
2N5421	NA	TS-3001	GE-28	ICC-S3001	IRTR-67	PTC 144	HEP-S3001	SK 3024	RT-144	ECG 128	WEP-243	NA
2N5422	NA	TS-3001	GE-28	ICC-S3001	NA	PTC 144	HEP-S3001	NA	RT-154	NA	WEP-S3023	NA
2N5423	NA	NA	GE-28	NA	NA	NA	NA	NA	RT-154	NA	WEP-S3023	NA
2N5424	NA	NA	GE-66	NA	NA	NA	NA	NA	RT-154	NA	WEP-701	NA
2N5427	NA	T-241	NA	ICC-241	NA	NA	HEP-241	NA	NA	NA	WEP-241	NA
2N5428	NA	T-241	NA	ICC-241	NA	NA	HEP-241	NA	NA	NA	WEP-241	NA
2N5429	NA	T-241	NA	ICC-241	NA	NA	HEP-241	NA	NA	NA	WEP-241	NA
2N5430	NA	T-241	NA	ICC-241	NA	NA	HEP-241	NA	NA	NA	WEP-241	NA
2N5431	NA	T-310	NA	ICC-310	NA	NA	HEP-310	NA	NA	NA	WEP-310	ZEN 129
2N5432	NA	T-801	NA	ICC-801	NA	PTC 152	HEP-801	NA	RT-176	NA	WEP-801	NA
2N5433	NA	T-801	NA	ICC-801	NA	PTC 152	HEP-801	NA	RT-176	NA	WEP-801	NA
2N5434	NA	T-801	NA	ICC-801	NA	PTC 152	HEP-801	NA	RT-176	NA	WEP-801	NA
2N5444	NA	NA	NA	NA	NA	NA	NA	SK 3509	NA	ECG 5693	NA	NA
2N5445	NA	NA	NA	NA	NA	NA	NA	SK 3509	NA	ECG 5695	NA	NA
2N5446	NA	NA	NA	NA	NA	NA	NA	SK 3522	NA	ECG 5697	NA	NA
2N5447	NA	T-715	GE-67	ICC-715	NA	PTC 127	HEP-715	SK 3114	RT-115	ECG 159	WEP-715	ZEN 106
2N5448	NA	T-715	GE-67	ICC 715	NA	PTC 127	HEP-715	SK 3114	RT-115	ECG 159	WEP-715	ZEN 106
2N5449	NA	TS-3001	GE-20	ICC-S3001	IRTR-87	PTC 136	HEP-S3001	SK 3024	RT-114	ECG 128	WEP-243	NA
2N5450	NA	TS-3001	GE-20	ICC-S3001	IRTR-87	PTC 136	HEP-S3001	SK 3024	RT-114	ECG 128	WEP-243	NA
2N5451	NA	NA	GE-20	ICC-S3001	IRTR-87	PTC 136	HEP-S3001	SK 3024	RT-114	ECG 128	WEP-243	NA
2N5452	NA	NA	NA	NA	NA	PTC 151	NA	SK 3112	RT-175	NA	NA	NA
2N5453	NA	NA	NA	NA	NA	PTC 151	NA	SK 3112	RT-175	NA	NA	NA
2N5454	NA	NA	NA	NA	NA	PTC 151	NA	SK 3112	RT-175	NA	NA	NA
2N5455	RS276-2021	T-51	NA	ICC-51	NA	PTC 103	HEP-51	NA	RT-101	NA	WEP-51	ZEN 101
2N5456	RS276-2009	T-53	NA	ICC-53	NA	PTC 123	HEP-53	NA	RT-100	NA	WEP-53	ZEN 102
2N5457	RS276-2028	T-801	GE-DET-1	ICC-801	NA	PTC 152	HEP-801	SK 3116	RT-176	NA	WEP-801	NA
2N5458	RS276-2028	T-801	GE-FET-1	ICC-801	FE-100	PTC 152	HEP-801	SK 3112	RT-176	ECG 133	WEP-801	NA
2N5459	NA	T-802	GE-FET-1	ICC-802	NA	PTC 151	HEP-802	SK 3116	RT-175	NA	WEP-802	ZEN 123
2N5460	NA	T-803	NA	ICC-803	NA	NA	HEP-803	NA	RT-177	NA	NA	NA
2N5461	NA	T-803	NA	ICC-803	NA	NA	HEP-803	NA	RT-177	NA	NA	NA
2N5462	NA	T-803	NA	ICC-803	NA	NA	HEP-803	NA	RT-177	NA	NA	NA
2N5466	NA	T-740	NA	ICC-740	NA	PTC 118	HEP-740	NA	NA	ECG 163	WEP-740	ZEN 206
2N5467	NA	T-740	NA	ICC-740	NA	PTC 129	HEP-740	NA	NA	ECG 165	WEP-740	ZEN 206
2N5471	NA	T-803	NA	ICC-803	NA	NA	HEP-803	NA	RT-177	NA	NA	NA
2N5472	NA	T-803	NA	ICC-803	NA	NA	HEP-803	NA	RT-177	NA	NA	NA
2N5473	NA	T-803	NA	ICC-803	NA	NA	HEP-803	NA	RT-177	NA	NA	NA
2N5475	NA	T-803	NA	ICC-803	NA	NA	HEP-803	NA	RT-177	NA	NA	NA
2N5476	NA	T-803	NA	ICC-803	NA	NA	HEP-803	NA	RT-177	NA	NA	NA
2N5481	RS276-2009	TS-3005	GE-28	ICC-S3005	NA	NA	HEP-S3005	NA	RT-154	NA	NA	NA
2N5482	RS276-2009	TS-3005	GE-28	ICC-S3005	NA	NA	HEP-S3005	NA	RT-154	NA	NA	NA
2N5483	NA	TS-3006	GE-66	ICC-S3006	NA	NA	HEP-S3006	NA	RT-154	NA	NA	NA
2N5484	NA	TF-0021	GE-FET-2	ICC-F0021	NA	PTC 152	HEP-F0021	SK 3116	RT-175	NA	WEP-801	NA
2N5485	NA	TF-0021	GE-FET-1	ICC-F0021	FE-100	PTC 152	HEP-F0021	SK 3116	RT-175	ECG 132	WEP-802	NA
2N5486	NA	TF-0021	GE-FET-2	ICC-F0021	NA	PTC 152	HEP-F0021	SK 3116	RT-176	ECG 132	WEP-802	NA
2N5489	NA	NA	GE-28	NA	NA	NA	NA	NA	NA	NA	WEP-S3023	NA
2N5490	NA	TS-5001	GE-66	ICC-S5001	NA	PTC 110	HEP-S5001	SK 3054	RT-152	ECG 196	WEP-S5004	ZEN 209
2N5491	NA	TS-5001	GE-66	ICC-S5001	NA	PTC 110	HEP-S5001	SK 3054	RT-152	ECG 196	WEP-S5004	ZEN 209
2N5492	NA	TS-5004	GE-28	ICC-S5004	NA	NA	HEP-S5004	SK 3054	RT-152	ECG 152	WEP-S5004	NA
2N5493	NA	TS-5004	GE-66	ICC-S5004	NA	PTC 110	HEP-S5004	SK 3054	RT-152	ECG 196	WEP-S5004	NA
2N5494	NA	TS-5001	GE-66	ICC-S5001	NA	PTC 110	HEP-S5001	SK 3054	RT-152	ECG 196	WEP-S5004	ZEN 209
2N5495	NA	TS-5001	GE-66	ICC-S5001	NA	PTC 110	HEP-S5001	SK 3054	RT-152	ECG 196	WEP-S5004	ZEN 209
2N5496	NA	TS-5004	NA	ICC-S5004	NA	NA	HEP-S5004	SK 3054	RT-152	ECG 196	WEP-S5004	NA
2N5497	NA	TS-5004	NA	ICC-S5004	NA	NA	HEP-S5004	SK 3054	ER-152	ECG 196	WEP-S5004	NA
2N5505*	NA	TF-1035	NA	ICC-F1035	NA	NA	HEP-F1035	NA	NA	NA	NA	NA
2N5506*	NA	TF-1035	NA	ICC-F1035	NA	NA	HEP-F1035	NA	NA	NA	NA	NA
2N5507*	NA	TF-1035	NA	ICC-F1035	NA	NA	HEP-F1035	NA	NA	NA	NA	NA

*Indicates a dual transistor for high-speed switching, diff amplifier etc. Likely to be a matched pair. Use two of the type specified, matching when necessary, on a curve tracer or lab-type transistor checker.

NA = NOT AVAILABLE

(continued next month)

RE's Service Clinic

The VRT saturated transformer

A problem that became a solution

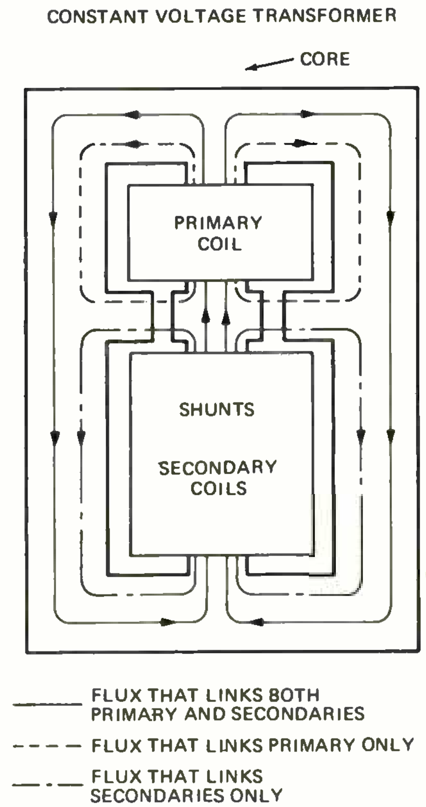
by JACK DARR
SERVICE EDITOR

ALL KINDS OF INITIALS ARE FLOATING around today. One that will be important to us is VRT. Not VTR that's Video Tape Recorder; not crt that's Cathode Ray Tube. This one, VRT, means Voltage-Regulating Transformer. Zenith came out with it a couple years ago, and it is reported that their entire line from 17 inches on up will use it this year. Many other manufacturers are beginning to use it as well.

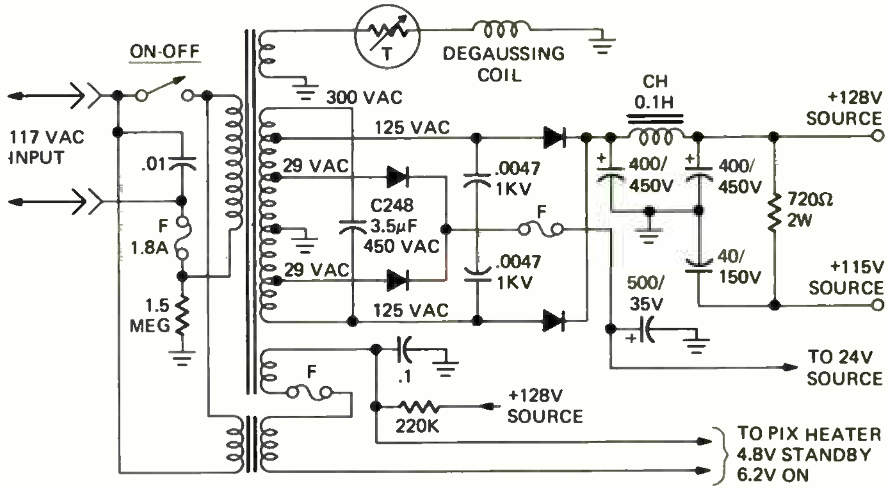
With the big swing to solid-state TV, added to the possibility of brownouts and severe line voltage fluctuations, tight and reliable voltage regulation became more important than ever. Transistors are well-known for their dislike of transients, too. Transistor voltage regulators have been extensively used in the past. However, these regulate only a few of the output voltages. The VRT regulates *all* secondary voltages, even the picture-tube heater. This should add to its life.

How it works

The operating principle of the VRT power supply is simple. The secondary of the transformer is tuned with series capacitor C248 in the diagram of Zenith's 25DC56 chassis. This is tuned to 60 Hz. The secondary is loosely coupled to the primary. In fact they're wound as separate windings on the core instead of the old method of overwinding the secondaries over the primary.



MAGNETIC COUPLING of the voltage regulating transformer is shown. The primary and secondary are wound on separate legs of the core.



ZENITH'S 25DC56 POWER SUPPLY using the voltage regulating transformer. Capacitor C248 tunes the secondary.

Now comes the kicker. With the secondary resonant, the voltage increases to the point where the transformer core *saturates*. With the core saturated, very little voltage increase is possible. You won't find much about this in the reference literature. I went through what is supposed to be *the* book on transformers, and all I found was about 25 pages of discussion dealing with ways of *preventing* core-saturation! So, what was a problem has now helped to find a solution.

This thing gives results that are amazing, to men used to dealing with "standard" power transformers. Normally,

(continued on page 67)

This column is for your service problems—TV, radio, audio or general and industrial electronics. We answer all questions individually by mail, free of charge and the more interesting ones will be printed here.

If you're really stuck, write us. We'll do our best to help you. Don't forget to enclose a stamped, self-addressed envelope. If return postage is not included, we cannot process your question. Write: Service Editor, Radio-Electronics, 200 Park Ave. South, N.Y. 10003.

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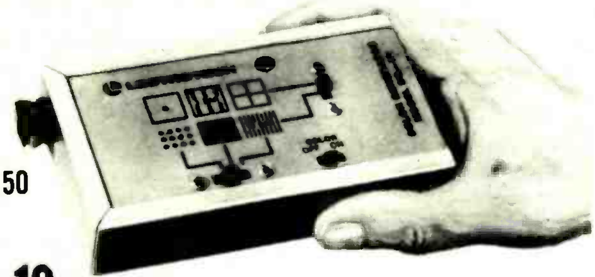

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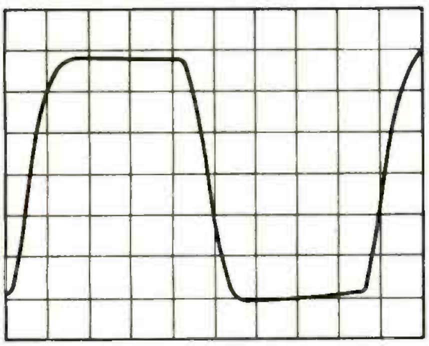
(continued from page 65)

secondary voltage rises and falls in direct proportion to the applied primary voltage. The VRT can operate over a tremendous range of primary voltage. In actual tests, the secondary voltages stayed practically constant over a range from 70 to 145 volts ac on the primary.

Besides this, there's a fringe benefit. For example, if a 30-volt transient appears in the primary for a duration of *two seconds,* it will show up in the secondary as a spike of less than 15 volts, for only 100 *milliseconds.* This is due to the characteristics of the saturated core; when the spike hits, the core is delivering all of the energy it can, and any more just doesn't get through; it's clipped off.

This action can be likened to a pair of back-to-back Zener diodes. The peaks are clipped off, holding the peak values down. This brings us to one of the important differences between these and conventional transformers.



OUTPUT VOLTAGE WAVEFORM for the voltage regulating transformer.

For the most important one, we cannot read the secondary ac voltage *accurately* with our old peak-reading ac voltmeters. Despite the fact that they are calibrated in rms values, they read peak voltages. They're calibrated on a pure sinewave. The VRT's output voltage is almost a square wave. (If you want to make up a correction chart for the voltages you actually read on these, OK.) But there is an easier way. Just read the dc voltage outputs. If they're normal, fine. If they're not check for the stock power supply troubles; shorted diodes, open electrolytic capacitors, etc. Of course a scope with a calibrated vertical amplifier *will* show you the waveform and its exact peak-to-peak voltage, and you can get the voltage you need from that.

The loose coupling of the primary and secondary, together with the saturated core, help hold down high currents due to a short. The current will rise to only about twice the normal value, and the circuit-breaker will trip. The transformer won't be damaged.

The VRT will run slightly hotter than the old transformers. This is caused by the core-saturation. It should not smoke, of course. Just a little too hot to hold your hand on. The original versions (made by Zenith for themselves) used round copper wire. They're planning new versions using flat aluminum ribbon wind-

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SERVICE CLINIC

(continued from page 67)

ings. This will not only reduce the weight of the transformer but keep it cooler. The inner windings, always the hottest spot, will run cooler.

The first VRT's were used in Zenith chassis such as the 25DC56. A small auxiliary power transformer was connected with its primary in series with the VRT primary; it served merely to keep the picture tube heater warm. The on-off switch shorted the primary of the I-O transformer, and applied full voltage to the VRT. Later versions won't use this instant-on arrangement.

There are a few unusual faults possible here, of course. For one, if the switch is off but you still hear a loud buzz from the speaker, the primary of the instant-on transformer could be shorted. The VRT will be energized, and dc voltages present, but the picture tube won't light.

Another "unlikely but possible" problem is, if *all* of the dc voltages, and the picture-tube heater voltage are about 20% low. Check the resonating capacitor in the VRT secondary. It could be open. This is a special 3.5-μF unit, oil-filled. It must be replaced with an exact duplicate or the VRT won't work as it should.

If you want to be sure that the set you're working on does have a VRT, check for the presence of the reasonating capacitor in the secondary. In the Zenith version, at least, if there isn't one, then it's not a VRT. **R-E**

reader questions

ELECTROLYTIC REPLACEMENT

I need a replacement filter unit for a Dyna-Kit Mk II audio ampl. Original is 500 volt 30-20-20-20 μF, and I can't locate one. What can I use to replace this?—R.S., Washington, D.C.

The rule for replacing electrolytics is "Never go down!" In other words, you can use larger units but never smaller ones. Same thing holds for working voltage. You can use higher voltage units, but never lower working voltage units. In this case, you could use a 500 volt (or more) 40-30-30-30 μF, or even a 40-40-40-40 μF. There is seldom a large difference in cost.

NEEDS NEW FLYBACK

I need a new flyback for a Symphonic model TCT-150 color TV. I can't find a replacement. Can you help?—G & S TV, Middletown, NJ.

As it turned out, I couldn't. I gave the reader some suggestions. He wrote back, "Thank you for your prompt reply. I have located a replacement. It is a Halldorson FLY-443 which is the same as a Sanyo part No. F-103. Works perfectly."

I don't know why he thanked me; I didn't do anything. Self-answering questions are the best kind. Thanks to G&S TV for the data. Remember it if you ever need this one.

CRAWLING CATHODE CURRENT

This Sears 528.81201 has had me in a spin for days. The 40KD6 cathode current slowly rises from 210 mA to over 400 mA. High voltage rises to 30 kV, regulation won't work, and finally the breaker trips. Grid drive remains normal at 200V p-p, but the grid voltage goes from −62V dc to −42V dc. All tubes, the flyback, etc. have been changed. No help. Does this with picture tube second anode unhooked, too. Any ideas?—D.B., Bremerton, WA.

The crystal ball tells me that this must be something related to that change in grid bias on the 40KD6. This drop in bias would let the tube "stay on" too long, thus making the output *rise*, and the current rise with it.

I'd suspect the high-voltage adjust circuitry, which in this set is a grid

(continued on page 70)

CLINIC QUESTIONS
(continued from page 69)

bias control, with a VDR, fed by a pulse from the flyback. It *should* hold the output and current *down,* but it seems to be working backward. It is supposed to develop a higher *negative* voltage if the output tries to go above normal. However, you're getting a *less negative* voltage on the 40KD6 grid. Check the bias across that VDR, also the pulse height. I don't have the exact figure, but this should develop about a −100 volts at this point.

SCOPE FADES OUT

Am having trouble with my old Dumont 304 scope. If I leave it on for an hour, the pattern fades out and I can't get it back at any intensity setting. However, if I turn it off for a few hours, it'll work for about an hour then fade out again. What is this?–P.S., Chicago, IL.

It doesn't sound like a weak CRT to me. They'll be dim but they will stay dim. I suspect a gradual loss of the high voltage. It is most likely to be one of the big resistors in the filter. This scope uses a −1400-volt supply and a +1600-volt supply. Check both of these voltages; one of them is probably dropping too far. **R-E**

State-of-Solid State

A digital IC course, a CMOS watch circuit patent, and a microtransmitter are this months topics.

by KARL SAVON
SEMICONDUCTOR EDITOR

Digital IC course

General Electronics Associates, sells a four-book series *Practical Applications of Digital Integrated Circuits* for $19.95. It is aimed at the person who wants to gain a good grasp of the essentials of combinational logic and sequential circuit design and analysis.

Interspaced throughout its pages are questions along with comprehensive answers and diagrams. This approach is much better than the practice adopted by many publishers of giving the answers in a separate book available only to instructors. Having the answers available demands self-discipline but gives immediate feedback telling the student whether he is learning the fundamentals or not.

Also included are numerous breadboarding experiments. They can be skipped, but they function as a complementary laboratory course and the value of "learning by doing" cannot be underestimated. The circuits can be built using General Electronic's Digi-Kit Model 200 breadboarding system or with other similar systems.

The 7400 series of TTL devices is stressed in the course with a section devoted to describing the available hardware. Perhaps the only omission is an in-depth discussion of CMOS logic circuitry. Of course, all the basic logic foundations can be applied but requirements peculiar to CMOS should be included. However, the loss is not great and the gap is easily filled by application notes available from CMOS manufacturers.

Mathematical logic analysis and design is handled by introducing Karnaugh Maps and Boolean Alegbra in an understandable manner. The mathematical treatment is not overly extensive since the four-volume set is not an engineering text, but it is substantive enough that the student should be able to simplify his logic designs using the techniques illustrated.

Asynchronous and synchronous counters are covered in detail including the pseudo-random shift register, a worthy technique often omitted in supposedly complete texts. In the same volume, sequential machines and the theory behind transiton truth tables and characteristic equations is demonstrated.

Finally the 4th volume discusses related equipment such as clock and waveform generators and operational amplifiers. The series ends with an extensive study of digital-to-analog and analog-to-digital converters. The important dual-slope method, the central element in many digital voltmeters is rightfully included.

My impressions of the book set was very favorable, and I have read many college texts and published papers on the subjects covered. I highly recom-

(continued on page 76)

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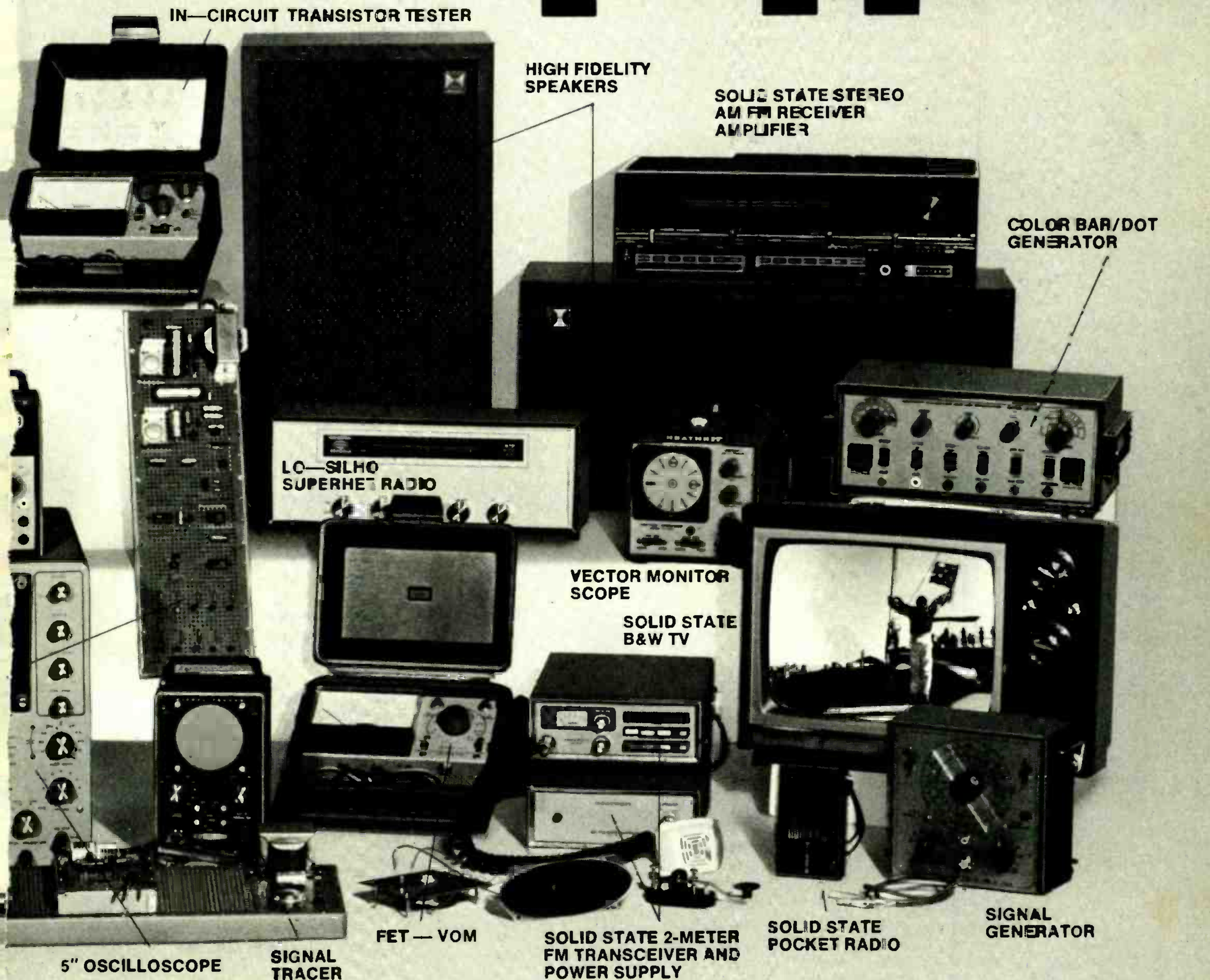

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STATE-OF-SOLID STATE

(continued from page 71)

mend these books to serious experimenters and technicans. They are not to be mistaken for some of the over simplified editions on the magazine racks. Even those not working today with digital circuits would be wise to expand their horizons. Contact with logic circuitry by anyone involved in electronics will be unavoidable as the inexpensive digital IC branches into traditionally analog fields.

CMOS watch circuit patent

A patent was issued to Cal-Tex Semiconductor of Santa Clara, California, covering the basic system concept of a single-chip CMOS watch circuit.

Under this patent, the company is producing the CT6002 clock chip. In addition to making the clock chips in die form and custom assemblies, Cal-Tex builds them into watches and markets them under the "Exetron" brand and other private labels for O.E.M. companies. Including the liquid-crystal display and batteries, the total parts count of the clock package is 11. Most of the voltage step-up circuitry needed to generated the LCD

(continued on page 82)

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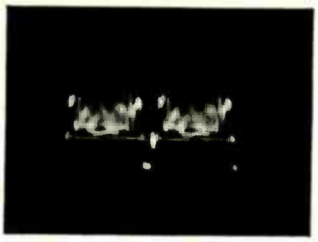
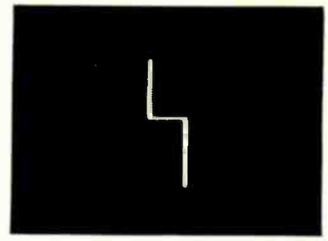
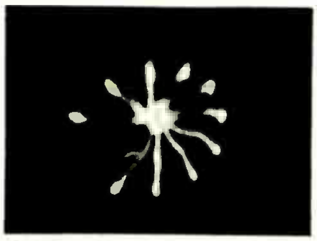


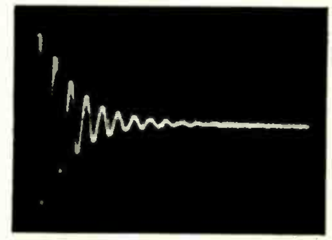
1. It's an 8 MHz general-purpose scope. Typical composite TV video signal.



2. It's a "Quicktracer" Transistor/ Diode and Component Tester. Typical junction waveform.



3. It's a Vectorscope for color TV AFPC alignment. Color bar generator used for test signal.



4. It's a "ringing" tester for coils, yokes, transformers. Typical ringing test pattern.

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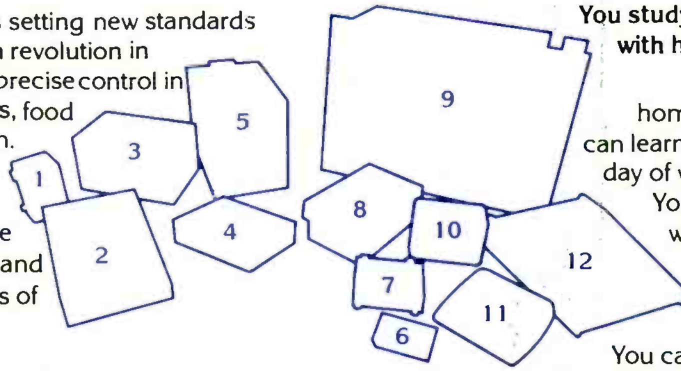

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STATE-OF-SOLID STATE

(continued from page 76)

drive voltages are contained right on the chip.

I hope to report back soon with more details on this circuit.

Cal-Tex is also entering the memory market with sample quantities of the CT8701, a 1000 bit N-channel Random Access Memory with a 60 nanosecond access time.

Zenith LED Target Tuning

Forward biasing the PN junction of a gallium light-emitting diode or LED injects electrons from the n material into the p region. Electrons recombine with holes giving up energy in the form of visible or invisible radiation. The emission frequency and the color of the light depends on the band-gap energy level of the device. Gallium arsenide emits infrared, gallium phosphide emits green or red depending on doping, and alloyed gallium arsenide emits red light.

Widely used as digital readouts in counters, voltmeters, and calculators, the LED makes an ideal indicator because it has the same long life we expect from all solid-state devices. It was originally produced exclusively in red but is now available in yellow, green and some other colors. Siemens makes an interesting device which has two LED junctions on a gallium-phosphide chip. One of the two diodes emits red light when energized and the other green. When both are activated the light mixes to yellow.

Zenith uses LED's in their Target Tuning system in two different versions. The simpler system used in some digital clock table radio models has a red LED is mounted right on the movable dial pointer. The LED lights when the receiver is accurately tuned in the center of the i.f. passband.

Some of the more elaborate Zenith high-fidelity receivers have a triple LED formation on the dial pointer to show low and high tuning as well as center tuning. The center diode is green and the two outer diodes red.

Lithic systems LP2000 microtransmitter

Twenty-one transistors and diodes, and 9 resistors are fabricated on a silicon substrate to form the latest version of the LP2000. This is a microtransmitter IC that is the nucleus for low-power AM, CW, or pulse-modulated transmitters. At 27-MHz, the 10-pin TO-100 package can deliver 100 milliwatts of output power in the CW mode or 50-mW AM modulated. A stud-mounted package, the LP2001 can deliver 2½ times this power.

Prices for the LP2000 range from $49.00 in unit quantites to $12.50 at the 100 level.

Lithic Systems also manufacturers other communication devices including VOX amplifiers, phase-locked loops, modulators, and the 555 timer IC's. **R-E**

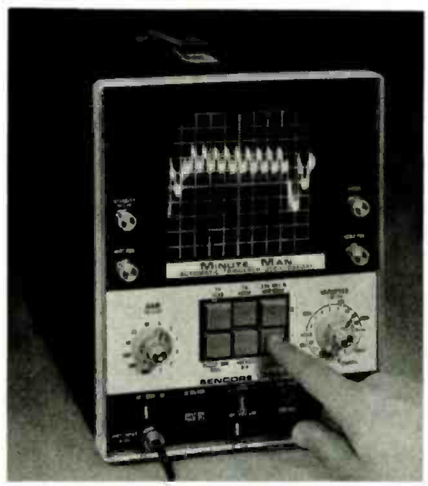
Circle 72 on reader service card

Circle 71 on reader service card

new products

More information on new products is available from the manufacturers of items identified by a Reader Service number. Use the Reader Service Card inside the back cover.

OSCILLOSCOPE, *PS29 Minute Man.* Automatic triggered pushbutton scope enables you to display any color TV or video waveform by simply pushing a button. Pushbutton displays include TV vertical, TV horizontal, 3.58 MHz for viewing color subcarrier information, five times expand and a completely front-end vector display. Sixth button sets scope for 60-Hz line sweep used in sweep alignment work. Triggers internally on any signal down to 20 mV. External trigger allows you to sync on any signal above a dc voltage. Absence of input signal is indicated by continuous running baseline.



Has dc coupling, 5000 Vac input protection, 10-MHz bandwidth with vertical sensitivity from 10 mV/div direct to 500 V/div using 10 x 1 probe at 3% calibration accuracy. Push the 3.58-varispeed button and horizontal sweep control activates which offers signal display for any non-video frequencies from dc to 10 MHz. $495.00.

Due to a typographical error, this release was published in the December 1974 issue with the statement that it had 500 Vac input protection rather than the 5000 Vac input protection which is the correct figure. **—Sencore, Inc.,** 3200 Sencore Drive, Sioux Falls, SD 57107.

Circle 31 on reader service card

SLIDE-RULE CALCULATOR KIT, *IC-2100* is designed for desk-top use. Has contoured, color-coded keys that fit your fingers. Bright ½-in./tall Beckman planar gas-discharge tube readouts are easy to read. To eliminate scratch pad work, there's a 4-key cumulative memory that isn't erased by use. Two register exchange keys interchange the display and working registers and display and memory registers.

Four arithmetic functions feature automatic constant and chain operation. Calculator performs the most needed slide-rule functions—trig and arc trig in degrees or radians, common and natural logs, powers of ϵ, inverses, square roots, pi and exponential functions — and automatically keeps track of the decimal. Operates on 120/240 VAC, 60/50 Hz. $119.95.—**Heath Co.,** Benton Harbor, MI 49022.

Circle 32 on reader service card

RF SIGNAL GENERATOR, *model 2050.* Solid-state unit is used for AM receiver alignment, marker source for TV sweep alignment, rf amplifier gain tests, signal tracing, signal source for production line and quality-control testing. Provides three types of outputs: rf, 400-Hz modulated rf and externally modulated rf. Accuracy is 1.5% of dial setting. Combination HIGH-LOW switch plus continuously variable rf output control provides 20-dB change.

Power supply is Zener-regulated; FET's are used in rf and audio oscillator stages; 90% of the components are mounted on a single PC board; isolated rf circuit assures maximum protection against external voltage sources. Other features include multi-colored, large 4½-in. dial with positive anti-backlash drive, case with carry handle, 3-wire, grounded ac line cord. Shielded leads supplied have insulated clip and banana plug. Operates from 117/234 Vac, 50-60 Hz. 7½ x 6⅛ x 9¾ in.; $107.00—**B & K, Div. of Dynascan Corp.,** 1801 West Belle Plaine Avenue, Chicago, IL 60613.

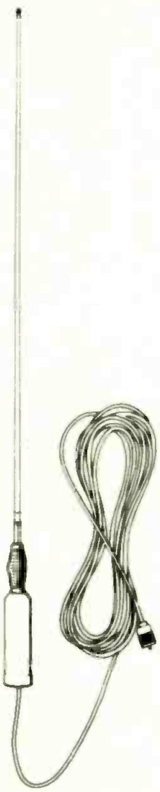
Circle 33 on reader service card

WHITE KNIGHT, *style 4041 & 4041-1,* is a base-loaded spring-mounted fiber glass whip with maximum power handling capability. Adjustable tip with set screw enables CB'ers

(continued on page 86)

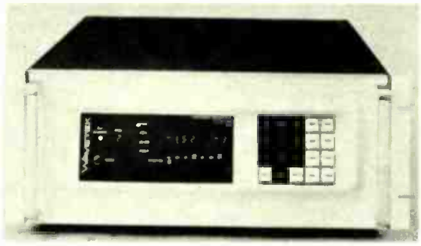
NEW PRODUCTS
(continued from page 84)

to "lock in" lowest SWR reading. Helical-wound coil is permanently sealed against environment to enable constant impedance and distributed capacitance. *4041* is roof-top mount with base spring; *4041-1* is trunk-mount.—**Shakespeare Co.**, P.O. Box 5806, Columbia, SC 29250.



Circle 34 on reader service card

VARIPHASE GENERATOR, *model 152*. Programmable function generator has variable phase outputs with manual or remote control of phase angle. Phase may also be referenced to an external sync input or its own sync output and controlled with 4-digit resolution. Each output is independently programmable for sine, cosine, triangle or square waveform or dc voltage as well as amplitude and offset to ± 9.99 volts peak; all with 3-digit resolution. Frequency is common for all channels and programmable with 3-digit resolution.



Programming is remote by 7-bit parallel ASCII coded characters or by front-panel keyboard with LED readout. Characters are accepted at a 1-MHz rate. Up to nine instruments may be placed on a common bus and individually controlled by one source. Frequency range is 1 Hz to 100 kHz; sine wave total harmonic distortion is less than 0.1%; square wave frequency accuracy is 1% of program plus 0.1% of range to 10 kHz and 3% of program plus 0.1% of range to 100 kHz; sine wave frequency response is 0.3 dB to 10 kHz and 0.5 dB to 100 kHz; sine wave phase accuracy is 0.3% to 1 kHz, 1% to 10 kHz and 4 % to 100 kHz. $4995.00 (standard 2-channel model).—**Wavetek,** P.O. Box 651, San Diego, CA 92112.

Circle 35 on reader service card

TURNTABLE, *model 2620W*, features heavy-duty synchronous motor that drives a heavy (approximately 4 lbs.) diecast platter which insures low wow, flutter and rumble. Variable speed control adjusts the pitch of recorded music—with a strobe disc provided for precise calibration. Pickup arm system

includes jam-proof, adjustable, counter-weighted arm of low-mass aluminum design suspended on low-friction needle and ball bearings; also includes a calibrated stylus force adjustment, dual range anti-skate control, viscous-damped cue/pause control and automatic arm lock.

Cartridge is an ADC K6E magnetic cartridge with diamond elliptical stylus and slide-in head. Converts to 4-channel operation when a CD-4 magnetic cartridge and necessary cables are used. $109.95.—**BSR MacDonald,** Route 303, Blauvelt, NY 10913.

Circle 36 on reader service card

SCREWDRIVER SET, *model PS-90MM*. Convertible hex socket screwdriver set manufactured to metric dimensions includes eight pocket-size hex socket screwdrivers plus the company's original piggyback torque amplifier handle that slips over the top of the midget tools to provide longer reach and greater driving power as required. Hex tip sizes of the 4-in. long drivers range from .89 mm to 5 mm. Drivers and 1⅛- x 3⅛-in.auxillary handle are housed in a flexible plastic see-thru stand-up case with snap lock cover.

Shafts of the miniature drivers are precision-formed and finished in a protective black oxide and embedded in black plastic handles.—**Xcelite Inc.**, Orchard Park, NY 14127.

Circle 37 on reader service card

IN THIS ISSUE

Don't miss the TV Typewriter II. It is primarily designed around TTL logic and features a variety of plug-in option boards that makes it a very versatile unit.

new lit

All booklets, catalogs, charts, data sheets and other literature listed here with a Reader Service number are free. Use the Reader Service Card inside the back cover.

FINISHING-GRINDING-DEBURRING-TOUCH-UP CATALOG *No. 19.* 16-page catalog contains burs, grinders, air turbine grinders, diamond points and carbide burs, deburring & grinding Moto-Tool, deburring and grinding points, deburring and grinding flexible shaft, deburring and grinding accessories, deburring and grinding Foredom accessories, grinders, burs and routers, diamond files, Swiss pattern needle files, Swiss pattern files and variable speed Moto-Tool kit. Contains many illustrations and prices.—**Technical Tool, Inc.** Apollo Road, Plymouth Meeting, PA 19462.

Circle 38 on reader service card

SIGNALLING DEVICES CATALOG. 24-page cataog contains residential door chime, surface mounting electric bells and buzzers, fully enclosed bell line, heavy-duty bells, recessed bell line, sirens for industrial and general use, indoor motor driven sirens, electronic siren, standard signalling transformers, photoelectric eye, unlighted pushbuttons, lighted pushbuttons, door trip switch, electric door switches, fire alarm components, burglar components and much more. Contains many illustrations.—**Lee Electric, Inc.** 309-11 51st Street, West New York, NJ 07093.

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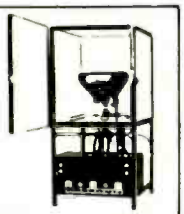

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3.3 UFD/35V	14c	12c	11c	47 UFD/16V	17c	14c	13c	470 UFD/16V	37c	30c	27c
4.7 UFD/35V	14c	12c	11c	47 UFD/25V	19c	15c	14c	470 UFD/25V	49c	39c	35c
10 UFD/16V	14c	12c	11c	100 UFD/16V	19c	15c	14c	1000 UFD/16V	49c	39c	35c
10 UFD/25V	14c	12c	11c	100 UFD/25V	24c	18c	17c	1000 UFD/25V	75c	60c	55c
22 UFD/16V	14c	12c	11c	220 UFD/16V	24c	18c	17c	2200 UFD/16V	75c	60c	55c
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.1.	12c	9c	7.5c	6c

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2N2712. .	TO- 98	.18	.160	.145	EN2907 . .	TO-106	.21	.185	.165
2N3391A.	TO- 98	.22	.190	.175	2N3392. .	TO- 98	.22	.190	.175
2N3393 . .	TO- 98	.22	.190	.175	2N3394. .	TO- 98	.22	.190	.175
2N3563. .	TO-106	.20	.175	.160	2N3565. .	TO-106	.20	.175	.160
2N3638. .	TO-105	.20	.175	.160	2N3638A .	TO-105	.20	.175	.160
2N3640. .	TO-106	.22	.190	.175	2N3641. .	TO-105	.20	.175	.160
2N3643. .	TO-105	.20	.175	.160	2N3645. .	TO-105	.20	.175	.160
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2N3906. .	TO- 92	.25	.225	.200	2N4124. .	TO- 92	.27	.240	.220
2N4126. .	TO- 92	.27	.240	.220	2N4401 . .	TO- 92	.32	.290	.260
2N4403 . .	TO- 92	.32	.290	.260	2N5087. .	TO- 92	.27	.240	.220
2N5089 . .	TO- 92	.27	.240	.220	2N5129. .	TO-106	.19	.170	.150
2N5133	TO-106	.19	.170	.150	2N5134. .	TO-106	.19	.170	.150
2N5137 .	TO-106	.19	.170	.150	2N5138. .	TO-106	.19	.170	.150
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40411	"	3036		35-100	80	90	5.0	30	15	150	1.5	TO-3	$3.75
40636	"	3027	704	20-70	95*	95*	7.0	15	7.0	115		TO-3	1.95
2N3714	"	3036	704	25-90	80	100	7.0	10	4.0	150	4.0	TO-3	2.59
2N3715	"	3036	704	50-150	60	80	7.0	10	4.0	150	4.0	TO-3	2.75
RF PWR AMP													
2N5320	"	3512	53002	30-130	75	100	7.0	2	1.0	10	50	TO-5	1.65
2N5322 (P)	"			30-130	75	100	7.0	2	1.0	10	50	TO-5	1.75
2N5321	"	3512	53010	40-250	50	75	5.0	2	1.0	10	50	TO-5	1.65
2N5323 (P)	"	3513		40-250	50	75	-5.0	2	1.0	10	50	TO-5	1.65
PWR DRIVER													
2N5679 (P)	Audio/RF		53031	40-150	100	100	-4.0	1.0	0.5	10	30	TO-5	1.70
2N5681				40-150	100	100	4.0	1.0	0.5	10	30	TO-5	1.70
AUDIO DRIVER													
40594	"	3024	53002	70-350	95*		4.0	2.0	1	10	1.0	TO-5	1.45
40595 (P)	"	3025	53031	70-350	95*		4.0	2.0	1	10	1.0	TO-5	1.65
2N5781 (P)	"			20-100	65	80	-5.0	3.5	1	10	1.0	TO-5	1.75
2N5784	"		53002	20-100	65	80	5.0	3.5	1	10	1.0	TO-5	1.75
2N5864 (P)	RF & Audio			25-500	70	90	5.0	1.5		8.75	50	TO-39	1.35
40348	"	3044	243	30-125	40	60	7.0	1.5	0.5	8.75	1.6	TO-5	1.72
40544	"	3045		35-200	50*	50*	5.0	0.7		7.0	100	TO-5	.79
GEN PURP AMP													
2N2895	RF & Audio	3024		40-120	65	120	7.0	1.0		1.8	120	TO-18	1.25
2N930A	Lo Noise	3039	50	100-300	60	60	6.0	.03		1.8	45	TO-18	.95
2N2219A	Audio-UHF Amp/SW	3024	53001	75-375	40	75	6.0	.8		1.8	300	TO-5	1.05
2N2846	High Speed Sw	3024		30-120	30	60	5.0	.8		3.0	250	TO-5	1.55
HF GEN PURP													
2N3933	VHF/UHF Amp	3039	56	60-200	30	40		.002		.2	750	TO-72	1.55
40894	VHF/UHF RF Amp	3039		50-250	12	20	2.5	.05		.3	1200	TO-72	1.10
40895	VHF/UHF Mix, Osc	3039		40-250	12	20	2.5	.05		.3	1200	TO-72	.95
40897	VHF/UHF IF Amp	3039		70-250	12	20	2.5	.05		.3	800	TO-72	.90
2N5179	LoNoise, Amp, Osc, Mix, Conv	3039	709	25-250	12	20	2.5	.05		.3	2000	TO-72	1.10
2N918	VHF/UHF Amp Mix, Conv	3039	709	20 Min	15	30	3.0	.05		.3	600	TO-72	.95
2N2905A(P)	DC, VHF, Amp Hi Sp Sw	3025	708	100-300	60	60	-5.0	.6		3.0	200	TO-5	1.15

** Manufacturers' (SK — RCA, HEP — MOTOROLA) Suggested Cross Reference. *External Res (R_{BE}) = 100 OHMS

TRANSISTORS ARE NEW, FIRST QUALITY, BRANDED DEVICES — ON HAND FOR IMMEDIATE SHIPMENT

RESISTORS

15	ohm	5%	1w Corning	Film	.08
15	ohm	5%	25w Ohmite	WW	.75
28.7	ohm	1%	1w Dale	Film	.25
75	ohm	5%	8w Ohmite	WW	.39
102	ohm	1%	½w Corning	Film	.15
200	ohm	5%	5w Intl. Tect.	WW	.30
220	ohm	10%	½w Stackpole	C Comp	.07
330	ohm	5%	½w Stackpole	C Comp	.10
390	ohm	5%	2w Allen Bradley	C Comp	.25
450	ohm	5%	5w Dale	WW	.30
500	ohm	5%	1w Allen Bradley	C Comp	.19
620	ohm	5%	½w Stackpole	C Comp	.10
681	ohm	1%	¾w Dale	Film	.20
750	ohm	1%	¾ Dale	Film	.20
1	Kohm	1%	½w Corning	Film	.15
1	Kohm	5%	10w Dale	WW	.35
1.2	Kohm	5%	1w Intl. Rect.	C Comp	.25
1.6	Kohm	5%	½w Stackpole	C Comp	.10
2	Kohm	1%	¾w Dale	Film	.20
2	Kohm	5%	5w Intl. Rect.	WW	.30
2.15	Kohm	1%	½w Corning	Film	.15
2.4	Kohm	1%	5w Intl. Rect.	WW	.50
2.5	Kohm	5%	25w Ohmite	WW	.75
2.7	Kohm	5%	5w Dale	WW	.30
3.01	Kohm	1%	½w Electra	Film	.15
4	Kohm	5%	10w Dale	WW	.35
4.7	Kohm	1%	½w Corning	Film	.15
5.6	Kohm	5%	2w A.B.	C Comp	.25
7.5	Kohm	5%	½w Burroughs	C Comp	.10
8.25	Kohm	1%	½w Electra	Film	.15
9.09	Kohm	1%	½w Corning	Film	.15
9.1	Kohm	5%	2w A.B.	C Comp	.25
10	Kohm	1%	½w Corning	Film	.15
15	Kohm	10%	½w Stackpole	C Comp	.07
17.4	Kohm	1%	½w Corning	Film	.15
20	Kohm	5%	1w A.B.	C Comp	.19
23.7	Kohm	2%	¼w Corning	Film	.15
39	Kohm	1%	½w Corning	Film	.15
51	Kohm	5%	½w Burroughs	C Comp	.10
75	Kohm	1%	½w Corning	Film	.15
100	Kohm	1%	½w Corning	Film	.15
120	Kohm	5%	½w Burroughs	C Comp	.10
130	Kohm	5%	½w Stackpole	C Comp	10

CAPACITORS

.0033	mfd	100V	5%	Skottie mylar axial	$ .10
.0047	mfd	100V	10%	G.E. mylar axial	.09
.0047	mfd	100V	10%	Gen. Inst. mylar axial	.09
.01	mfd	200V	20%	Aerovox paper axial	.05
.02	mfd	100V	1%	Sprague mylar axial	.15
.1	mfd	600V	3%	Aerovox paper axial	.20
.1	mfd	400V		Aerovox paper axial	.20
.1	mfd	200V		CDE paper axial	.15
.1	mfd	200V		Aervox paper axial	.15
.5	mfd	400V	10%	Gen. Inst. mylar axial	.35
1.0	mfd	200V		Aerovox axial	.20
2.0	mfd	200V	20%	Aerovox axial	.20
4.0	mfd	350V		Sprague Elec axial	.45
5.0	mfd	25V		Gen. Inst. Elec axial	.15
10	mfd	150V		Sprague Elec axial	.30
30	mfd	300V		Mallory Elec axial	.35
60	mfd	350V		Mallory Elec axial	.75
1,000	mfd	100V		Sangamo Comp grd can	2.65
1,000	mfd	50V		CDE Elec axial	1.25
2,000	mfd	15V		Mallory Elec can	.85
6,000	mfd	25V		Sangamo Comp grd can	3.75
50	mfd	285V		I.C.C. oil Imp bathtub	.60

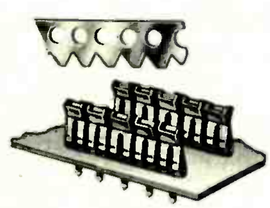
SWITCHES

SPST	1A Momentary Return P.B. A.H.&H.	.25
SPST	15A Micto switch Flat leaf	.50
DPST	5A Micro switch Pin plunger	.75
DPST	10A Micro switch-mini Pin plunger	.65
4P3T	6A Slide Stackpole	.25

MISC. COMPONENTS

1 ohm 25w 5A Memcor wire wound pot.	1.95
100 ohm ½w Bourns EZ trim WW 30 turn pot.	1.50
10 Kohm ½w Bourns EZ trim WW 10 turn pot.	1.50
MDA 962 Motorola fullwave bridge 10A-100V	4.95
AEX 43-1 TEC selenium Rectifier	.05
IN 2990A Motorola 33V 1w zener diode	1.95
LA 2751 Fenwell Thermister 550-100	.75
6113 Elwood Thermal	.75
Panel Light PTT red DPST SW W/ Mount Tec	.95
Panel Light red Neon W/NE 2 Bulb Snap Mount	.45
4 Terminal Chassis Count Terminal Strip	10/.25
Chassis Mount Cable Clamp ½" Nylon	15/.25

molex
I C TERMINALS



0.1" SPACING FOR STANDARD DIP SOCKETS.

SUPPLIED IN STRIPS TRIM TO DESIRED LENGTH.

2 - 50 TERMINAL STRIPS $2.26

THESE COMPONENTS ARE NEW, UNUSED, FIRST QUALITY DEVICES

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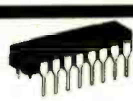
TTL



	Ea.		Ea.		Ea.
7400	$ .19	7447	$1.15	74141	$1.23
7401	.19	7448	1.15	74145	1.15
7402	.19	7450	.24	74150	1.09
7403	.19	7451	.27	74151	.89
7404	.22	7453	.27	74153	1.29
7405	.22	7454	.39	74154	1.59
7406	.39	7460	.19	74155	1.19
7407	.39	7464	.39	74156	1.29
7408	.25	7465	.39	74157	1.29
7409	.25	7472	.36	74161	1.39
7410	.19	7473	.43	74163	1.59
7411	.29	7474	.43	74164	1.89
7413	.79	7475	.75	74165	1.89
7415	.39	7476	.47	74166	1.65
7416	.39	7483	1.11	74173	1.65
7417	.39	7485	1.39	74175	1.89
7420	.19	7486	.44	74176	1.65
7422	.29	7489	2.75	74177	.99
7423	.35	7490	.76	74180	1.09
7425	.39	7491	1.29	74181	3.65
7426	.29	7492	.79	74182	.89
7427	.35	7493	.79	74184	2.69
7430	.22	7494	.89	74185	2.19
7432	.29	7495	.89	74190	1.59
7437	.45	7496	.89	74191	1.59
7438	.39	74100	1.65	74192	1.49
7440	.19	74105	.49	74193	1.39
7441	1.09	74107	.49	74194	1.39
7442	.99	74121	.57	74195	.99
7443	.99	74122	.53	74196	1.85
7444	1.10	74123	.99	74197	1.15
7445	1.10	74125	.69	74198	2.19
7446	1.15	74126	.79	74199	2.19
				74200	7.95

LOW POWER TTL

74L00	.33	74L51	.33	74L90	1.69
74L02	.33	74L55	.33	74L91	1.45
74L03	.33	74L71	.33	74L93	1.69
74L04	.33	74L72	.49	74L95	1.69
74L06	.33	74L73	.69	74L98	2.79
74L10	.33	74L74	.69	74L164	2.79
74L20	.33	74L78	.79	74L165	2.79
74L30	.33	74L85	1.25		
74L42	1.69	74L86	.69		

HIGH SPEED TTL

74H00	.33	74H21	.33	74H55	.39
74H01	.33	74H22	.33	74H60	.39
74H04	.33	74H30	.33	74H61	.39
74H08	.33	74H40	.33	74H62	.39
74H10	.33	74H50	.33	74H72	.49
74H11	.33	74H52	.33	74H74	.59
74H20	.33	74H53	.39	74H76	.59

8000 SERIES TTL

8091	.59	8214	1.69	8811	.69
8092	.59	8220	1.69	8812	1.10
8095	1.39	8230	2.59	8822	2.59
8121	.89	8520	1.29	8830	2.59
8123	1.59	8551	1.65	8831	2.59
8130	2.19	8552	2.49	8836	.49
8200	2.59	8554	2.19	8880	1.33
8210	3.49	8810	.79		

9000 SERIES TTL

9002	.39	9309	.89	9601	.99
9301	1.14	9312	.89	9602	.89

Data sheets supplied on request
Add $.50 ea. for items less than $1.00

CMOS

74C00	.39	74C74	1.15	74C162	3.25
74C02	.55	74C76	1.70	74C163	3.25
74C04	.75	74C107	1.50	74C164	3.50
74C08	.75	74C151	2.90	74C173	2.90
74C10	.65	74C154	3.50	74C195	3.00
74C20	.65	74C157	2.19	80C95	1.50
74C42	2.15	74C160	3.25	80C97	1.50
74C73	1.55	74C161	3.25		

FEBRUARY SPECIALS

930	Dual 4 input gate w/exp	$ .10
936	Hex inverter	.10
937	Hex inverter	.10
311	Hi perf volt comp mDIP	.89
322	Prec timer. Operates on unreg supply 4.5-40v	1.59
709	Op amp	.21
739	Dual hi perf op amp	.99
40411	Audio pwr amp	3.40
40594	Audio driver	1.33
40595	Audio driver	1.49
2N2219A	Audio-UHF amp/sw	.89
5001	12 dig calculator chip	3.39
5312	4 dig clock chip	5.25
7404	Hex inverter	$ .18
7410	Triple 3-input NAND gate	.16
7420	Dual 4-input NAND gate	.16
7437	Quad 2-input NAND buffer	.29
7440	Dual 4-input buffer	.17
7445	BCD–dec dcdr-drvr	.90
7489	64 Bit RAM	2.35
7490	Decade counter	.69
74154	4-6 line dcdr demux	1.19
74181	Aritmetic logic unit	2.95
74L00	Quad 2 input gate (l.p.)	.27
74L74	Dual D flip flop (l.p.)	.49
MAN1	Red 7 seg LED	2.19
MCT2	Opto iso trans	.59

MEMORIES w/data

1101	256 bit RAM MOS	1.75
1103	1024 bit RAM MOS	4.95
5203	2048 bit erasable PROM	24.95
5260	1024 bit RAM Low Power	3.95
7489	64 bit RAM TTL	2.75
8223	Programmable ROM	4.95

CALCULATOR & CLOCK CHIPS w/data

5001	12 DIG 4 funct fix dec	3.95
5002	Same as 5001 exc btry pwr	7.95
5005	12 DIG 4 funct w/mem	8.45
MM5725	8 DIG 4 funct chain & dec	2.79
MM5736	18 pin 6 DIG 4 funct	4.95
MM5738	8 DIG 5 funct K & Mem	7.95
MM5739	9 DIG 4 funct (btry sur)	6.95
MM 5311	28 pin BCD 6 dig mux	6.95
MM 5312	24 pin 1 pps BCD 4 dig mux	6.95
MM 5313	28 pin 1 pps BCD 6 dig mux	7.95
MM 5314	24 pin 6 dig mux	8.95
MM 5316	40 pin alarm 6 dig	8.95

LED & OPTO ISOLATORS

MV10B	Red TO 18	$ .25 ea.
MV50	Axial leads	.20
MV5020	Jumbo Vis. Red (Red Dome)	.33
	Jumbo Vis. Red (Clear Dome)	.33
ME4	Infra red diff. dome	.60
MAN1	Red 7 seg. .270"	2.50
MAN2	Red alpha num .32"	4.95
MAN3A	Red 7 seg. .127"	.79
MAN3M	Red 7 seg. .127" claw	1.15
MAN4	Red 7 seg. .190"	2.15
MAN5	Green 7 seg. .270"	2.95
MAN6	.6" high solid seg	6.95
MAN7	Red 7 seg. .270"	1.35
MAN8	Yellow 7 seg. .270"	3.95
MAN64	.4" high solid seg	4.50
MAN66	.6" high spaced seg	4.65
DL707	Red 7 seg. .3"	2.15
MCT2	Opto-iso transistor	.69

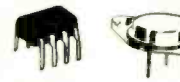
DTL

930	$ .17	937	$ .17	949	$ .17
932	.17	944	.17	962	.17
936	.17	946	.17	963	.17

4000 SERIES – RCA EQUIVALENT

CD4001	.55	CD4013	1.20	CD4023	.55
CD4009	.85	CD4016	1.25	CD4025	.55
CD4010	.85	CD4017	2.95	CD4027	1.35
CD4011	.55	CD4019	1.35	CD4030	.95
CD4012	.55	CD4022	2.75	CD4035	2.85

LINEAR CIRCUITS



300	Pos V Reg (super 723)	TO-5	.79
301	Hi Perf	mDIP TO-5	.32
302	Volt follower	TO-5	.79
304	Neg V Reg	TO-5	.89
305	Pos V Reg	TO-5	.95
307	Op AMP (super 741)	mDIP TO-5	.35
308	Micro Pwr Op Amp	mDIP TO-5	1.10
309K	5V 1A regulator	TO-3	1.65
310	V Follower Op Amp	TO-5 mDIP	1.19
311	Hi perf V Comp	mDIP TO-5	1.05
319	Hi Speed Dual Comp	DIP	1.29
320	Neg Reg 5.2, 12, 15	TO-3	1.35
324	Quad Op Amp	DIP	1.95
339	Quad Comparator	DIP	1.69
340T	Pos Volt Reg (6V-8V-12V-15V-18V-24V)	TO-220	1.95
370	AGC/Squelch AMPL	TO-5 or DIP	1.15
372	AF-IF Strip-detector	DIP	.79
373	AM/FM/SSB Strip	DIP	3.25
376	Pos. V Reg	mDIP	.59
377	2w Stereo amp	DIP	2.69
380	2w Audio Amp	DIP	1.49
380-8	.6w Audio amp	mDIP	1.25
381	Lo Noise Dual preamp	DIP	1.79
382	Lo Noise Dual preamp	DIP	1.79
550	Prec V Reg	DIP	.79
555	Timer	mDIP	.99
560	Phase Locked Loop	DIP	2.75
562	Phase Locked Loop	DIP	2.75
565	Phase Locked Loop	DIP TO-5	2.65
566	Function Gen	mDIP TO-5	2.75
567	Tone Gen	mDIP	2.95
709	Operational AMPL	TO-5 or DIP	.29
710	Hi Speed Volt Comp	DIP	.39
711	Dual Difference Compar	DIP	.29
723	V Reg	DIP	.69
739	Dual Hi Perf Op Amp	DIP	1.19
741	Comp Op AMP	mDIP TO-5	.35
747	Dual 741 Op Amp	DIP or TO-5	.79
748	Freq Adj 741	mDIP	.39
1304	FM Mulpx Stereo Demod	DIP	1.19
1307	FM Mulpx Stereo Demod	DIP	.82
1458	Dual Comp Op Amp	mDIP	.69
LH2111	Dual LM 211 V Comp	DIP	1.95
3065	TV-FM Sound System	DIP	.69
3075	FM Det-LMTR & Audio preamp	DIP	.79
3900	Quad Amplifier	DIP	.59
3905	Precision Timer	DIP	.65
7524	Core Mem Sense AMPL	DIP	1.89
7534	Core Mem Sense Amp	DIP	2.59
8864	9 DIG Led Cath Drvr	DIP	2.50
75451	Dual Peripheral Driver	mDIP	.39
75452	Dual Peripheral Driver	mDIP	.39
75453	(351) Dual Periph. Driver	mDIP	.39
75491	Quad Seg Driver for LED	DIP	.79
75492	Hex Digit Driver	DIP	.89

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ALL IC'S & LED'S ARE NEW, UNUSED, MARKED, SURPLUS PARTS, TESTED FUNCTIONAL. SATISFACTION GUARANTEED.

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"ALL LED" MONSANTO READOUTS

MONSANTO TYPE	CHAR. HT.	SALE EACH	Quantity Discounts
☐ MAN-1	.27	$3.50	3 for $ 9.
☐ MAN-2	.32*	4.95	3 for $14.
☐ MAN-3	.12	1.00	3 for $ 2.50
☐ MAN-6	.60	4.50	3 for $12.
☐ MAN-64	.4	3.50	3 for $ 9.
☐ MAN-7	.27	1.50	3 for $ 3.

* 35 LED matrix

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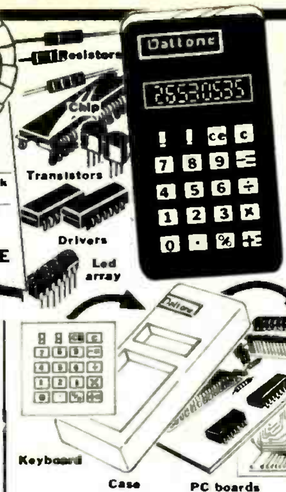
48-HR. SERVICE

WRISTWATCH LIQUID CRYSTAL DISPLAY

☐ **$9.95** 3½ digit, 7-segment — only 1 1/16 x 11/16 x 1/4". Includes readout, socket, "slide-in-place chrome slide face plate". Same display as found in $200. units.

THE SIMPLEST! FINEST! SMALLEST!

6-FUNCTION AC-DC CALCULATOR KIT! $24.50



- Lightweight, pocket size Extra large display
- 6 functions plus, minus, times, percentage, constant
- Floating decimal
- Chain and Mix calculations
- True credit balance
- Simplified indexing
- Mark up and Mark down
- Constant multiplication and division
- AC adaptor jack

Designed specifically for Poly Paks under the Daltone 80 brand. IMAGINE! only 2⅛ x 1 x 4½". Slides easily into your vest pocket, brief case, or handbag. We hunted everywhere to find a calculator kit that can be small, do the many functions, with fine engineering design and SIMPLE TO BUILD! WHY? Because it has the fewest parts in a kit. Imagine the pc board only has the chip, 4 resistors, two transistors, two driver ic's with the 9 digit readout. SIMPLE! You bet it is. The entire kit is even packed in a multicolor attractively designed box that in itself tells the mini calculator story. Kit includes: attractive black case with red filter; Flex Key (type 20SK-66) 18 key keyboard that measures only 2½ x 2" with 2 switches, one for ON-OFF, one for K constant; MAIN pc board; readout board; famous Cal Tech 5030 26-pin calculator chip; two 75491 ic drivers; Hewlett Packard 9 digit array; ac jack; 9 Volt battery connector resistors; two transistors; back protective plate; necessary wire plugs; easy instructions. (Less 9 volt standard battery and AC adapter) **EASIEST KIT TO BUILD**

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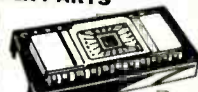

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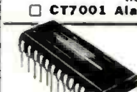

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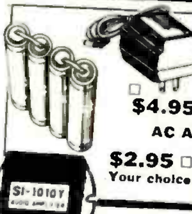

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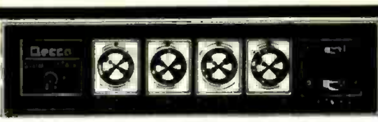

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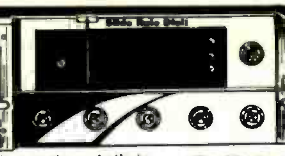
- All Purpose, All Family System!



Features: 4-speaker system, built-in FM antenna, record player jacks on separate panel. Another external panel consists of provisions for external FM and AM antenna, "satellite" speakers to provide 4-speaker ground, jacks for connecting a tape recorder to radio tuner or phono of systems to record. Lower inputs for connecting tape deck that will play back thru the internal amplifier for systems. AC jack for phono power connection. RED, GREEN and CLEAR indicators for Phono, AM, and FM respectively. Includes red indicator on front panel for STEREO indicator. Has separate input to plug into mike, guitar and other musical instruments has front panel controls, PHONO-STEREO-AM-FM, MONO, FM STEREO, GUITAR, TAPE, MIKE master control switch, LOUDNESS, BALANCE, TREBLE, BASS controls, with power ON-OFF rocker switch, and AFC ON-OFF. Designed for all audio-philes to use as wall unit in DEN or FAMILY ROOM, or control unit by easy chair in family room, or for those who wish to design their own console or modular system. With 6 ft. 115 VAC cord and plug. Only 13 x 7 x $3\frac{1}{2}$" deep. With knobs. Shpg. wt. 3 lbs.

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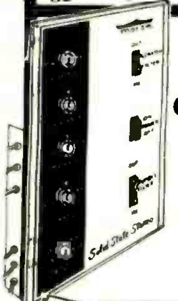

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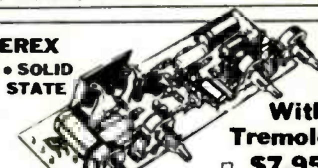

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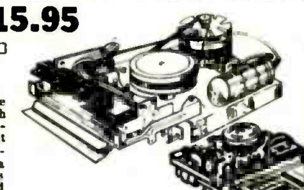

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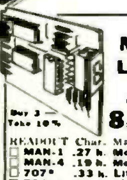

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☐ SLA-1*	.33 h.	Opcoa

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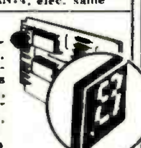

8 WATT STEREO AUDIO AMP — 5.95

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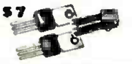
$3.98 ☐ 2 for $7
35 WATT AUDIO AMPLIFIER BASIC



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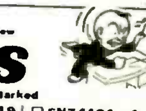

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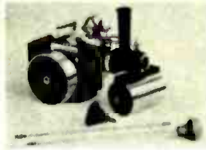

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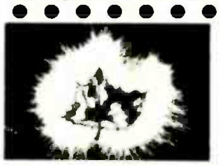

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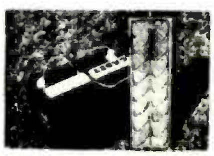

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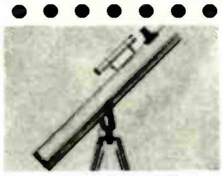

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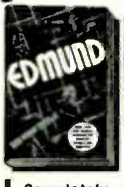

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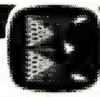

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